Mohamed Behnassi · Sidney Draggan
Sanni Yaya *Editors*

# Global Food Insecurity

## Rethinking Agricultural and Rural Development Paradigm and Policy

Springer

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ISBN 978-94-007-0889-1 e-ISBN 978-94-007-0890-7
DOI 10.1007/978-94-007-0890-7
Springer Dordrecht New York Heidelberg London

Library of Congress Control Number: 2011925659



*Front cover image*: Courtesy of Daina Rechner ©IRD

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

The North-South Research Center for Social Sciences (NRCS) is a research organism founded by a group of researchers and experts from both Northern and Southern countries as an independent institution, with no political or state affiliation. Based in Morocco, NRCS aims to develop research and expertise in many social sciences areas with global and local relevance from a North-South perspective and within a complex and interdisciplinary approach. As a think tank, NRCS aspires to serve as a reference locally and globally through rigorous research and active engagement with the policy community and decision-making processes. The Center is currently chaired by Mohamed BEHNASSI, Dr. Prof. in Global Sustainability Politics.

# Preface

This volume is the outcome of an International Conference held in Agadir (Morocco), in November 2009, titled "The Integration of Sustainable Agriculture, Rural Development, and Ecosystems in the Context of Climate Change, the Energy Crisis and Food Insecurity", chaired by Dr. Mohamed Behnassi. The Conference was jointly organized by the Faculty of Law, Economics and Social Sciences of Ibn Zhor University of Agadir (Morocco) and the North South Center for Social Sciences (NRCS), with the fruitful support and sponsorship of the German Technical Cooperation (GTZ).

The ambitious goal of this volume, and of the Conference that forms its basis, is to effect a serious *rethinking* of the complex interface of a baffling array of problems, issues, challenges and opportunities. Deliberations at Conference focused on the critical challenges of sustainable agriculture, rural development, and human and environmental support systems (all within a multilayered context of climate change, the energy crisis, the rise in global population and food insecurity). This complex interface defines the boundaries of paradigms, policies, practices and management actions that converge in such a way as to threaten the condition and well-being of humankind and of ecological systems, globally.

As a focus for the Conference and this volume, what could be more compelling than food? It is no mistake that foods are known as staples (that is, they are major parts, elements or features) of all human activity, aspiration and undertaking. Take away these staples and civilization disappears – completely. Without food, there can be no reasoned, sustained development; there can be no trade; there can be no life. The focus of our efforts is, therefore, most fundamental to humanity.

We take comfort in utilizing reductionist approaches to the measurement and observation, and to the mitigation or resolution of questions; and, such approaches have served – and continue to serve – human inquiry and subsequent action relatively well. Nonetheless, from such approaches we are reminded continually of the sheer complexity of the world around us. Arising from this growing recognition of the complexity of things, processes, and social constructs, there is corresponding growth in recognition of the need for *integrative* tools (and integrative *mindsets*). Such tools, based in science and in technology – and in social dynamics – now look to include a wider complement of stakeholders that are enmeshed in taking decisions and in undertaking solutions under illuminated, participatory mindsets.

Significantly, the Conference's participants agreed that scientific and technological development is not enough in itself. It is critical to make sure that sustainability and poverty reduction remain the guiding principles, and that we use our resources, harness our intellect and direct our knowledge to benefit the poor and the marginalized. In addition, they found that networking and knowledge sharing must become encouraged and undertaken among all stakeholders. The strengthening and broadening of linkages, networking and collaboration fit solidly within their mantra. In a wider realm, objectives of the Conference's expected outcomes include the strengthening of democratic governance, crisis prevention and recovery, development of processes for reducing poverty, and bridging the gap between traditional knowledge and Western approaches to scientific inquiry and assessment, worldwide.

These observations hint at the beginnings of a roadmap to address the central foci of the Conference (that is, agricultural sustainability, rural development and food security). This volume aims at providing structure to effect achievement of this critically needed roadmap.

The Editors

# Acknowledgements

I have been privileged to share the responsibility of editing this volume (one of the three books based on the best Proceedings of the above cited Conference) with my colleagues Dr. Sidney Draggan (Environmental Information Coalition, USA) and Dr. Sanni Yaya (Associate Professor of Economics and International Health, University of Ottawa's Interdisciplinary School of Health Sciences) whose expertise, commitment, intellectual generosity and insight greatly speeded up the process, and undeniably improved the final version of the book manuscript.

On behalf of my co-editors, I would like to gratefully and sincerely thank all the members of the Scientific Committee who have actively taken part in the peer-review of the submitted chapters. Deepest thanks and appreciation go to Dr. Shabbir A. Shahid (International Center for Biosaline Agriculture-ICBA, UAE), Joyce D'Silva (Compassion in World Farming, UK), Dr. Nira Ramachandran (Earth Care Foundation, India), Dr. Jennifer L. Lanier (World Society for the Protection of Animals, UK), Dr. Ingrid Hartmann (Humboldt-University of Berlin, Department of Gender Studies, Agricultural Faculty, Germany), Dr. Marie Bonnin (Institute for Research and Development-IRD, France), Dr. Samira Omar Asem (Food Resources and Marine Sciences Division, Kuwait Institute for Scientific Research, Kuwait), Dr. Ghazi Abu Rumman (ICT International Pty Ltd., Australia) and Dr. Gerald K. Sims (Agriculture Research Service, United States Department of Agriculture, USA).

While the real value of this volume should be credited to authors of chapters, whose papers have been accepted for publication after a riogorous peer-review, any shorthcomings or errors are undoubtedly the editors'responsibilty. However, the Editors and the Publisher are not responsible for any statement made or opinion expressed by the authors in this publication.

Mohamed Behnassi

# Contents

# List of Figures

# List of Tables

# List of Abbreviations and Acronyms

| | |
|---|---|
| ACMAD | African Centre of Meteorological Applications for Development |
| AERLS | Agricultural Extension Research and Liaison Services |
| AFCR | African Food Crisis Response |
| AFFM | African Fertilizer Financing Mechanism |
| AGRA | Alliance for Africa Green Revolution in Africa |
| AGRHYMET | Research Center for Agriculture, Hydrology and Meteorology |
| AIDAs | Agro-Input Dealers Associations |
| AIDS | Acquired Immuno-Defficiency Syndrome |
| ASCV | Guidelines for Social Life Cycle Assessment of Products |
| BOD | Biological Oxygen Demand |
| BSE | Bovine Spongiform Encephalopathy |
| CIRDAP | Centre on Integrated Rural Development for Asia and Pacific |
| CPI | Corruption Perceptions Index |
| CPPs | Crop Protection Products |
| CREP | Conservation Resource Environment Program |
| CRF | Crisis Response Facility |
| CSM | Cerebro-Spinal Meningitis |
| DFID | Department for International Development |
| ENSO | El Niño-Southern Oscillation |
| EPA | Environmental Protection Agency |
| EPR | Extended Producer Responsibility |
| ESAP | Economic Structural Adjustment Programme |
| FAC | Food Aid Convention |
| FAD | Food Availability Decline |
| FAO | Food and Agriculture Organization of the United Nations |
| FED | Food Entitlement Decline |
| FGN | Federal Government of Nigeria |
| FMAWRRD | Federal Ministry of Agriculture, Water Resources and Rural Development |
| FPDD | Fertilizer Procurement and Distribution Division |

| | |
|---|---|
| FSFC | Federal Superphosphate Fertilizer Company |
| FTAs | Free Trade Agreements |
| GAP | Good Agricultural Practices |
| GDP | Gross Domestic Product |
| GHGs | Greenhouse Gases |
| GNI | Gross National Income |
| GT | Grounded Theory |
| GTZ | German Technical Cooperation |
| HACCP | Hazard Analysis Critical Control Point |
| HIV | Human Immuno-Defficiency Virus |
| IAASTD | International Assessment of Agriculture Science and Technology for Development |
| IAC | InterAcademy Council |
| ICDDR | International Centre for Diarrhoeal Disease Research |
| ICDS | India's Integrated Child Development Services |
| IDRC | International Development Research Centre |
| IEA | International Energy Agency |
| IFAD | International Fund for Agricultural Development |
| IFPRI | International Food Policy Research Institute |
| IGAD | Intergovernmental Authority for Development |
| IITA | International Institute of Tropical Agriculture |
| IMF | International Monetary Fund |
| IPCC | Intergovernmental Panel on Climate Change |
| IRD | Institute for Research and Development |
| IRDP | Integrated Rural Development Programme |
| ISO | International Standardization Organization |
| ITC | International Trade Centre |
| IUCN | World Conservation Union |
| LCA | Life Cycle Analysis |
| LCC | Life Cycle Costing |
| LIFDCs | Low-Income Food-Deficit Countries |
| MDGs | Millennium Development Goals |
| MPAs | Marine Protected Areas |
| NAFCON | National Fertilizer Company |
| NARI | National Agricultural Research Institutes |
| NASA | National Aeronautics and Space Administration |
| NASC | National Agricultural Seed Council |
| NEPA | National Electric Power Authority |
| NEPAD | New Partnership for Africa's Development |
| NGOs | Non-Governmental Organizations |
| NIMET | Nigerian Meteorological Agency |
| NOAA | National Oceanic and Atmospheric Administration |

| | |
|---|---|
| NRC | National Research Council |
| NRCS | North-South Center for Social Sciences |
| NSS | National Seed Service |
| OECD | Organization for Economic Co-operation and Development |
| OTDS | Overall Trade Distorting Support |
| PA | Participatory Appraisal |
| PCP | PentaChloroPhenol |
| PROUT | Progressive Utilization Theory |
| PRSP | Poverty Reduction Strategy Paper |
| PSNP | Productive Safety Nets Programme |
| PSPB | Pakistan Statistical Pocket Book |
| RCTs | Resource-Conserving Technologies |
| RMCs | Regional Member Countries |
| RRA | Rapid Rural Appraisal |
| RWC | Rice-Wheat Consortium |
| SAARC | South Asian Association for Regional Cooperation |
| SACEP | South Asia Cooperative Environment Programme |
| SADC | Southern African Development Community |
| SCAHAW | European Commission's Scientific Committee on Animal Health and Animal Welfare |
| SDN | Stakeholder Democracy Network |
| SME | Small and Medium Enterprises |
| SOS | Save Our Souls |
| SSM | Special Safeguard Mechanism |
| SSA | Sub-Saharan Africa |
| SSHRC | Social Sciences and Humanities Research Council of Canada |
| SVC | Scientific Veterinary Committee of the European Union |
| TCA | Total Cost Assessment |
| TI | Transparency International |
| UAE | United Arab Emirates |
| UK | United Kingdom |
| UMP | Uzumba Maramba Pfungwe |
| UNDP | United Nation Development Programme |
| UNEP | United Nations Environment Programme |
| USA | United States of America |
| USAID | United States Agency for International Development |
| VWC | Virtual Water Content |
| WCED | World Commission on Environment and Development |
| WFP | United Nations World Food Programme |
| WHO | World Heealth Organization |
| WRI | World Resource Institute |

# Part I
# Agriculture and Rural Development at the Heart of Sustainability and Food Security

# Chapter 1
# A New Conceptual Framework for Assessing Rural Development Performance: Sustainability of Scale, Scope and Integration

**Kiyotada Hayashi**

**Abstract** Many sustainability indicators have been used for assessing rural development. They evaluate relative performance of alternative rural development projects and programs from economic, environmental and social perspectives. However, they do not illustrate why a project outperforms others and thus a conceptual framework for explaining the results is needed. Here, we present a new framework for assessing rural development performance on the basis of sustainability of scale, scope and integration. The framework we developed can be expressed as a 3 × 3 matrix. Row headings include "economy", "ecology" and "sociology", which explain three pillars of sustainability. Column headings contain "scale", "scope" and "integration", which illustrate three types of strategies. Each cell explains the concepts: such as "economy of scale", which is a classical concept for describing reduction in cost per unit as the increase of production; "ecology of scope", which will be useful in illustrating the fact that environmental impacts of diversified production can be small; and "sociology of integration", which can be used as a concept for justifying rural activities such as local-production and local-consumption. After presenting an outline of the new conceptual framework, tripartition of strategies and tripartition of criteria are illustrated. Then, theoretical and practical implications of the framework are discussed using the concepts such as eco-industrial parks.

**Keywords** Economies of scale • Ecologies of scope • Sociologies of integration • Diagonal hypothesis

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_1,

# 1 Introduction

Many sustainability indicators have been proposed for assessing alternative projects and supporting policy decisions (Hák et al. 2007; United Nations 2007; Bell and Morse 2008). They can be used for assessing rural development (Pínter et al. 2005) and evaluate relative performance of alternative rural development projects and programs from economic, environmental and social perspectives.

They, however, do not illustrate why a project outperforms others. All they illustrate is relative or absolute performance of projects, and thus they do not provide systems of explanation for the differences in performance. Therefore, a conceptual framework for explaining the mechanisms is needed.

Here, we present a new integrated framework for assessing rural development performance. It is an integration of two types of disciplines. One is related to sustainability indicators and industrial ecology, and gives the theory on the basis of the three pillars of sustainability. The other includes microeconomics and management science, and provides the theory about scale, scope and integration, although the last word – integration – is also discussed in industrial ecology.

In this paper, after presenting an outline of the new conceptual framework in Sect. 2, tripartition of strategies and tripartition of criteria are illustrated in Sects. 3 and 4. Then, theoretical and practical implications of the framework are discussed in Sect. 5.

# 2 A New Conceptual Framework

The framework we developed can be expressed as a 3 × 3 matrix (Table 1.1). Row headings include “economy”, “ecology” and “sociology”, which explain three pillars of sustainability. Column headings contain “scale”, “scope” and “integration”, which illustrate three types of strategies. Each cell explains the concepts: such as “economy of scale”, which is a classical concept for describing reduction in cost per unit as the increase of production; “ecology of scope”, which will be useful in illustrating the fact that environmental impacts of diversified production can be small; and “sociology of integration”, which can be used as a concept for justifying rural activities such as local production and local consumption.

**Table 1.1** A new conceptual framework for performance of sustainability

| | Scale | Scope | Integration |
|---|---|---|---|
| Economy | Economy of scale | Economy of scope | Economy of integration |
| Ecology | Ecology of scale | Ecology of scope | Ecology of integration |
| Sociology | Sociology of scale | Sociology of scope | Sociology of integration |

## 3 Scale, Scope, Integration: Tripartition of Strategies

Increase of scale (business expansion of a single product type), increase of scope (business changes to introduce different types of products) and progress of systems integration (internalization of the material cycles) can be considered as three strategies to improve management performance.

### *3.1 Scale and Scope*

Economies of scale are quite common and they are applicable to the case of rural development performance, although the concept is originally related to a business unit. Economies of scope are also common in microeconomics. Thus, we will simplify the description of this subsection.

### *3.2 Integration*

The purpose of introducing this concept is to consider returns to systems integration (returns to internalization) of material cycles (Ayres 2002). Since the complex web of exchanges of materials among a set of firms and industrial symbiosis can be considered as industrial ecosystems, the concept originates in the research field of industrial ecology.

An important fact to be mentioned here is that the same concept was used in Japan. That is, the term of "economies of coupling" was invented by Miyazawa (1988) to illustrate the synergetic effects caused by the connection of information and know-how of firms.

## 4 Economy, Ecology, Sociology: Tripartition of Criteria

Our discussions so far are restricted to economic returns. We now extend the framework into ecological and sociological (societal) returns. In order to understand the meaning of the three evaluation criteria (economic, ecological and sociological indicators), we will review sustainability assessment.

### *4.1 Economy*

In addition to economies of scale, the discussions on economies of scope are common in economics. As already discussed in the earlier section, economies of integration (economies of coupling) attract attention in microeconomics and industrial ecology.

Although the explanation of economies of scope in microeconomics does not mention performance measurement techniques, Life Cycle Costing (LCC) is a common method to measure economic performance of projects in sustainability assessment.

## 4.2 Ecology

"Ecologies" in this case mean the ecological aspects of sustainability, and they can be measured by Life Cycle Assessment (LCA). Actually, there are discussions on ecologies of scale in the research field of LCA (Schlich and Fleissner 2005). They point out that environmental impacts per product will decrease as the increase of scale. It seems that there are no empirical studies on ecologies of integration.

## 4.3 Sociology

As the terminology for illustrating social aspects of sustainability, "sociologies" have been introduced in this paper. If there are sociologies of scale in the development project, social aspects of sustainability will be improved by increasing the scale in the development project. Likewise, if there are sociologies of scope in the project, the social aspects will be improved through diversification of products. The same illustration can be applicable to sociologies of integration.

Social impact assessment (van Schooten et al. 2003) and social or societal LCA (Klopffer 2008; Benoît and Mazijn 2009) will be the methods for assessing social aspects of sustainability. Indicators used in social impact assessment are shown in Table 1.2. It is important to mention that there are duplications between social and economic indicators and between social and environmental indicators, and thus the indicators in Table 1.2 should be adapted to sustainability assessment by avoiding double counting. The theory of social capital can also be applicable to measure the social impacts.

# 5 How It Works

## 5.1 Theoretical

One of the important advantages of using this framework is that it provides a theoretical foundation for explaining the performance outcomes of development alternatives. Previous applications of sustainability indicators to rural development projects tell us relative or absolute performances of the projects, and they can be

**Table 1.2** Classification of social impacts (van Schooten et al. 2003)

| Category | Indicator (three examples) |
|---|---|
| Health and social well-being | – Death of self or a family member<br>– Nutrition<br>– Actual physical health and fertility |
| Quality of the living environment (livability) | – Leisure and recreation opportunities and facilities<br>– Environmental amenity value/aesthetic quality<br>– Physical quality of housing |
| Economic impacts and material well-being | – Workload<br>– Standard of living<br>– Economic prosperity and resilience |
| Cultural impacts | – Change in cultural value<br>– Cultural integrity<br>– Loss of local language or dialect |
| Family and community impacts | – Family violence<br>– Community cohesion<br>– Social differentiation and inequity |
| Institutional, legal, political and equity impacts | – Functioning of government agencies<br>– Tenure or legal rights<br>– Human rights |
| Gender relations | – Woman's physical integrity<br>– Gendered division of production-oriented labor<br>– Political emancipation of woman |

the basis for political judgment. However, they do not tell us why a project outperforms others. Here, the framework can be used as a reference for explaining the results.

In this case, it will be useful to present a hypothesis – diagonal hypothesis – that illustrates the tendency in Table 1.1. Although Table 1.1 contains nine cells, there may be dominant cells; economies of scale, ecologies of scope and sociologies of integration. This hypothesis, however, does not neglect the importance of non-diagonal cells, and moreover there would be the win-win relationship between, for example, economies and sociologies of integration.

Eco-industrial parks (e.g., Lowe 2001; Ayres 2002; Jacobsen and Anderberg 2004; Liwarska-Bizukojc et al. 2009) will be a good example to apply the hypothesis, because the goal of establishing eco-industrial parks is to enhance environmental, economic and social performance through collaboration in managing environmental and resource issues (Lowe 2001). If we apply diagonal hypothesis to eco-industrial parks, we will understand the main sources of symbiosis; economic returns for scale, ecological returns (environmental benefits) for scope, and sociological returns (social revitalization) for integration, although the understanding is still relying on a hypothesis. The justification of local production and local consumption should be based on the same logic.

### 5.2 Practical

Practically, the framework can be used as a system of explanation for real-world phenomena; it can be used as a descriptive theory as illustrated in the previous subsection. In this case, the areas of application include eco-industrial parks and food parks (Annevelink et al. 2003). Industrial clusters are other examples, which are useful in explaining the characteristics of the framework. That is, although cluster theory (Porter 1988) explains the sources for productivity advantages of industrial clusters (access to specialized inputs and employees, access to information, complementarities, access to institutions and public goods, and incentives and performance measurement), the attention is restricted only to economy. The recent activities in Japan such as "Biomass Towns" (communities try to construct integrated biomass utilization systems with the help of government support) and "Model Towns for Organic Agriculture" (communities try to establish organic agricultural systems with the help of government support) may be classified as a kind of clusters.

## 6 Concluding Remarks

Since theoretical and practical implications as a descriptive tool have been presented in the previous section, our next task will be the discussion of the potentialities of the framework as a system design tool. Thus, rather than considering which system performs well, how to design optimal levels of scale, scope and integration becomes the central topic. In this case, the mode of application must be prescriptive, and the problem is how to support decisions. This implies that alternatives generation techniques and scenario development methods will be important in conducting meaningful comparative studies. This approach is also useful for facilitating innovation.

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# Chapter 2
# A Knowledge Approach to Sustainable Agriculture

**Jesús Rosales Carreón, René J. Jorna, Niels Faber, and Rob van Haren**

**Abstract** The Dutch agricultural sector is facing major challenges, which can affect the entrepreneurial farming activities. One of the major challenges is the adoption of practices leading to sustainable agriculture. Therefore, it is relevant to investigate the knowledge of the main actors in agriculture: the farmers. In this project, the way farmers structure their knowledge is studied. The study was completed through filling questionnaires by interviewing them. It was revealed that farmers possess knowledge of their own about their enterprise, but they also receive knowledge from external sources. Through this organized survey, we identified the concepts that farmers associate with sustainable agriculture. However, it is not clear whether the famers' knowledge is sufficient and suitable to adopt sustainable practices.

**Keywords** Agriculture • Cognition • Knowledge • Netherlands • Sustainable

## 1 Introduction

In the Netherlands, there is an increasing social demand for making agriculture more sustainable (Poppe et al. 2009). There have been many definitions about sustainability; however, none of these definitions clearly defines the concept of

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_2,

sustainability (Jorna 2006). It is a matter of serious debates (Robinson 2004). Sustainable agriculture was not a major issue in the 1960s and 1970s. The goal in those years was to grow enough food thanks to the green industrial revolution (Brady 1990). After being highly productive for more than half-century, agriculture now aims at being sustainable. There is a consensus that the different definitions of sustainable agriculture discussed in literature include (to a different extent) three basic elements: the natural environment, economic profit and the welfare of society. These concepts are included in the term “Triple Bottom Line or 3P’s (People, Planet and Profit or Prosperity)” coined by Elkington in 1994. It should be noted that the three basic elements that are specified are only for clarifying and analyzing human thinking about sustainability, since these issues seldom fall in one specific category. Sustainability issues are a complex combination of the 3P’s.

From a “Planet” perspective, agriculture is based on plant growth and on how different conditions as soil fertility, climate and pests affect it. The focus is on how various management practices and environmental conditions affect yield and how these conditions can be improved. Focusing on this aspect of sustainable agriculture leads to maintaining or improving current levels of biophysical productivity. From a “profit” perspective, agriculture is an enterprise at the farm level and an important economic sector at the international, regional, national and local levels. The focus on massive production was the main driver of the so-called green revolution, also known as the industrialized or conventional model of agriculture. The downside of conventional agriculture is that massive application of modern agricultural techniques has resulted in numerous ecological disadvantages, such as mismanagement of resources leading to land degradation, impoverishment of the rural masses and the fact that farmers increasingly depend on a few agricultural multinationals.

From a “people” perspective, agriculture is viewed as a producer with focus on its ability to satisfy requirements for food and fiber. Here, sustainable agriculture is associated with the prospects of meeting national and global food needs, quality and security of food supply, labor conditions, learning, well-being of people and human development on a general sense. Human development comprises the process of enlarging people’s choices at three essential capabilities: to lead a long and healthy life, to be knowledgeable and to have a decent standard of living (McKinney and Schoch 2003; Szirmai 2005). Table 2.1 shows the positive aspects of sustainable agriculture and the challenges it faces.

As Viederman (1990) points out, sometimes we are self-satisfied with our wisdom in moving ahead with sustainable agriculture. However, sometimes that wisdom is difficult to transfer and it requires not only speaking about sustainable agriculture, but also understanding its meaning for different stakeholders to satisfy their needs. In agricultural sector, the main stakeholders are those directly linked with agricultural practice and activities: the farmers. Thus, a key issue is not to establish just a conclusive list of sustainability indicators, but to investigate and understand the concepts that farmers associate with sustainable agriculture and find ways as how to achieve it. In trying to understand sustainable agriculture, it is important to focus not only on the state of affairs in the physical world, but also on how humans process knowledge about sustainability. It can be argued that in order to explore the meaning of sustainable development for different actors, a framework based on knowledge theory and

**Table 2.1** Characteristics of sustainable agriculture

| Positive aspects | Challenges |
|---|---|
| Aims at equilibrium among the basic ecological cycles and natural balances diminishing pollution | Lack of a concise definition |
| Ensures that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products | Operationalization is sometimes difficult, especially concerning the social aspect |
| Provides long-lasting employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production | Time consuming in reaching consensus among the different actors |
| Maintains and enhances the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources | Requires a new approach in thinking |
| Strengthens self-reliance of the farmers | To be independent |

knowledge management can be used. Such a knowledge approach focusing on farmers is hardly found in the literature on sustainable agriculture. Only Laukkanen (2000) explores the notion of sustainability of the structure and dynamics of different agrarian municipalities in Finland as social entities and micro economies, and Boone et al. (2007) reported about the knowledge that extension educators have concerning the dimensions of sustainable agriculture.

## 2 Knowledge Approach

McElroy (2008) identifies knowledge as the key factor regarding sustainability. Farmers can be considered as human information processing systems. Human decision-making involves two components (Newell and Simon 1972). First, we have the farmer personal characteristics. In this respect, there have been studies regarding the personal characteristics (or traits) that influence farmers in order to adopt (or not) specific farming practices (de Lauwere et al. 2004). In the second place, there are person's knowledge processes regarding farming practices. With knowledge processes, we mean the processes that individual farmers undertake to understand the information they received. These processes are divided in two domains: the static domain (which deals with the way an individual structures knowledge), and the dynamic domain (which deals with the reasoning processes of an individual). According to Gardner and Stern (2002), in spite of agreement on the fact that human activity is the cause of several environmental threats, there are just a few studies that study the human (cognitive or mental) dimension in detail, let alone in an operational way. We think that by studying the two domains of knowledge (static and dynamic), we get insights into the alignments farmers have with sustainable agriculture. The study of the static domain allows identifying the associated concepts with sustainable agriculture. The dynamic domain allows distinguishing mindset orientations as well as reasoning patterns. We state that agriculture is sustainability oriented, when it is ecologically sound, economically viable and socially appropriate. Since the study of sustainable agriculture is not about optimizing one of these single factors, but about having equilibrium among them, we claim that a sustainable-oriented mindset looks for an overall and integrated view among these aspects. In Table 2.2, we present concepts that can be used to distinguish a sustainable oriented mindset from the mindset of classical farming.

From a knowledge perspective, we can distinguish in the European Union (Fig. 2.1) a transition in the knowledge approaches for every model of agriculture going from a conventional model of agriculture towards a sustainable model. Before 1945, there was a traditional model of agriculture. After the war period, the agricultural policy was based on maximizing the production yields in order to avoid food shortages. This goal developed into a situation that fosters a maximization of possible profits. In this period, the knowledge approach was oriented towards increasing production. The focus was on private companies and universities that helped the farmer and relied on public and private investments (Van der Ploeg and Roep 2003). The concept of sustainable agriculture appeared along with the concept of sustainable development, during the 1980s. The importance of the concept was recognized and confirmed at the Rio Earth Summit in 1992 (United Nations Division for Sustainable Development 2010). After 20 years, it is now recognized that the one-way top-down approach – where the farmer is told what to do – is insufficient to allow bottom-up interactions and feedbacks necessary for ‘natural’ diversification and system adaptation (Morgan and Murdoch 2000).

**Table 2.2** Focus of sustainable oriented mindset on an agricultural system

| Less sustainable oriented mindset | More sustainable oriented mindset |
|---|---|
| Focus only in specific units of the system | Focus on interrelations among units |
| Focus on “straight” chains in the system | Focus on networks within the system |
| (Lack of) focus on different interactions | Focus on feedback loops among units |
| Short time perspective (here and now) | Long time perspective (there and then) |

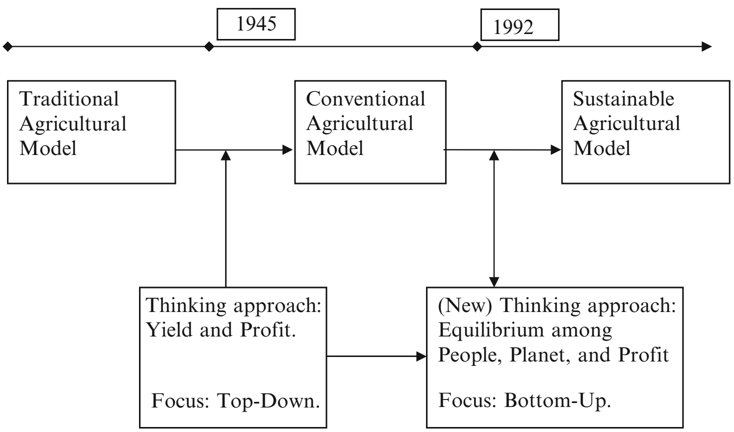


**Fig. 2.1** Knowledge transition in agriculture

The top-down approach still dominates current visions of sustainable development of the agro-sector. Consequently, scientists and policy makers have typically defined indicators of sustainable development only. We argue that the "top-down" focus in the "old thinking" approach has to be adapted such that practice is embodied in the farmer's knowledge structures as part of the farmer's models of the world. We argue in favor of bottom-up models. These models provide a basis for planning, deciding and acting or reacting upon in specific circumstances. Farmers should possess agricultural-related knowledge structures that are used to interpret events or to initiate, formulate or recommend plans, projects or decisions.

The complexity of sustainable agriculture requires individuals to possess much knowledge regarding agricultural systems in order to make them behave in a sustainable way. Additionally, individuals require the acquisition of new insights and forgetting old customs that stand in the way of sustainability. Hence, local knowledge constitutes an extensive realm of accumulated practical knowledge and knowledge-generating capacities that is needed if sustainability and development goals have to be reached. This asks for a bottom-up approach, meaning an approach starting from the individual interpretation of that context. Therefore, it seems to be relevant to understand what knowledge farmers have about sustainable agriculture. It is also relevant to identify mind-settings and reasoning patterns used by farmers to interpret this knowledge.

The lack of a standard definition of knowledge is reflected in the different classifications of knowledge in literature. Jorna (2007) offers a model for knowledge types. The model can be used to assess the types of knowledge an agent has in performing certain kinds of tasks. The model refers to the three dimensions involved in knowledge representation. The first dimension is *sensory* knowledge. It starts from a perception of difference, interpreted in terms of an analogy, which is imitated in behavior. The second dimension is *coded* knowledge (texts and manuals). Codes can be categorized by taking into account the kinds of elements and combination rules a code consists of. The third dimension concerns *theoretical* knowledge. This dimension is about the structural relationships among events and categories of events. It looks into chains of reasoning, operationalized in "questions-why". In the case of agriculture, we are interested not only in the mental models that farmers possess, but in the types of knowledge they might favor. The types of knowledge give an insight regarding the way farmers prefer to reason and to learn. Their understanding is relevant to support the bottom-up approach towards sustainable agriculture.

## 3 Exploratory Study

In order to understand the knowledge that farmers have regarding sustainable agriculture, we decided to carry out a pilot study to test communication and gather information prior to a more detailed investigation. Soil conservation practices should be a prime target in sustainable agricultural systems (Sojka et al. 2003;

Janvier et al. 2007). Hence, we work in combination with a leading laboratory in the agricultural sector in the Netherlands (BLGG, Oosterbeek, The Netherlands). Its core business is to analyze soil samples to determine its physical and chemical characteristics. The laboratory staff collect around 500,000 samples every year and provide technical advice when the customer asks for it. The laboratory aims at helping their customers to improve production and reduce costs through using improved farming practices. The process starts when a farmer calls them in order to collect a soil sample to determine its chemical and physical composition. The laboratory collects the sample for its analysis. The results are sent back to the customers. However, it is not known how much of these results are understood and used by farmers. Furthermore, we do not know if this knowledge is suitable and sufficient to cope with the challenges the Dutch agricultural sector faces, namely being more sustainable.

The aim of this exploratory study is to understand what knowledge farmers have and what farmers do, in cognitive terms, with the information they receive. The knowledge of sustainability in agricultural activities was evaluated using a semi-standardized interview. This is a method for reconstructing subjective theories (Flick 2006). The term "subject theory" refers to the fact that interviewees have a complex stock of knowledge about the topic under study: sustainable agriculture in our case. This knowledge includes assumptions that are explicit and immediate, and that interviewed farmers are more likely to express spontaneously in an openly designed interview situation than in a standardized interview or questionnaire. Additionally, more directed questions were asked to make the interviewee's implicit knowledge more explicit.

The interview consists of three parts. The first one is devoted to gather demographic data. In the second one, interviewees were asked a series of questions to assess their knowledge about sustainable agriculture. The third one consisted of specific questions regarding their farming practices and the sources of information they used (regarding sustainability). In some of the questions, a 5-point Likert scale was used. In order to guarantee the validity of the interviews, we follow the directives from Wolcott (1990) during the interview process. A total of 11 participants were asked for the interviews. The participants are farmers that work in the Municipality of the Noordoostpolder in the Netherlands. The participants were interviewed at their offices for 1 h. The interview was held in Dutch. This interview guide was pre-tested with a group of experts on the topic of sustainability working at the University of Groningen. In order to reproduce the interviews as exactly as possible, each one of the meetings was voice recorded.

## 4 Results

The interviewees were asked to provide basic demographic information, including age, years worked, educational level, the extension of their farm and the products they grow. The average age was 43 years, the oldest farmer was 62 years and the

**Table 2.3** Knowledge about sustainable agriculture

| Concepts | | Content | No. of mentions |
|---|---|---|---|
| P's | People | Working conditions | 1 |
| | | Social issues | 1 |
| | | None | 9 |
| | Planet | Environmental protection | 5 |
| | | Soil protection | 6 |
| | | None | 0 |
| | Profit | Market | 4 |
| | | Price | 3 |
| | | Earnings | 1 |
| | | None | 3 |

youngest farmer was 22 years. The average years worked in the farm was 23 years. The 11 respondents had a technical vocational degree.

The results concerning the static domain of knowledge are summarized in Table 2.3. We asked open questions to gain an insight in the concepts the interviewees associated with sustainable agriculture. The 11 participants were familiar with the term "sustainable agriculture". Most of the interviewees mentioned that sustainability is related to environmental protection, especially to the protection of the soil. Most of them mentioned that it has also some economical implications.

Six participants expressed that sustainability has mainly to do with balancing their market with environmental protection. Just one of them mentioned it has to do with social issues, such as improving the working conditions of the farmers. Two persons mentioned that sustainability has to do with the way one looks at the future. One of these persons mentioned that there are many factors to be taken into account to be sustainable, but he thinks that one should start with soil quality. Five participants mentioned that even though they had some knowledge about sustainable agriculture, they did not know how it would look like in practice.

We wanted to get insight into the opinions of the participants relative to their main sources of information when it comes to sustainable agriculture. Participants were presented with 16 possible sources of information. Participants were asked: "when you want to know about sustainable farming practices you ask to." They were asked to rank the sources of information using a 5 point Likert scale (1: strongly disagree, 5: strongly agree).

Media communications such as internet and newspapers were mentioned as the main indirect sources of information. Direct sources of information appear to be favored by the participants. Colleagues (other farmers) and fertilizer suppliers were mentioned as the main sources of information. In this point, it is important to state that nine interviewees mentioned that they had as a main source of information agricultural organizations, such as "Land en Tuinbouw Organisatie" (Federation of Agriculture and Horticulture) or "Agrarische Unie" (Agricultural Union). These organizations were their communication link with the Dutch Government (or even with the European Union). Also, fertilizer suppliers were considered as an important source of information regarding environmental regulations in the agricultural sector. Participants valued the sensory (tacit) type of knowledge higher and clearly the theoretical (determine and analyze relations of concepts) type of knowledge lower. This is an indication that they favor knowledge acquisition through searching for perceptual analogies rather than by inductive and deductive reasoning.

Concerning the dynamic domain of knowledge, we used a 5 point Likert scale (1: strongly disagree, 5: strongly agree). The 11 interviewees were asked a series of questions about their mindset towards sustainable agriculture in their farming practices. For this, the questions reflected the time perspective that farmers have when thinking about their agricultural practices, their focus on new knowledge acquisition and simply not interacting with new knowledge. We argue that thinking about (impacts in) the future is an important element of a sustainable-oriented mindsetting. The results suggest that the group of farmers denied that they practice the same techniques as 10 years ago. This is an indication of the acceptance of new techniques in work. However, they also agree in the fact that they use a new practice only if they see that it makes a major difference. In the case of sustainable practices, this implies that farmers adopt these practices if they see that their colleagues are also adopting sustainable practices. The results also show that the group of interviewees prefers to discuss problems with other farmers. This supports the finding of interviewees favoring direct sources of information.

We found that farmers are used to receive information from experts. This is an indicator that the conventional model towards agriculture discussed in Fig. 2.1 is present among them. However, it gives an opening to another issue: how do the experts think? If the experts favor sustainable practices, then it is likely that farmers eventually will know (and adopt) these practices. We also asked some questions to see whether "Triple Bottom Line" concepts were included in their way of thinking. Seven farmers agree in the fact that they try to minimize the environmental damage they may cause. This supports the findings of Table 2.3 where it is shown that the 11 interviewees mentioned concepts related to "Planet" in the Triple Bottom Line Approach.

## 5 Conclusions

We presented a knowledge approach towards sustainable agriculture. Through this approach, we identified which concepts are linked with sustainable agriculture (static knowledge domain). The term "sustainable agriculture" was familiar for all the interviewees even if it was not a priority for them. Participants of the study concur with the notion that sustainable agriculture has mainly to do with the environment. We got insights in the sources that provide information regarding sustainable agriculture. Direct sources are valued higher. The interviewees also favored favor knowledge acquisition through searching for perceptual analogies (sensory knowledge) rather than by inductive and deductive reasoning (theoretical knowledge).

There were some signs of both conventional and sustainable-oriented mindsets, but there was not a clear indication regarding the participant's mindsets (dynamic knowledge domain). With such a divergence of findings, across even this small sample of Dutch farmers, we point to the possibilities and the barriers of the adaptation of "sustainable agriculture" used in the sources of information that farmers have. One favorable sign on the mindset of farmers is that most of them discuss problem with others to solve the problems. The goal of developing sustainable agriculture is the responsibility of all participants in the system, including farmers, workers, policy makers, researchers, retailers and consumers. Each group has its own part to play and its own unique contribution to strengthen the sustainable agriculture community. We believe that considering the concepts that farmers include in each model of farming practice will help the transition from a conventional to a sustainable agriculture. Hence, we will continue our research efforts studying and evaluating farmers' world-views and reasoning patterns regarding sustainable agriculture.

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# Chapter 3
# Sustainable Agriculture Ensures Sustainable Rural Development: A Reality or a Myth

**Mirza Barjees Baig and Gary S. Straquadine**

**Abstract** Agriculture sector is a dominant driving force for the growth and development of the national economy of Pakistan, making the country predominantly an agrarian state. Agriculture is the source of livelihood for 44.7% of the country's total employed labour force. Its present share in GDP is 21.8%, and this contributes to over 79% to the foreign exchange earnings of the country by exporting raw material and semi-processed and processed agricultural products. Pakistan has been ranked the sixth most populous country in the world with the total population of 167 million in 2010. About 67% of the total population resides in the rural areas and directly or indirectly depends on agriculture. Based on these facts and figures, the sector is viewed as the lifeline of country's economy. Nevertheless, poverty in Pakistan is largely a rural phenomenon; therefore, the development of agriculture must be a principal vehicle for alleviating rural poverty. Unfortunately, the country's agriculture is negatively affected by various issues and constraints which have been enlisted in this chapter. These issues, in turn, influence Pakistan's developmental activities, particularly in the rural areas. It is believed that the revitalization of rural development will provide a sound foundation for broad-based accelerated economic growth. In this chapter, an effort is made to demonstrate that sustainable agriculture and holistic approach are imperative to achieve rural development. The analysis leads to the conclusion that sustainable agriculture results in sustainable rural development, and that this is a reality, not a myth.

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_3,

**Keywords** Holistic approach • Improvement strategies • Production constraints • Rural development • Sustainable agriculture

## 1 Introduction

Pakistan is basically an agricultural country, and its agricultural sector has been named the lifeline of the country's economy (Hanif et al. 2005). A major portion (about 67%) of the population lives in the rural areas. Rural people are directly or indirectly dependent on agriculture for their livelihoods (Baig and Khan 2006). Agriculture is a dominant driving force of livelihood for the rural population. In the Economic Survey of Pakistan (2008–2009), it has been noted that although a structural shifts towards industrialization is happening, the agricultural sector continues to be the largest sector of the economy with deep impact on the socio-economic set up. Agriculture is the source of the livelihood of almost 44.7% of the total employed labour force in the country. Also, the World Bank (2007) views agriculture as the largest source of household income for 38 million Pakistanis, including 13 million of the poorest 40% of rural households. With its present contribution to GDP at 21.8%, the agriculture sector is the mainstay of the rural economy (Economic Survey of Pakistan 2008–2009). Further, it was revealed by the Survey that major crops, such as wheat, rice, cotton and sugarcane account for 89.1% of the value added in the major crops.

The value added in major crops accounts for 33.4% of the value added in overall agriculture. Thus, the four major crops (wheat, rice, cotton and sugarcane), on average, contribute 29.8% to the value added in overall agriculture and 6.5% to GDP. The minor crops account for 12.0% of the value added in overall agriculture. Livestock contributes 51.8% to agricultural value added – much more than the combined contribution of major and minor crops (45.4%). Despite all of its positive contributions towards economy, GDP, export earnings, livelihood and labour force engagement, the sector also faces many issues and constraints, and in turn influences the pace of rural development endeavours in rural Pakistan. The country is facing the problems of low and stagnant yields in cereal crops and above all a wide yield gap exists between the potential and the yields realized at the farms (PSPB 2005; Hanif et al. 2005). The agriculture sector and rural development initiatives are constrained by several factors (discussed below). This chapter attempts to identify threats and challenges, and outline remedies to realize sustainable agriculture. However, substantial scope exists for increasing productivity and overall economic efficiency in the sector. It argues that sustainable agriculture has a tremendous potential for sustainable rural development.

## 2 Overview of Pakistan's Agricultural Sector

Pakistan produces all the major food grain crops, vegetables and fruits due to its various ecological regions, soil types, climatic variations and abundant water supplies. There are two main crop seasons, i.e. Kharif and Rabi. Crops of the Kharif season are sown during April to June, and are harvested during October to

December; whereas Rabi crops are sown during October to December, and are harvested during April to June. The country has the biggest canal system in the world, and due to water availability in all the four seasons, about 25 million tons of cereal crops are produced per annum. Major crops include wheat, rice, cotton, sugarcane, maize, tobacco, barely and rapeseed. Important fruits are mango, citrus, banana, guava, dates, apple, apricot, pear, plum and peach (PSPB 2005). Among these crops, wheat is the most important and major staple food. Rice occupies a very prominent position in the dietary menu of the nation. Export of rice is a decent source of foreign exchange earnings and the country maintains its supremacy and monopoly in long grain, aromatic Basmati rice production on the international market. Cotton is the lifeline of Pakistan's economy. The quantum of cotton production has moved up sizably to over ten million bales (Hanif et al. 2005). The area under cotton cultivation has also increased considerably to about three million hectares. Currently, Pakistan is the third largest cotton producing country in the world. Coarse grains as maize, millets and barley are important crops, especially in harsh areas of arid climate. The country has been blessed with the finest breeds of farm animals (Hanif et al. 2005), and is the fifth largest milk producer in the world (Economic Survey of Pakistan 2005–2006). Based on the roles of the crops and livestock sector in the economy, agriculture remains a priority area for addressing problems of unemployment, poverty alleviation and for fostering economic development. Significantly, the country is focusing primarily on sustainable food security, increasing productivity, commercial agriculture, imports substitution, income diversification and export orientation.

## 3 Constraints Associated with Pakistan Agriculture

Despite of the very significant role of the agricultural sector in the economy, employment, food self-sufficiency, this sector is constrained by many issues that create unfavourable environments for growth and increased yields. This is due to many factors, including inadequate use of quality seeds particularly hybrids, occurrence of insect pests and diseases, slow down of breeding programs, failures to cope with increasing demands for water for crops, deteriorating soil quality and above all, withdrawal of domestic support policies. In addition, the productivity levels of crops in Pakistan are generally low. Even within Pakistan, there are wide variations in productivity of crops at the farm of progressive growers and the subsistent growers. In wheat, the progressive growers are harvesting yield of 5.5 tons/ha and the national level yield is 2.3 tons/ha (Hanif et al. 2005). However, to improve production levels, the problems of water scarcity, water and wind erosion, salinity and sodicity, water logging, flooding and loss of organic matter from the soil must be addressed. Water is a limiting factor and is used inefficiently as only 30% of the water diverted from the river system actually reaches crops. On the other hand, there are significant natural limitations to increase the quantity of arable land. The continuing demand for more food crops has led to an expansion of dry land farming on fragile marginal lands. Some prime issues have been identified and enlisted in Box 3.1; however, some of the constraints of paramount importance are discussed below:

**Box 3.1** Constraints and Threats Associated with the Agricultural Sector and Rural Development in Pakistan

- Stagnant, flat and low yields and big yield gaps;
- Use of old and poor quality seed; and absence of seed technology/testing Labs;
- Under-investment in research and technology development;
- Unreliability of water services; water shortage; low storage capacities of dams; and high conveying losses of irrigation water during delivery;
- Unreliability of water services; water shortage; low storage capacities of dams; and high conveying losses of irrigation water during delivery;
- Small, uneconomic, and fragmented land-holdings;
- Ignorance on scaling up of diversification into new higher value crops and the use of new and more efficient farming technologies;
- Insufficient funds to purchase improved varieties of seeds, fertilizers, pesticides, and machinery etc., to practice modern farming practices and adopt high-tech agriculture;
- Low re-payment capacity and inability to pay back loans;
- Selling of produce at a very low price immediately after the harvest in hurry;
- Weak Extension delivery and lack of extension services;
- Land issues like low fertility status, erosion, water logging and salinity;
- Backward local institutions (Research, Extension, Local bodies, Cooperatives);
- Lack of effective pest management programs and high yield losses due to weeds, pests, and diseases;
- Inadequate credit; poor co-operatives, storage, transport and marketing facilities;
- Lack of knowledge and availability of agricultural machinery etc.;
- Un-expected exposure to natural hazards such as rains, floods, droughts etc.;
- Under performance of rural sector markets;
- Poor communication facilities; undeveloped poor rural infrastructure (lack of roads to markets);
- Low educational levels and literacy rate; and lack of educational facilities;
- Poor and ill health conditions; insufficient basic health and lack of medical facilities;
- Poverty, lack of sanitation, poor health facilities, lower quality of social services and
- Limited employment and income opportunities in agriculture and rural areas.

Modified after IMF (2004); Hanif et al. (2005); Mahmood and Malik (2007).

## 3.1 Water Shortage

Among all other constraints, water shortage remains the most critical challenge faced by the agriculture sector. The capacity of existing reservoirs is shrinking because of silting. Shortage of water at critical times creates controversies over its sharing and adds to poverty. According to Economic Survey (2005–2006), Pakistan's agriculture has been suffering, off and on, from severe shortage of irrigation water in recent years. The recent drought exposed the vulnerability of the vast Indus Basin irrigation, the need for additional storage to improve and increase supply and to provide greater operating flexibility and insurance. The projected water shortage is estimated to be 23–25 MAF to meet the incremental demand of irrigation for sustained agriculture growth (IMF 2004). On the other hand, precipitations tend to be unevenly distributed throughout the year on much of the rainfed areas. Water is the key engine of agricultural growth and is thought to be the most critical and important input into crop production. Unfortunately, it remains the most limiting factor on both the irrigated and rainfed areas, which are suitable for crop production.

## 3.2 Smaller Land Holdings and Neglect of Small Farmers

According to PSPB (2005), the country comprises the 48,363 rural localities (villages) where, in addition to crop production, livestock and non-farm activities are also the major sources of employment and income. In the past, agricultural policy was biased in favour of medium-to large-scale farmers. In recent years, however, the Government has come to realize the comparative advantage of smallholder agriculture, and is now reorienting its policies in support of smallholders (IFAD 2007). Because of the law of inheritance, holdings are subdivided and continue to become smaller up to a level that frequently becomes uneconomic under the present conditions, and owners of small farms do frequently not have enough resources to invest into improved production methods. As depicted in Table 3.1, about 75% of

**Table 3.1** Numbers of private farms in Pakistan

| Size of farm in hectare | Percent of the total number of farms | Percent of the total farm area | Percent of farm area cultivated |
|---|---|---|---|
| <2 | 47.5 | 11.2 | 92 |
| 2–<5 | 33.4 | 27.5 | 91 |
| **Sub-total** | **80.9** | **38.7** | **–** |
| 5–<10 | 12.2 | 21.5 | 80 |
| 10–<10 | 4.7 | 15.8 | 79 |
| 20–<60 | 1.8 | 13.9 | 70 |
| > 60 | 0.3 | 10.1 | 54 |
| **Sub-total** | **6.8** | **39.8** | **–** |
| **Total** | **100** | **100** | **–** |

*Source*: PSPB 2005

farms have less than 5 ha of land, which, however, covers only 35% of the total area. Similarly, only 9% of farms, with an area of 10 ha and above, expand over 40% of the cultivated area (PSPB 2005).

While citing the Agriculture Census of 1990, Hanif et al. (2005) reported that there are 5.07 million farms in the country, and 81% of them are small farms that account for 39% of total cultivated area. Middle size farms (5–10 ha) are 12% and account for 22% of cultivated area. Large farms (10 ha and above) are 7% of total farms, but account for 40% of total cultivated area. The average size of small, medium and large farms is 1.8, 6.6 and 21.6 ha respectively (Hanif et al. 2005). Great inequality and land concentration exist between small and big farmers. The agriculture sector is characterized by strong inequality in the distribution of assets, particularly land and water. About 2% of farm households control more than 45% of the land area. Also, large farmers have captured the subsidies in water and agriculture, as well as the benefits of agricultural growth (World Bank 2007).

## *3.3 Gaps in Productivity*

Productivity levels of crops in Pakistan are generally low. Even within Pakistan there are wide variations in productivity of crops at the farm of progressive growers and the subsistent growers. In wheat, progressive growers are harvesting yield of 5.5 tons/ha and the national level yield is 2.3 tons/ha. In cotton, the yield of progressive growers is 3.5 tons/ha and the national average yield is almost half of that as shown in Table 3.2. Similar findings have been reported by the (PSPB 2005; Hanif et al. 2005).

## *3.4 Women Farmers Working in Agriculture and Their Status*

In Pakistan, the women farmers are viewed generally as unproductive and deprived in many ways, due to early marriages, lack of schooling and employment, menial tasks and social isolations (Mahmood and Malik 2007). Women in poor families and in rural areas who account for 70% of the female population are forced to live inferior lives due to the double discrimination of poverty and discrimination against women (Maria 2001). Women constitute one of Pakistan's most disadvantaged

**Table 3.2** Potential yield and yield gaps of various crops (tons/ha)

| Crops | Potential yield | National average | Yield gaps |
|---|---|---|---|
| Wheat | 6.4 | 2.2 | **4.2** |
| Rice | 9.5 | 2.0 | **7.5** |
| Maize | 6.9 | 1.5 | **5.4** |
| Sugarcane | 160.0 | 46.0 | **114.0** |

*Source*: PSPB 2005

groups. Almost all of the women in rural areas engage in agriculture as unpaid family workers, and their participation rate in wage work is extremely limited. Many women seasonal workers are engaged in cotton agriculture in the Southern region. Often, men are obliged to migrate to the Northern region looking for employment opportunities in the non-agricultural sectors for the reason that cotton production alone is not sufficient to earn a living. Because of this, women workers' responsibilities in agriculture have increased as a result. Since migration work in the Gulf countries has increased lately, the labour force participation rate of women in the agricultural sector has further increased. Furthermore, the delay in the modernization of farm work is also one of the reasons for needing women in the labour force (JICA 1999).

## 4 Pakistani Rural Development

Recently, the subject of "rural development in Pakistan" has received great attention and considerable importance. Since independence, Pakistan has tried many programs for Agriculture and rural development (GoP 2008). The first formal attempt to reconstruct and improve the rural areas was made in 1953, when the Village Agricultural and Industrial Development Programme (or V-Aid programme) was introduced with American assistance (Ahmed 2005). As reported by Malik (2003b) and Ahmed (2005), many programs and initiatives were undertaken in the country, the important of them include: Village Aid Programme (1952–1961); Integrated Rural Development Programme (1952–1961); Basic Democracies (1959–1970); Integrated Rural Development Programme-IRDP (1972–80); People's Works Programme (1972–1977); Local Government. and Rural Development Programme (1979–1985); Prime Minister's Five Point Programme (1985–1988); People's Programme (1989–1990 and 1994–1997); Tameer-e-Watan Programme (1991–1993 and 1996–1998); Social Action Programme SAP-I (1993–1996); Social Action Programme SAPP-II (1997–2002); Khushhal Pakistan Programme (1999–2000); Tameer-e-Pakistan Programme (1991–1993 and 1998–2000); and Khushal Pakistan Programme (KPP)-II (2003–2007).

All these programs could not contribute susbstantially to the development of the rural areas on a long term; rather they remained confined only to the visible physical structures (roads and buildings for schools and hospitals, etc.). Several approaches designed primarily to improve the living standard of rural people, through increased agricultural production and improved farm income, have been tried, however, it remained un-successful. In rural areas, socioeconomic development is low, with high levels of poverty and low levels of literacy, especially among women (Baig et al. 2009; WHO 2010). Some development indicators and their implications for rural development in Pakistan are presented in Table 3.3. Prime threats and challenges have been identified and discussed in the preceding paragraphs. Because women play a very productive role in the agriculture sector and rural development as well, their role deserves further discussion.

**Table 3.3** Summary implications for rural development in Pakistan

| | |
|---|---|
| **Shortage of:** | |
| • Educational facilities | • Living space |
| • Health services | • Arable land |
| • Housing units | • Clean water |
| • Food | • Sanitation/waste water disposal facilities |
| **Increase in:** | |
| • Unemployment | • Over crowding |
| • Land fragmentation | • Katchi abadies[a] |
| • Import of food and edible oil, etc. | • Poverty |
| • Environmental problems | • Unrest and unsafe conditions |
| • Congestion in households | • Crime rate |

*Source*: Modified after NIPS 2005

[a]Residential areas developed by the poor segment of society where houses are built by the mud and sand. Usually these people encroach the state land occupy it illegally

## 4.1 Women and Their Role in Rural Development

In rural families, women's role is significant even economically as they help their men in farm activities. Women constitute a little less than half of the total population of Pakistan. They offer great help in the fields, in cottage and in business. On the other hand, Mahmood and Malik (2007) note that Pakistani women are generally viewed as unproductive and deprived in many ways, due to early marriages, lack of schooling and employment, unskilled tasks and social isolations. Maria (2001) notes that opportunities for women and girls in rural Pakistan are limited by strict observance of the customs and traditions practiced in different regions. Since empowerment is a necessary condition for women to improve their lives, establishment of small women groups can improve their lives. Innovative approaches to increasing women's economic opportunities, developing skills, literacy programmes, organization and mobilization within socially and culturally acceptable norms, have been and continue to be initiated in the country.

## 4.2 Poor Infrastructure and Lower Quality of Social Services

It is not possible to achieve any improvement endeavour without developing a good infrastructure. The country does not have the strong infrastructure and enough social services are not available to its rural poor. For example, over one third of adult females are literate, compared to nearly two thirds of adult men due to lack of proper educational set up and facilities. In 2004/2005, some 66% people had access to a tap or hand water pump, and 54% had access to a flush toilet. An overview of the services available to rural localities has been presented in Table 3.4.

**Table 3.4** An overview of infrastructure and services available to rural society

| | |
|---|---|
| Total estimated population of Pakistan in millions (2010)[6] | 167 |
| Annual population growth rate[6] | 1.87 |
| Percent population in rural areas (2009)[1] | 65 |
| Percent contribution of agriculture to GDP | 21 |
| Percent workforce employed in agriculture | 44 |
| Percent over all adult literacy rate in 2004–2005 (age 15 and above)[2] | 50 |
| Percent male adult literacy rate in the country (age 15 and above)[2] | 63 |
| Percent female adult literacy rate in the country (age 15 and above)[2] | 36 |
| Percent rural male adult literacy rate (age 15 and above)[2] | 56 |
| Percent rural female adult literacy rate (age 15 and above)[2] | 24 |
| Percent GDP spent on health[2] | 0.6 |
| Government expenditure on health as % of total government expenditure[2] | 6.4 |
| Percent population with sustainable access to an improved water source[2] | 90 |
| Percent rural localities where drinking water is either brackish or it is not available at all[2] | 21 |
| Percent population with improved access to sanitation[7] | 62 |
| Percent rural localities not having toilets and any sanitation system[3] | 46 |
| Percent of rural localities not having pacca (metal led) streets and cemented drains[5] | 56 |
| Percent localities with partial network of pacca (cemented/metalled) streets and drains[5] | 26 |
| Only a few rural communities have wastewater treatment plants. Percent of the rural communities having water treatment facilities, but the current flows exceeded the designed capacity[3] | 70 |
| Percent rural communities have partial availability of electricity[5] | 25 |
| Percent population not having the electricity at all[5] | 25 |
| Per capita real income in USD (2009)[6] | 1,046 |
| Rural population density – persons per square kilometer (2001)[7] | 438 |
| Percent rural population living below national poverty line (2004)[4] | 32.6 |

*Sources*: (1) United Nations Population Division; (2) Pakistan Social and Living Standard Measurement Survey (PSLM), 2004/2005; (3) World Health Report, 2006; (4) Human Development Report 2005; (5) World Development Indicators, 2005 (World Bank); (6) Economic Survey of Pakistan 2009; (7) CIRDAP 2005

# 5 Suggested Strategies to Achieve Sustainable Agriculture and Rural Development

The World Bank (2008) presumes that agriculture will continue to be a fundamental instrument for sustainable development and poverty reduction. Without developing agriculture and making sustained progress in these areas, rapid overall economic growth and poverty reduction targets are impossible to achieve (World Bank 2007). Many workers believe that Good Agricultural Practices (GAP) enhance crop yields, bring prosperity, elevate living standards and enhance livelihood of rural people. Hanif and his co-workers believe that the use of quality inputs in appropriate proportion and quantity has a great bearing on productivity of crops. Important inputs include quality seeds, fertilizers and pesticides and an easy and timely access to agricultural credit facilitates are required to expand the capacity of the farmers to purchase these inputs. Whereas many workers (Memon 1993; Gill et al. 1999; Malik 2003a; Baig and Khan 2006; Mahmood and Malik 2007) maintain that sustainable agriculture is pre-requsisite to make development initiatives in rural areas. Without addressing the issues associated with the agricultural sector of the country, it likely would be impossible to realize both the sustainable agriculture and resultant rural development.

In the scenario, to realize both the sustainable agriculture and rural development, a two-step strategy is proposed. As a first step, the most important task must be to make dedicated efforts to address the issues and constraints associated with the agricultural sector. The second part of the strategy should be to improve agriculture through the combination of modern scientific technologies and indigenous knowledge. Diversification within agriculture will enhance agriculture role in the economy and society and it will ultimately result in sustainable rural development. An improved and sound infrastructure with the suitable facilities can further strengthen the rural sector. In addition, a small and medium enterprises (SMEs) sector may have a great potential for generating employment, especially for the low-income groups. Additionally, creating a business environment that is supportive of SMEs is also an important strand of the poverty reduction strategy. For example, the development of an agro-processing sector consisting primarily of fruits, vegetables, dairy and livestock is proving quite promising (PRSP 2004), and can help improving rural economies and livelihoods. There was neglect of the rural non-farm sector, which is of particular importance in the livelihood of small farmers and the landless; this had led to unemployment and migration. It may not have happened if different rural development policy could have been in place and implemented.

It seems imperative to devise an integrated approach and a comprehensive strategy (by incorporating the above-mentioned points) that could cater the needs of rural people, and address the threats and challenges faced by the rural development institutions, involving all the stake-holders: including academia, researchers, rural communities, members of the civil societies, NGOs, donors, planners, policy makers and local institutions. All the key players and stakeholders involved in both the development of agriculture and rural development sectors must play their roles in order to realize sustainable development. Aga Khan Rural Support Program (AKRSP 2005) can be presented as a unique example. It was launched in various parts of Pakistan and proved very successful in bringing development and enhanced income levels and livelihood, as its practitioners enjoyed the sense of ownership. The model was replicated in many parts of the world and proved successful in each and every place it was implemented. Based on its successful working, many prestigious organizations (like United Nations and World Bank) appreciated it, presented it as a role model and endorsed it to realize rural development (AKRSP 2005).

## 6 Conclusions and Recommendations

Agriculture is the prime sector of the national economy of Pakistan. Two-thirds of the country's population and 80% of the poor live in rural areas, and a significant segment is involved in farming. Agriculture is an effective engine for growth, and an important basis for prosperous livelihood for most agriculture-based countries. The constraints in the rural areas include: unequal distribution of land and access to water, water shortage and big conveyance losses, poor quality seed, soil problems (like the declining of soil fertility and land degradation), low productivity of crop agriculture, inadequate infrastructure, ineffective public-service delivery and insufficient participation by rural people in most public-sector development programs. Moving ahead towards sustainable development will remain impossible without addressing these issues through sustainable farming practices. Dedicated efforts are needed to strengthen the agriculture sector and achieve higher growth. Potentially efficient and equitable solutions for increased agricultural growth and poverty reduction includes increasing current yields as well as promoting diversification to high value-added crops (including mushrooms, flowers, medicinal plants and spices) and activities, especially by the small-farm sector. In addition, non-farm income sources (like cottage industries) deserve due attention. Small and medium enterprises (SME) have great potential to elevate rural economies. To realize sustainable growth and development, it is also imperative that all key actors are allowed to play their productive and constructive roles. All the stake-holders (including youth and women, academia, researchers, rural communities, planners, policy makers and local institutions) should join hands towards a sustainable future. Among all the contributing factors, sustainable agriculture has the greater share in the development initiatives. It clearly indicates that sustainable agriculture means sustainable rural communities. It is a reality – not a myth.

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# Chapter 4
# Policies for Sustainable Agricultural Production and Consumption

**Joyce D'Silva**

**Abstract** The world is both obese and hungry. People die from the effects of both over-consumption and malnutrition. Much agricultural production produces excessive amounts of greenhouse gases, uses unsustainable amounts of resources (such as water) and pollutes the environment. The resulting food often contributes to diet-related ill-health and disease. We need to develop policies that promote an agriculture that produces health-giving foods in a way that minimises resource use and environmental impact and ensures the welfare of farm animals. This must include trade in healthy foods at affordable prices. Policies need to be developed in co-operation between relevant national and international bodies and with the active involvement of such intergovernmental organisations as the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO). Policies could include public health awareness programmes, ending subsidies for intensive agriculture, promotion of low-impact farming, government sponsorship of healthy food programmes and selective taxes on unhealthy foods.

**Keywords** Sustainable food system • Water use • Climate change • Livestock production • Animal welfare

## 1 Introduction

The world is both obese and hungry. People die from the effects of both over-consumption and malnutrition. In order to achieve an effective, equitable and sustainable food system by 2050, the world has to solve the linked problems of poverty allied to under-nutrition and over-consumption, which also results in poor health.

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_4,

Over one billion people are now suffering from hunger, according to FAO (2009). The number of people living in extreme poverty in 2009 is estimated to be 55 million to 90 million higher than predicted before the global economic crisis. Poor people are often hungry people. Also, the proportion of people suffering from under-nourishment rose for the first time in 2008, mainly due to escalating food prices (UN 2009). Shockingly, 35% of the deaths of children and 11% of the world's burden of disease are caused by under-nutrition (Nature 2008).

As fellow human beings on this planet, these figures should be a source of shame for all of us as individuals, for governments in both developed and developing countries and for the international organizations and lending banks, whose efforts appear to be too often misdirected.

In 2009, the world celebrated the 40th anniversary of the first human landing on the moon. If all the human ingenuity and effort and all the finance that was directed into that project, or into the many regional wars that have been fought in the last 40 years, had instead been devoted to finding ways to produce enough food for all in humane and sustainable ways, then these shocking figures of hunger and poverty might well have been relegated to our history books.

But whilst so many go hungry, others eat far more food – and inappropriate food – than is good for them.

The WHO European Anti-Obesity Charter of 2006 reported that in Europe, 50% of adults and 20% of children are overweight, with 16.5% of adults and 7% of children classified as obese (WHO 2006). More than a million deaths annually can be attributed to people being overweight, often related to such chronic diseases as diabetes, heart disease, hypertension and some cancers. Adult obesity and overweight is responsible for up to 6% of the entire health care costs in the European region (WHO 2006).

In the US, rates of overweight and obesity are apparently going up rather than down, in spite of clear United States (US) Department of Health and US Department of Agriculture guidelines on healthy eating. Numbers have increased dramatically in the last decade and now 65% of adults and 16% of children are overweight and 30% of adults are classified as obese. Already 90 million Americans are affected by chronic and weight-related diseases (US Department of Health 2005).

But it's not just in the western world that obesity has become a problem. Obesity is also increasing in developing countries where people are adopting a 'western' style of diet (Lang 2006; Lang and Heasman 2004). A recent Editorial in the *British Medical Journal* by Professor Yangfeng Wu says that around one fifth of the one billion overweight or obese people in the world are Chinese (Wu 2006). As more and more Chinese people abandon traditional rural lifestyles and migrate to the cities, increase their incomes and add more animal products to their diets, their health problems change and start to resemble more closely the problems of the overweight western world. Professor Wu refers to research showing that in China, energy intake from animal sources has increased from 8% in 1982 to 25% in 2002 (Wu et al. 2005), and the average energy intake from dietary fat among urban Chinese increased from 25% to 35% (Wang 2005), which is higher than the upper limit of 30% recommended by the WHO.

Even in North Africa, obesity is a problem, particularly among women. Mokhtar et al. (2001) confirm that overall levels of obesity were 12.2% in Morocco and 14.4% in Tunisia, with half of all women being overweight or obese (BMI>25) with 50.9% in Tunisia and 51.3% in Morocco (Mokhtar et al. 2001).

Obesity is often multi-factorial in origin, and partly a reflection on increasingly sedentary lifestyles and sometimes on cultural tradition, where plumpness may be seen as a sign of female beauty or of fertility. However, inappropriate diets are a major contributor to the growing global obesity crisis. According to a WHO paper on social inequalities and food-related ill-health, 'An energy-dense diet high in saturated fat and low in foods of plant origin, together with a sedentary lifestyle, is the major cause of the pan-European epidemic in obesity and overweight, with increased risk of non-communicable diseases including cardiovascular diseases, certain cancers and diabetes' (Robertson 2001). A 2008 research report in the *Bulletin of the World Health Organization* suggests that the consumption of full-fat dairy products in Europe is an important source of cholesterol and risk of cardiovascular disease, and may be responsible for at least 9,822 deaths from coronary heart disease and 3,024 deaths from stroke annually, based on 'very conservative estimates' (Lloyd-Williams et al. 2008).

We have created a totally imbalanced world, where many of our fellow human beings go to sleep at night suffering pangs of hunger, whilst many others, who have over-eaten, have to take indigestion tablets in order to achieve a good night's sleep.

What we eat and the amount we eat may be influenced by our income, by our culture, ethical stance or religion, by the choices available to us and by subtle influences from advertising or family members. However ultimately what we eat is determined by what crops farmers grow or what animals they raise. Going back further in the cycle of cause and effect, we can see that what farmers grow also may be determined by local and international markets, by commodity trading, by government subsidy, by support from global lending banks and intergovernmental organizations, by the policies of agribusiness companies and the buying policies of the supermarket and food service industries.

This is a tangled web of inter-actions. We can look at it as a success story, with global supermarket shelves offering an abundant choice to shoppers, or we can look at the hunger and obesity figures and conclude that something is going seriously wrong in our farming and food systems.

If we look at the current trends in farming and the impact of these trends, there is major cause for concern as we seem to be fast-forwarding down an unsustainable path.

The advent of synthetic nitrogen fertilizers and fossil-fuel-powered farm machinery and transport systems, combined with more sophisticated irrigation methods and the development of high-yielding crop varieties have indeed transformed farming over the last century. In the last 50 years, the livestock revolution has also transformed the way we breed and raise animals for meat, milk and eggs, with a huge move away from traditional free range farming to large-scale indoor rearing. Realistically, the Americans refer to these farms as CAFOs – confined animal feeding operations. And of course the feed that the animals eat is no longer necessarily locally grown, but may be imported from across oceans many thousands of miles away. These intensive farms bear little resemblance to more traditional farms, where farmers knew their own animals and were able to take pride in them and give them a level of personal care. This is simply impossible in today's multi-thousand chicken, dairy or pig units.

This twentieth century farming revolution has raised productivity and been a factor in population growth, but it has fundamental and serious flaws. These include devastating environmental impacts, including major contributions to greenhouse gas (GHG) emissions, deforestation and biodiversity loss, over-reliance on fossil fuels and on high-yielding and GM crops, use of selectively bred farm animals that often display a range of associated health and welfare problems, loss of livelihoods for small-scale farmers, the diversion of cereals to animal feed rather than direct food for hungry humans and finally, the production of excessive amounts of saturated fats, sugars and edible oils, all of which contribute to the growth in "western diseases" worldwide. In several of these areas, we appear to be approaching – or have already arrived at – the tipping point, where they are simply no longer sustainable.

This chapter will focus primarily on the impact of the so-called "livestock revolution". Globally, farm animal numbers have increased massively. We now use about 60 billion animals a year for food and, according to the FAO, that figure is set to roughly double by 2050 (FAO 2006).

## 2 Resource Use

All those 60 billion farm animals need food and water, and those that are not factory-farmed indoors need land on which to graze or forage. The intensive production of meat is known to be one of the most resource-inefficient methods of producing food for people. One kilogram of meat requires several kilograms of animal feed (Smil 2000). One kilogram of edible boneless beef requires around 20 kg of animal feed (Smil 2000). One calorie of food energy obtained from beef requires inputs of 9 cal of food energy from plants (IAASTD 2008) and 40 cal of fossil fuel energy (Pimentel 2008).

One third of the world's current cropland is used for animal feedcrops (Steinfeld et al. 2006). Around 40% of the world's cereal harvest is used as livestock feed, and that proportion is 70% in most rich countries (Lundqvist 2008). Over 90% of soya beans and 60% of maize (corn) and barley are grown for animal feed (Steinfeld et al. 2006). Much of the land, energy and water used to grow feed-crops for intensively produced animals could have been more efficiently used to grow food that is directly consumed by people.

The net result is that excessive production and consumption of animal products in rich and rapidly developing countries, using large quantities of grain for animal feed, is one of the main drivers of global food price rises that harm poorer people.

It takes 15,500 l of water to produce 1 kg of edible boneless beef (Hoekstra 2007) – equivalent to filling up 100 average-sized bathtubs. One kilogram of beef requires 12 times the quantity of water needed to produce 1 kg of wheat and 5 times the quantity of water needed to produce 1 kg of rice (Hoekstra 2007). Beef production consumes 17 times more water than wheat in order to supply the same amount of food energy (Liu 2008).

With around one third of the world's population living in countries suffering water stress (Oki and Kanae 2006), it is important to look at the impact of livestock production on global water resources. To produce 1 kg of beef requires between 5,000 and 20,000 l of water, mainly to grow the animal feed (Lundquist 2008). To produce 1,000 kcal of animal-based food requires 4,000 l water, but to produce 1,000 kcal of plant-based food requires only 500 l water (Lundqvist et al. 2008).

With a basic daily human water requirement of 50 l a day per person for drinking, human hygiene, sanitation and modest household needs for preparing food, or 18,000 l per person per year (Liu and Savenije 2008), we can see that a person's annual water requirement may equate with the water requirement to produce just 1 kg of beef (on 1 day in 1 year)! In some cases the kilogram of beef may actually require more water than one person in a whole year!

We need to put these figures into the global water scenario: demand for water has tripled in the last half century. Water tables are falling in large parts of China, the United States and India. In places like Saudi Arabia, deep fossil aquifers are being virtually mined for water. There are forecasts that some cities like Quetta in the Baluchistan province of Pakistan and Sana'a, the capital of Yemen, may totally run out of water in the next few years (Brown 2008). The Colorado and Yellow rivers are drying up and the Nile, Indus and Ganges are reaching dangerously low levels at certain times of the year. Inland lakes are disappearing and the Aral Sea is virtually dry.

It is estimated that if a country has an annual supply of 1,700,000 l water per person, it has enough, but below 1,000 000 l scarcity begins. Below 500 000 l acute scarcity takes hold (Brown 2008). Morocco and Egypt fall into the scarcity zone, and Algeria Tunisia and Libya into the acute zone. Saudi Arabia, Yemen and Kuwait have less than 300 $m^3$ water per person per year (Brown 2008).

Rising global temperatures are expected to increase water stress by 2050. According to a technical report released by the Intergovernmental Panel on Climate Change (IPCC) on water and climate change, the number of people in water-stressed river basins (already over two billion) is likely to increase between four and nearly seven billion by 2050, more than half of the world's population (Bates et al. 2008).

The projected doubling of livestock production by mid-century is likely to impact water use severely, even in the absence of climate change. Water use for all crops (food, feed and fibre) could almost double on present trends by 2050, from 7,000 $km^3$ a year to 13,000 $km^3$, according to the International Water Management Institute (Lundqvist et al. 2008). The use of water for livestock production is projected to increase by 50% up to 2025 alone (Steinfeld et al. 2006).

As countries run out of water to nourish their grain production, they start importing grain instead. This is sometimes seen as importing "virtual" water, due to the amount of water used to grow that grain. As renowned economist Lester Brown has pointed out, trading in "grain futures" is actually trading in "water futures" (Brown 2008). Egypt now has to import 40% of its grain and Algeria over 50% (Brown 2008).

Research on water use and food in China has concluded that the increase in meat consumption is a major cause of the water shortages that exist in that country. Increased consumption of meat has resulted in a 3.4-fold increase in the amount of water needed per person for food in China since the early 1960s.

Writing in the journal *Nature* in 2008, researchers in water science institutes in Switzerland and the Netherlands conclude that: "In China, changing food-consumption patterns are the main cause of the worsening water scarcity. If other developing countries follow China's trend towards protein-rich Western diets, the global water shortage will become still more severe" (Liu et al. 2008).

It seems fundamentally wrong that people go hungry for any kind of food at all. It seems that the meat and dairy consumption habits of those in the richer world are taking the cup of water or the bowl of grain from the poor woman's hands.

It is also increasingly likely that civil unrest and water wars may increase in the years ahead. Already the UN Secretary General has warned that water should be a top environmental priority in order to avoid future conflicts over water supplies (Chenoweth 2008).

## 3 Impacts on the Earth

*Deforestation and desertification*: A major impact of the increased global demand for meat and dairy products has been deforestation in order to free up land either for rearing animals, usually cattle, or for growing crops such as soya which is mainly used for animal feed. Under a 'business as usual' scenario, WWF expects soya expansion to result in the loss of 16 million hectares of savannah and six million hectares of tropical forest by 2020 (Dros 2004).

The World Conservation Union (IUCN) Red List of Threatened Species (41,000!) shows that 'most of these are suffering habitat loss where livestock production is a factor' (Steinfeld et al. 2006).

Nearly 80% of deforestation in the Brazilian Amazon results from cattle ranching. More than 38,600 mile$^2$ has been cleared for pasture since 1996, bringing the total area occupied by cattle ranches in the Brazilian Amazon to 214,000 mile$^2$, an area larger than France (Greenpeace International 2009).

Loss of forest has huge implications for the long-term survival of our planet, with ecosystems disrupted or destroyed, biodiversity devastated and millions of wild animals suffering as their habitat is destroyed. Although human habitation of forested areas is light, these people too, who often live non-harmful, simple but socially enriched lives, are also exposed to foreign "culture" and lifestyles – and, of course, diseases for which they have no natural immunity. The consequences can be devastating for them.

As for the animals themselves, not all are kept in confinement systems, with their food brought to them. Most of the ruminants, beef cattle, sheep and goats are still reared on grazing land. But already 20% of all grasslands, including 73% of the world's dry rangelands are degraded, some severely, from overgrazing, erosion and compaction (FAO 2006). This is a serious situation for the 200 million pastoral people who depend on their herds for a livelihood. According to the Millennium Ecosystem Assessment, desertification already affects the livelihoods of more than 25% of the world's population (Kéfi et al. 2007).

Nigeria is losing 351,000 ha of rangeland and cropland to the desert each year. Between 1950 and 2006, Nigeria's human population grew from 34 million to 145 million, a four-fold increase. During the same period its livestock population grew from 6 million to 67 million, an 11-fold increase (Brown 2008). There are simply too many animals trying to feed on too little land.

China is now losing around 3,600 $km^2$ of land to desert each year (Brown 2008). Huge dust-storms regularly load sand and grit onto the capital, Beijing, and sometimes reach South Korea. Sand from West Africa now blows as far as the Caribbean. In both cases, overgrazing and its associated impacts are the primary cause.

Reporting on the horrendous conflict situation in Sudan, the United Nations Environment Programme (UNEP) cites land degradation, deforestation, desertification and overgrazing of fragile soils by a livestock population that has exploded from 27 million animals to 135 million as being major factors (UNEP 2007).

## 4 Greenhouse Gas Emissions (GHGS)

From a global perspective, livestock production is now known to be a major contributor to climate change. The FAO estimates that livestock production contributes 18% of the world's human-induced (anthropogenic) greenhouse gas emissions (FAO 2006). Globally, this is higher than the share of all transport (14%), including road, rail, air and shipping (Stern et al. 2006).

The livestock sector is responsible for the following proportions of the main greenhouse gas emissions: 37% of total methane ($CH_4$) emissions, 65% of total nitrous oxide ($N_2O$) emissions and 9% of total carbon dioxide ($CO_2$) emissions. In addition, 64% of ammonia emissions originate in livestock production and contribute to air, soil and water pollution, acid rain and damage to the ozone layer (Steinfeld et al. 2006).

One of the major causes of livestock-related GHGs is animal manure that releases both methane and nitrous oxide. All manure-related emissions are about 30% of livestock-related emissions and over 5% of total anthropogenic GHGs (Steinfeld et al. 2006). In addition, the "enteric fermentation", which takes place during the digestive processes of animals, particularly ruminants (such as cattle, sheep and goats), releases large amounts of methane (Steinfeld et al. 2006).

It is notable that livestock manure and enteric fermentation alone account for 10% of all anthropogenic GHG emissions (Steinfeld et al. 2006), five times the proportion of global emissions due to air transport (Stern et al. 2006).

But it's not just the emissions from the animals themselves. Huge amounts of GHGs are released during the production of animal feed, be it crops or grassland. Feed-crops require the use of land, fertilizers, machinery and transport. Carbon dioxide is emitted during the manufacture of mineral (N) fertilizer, and nitrous oxide is emitted from mineral fertilizer used on land (Steinfeld et al. 2006). In most developed countries, over 50% of N fertilizer is used for feed crops (as a world average, the proportion is estimated at 25–40%) (Steinfeld et al. 2006; Galloway et al. 2007). The manufacture of fertilizer and pesticide also uses large amounts of costly fossil fuels.

The worst offender is deforestation for cattle grazing and/or for the production of soybeans or cereals for animal feed (mainly in South America). Deforestation releases large amounts of $CO_2$ previously stored in vegetation and soil. Deforestation for animal production accounts for 34% of all livestock-related GHG emissions and over 6% of all human-induced GHG emissions (Steinfeld et al. 2006). If animal production doubles by 2050 as predicted, this will lead to a massive increase in livestock-related GHG emissions in the next decades, even allowing for increases in energy efficiency and other mitigation measures.

The expected increases in methane and nitrous oxide emissions have been set out by the IPCC and the US Environmental Protection Agency (US-EPA). The US-EPA (2006) considered that: 'The key factors influencing both methane and nitrous oxide emissions in this category [from storage and disposal of manure] are expected to be the growth in livestock populations necessary to meet the expected worldwide demand for dairy and meat products, and the trend toward larger, more commercialized livestock management operations'.

## 5 Pollution of the Environment

Livestock production is also a major cause of environmental pollution, habitat damage and loss of biodiversity. The authors of the 2006 FAO Report "*Livestock's Long Shadow*" considered that 'the livestock sector has such deep and wide ranging impacts that it should rank as one of the leading focuses for environmental policy' (Steinfeld et al. 2006).

Industrial animal farms keep unnaturally large numbers of animals crowded together in relatively little space. These systems break the link between livestock and the carrying capacity of the land and its ability to recycle wastes.

Animal manure has a high nitrogen (N) and phosphorus (P) content. Nitrogen and phosphorus are essential to plant and animal life and growth, but excessive quantities of N and P causes serious environmental pollution. Intensive agriculture, especially livestock farming, is a major source of nitrogen pollution worldwide. The main livestock-related causes of water pollution are the large quantities of animal manure generated and the use of excessive quantities of fertilizers to produce animal feed. Globally, an estimated eight million tonnes of nitrogen and nearly 15 million tonnes of phosphorus contaminate freshwater courses from livestock manure (*Tao Te Ching* (Lao-Tzu, translated by Mitchell 2000)), (Steinfeld et al. 2006).

There is a huge global problem of disposal of livestock manure from factory farms. A US Senate Committee Report of 1997 calculated that large livestock operations can have the waste equivalent of towns or even cities. 200 dairy cows can produce as much manure as a town of 10,000 people. A pig operation producing

2.5 million pigs a year would have a waste output greater than the urban area of Los Angeles (US Senate Committee Minority Staff Report 1997).

The European Commission reported in 2000 that, 'more than 20% of EU groundwaters are facing excessive nitrates concentrations, with a continuous increasing trend in the most intensive areas of livestock breeding and fertilizer consumption'. The same document reported that at least 30–40% of rivers and lakes in the EU show eutrophication symptoms of over-enrichment by nitrogen and phosphorus (European Commission 2002).

In China's Guangdong Province, pig waste has been found to be the source of 72% of the nitrogen and 94% of the phosphorus pollution of water systems (Steinfeld et al. 2006). Livestock are also responsible for a considerable percentage of the pollution of freshwater by sediments (erosion), pesticides, antibiotics and heavy metals. Watercourses are also polluted by such pathogens from livestock as Salmonella, Campylobacter and Escherichia coli (E. coli), all of which can cause foodborne disease in people. Other such industries associated with livestock production as slaughterhouses, processing plants, dairies and tanneries have the potential to cause serious pollution in their local area (Steinfeld et al. 2006).

Cattle and pig slurry and silage (grass that is cut and fermented for animal feed) effluent are very much more polluting in water than raw domestic sewage from human wastes because they have a much higher biological oxygen demand (BOD), the quantity of oxygen that is taken from the water in the process of degrading a material. The huge lagoons full of pig slurry from large intensive pig farms, are considered a 'major environmental and health concern (Pig Progress 2008). Pig slurry has a 75-fold higher biological oxygen demand than raw domestic sewage and silage effluent has a 200 times higher BOD than domestic sewage (Archer and Nicholson 1992).

## 6 Ethics, Religion and Science

There is a growing global recognition that some of the ways in which we manipulate and rear farm animals for our food are unacceptable. The type of industrial, intensive farming, often called factory farming, which developed after the Second World War, was in effect a combination of response to food shortages and a consequence of the development of antibiotics and vaccines, that made it possible to keep hundreds or thousands of animals in a confined space and get them to live long enough to make a profit.

At the time, few reflected on the impact of these new conditions on the animals themselves. By the mid-1960s, concern was being raised and over the last 40 years a sizeable shift in research and thinking has taken place.

Perhaps the most notable of these changes was the adoption in 1997 by the European Union of the Protocol on Improved Protection and Respect for the Welfare of Animals, that recognized that animals are "sentient beings", in other words that they are capable of suffering, and which called on EU member states to "pay full regard to the welfare requirements of animals" (Protocol on Protection and Welfare of Animals 1997).

The Protocol itself gave the ethical ground for the various Directives and Regulations on protecting the welfare of farm animals that have been adopted by the EU Member States.

In fact protecting the welfare of animals has historic roots in most major religions and philosophies. At the same time, there have always been some for whom animals are merely instruments to be exploited for human benefit.

Religious writings have varied in their views of animals as manifesting the divine or simply as creatures put on the earth to support human life. An example of the first can be found in the Shvetashvatara Upanishad, one of the ancient spiritual texts of India, dating from well before the Common Era:

> As the sun shines and fills all space with light,
> Above, below, across, so shines the Lord
> Of Love and fills the hearts of all created beings

This text implies that animals are capable of feeling joy (*The Upanishads*). Other verses in the Upanishads refer to the desirability of owning large herds of cattle.

The Tao Te Ching, written in China several hundred years before the Common Era, refers to the Tao, which is described as "older than God", "the great Mother" and "always present within you" and "infinite and eternal". One verse reads:

> Every being in the universe
> Is an expression of the Tao.
> That is why every being
> Spontaneously honors the Tao
>
> *Tao Te Ching* (Tao Te Ching, trans. Mitchell 2000)

Buddhism has strong exhortations regarding animals: "All beings seek for happiness; so let your compassion extend itself to all" (*Mahavamsa*).

In the Judaeo-Christian tradition, we have the anomalies of the book of Genesis, in which man was given dominion over other creatures: "And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth" (Genesis 1:26).

Yet in a few verses later, man is exhorted to apparently follow a non-meat diet: "And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, in the which is the fruit of a tree yielding seed; to you it shall be for meat" (Genesis 1:29). However, the duty of care is referred to in the book of Proverbs: "A righteous man regardeth the life of his beast" (Genesis 12:10).

Islam appears to give animals an equal status with humans – both are created by God: "All the creatures on earth, and all the birds that fly with wings, are communities like you". (Qur'an 6:38). However, animals are also there for man's use: "And he has created cattle for you: you get from them your warm garments and other benefits, and you eat of their produce" (Qur'an 16:5).

There seems to be definite recognition that animals have feelings. One of the Hadith or recorded stories about the Prophet Muhammad (pbuh) says: "We were on a journey with the Apostle of God and he left us for a while. During his absence, we saw a bird called hummara with its two young and took the young ones. The mother-bird was circling above us in the air, beating its wings in grief, when the

Prophet came back and said: ‘who has hurt the FEELINGS of this bird by taking its young? Return them to her’.” (in Masri 2007).

It seems that religions tend to recognize animals as part of God’s creation, may recognize that they are used by humans but that, because they are divinely created and because they can suffer and they do have feelings, they should be treated with compassion.

Although the Western Age of Reason and the emphasis on behaviourism denigrated the capacity of animals to experience feelings, modern science is telling us more and more about animals’ inherent capacities. For example, we now know that the central nervous system and even the recently evolved neo-cortex exist in all vertebrates (Butler 2008; LeDoux 1996) and that large cetaceans and elephants have almost as many neurons as humans (Roth and Dicke 2005). There is increasing scientific evidence for the emotional lives of animals. For example, we now know that humpback whales have cortical spindle cells, which are used for processing emotions (Hof and Van der Gucht 2006) and that not only do macaque monkeys have mirror neurons involved in empathic behaviour (Damasio and Meyer 2008), but that mice exhibit increased pain response when seeing their cage mates being given a noxious substance (Langford et al. 2006).

Little of this research into animals’ abilities has taken place on farm animals, but there is no reason to doubt that they share these capacities. In fact, it was the father of modern biology, Charles Darwin himself, who wrote, “We have seen that the senses and intuitions, the various emotions and faculties, such as love, memory, attention and curiosity, imitation, reason, etc., of which man boasts, may be found in an incipient, or even sometimes a well-developed condition, in the lower animals” (Darwin 1871).

Perhaps the great Indian leader Mahatma Gandhi presented us all with a true challenge when he wrote, ‘The greatness of a nation and its moral progress can be judged by the way its animals are treated’ (Wynne-Tyson 1990).

## 7 Animal Welfare

The combined wisdom of religious teachings and science lead us to the conclusion that many aspects of post-war industrial factory farming are unethical and based on poor overall scientific wisdom.

This kind of farming is associated with selective breeding for ever greater productivity at the expense of animal health and welfare, the keeping of social animals in isolation or in vast overcrowded sheds, the mutilation of their bodies, often without pain relief, and the use of chemicals and feeds which can promote productivity, again often at the animals’ expense.

Farm animals have been selectively bred for centuries, but new technology has speeded up the rate of change enormously. Increased growth rates and muscular development or higher yields of milk or eggs can put enormous strain on both the skeleton and the cardiovascular systems of animals. A prime example of this is the modern meat chicken or broiler.

Most of the breeding stock for the 48 billion broiler chickens slaughtered globally per annum comes from just three companies. Many breed lines are developed to reach market weight 1 day earlier each year (Cruickshank 2003). Already broiler chickens can grow from fluffy yellow chick to slaughter weight in less than 6 weeks.

The impact of fast growth can be seen most clearly in the prevalence of lameness in the broiler chicken flock. In 2006, the UK government published the results of a 3 year study, which showed that 27.6% of the chickens surveyed showed lameness problems (University of Bristol 2006). These same chicken breeds are farmed in very similar ways across the world, presumably with the same unacceptable rates of painful lameness.

In 2000, the European Commission's Scientific Committee on Animal Health and Animal Welfare (SCAHAW) produced a report on the welfare of broilers saying: 'It is clear that the major welfare problems in broilers are those which can be regarded as side effects of the intense selection mainly for growth and feed conversion. These include leg disorders, ascites, sudden death syndrome in growing birds and welfare problems in breeding birds, such as severe food restriction' (SCAHAW 2000). They concluded: 'Most of the welfare issues that relate specifically to commercial broiler production are a direct consequence of genetic selection for faster and more efficient production of chicken meat' (SCAHAW 2000).

The effects of selective breeding can also be seen in the modern dairy herd. The average dairy cow in the UK now produces over 7,000 l of milk a year, about 20% more than her counterpart of just 10 years ago (DairyCo, 2010). This is five times more milk than her calf would need. Yield in the US is around 9,000 l a year (USDA ERS 2009), indicating an even higher intensification.

Rates of 20–50% lameness per annum are regularly revealed in Western dairy herds (Webster 2005). A study in the Netherlands found that more than 83% of cows examined suffered lameness (Broom 2007). If not treated swiftly and well, the pain from lameness can be "severe and enduring" (Webster 1987). Cows are natural grass-eaters and lameness can often be related to the high levels of starchy feeds given to the cow to increase her milk yield. This type of food can result in widespread acidosis that weakens the feet.

The actual shape of the cow has also been altered to give an ever-larger udder so that she can produce more milk. This is also one of the contributory factors to increasingly high levels of mastitis, painful udder inflammation. In a wide-ranging investigation into the incidence of mastitis in dairy herds in England and Wales, the authors estimated 47–65 cases of mastitis per 100 cows per year as the likely average (Bradley et al. 2007).

Not only are industrially farmed animals bred to have bodies that have become their own worst enemies, they are also kept in totally unacceptable conditions. Day old broiler chicks are placed, perhaps 20,000 at a time, into huge, often windowless, sheds. In the early days, there is plenty of room for the chicks to move round, but as they get near slaughter weight, their space allowance drops so that often there are 16–21 chickens per sq m of floor space (less than a sheet of A4 paper per chicken). The birds' natural behaviours of perching, walking, running, even flying, are obviously frustrated. By this time, the floor appears to be carpeted with chickens and birds can be seen struggling to get to the food and watering points. The floor becomes increasingly filthy with excreta and the build up of ammonia. Burns to the hocks and blisters on the feet are a frequent result (SCAHAW 2000).

The modern highly productive egg-laying hen is kept with four or more cage-mates in a battery cage. The Scientific Veterinary Committee of the European Union (SVC) declared in 1996 “It is clear that because of its small size and barrenness, the battery cage as used at present has inherent severe disadvantages for the welfare of hens” (SVC 1996). Research by Professor Marian Dawkins at Oxford University has shown that the average space used by hens to perform such basic behaviours as standing, ground-scratching, wing-flapping and preening varies between 475 and 1,876 cm$^2$, although the top end of the range was up to 2,606 cm$^2$ (Dawkins and Hardie 1989). Under current EU rules, each caged hen has, at the moment, 550 cm$^2$, although in the US it is considerably less.

Because caged hens stand on a sloping wire mesh floor, they are unable to indulge their instincts for dust-bathing or pecking at the ground for food. They tend to turn on each other and peck each other’s feathers out instead. Often the birds have the front third of their beak cut off when they are a day or two old to prevent severe damage being done during feather pecking. The beak tip is apparently well supplied with blood vessels and nerve endings and the cutting of it with a hot metal guillotine has been shown to cause both immediate and enduring pain (Duncan et al. 1989; Gentle et al. 1982).

Hens have a strong preference for laying their eggs in a nest and are highly motivated to perform nesting behaviour (SVC 1996). Frustration of nesting is the most severe behavioural problem of hens in battery cages (Appleby et al. 1992). Research shows that hens will “work” harder to gain access to a nest box prior to laying than they will work to get to food, even after several hours’ food deprivation (Cooper and Appleby 1996, 2003). The traditional battery cage does not provide a nest.

In 1999, the EU voted to ban these barren battery cages by 2012. A rearguard action is being fought by the egg industry to postpone that ban for several years. Even after it comes into effect, so-called “enriched” cages, which offer a token nest box and marginally more floor space, will be allowed. Battery cages are widely used across the globe and an increasing number of hens are being incarcerated in them.

The industrial farming of pigs raises serious welfare issues. We know that pigs are highly inquisitive, intelligent animals with a strong instinct to root in the soil and explore their environment. Yet in modern industrial systems we routinely surround them with concrete and metal bars.

For example, pregnant sows are commonly kept in single stalls, known in Europe as sow stalls, and in North America as gestation crates. The sow spends most of her 16½-week pregnancy in the individual stall, and is unable to turn round throughout that time. She lies on a concrete and slatted floor with no straw or other bedding material for comfort. As pigs, too, have been bred to grow heavier and meatier, the sows often develop leg sores as they lie on the wet concrete. This particular system is now being phased out within the EU.

The pig’s snout is highly sensitive and well innervated (Jensen 2002). In light woodland, that is the natural environment for pigs, the animals spend up to 50% of their time using their snouts to root in the soil, seeking tubers and grubs to eat, and spend another 23% in foraging behaviour (Stolba and Wood-Gush 1989). Such behaviour is made impossible within the confines of a concrete and metal-barred crate or the darkened concrete pens in which the young pigs are fattened for slaughter.

These factory farm environments are so far removed from the animals' 'natural' habitat, that not only is movement restricted, but psychological and social well-being are adversely affected. Sometimes, in order to curb the effects of the resulting aberrant behaviours, the animals are mutilated by a variety of techniques, such as tail-docking of pigs and debeaking of hens.

Industrial animal farming frustrates strong inherited behaviors, such as maternal behaviours. It denies young animals the opportunity for exploratory 'play' behaviour. It either keeps animals in isolation, away from their peers, or in such close proximity to them that the animals are unable to establish normal group sizes.

As our appreciation for the mental and emotional capacities of farm animals develops, and as their intelligence and sentience are realized, such farming systems are not only seen as old-fashioned and out-dated, but inherently cruel. Compassion in World Farming believes there is a better way forward.

## 8 Compassion, Health and a Better Environment – a Positive Way Forward for Farming

Compassion in World Farming believes that farm animals' intelligence, family relationships and sentience should be respected in farming systems. Selective breeding for faster growth and higher yield should be abandoned in favour of breeding and rearing dual-purpose, more traditional breeds. Healthier animals will result in a decrease in the overwhelming use of antibiotics in intensive agriculture and will reduce the risk of the development of human antibiotic-resistant bacterial infections. Allowing the animals free movement and access to adequate space will encourage healthy bone and muscular development and reduce the likelihood of anti-social and stereotypic behaviours. Free movement will promote behaviours, such as mothering or exploratory play, that have positive effects on the health and well-being of farm animals.

Keeping animals in better environments will be better for the environment itself too. The tonnes of liquid slurry which pour from the intensive dairy and pig farms can be replaced by more healthy manure, or if the animals are free-ranging, the manure can serve to fertilize fields naturally. Therefore, less artificial fertilizers would be required and water pollution and air pollution caused by intensive units could be dramatically reduced.

Most importantly, Compassion in World Farming sees free-range and organic farming systems as the means to providing animals with the more natural lives that they surely deserve. If they are to end up on our plates and in our stomachs, then we owe them a life worth living.

## 9 Conclusions

We need to develop policies that promote an agriculture that produces health-giving foods for all in a way that minimizes resource use and environmental impact and ensures the welfare of farm animals. Industrial animal farming uses so much of the world's cereals and soya that it can no longer be seen as a realistic way to feed our growing human population.

One solution must be to reduce the overall numbers of farm animals. This would lessen pressure on grazing land and water resources and reduce deforestation for cattle ranching or growing soya for animal feed.

Although ruminants produce higher levels of methane than pigs and poultry, when they are kept in lower numbers on grassland, that land can act as a carbon sink and their manure can fertilize it. They can also help to preserve particular grassland habitats and such more agile ruminants as mountain sheep and goats can live in areas that might not otherwise be productive.

In suitable areas, with light soils, pigs can be kept in lower numbers outdoors. Alternatively in crop-growing areas, they can be kept in enriched indoor housing with deep straw bedding, which can later be used for fertilizer and which avoids the contaminating aspect of large lagoons of liquid slurry.

The scandal of the modern fast-growing meat chicken must be stopped. More slow-growing breeds should be used. As chickens are natural scavengers, small-scale household chicken farming with hardy local breeds could be encouraged in countries with large impoverished rural populations.

Some systems of animal breeding and production are so unethical that they should have no place in the farming of the future. Sow stalls and battery hen cages should be consigned to history. In addition, any climate change mitigation measure affecting animals should be screened for its impact on animal health and welfare.

You might ask "But if we reduce the numbers of farm animals, how will we feed the world?" The immediate answer might be: "If we continue down the track of doubling livestock numbers, how will we sustain our planet?".

If more and more forests are felled for cattle ranching and soya-growing, if more and more grassland becomes desert through overgrazing, if ever greater proportions of cereals are assigned to animal feed, if more and more greenhouse gases are emitted through livestock production, if more and more soils, rivers and seas are polluted with slurry run-off, then what hope is there for a sustainable future for all people and for our planet?

From the climate change perspective, reducing meat consumption is equivalent in carbon savings to an individual cutting out hundreds of kilometers of car travel (Fanelli 2007) or switching to a carbon-efficient hybrid car (Eshel and Martin 2006).

A reduction in meat consumption in developed countries, starting within the next 10 years, would help to free up global resources of land and water, reducing global food prices and increasing the world supply of food energy available for human use.

Inequalities in food supply between rich and poor countries are likely to exacerbate the social tensions that are expected as a result of population growth and climate change. According to the UN Secretary General, 'hunger, especially when man-made … breeds anger, social disintegration, ill-health and economic decline' (Ki-Moon 2008).

Factory farming and the over-consumption of animal products in rich countries are man-made contributions to the world's food inequalities. The supply of animal products in the diet is more than 1,000 kcal per person per day in the US and 96 kcal per person per day in Ethiopia (2003 statistics) (Brown 2008). A more equitable global food system, including a proportionate reduction in meat consumption in developed countries, needs to be developed.

Whilst we can encourage small-scale livestock production for family and local use in poorer nations, those who eat high up the food chain surely have a moral obligation to reduce their consumption of animal products. We can eat less, so that others can eat more. This theory of contraction and convergence has been outlined by leading public health academics such as Tony McMichael. He and his colleagues believe that those in the developed countries should reduce their meat consumption to no more than 90 g a day as this would be better for the climate and for their own health (McMichael et al. 2007). Those in the developing world could eat more meat until they too reached this level. Even 90 g a day only helps to stabilize and does not in itself reduce GHG emission figures.

The current very costly epidemic of overweight and obesity is leading to an increased burden of chronic disease such as diabetes, heart disease, cancer and human suffering. Consumption of such energy-dense foods containing saturated fats, such as meat and dairy products, is known to be an important factor in this epidemic. An increase in the proportion of plant-based foods and a corresponding reduction in the proportion of animal products in the diet of people in rich countries would make an immediate contribution to improving the future health of the generation of children born today.

Such intergovernmental organizations as WHO and FAO, together with national governments, must urgently develop farming and food policies which are based on all these factors. Right now it appears that livestock farming is being encouraged and the growth in meat consumption is being accepted in a purely fatalistic way.

Culturally appropriate education programmes about diet and health must be widely promoted and accompanied by economic and fiscal reform, so that livestock production is never subsidized unless it can be proven to be environmentally beneficial and animal-welfare-friendly. Governments should sponsor healthy eating programmes through public procurement initiatives and use of the media. It may be wise to place taxes on unhealthy foods containing high levels of saturated fats.

We have created an unhealthy agriculture, over-dependent on chemical inputs and on livestock production. This agriculture is devastating the planet's resources and polluting our environment. It is linked to the growing obesity crisis and associated diseases. It is taking food from the poor to fatten the rich. It is causing animal suffering on an unprecedented scale.

It is surely time to be creative and energetic in designing a more compassionate and sustainable future.

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# Chapter 5
# Cultivating Faith: The Relationship Between Islam and Sustainable Agriculture in Rural Communities of American Muslims

**Eleanor Finnegan**

**Abstract** Many thinkers and activists have recognized the need for a paradigm shift within agricultural practices (Wirzba 2004; Shabbir et al. 2009). Religion has often been hypothesized as a source that can provide an alternative to the dominate paradigm (Oelschlaeger 1994; Leopold 1990). It has been argued that religious beliefs, practices and institutions can usher in a new paradigm by providing new discourses, creation stories and ideal communities, as well as providing social capital and new practices (Oelschlaeger 1994; Peterson 2005; Taylor 2007; Wirzba 2004). Through my historic and ethnographic study of small-scale American Muslim farms in the United States, I found that religious beliefs, practices and institutions have been an integral part of these communities, providing motivation, ethics, material support, communal practices and institutions, while also creating barriers to these projects. By being involved with farms that are an important part of their religious communities and motivated in part by concerns over food security, these American Muslims have become involved with food production systems and rural environments and communities. This has led them to become involved with governmental and non-governmental programs and policy making aimed at helping rural areas or small-scale farms, as well as allowed them to learn first hand about biodiversity and changes to the environment caused by humans. Although a small-scale study, these types of farms are likely important to the future of agriculture, making it also important to learn from this project when investigating other religious groups.

**Keywords** Islam • Religion • Rural communities • Small-scale agriculture

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_5,

Many thinkers and activists, including those present at the Agadir International conference on "The integration of sustainable agriculture, rural development and ecosystems in the context of climate change, the energy crises and food security",[1] have recognized the need for a paradigm shift within agricultural practices (Wirzba 2004; Shabbir et al. 2009). Religion has often been hypothesized as a source that can provide an alternative to the dominate paradigm or a shift in cultural values and ethics concerning the environment (Oelschlaeger 1994; Leopold 1990). It has been argued that religious beliefs, practices and institutions can usher in a new paradigm by providing new discourses, creation stories and ideal communities, as well as providing social capital and new practices (Oelschlaeger 1994; Peterson 2005; Taylor 2007; Wirzba 2004). Through my historic and ethnographic study of small-scale American Muslim farms in the United States, I found that religious beliefs, practices and institutions have been an integral part of these communities, providing motivation, ethics, material support and communal practices and institutions, while also creating some barriers to these projects. By being involved with farms that are an important part of their religious communities and motivated in part by concerns over food security, these American Muslims have become involved with food production systems and rural environments and communities. This has led them to become involved with governmental and non-governmental programs and policy making aimed at helping rural areas or small-scale farms, as well as allowed them to learn first hand about biodiversity and changes to the environment caused by humans. Although a small-scale study, these types of farms are likely important to the future of agriculture, making it also important to learn from this project when investigating other religious groups.

Throughout American history, different groups of Muslims have been involved in agriculture. Often farming has been part of an effort to create a physical place where American Muslims can intentionally live out their religious beliefs and practices, as well as their ideas about food production, self-sufficiency and human-nature relationships. Starting in the 1930s, after the experience of the Great Depression, a group of African American Muslims were the first to create an intentional Muslim agricultural community. Since then, several other groups of American Muslims, including New Medinah, the Bawa Muhaiyaddeen Fellowship and the Dayemi Tariqat, have also been attempting to create intentional Muslim agricultural communities. All of these American Muslim farms have been religious projects that have been motivated in part by concerns over food security. However, none of the farms have achieved sustainability or even some degree of food security. Instead, the power of these farms lies in their ability to make people responsible to the natural world and surrounding rural area and to help more people, especially those from urban area, become involved in rural communities, specific environments, agricultural production and often broader policy debates.

[1] Conference organized by the Faculty of Law, Economics and Social Sciences of Agadir and the North-South Center for Social Sciences (NRCS), in collaboration with the German Technical Cooperation (GTZ), November 12–14, 2009, Agadir (Morocco).

In 1938, a group of Sunni African-American Muslims created the "Jabul Arabiyya: Muslim community, Governed by Sharia" near Buffalo, New York. Given their experience of the Great Depression and their practice of Sunni Islam, community members wanted to own land where they could live out their religious ideals, as well as their beliefs about economic self-sufficiency. Each resident was entitled to build on the land and got a portion for farming and gardening, but the title to the land was retained by the community. Each member had to return 10% of their profit to the group for religious and educational purposes. Most of the residents worked in factories in the Buffalo area, but many also received welfare from the U.S. government. The community had hoped to be self-sufficient, but it was plagued by the difficulty of finding new members, economic troubles and the lack of member involvement in the greater community (Dannin 2006; Fess 1946).

In 1964, the Nation of Islam made its first attempt at a farm program that would provide economic self-sufficiency, as well as ritual purity and food security to all members of the Nation. The Nation of Islam's three farms were sold to pay back taxes after Elijah Muhammad's death in 1975. However, in 1994, Louis Farrakhan bought land in Georgia to restart the farm program. The goal of this program has been to provide one meal per day and raw materials to every black person in America. As a result, the Nation's Minister of Agriculture has been active in working and networking with other black landowners, whether Muslim or not. However, the farm is plagued by lack of human resources, difficult growing conditions and difficulty finding a market that would make the farm economically viable (Curtis 2006; Gomez 2005; Rouse 2004; Turner 2003; White 2001).

Three different groups of Sunni, American Muslims have had farms in Mississippi, Pennsylvania and Illinois. In these places, community members have been inspired and limited by religious and agricultural beliefs, institutions and practices, personal and communal experiences, the geography of the area and various cultural ideas and histories. Although these groups have drawn on some similar resources, there have been differences between these communities.

New Medinah is an intentional agricultural community in Southern Mississippi, covering 64 acres of land in Sumrall where many, although not all, of its approximately 225 members live and work. Intentionally planned to have minimal impact on the environment, ten families live in houses that are clustered together, which leaves plenty of open space for gardens, a large farm and pasture area, and woodlots. On the land, there is also a mosque, a Clara Muhammad School and the only exclusively Islamic cemetery in Mississippi. The community also owns another plot of land that does not adjoin the community land where they are partnering with the University of Southern Mississippi to grow organic crops. Some residents manage the cultivation of organic fruits and vegetables, but pastured poultry has been the main agricultural enterprise, and most members have jobs outside of the farm. Although they live together, each family has been responsible for their own economic well-being.

Most of the members of New Medinah became Muslims by converting to the Nation of Islam from a Christian background, and then reoriented their beliefs and practices as Warith Deen Mohammad transformed the Nation of Islam to the

American Muslim Mission, although some reverted directly to Sunni Islam. Members of New Medinah are involved with many groups of Sunni Muslims, especially those in Southern Mississippi and New Orleans.

The land which became New Medinah was originally bought in 1983 and intended for use as a Muslim retreat center. However, in 1985, New Medinah was started when some of the purchasers suggested that the area be used as an Islamic residential community. They wanted a place where they could live and work in a rural area, strive for economic independence and practice their religious beliefs. Moved by the idea of an old Medina that helped bring Europe out of the Dark Ages and the teachings of Elijah Muhammad about self-sufficiency, the founders wanted their community to be an inspiration for people in Mississippi and America.

Most of the community members are from urban areas and have little to no agricultural experience. They come from cities, such as Chicago, and have little experience with agriculture. They have moved to New Medinah because they wanted to earn their livelihood with their hands, live rurally, own land and/or live their Muslim beliefs. Further, many value 'being away from the big cities, eating healthy food that we grow with few chemicals, and uncrowded living conditions' (Reckdahl 2003).

The Bawa Muhaiyaddeen Fellowship Farm is part of the Bawa Muhaiyaddeen Fellowship, which is a group of Sufi Muslims headquartered in Philadelphia who follow the teachings of Muhammad Raheem Muhaiyaddeen. Although the group is headquartered in Philadelphia and has branches in Massachusetts, Iowa, Michigan, New York, Connecticut, the District of Columbia and Canada, the community owns a 108 acre farm in Coatesville, Pennsylvania and has a branch there for members who live surrounding the farm. The Bawa farm is a place where community members are living out religious and environmental ideals, experiencing new ones, and beginning to formulate a holistic plan for the community to reflect the interconnectedness of these concerns. The farm itself covers 108 acres of land in the rural area of Coatesville, Pennsylvania, which is 40 miles outside of Philadelphia. Members' houses surround the area, and some members have even bought tracts of farmland adjacent to the Bawa farm.

The land functions as a farm, a place of worship, an Islamic cemetery and the final resting place (mazar) for their spiritual teacher. It also houses a farm kitchen (which also has space to hold meetings and worship) and covered pavilions for eating and praying. After attempting individual gardening and cultivation of vegetables, a CSA, and leasing out some of the land to a local farmer, community members enrolled 80 acres in the federal government's Conservation Resource Environment Program (CREP) in 2000. Some members still cultivate Bawa's garden, which is an area near the mazar that is intended for quiet reflection. Most activity on the farm is funded by donations, and no one earns a living from the farm.

The Bawa Muhaiyaddeen Fellowship began in 1971, when Bawa, who was a renowned spiritual teacher and healer in Sri Lanka, moved to Philadelphia. In the United States, Bawa continued to cultivate plants for healing and had his followers grow plants as well. In 1976 and 1977, Bawa had communities members come to work on his farm in Sri Lanka; and in 1980, Bawa had the community buy a quarter and a half of an acre of land not only for a cemetery, but also to be able to learn from the experience of farming, which he believed provided religious lessons about cooperation, unity and taking care of the needy, as well as lessons on how to provide materially for one's own self and community. Some community members recall that he often warned that there would be a day where the group would need to produce its own food.

Most members did not move to Coatesville until after Bawa's bodily death and creation of his mazar in 1986. Like the many pilgrims from around the world who come to the holy site, community members were drawn to living near the mazar and grounds. They have also been drawn to the area due to the opportunity to live out religious lessons, beliefs about the environment and the interconnectedness of these ideas.

The community has been crafting a plan that will make these values more explicit. They are trying to build a green retirement community and mosque on the land, and they plan to become organic certified when the government program is finished. There has been debate and tension over the plan, as some believe that the proposed mosque and related buildings go against the purpose and meaning of the place and Bawa's teachings. There has also been contention over the amount of time it has taken to get the zoning permission to build a village.

The Dayempur Farm in Anna, Illinois, is one of the community institutions of the Sufi group, the Dayemi Tariqat. Members of the Dayemi Tariqat follow the teachings of Sheikh Din Muhammad Abdullah Al-Dayemi, an American trained in Bangladesh. Most community members live in the town of Carbondale, Illinois where the community also owns and runs a restaurant, a general store, a preschool, an alternative medicine clinic, a home school cooperative, a park and garden and a community house. With all of these businesses, the Dayemi Tariqat employs 40 people in the community, both Muslim and non-Muslim. Central to all of these projects is God, as well as a concern for being self-sufficient and revitalizing the local community based on resources available in the area.

In a location where five ecosystems come together and there is still plenty of pristine forest land, the community owns 60 acres of land and currently cultivates only 2.5 acres. There are four people employed full time at the farm, and every member of the community has to volunteer on the farm at least 1 day a month. Together, they grow medicinal herbs, cooking herbs, vegetables, fruit and nuts, using select methodologies and practices from permaculture, Grow Bio-intensive gardening, natural farming and Biodynamics. The farm also produces eggs and honey. The products from the farm are used at the restaurant and store, to make medicine and to create communal meals. The extras are given to members of the community or handed out at the store. The farm land includes two cabins made from recycled materials, a shop, and a barn with solar panels, a wind generator and a backup generator that serves as a power station. There are plans to add a bio-diesel brewing apparatus.

The Dayemi Tariqat is part of a larger Sufi community, the Dayera Sharif, which began 1,400 years ago in Bangladesh. Sheikh Din was trained in Bangladesh by Hadrat Shah Sufi Sayyid Dayemullah, a teacher from this community. Sheikh

Dayemullah then appointed him to teach in the United States, as earlier teachers had foreseen that there would be someone from outside the community who would bring their teachings to the United States. Sheikh Din began the Dayempur Farm when he moved seven people to Southern Illinois and bought some farmland in 1995. The community also has branches in South Carolina, Colorado, Texas and Germany, and it still maintains close connections with the community in Bangladesh. In fact, the Dayemi Tariqat is not only involved with their farm but also with similar the farm communities in Bangladesh that were established by Sheikh Dayemullah.

The seeds for the Dayempur Farm were planted when some of its future farm employees and Sheikh Din, became disciples of the yogic idea of Progressive Utilization Theory (PROUT), which taught that progress can only be achieved with spiritual intention. This idea was reinforced while Sheikh Din was training in Bangladesh. Therefore, as part of his teaching, Sheikh Din has the responsibility of guiding his community in an attempt to create a self-sustaining society, which not only provides for everyone's physical needs but their spiritual needs as well. Some of the farm employees told me that they were drawn to the Dayemi Tariqat because of its ideas about attempts at intentional living. They said that it was not important to them that it was a Sufi group. Instead, they saw the group as promoting a universal truth that could be found in many spiritual traditions about how people should live. Either based on personal experience or knowledge of secular intentional communities that all failed, every member of the farm staff said that they thought their task would be impossible without a shared religious vision, a spiritual teacher and open lines of communication that are an important part of their religious practice. For everyone involved in the farm, it provides a place where they can embody ideas about experiencing God's power and plan in all things.

Together, these communities represent a diversity of membership, experience, thought and practice within American Islam and among religious farmers. They arise from different concerns and ideas about the place of religion and nature in a good, meaningful life. They also demonstrate unique attempts at intentional living and agricultural. Some of these communities have been successful, whereas others are struggling. Some of these communities are only gardening, and others have functional farms.

All of these farms have been motivated in part by community members' religious beliefs and commitments, as well as their desire to practice what they believe. For members of New Medinah, their desire to live closer to the land in a rural area and to live their religious beliefs coincided. In Pennsylvania, the members of the community saw their work at the farm as embodying Bawa's teachings about God, and they have draw upon the religious teachings of their community to guide them and motivate them in their work. Later members of the farm community were often initially drawn to the Bawa farm because they wanted to be close to the mazar. At the Dayempur Farm, community members not only rely on the teachings of Sheikh Din and the example of their brethren in Bangladesh, but they also gain inspiration for their work from the example of the Prophet Muhammad and the teachings of the Qur'an.

Although all of these groups pull from their religious beliefs to gain motivation for farming, these farmers have also had a difficult time explaining to me how religion inspires their specific actions on their farms. However, this has not prevented them from practicing specific forms of agriculture, such as organic farming, permaculture and or planting native species that are considered to have less negative impact on the environment. In fact, as these Muslims have been involved with a farm, they have grown in their understanding and use of such methods. At the Bawa farm, the community first elected to plant all fruit trees as part of CREP, which required that they stop farming and plant all grasses and trees to protect streams and prevent erosion. However, when they went to replant all of the places where the trees did not take, they chose to plant all native species, because they had noticed a decline in native animal populations. Besides drawing on particular interpretations of their Islamic faith, these farmers are also gaining inspiration from personal experience, American and Asian cultures, science and environmentalism.

Religious groups have also provided cultural and material support for these farm communities. In some instances, like New Medinah and the Dayemi Tariqat, they provide a community that makes it more comfortable and less risky to become involved in an intentional community. Two of the people involved with the Dayempur Farm told me that they valued being a part of the Dayemi Tariqat because it provided an instant community that has similar values about how to live a good life and there were already people and institutions in place to help them attempt to live these ideals. The Minister of Agriculture at the Muhammad Farm has begun to link people by marketing and selling its produce through buying clubs associated with Nation temples throughout the United States (Muhammad Farms 2007).

Religious groups have only been able to provide some of the necessary material support. Farmers are still learning how to best farm in their environs and to establish the infrastructure necessary to make these farms more self-sufficient. In fact, in the early communities, such as Jabul Arabiyya, lack of knowledge about farming and a failure to teach new members eventually led to the end of the farm.

Each of these farms has been able to gain necessary knowledge and material support through contributions from larger networks. These networks include non-Muslim groups and programs, as well as people from their religious community (both broadly and narrowly conceived). For example, all of these farms have been involved in governmental programs or private programs, such as Heifer International, that aim at helping and educating small-scale farmers (Pastured Poultry 2007). In fact, these communities often use their farms as a way to make connections with their non-Muslim neighbors, often sharing tools or methods. Becoming involved in farms has also been a way for these new farmers to get involved with policy or programs aimed at helping rural areas, the environment or small scale farms. Members of the Dayemi Tariqat have become involved in crafting state policy that will help keep rural communities economically vibrant, and people associated with the Bawa farm have begun several conservation groups. A former farm director for one of Elijah Muhammad's farms now owns a business that does urban agriculture in Atlanta (Truly Living Well Urban Farms 2010).

Although farming has been an excellent form of outreach, some communities have had trouble connected with and gaining support from their neighbors because of their religious identity. Some members of the Bawa farm believe that the community has had trouble securing permits to construct a retirement village on its farmland, because people in town are wary of a community of Muslims. The Muhammad Farm has also had trouble finding a market that will make the farm economically viable (Muhammad Farm 2007).

The members of these farm communities have not created a network between their farms. Most of these farmers have little knowledge about each other. Since I have met with these farms, they are excited to learn about each other from my work, and they have given me the names of some groups and places that they think may have had farms. However, I have not been able to find all of these communities.

Within these communities, religion has provided an alternative to the dominate social paradigm in the United States, and some infrastructure to help realize this vision. However, there are limitations to these institutions, and these limitations have forced these communities to continue to work within the dominate economic paradigm. Only four farmers on the Dayempur Farm make their living from farming. All of the other farmers involved with these communities have to earn their livings through other means.

Although many community members believed that creating an intentional community without a common vision, purpose and ethic grounded in religion was impossible, common religious beliefs did not create a cohesive group. Even within the Dayemi Tariqat, which many farm employees believed provided better lines of communication and a common vision due to the religious practices of the group and the figure of the sheikh, there were still conflicts and dissenting ideas. This has also been true at the Bawa farm, where there have been tensions between groups of people who see the farm as having different meanings and purposes. One community member described these factions as pioneers, shopkeepers and industrialists, and he then explained that each of these groups had different ideas about what to do with the land. He also made it sound inevitable that there would have to be a progression where each of these groups in turn would control the land.

Looking at these farms together, it is possible to see that religious beliefs, practices and institutions provide in varying ways depending on the specific community general motivation and ethos, materials, community organization and support, and practices that assist farming and community formation, such as specific religious practices that stress communication. However, these groups do not all draw upon the same aspects of religion. There is some overlap, as all of these farms look to the example of Prophet Muhammad (often as stated through Hadith) and the Qur'an. Depending on the specific religion of the farm, they may draw on other diverse beliefs and practices, such as the teachings or practices associated with a spiritual teacher or the example and teachings of other religious figures, such as Elijah Muhammad. Religious beliefs and practices may also have limitations. Religious beliefs and practices do not provide full social cohesion, can provide barriers to other communities, do not provide specific guidance when picking particular agricultural practices, and do not provide enough institutional support to complete transcend the dominate social paradigm.

Despite these shortcomings, these farms do serve an important role in bringing urban dwellers back to rural areas, and in making them involved in the environment and society in these areas. These farms are bringing people into community with nature, and ultimately, as posited by William Jordan about restoration ecology, making people responsible to nature (Jordan 2003). The concern, awareness and skills developed on these farms are making these farmers more aware of the need for changes to address issues of food security, viability of rural areas and environmental change due to human action.

The lessons from this study are important when studying other religious farm communities, and the role of religion may become increasingly important, as often religion is one of the reasons that people at least believe that it is socially acceptable to change their practices from the norm (Wirzba 2004). Besides the earlier lessons from this study, it is necessary not only to look at a religious group's beliefs, but also their practices and institutions. Practices and institutions may be aiding these small-scale farms, but they might also be creating barriers to success. Second, due to variation in religious and agricultural beliefs and practices among community members, it is necessary to talk with as many people as possible about the role of religion in a farm community. This helps providing a more complete picture of the complicated ways that faith and farming can intersect or diverge. Third, it is also important to have an understanding of what groups that may seem on the boarders of a tradition are doing, because they may, like the Nation of Islam, be influencing groups that are considered far more mainstream.

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# Chapter 6
# Agricultural Development for Food Security and Sustainability in Nigeria

**Usman Haruna and Mohammed Bashir Umar**

**Abstract** This chapter examines Nigeria's agricultural sector, rural economy, population growth and environmental degradation, the concepts of food security, technology and technical change. It also tries to look into the global economic system with its attendant consequences in which three fundamental reasons were advanced for its unsustainability. Moreover, the chapter attempts to briefly link environment as a sphere for agricultural development. It proffers sustainable agricultural methods such as land use options, promotion of low input technologies and participative management as some of the few ways to attain food security and sustainability in agriculture in the country. It concludes by recommending an integrated approach not only to agriculture, but also to other sectors of the economy; aimed at providing employment, access to production inputs, social services and management of development resources. These are viewed to be achieved through increased mobilization and motivation of the rural people to participate actively in decision making process concerning their progress and in the development activities. It also recommends the establishment of institutional relationships which will facilitate the development of the various sectors; otherwise, there is no hope for a better tomorrow for a sustainable working relationship between the country's teeming population and its source of livelihood.

**Keywords** Agricultural development • Food security • Rural economy • Sustainability • Technological change

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_6,

## 1 The Nigeria's Agricultural Sector

Agriculture has important functions to perform in the economic development of most developing countries. This is true of Nigeria where the agricultural sector is expected to meet the demand for better staple food and supply of sufficient industrial raw materials to expanding local industries. It is also expected to contribute to foreign exchange earnings through increase in exports, as well as providing a major market for industrial sector products. As Mohammed et al. (2005) observed, accelerated increase in agricultural output, income and resource productivity is a precondition for the effective performance of these functions. Also, many agricultural economists believed that each increase can only be achieved with introduction of new technology in traditional agriculture (Leathers and Smale 1991; Lin 1991; Haruna and Kushwaha 2003).

However, the need for new technology arises from two important characteristics of traditional agriculture. First, no appreciable increase in agricultural production can be achieved by reallocating the factors at the disposal of farmers in traditional agriculture (Behrman 1968). Secondly, "the marginal increment" to production of additions to either land area or traditional forms of capital and labour on old lands will be small due partly to the low productivity inherent in older technologies, and partly to diminishing returns to the inputs added to those already used in present production processes.

Therefore, various governments of Nigeria have fully recognized the importance of technological change as a source of rapid growth and development in the agricultural sector. It is believed that the introduction of simple technologies in the form of improved seeds, agrochemicals, fertilizers and improved cultural practices is one of the quickest ways of improving agricultural production technology raising the productivity of agricultural resources (Haruna and Kushwaha 2003). Probably, the rationale of this belief is based on the spectacular results obtained from the use of modern inputs on research stations and the experiences of other countries. Over the years, past efforts by the governments to increase agricultural production through large-scale introduction of modern inputs have not yielded the much desired results. Both the degree and level of adoption of modern inputs have been very disappointing (Haruna and Kushwaha 2003).

Even where there has been a serious attempt at adoption, the impact on output has been minimal in comparison with needs. Moreover, the potential of the new technology has not been fully expressed on the small farms that produce the bulk of the country's agricultural products. The consequence leaves no one in doubt that agricultural production continues to grow at a lower rate compared to the growth in population annually in the country. Shortages of essential agricultural commodities remain as evidenced by spiral increases in food and huge import bills. At this juncture, one is tempted to ask what went wrong with the agricultural sector.

However, a number of reasons have been suggested, one of which is that a careful examination of the past programmes reveals that the development of smallholder agricultural producers has been pursued with blatant disregard for the attainment of food security and ultimately sustainability of the system. This is perhaps due to the fact that politicians, planners and development administrators still hold on to the myths of well-conceived development models from the above (trickle down), without considerations of the dynamics of peasant agriculture as the mainstay of the economy. This suggests that, is it possible for the country to attain development in agriculture for food security and considering past efforts in revitalizing the sector? In an attempt to provide an answer to the poser, this chapter reviews the Nigerian rural economy, poverty, environment, the concepts of food security and technology, and proffers sustainable agricultural methods as *sine qua non* for development in the sector and the economy.

## 2 The Nigerian Rural Economy, Poverty and Environmental Degradation

In Nigeria, for a long list of essential products, rural families depends on forests and trees for fuel wood, fodder, nuts, fruits, dyes, medicines, building materials, to mention but a few. Also, in many Nigerian societies, fuel wood and fodder formed two of the most important ingredients for survival, without them life will degenerate quickly into a mere struggle for existence. To even be more specific, more essential is perhaps, the fact that many rural farm families depend on forest products and trees for generating income. Collecting, processing and selling are often the only means in which a stream of cash income is assured especially where seasonal agriculture is the dominant occupation. Moreover, the forest forms the great, but cheap source of industrial raw materials for the country's local industries.

However, expanding population, which exacerbate social, economic and ecological impoverishment, make all the existing environmental problems more critical. The increase has several components, including a desire for large families, mounted fertility and population momentum; to increase for sometime after fertility has stabilized. The environmental impact of continued population growth is felt through increases in energy demand, production, consumption and waste. It is currently estimated that Nigeria loses about 351,000 ha of land to desert encroachment advancing southwards at the rate of an average of 8 km per annum. As reported by Abdul (2001), economically, desertification accounts for 73% of the estimated US $5.1106 million the country is losing to environmental degradation. He further noted that with Nigeria's population projected to rise to 114.5 million by the year 2020, the fuel wood demand (a principal cause of deforestation) is expected to reach 83.5 million cubic meters.

The disproportionate disappearance of these free gifts of nature will definitely be replaced by human misery in the form of "food and social insecurity", because nature abhors a vacuum (Abdul 2001). This is a cause for concern since both the intensity and urgency of the situation requires a concerted and well-articulated planning and action by all and sundry. For the simple fact that the first victims of desertification, hence environmental degradation, are the rural dwellers.

Hungry, unemployed and uneducated, they will be forced to migrate into towns and cities to engage in menial jobs, and eventually become a powder keg for social instability. No wonder, Nigeria records the re-current communal – cum – religious crises in its chequered history. Fortunately, these problems are avoidable, what is needed is political commitment, strong will power and consistency in policy planning and implementation, more especially a favorable climate for agriculture and the environment.

## 2.1 Food Security

At a simpler level, food security may be understood as the access by all people at all times to food sufficiency for a healthy life. Obviously, food insecurity is the lack of access to enough food. Specific models have been developed in the literature based on supply, demand and market failure theories, as methodological approaches to explanations of food insecurity and famines. The supply-side explanation is popularly known as Food Availability Decline (FAD) model, and refers to the decline in per capita food availability. The demand-side explanations however, are known as Food Entitlement Decline (FED). Food availability refers to the supply of food; and entitlement refers to the household's or individual's command over it (Sen 1981). Moreover, the entitlement of a person stands for the different alternative commodity bundles that a person can acquire through the uses of various legal channels of acquirement open to someone in his position. The argument of FED is that, the mere presence of sufficient food in aggregate terms does not necessarily entitle a person access to it. Other types of entitlements include trade, production-based, personal labour, inheritance and transfer entitlements. Sen and Dreze (1989) have included extended co-operative and conflict entitlement to the list.

However, food availability and entitlement models are not independent explanations, but in fact complement each other, because they do not address the problem at household level. Moreover, how food security causation may be explained at the household level involving access to the individual resources has not been considered in these models. In addition to availability and entitlements, the attitudes of the people are also important. Other issues on famines and food insecurity, such as the stages of coping (Rahmato 1987), transitory, chronic and acute vulnerability (Maxwell 1986), empowerment and enfranchisement (Watts and Hans 1992), resource scarcity (Devereaux and Hay 1986) etc., have received considerable attention. More so, the issue of food aid has been considered controversial in terms of its political and commercial implications and its disincentive impact on domestic efforts (Maxwell 1986).

Having reviewed the concept of food security, one may perhaps be at liberty to ask: has Nigeria attained food security or to be more precise does agricultural sector perform its function of providing better staple food supply as envisaged in the National Development Plans? Obviously, shortages of essential agricultural commodities remain perpetually as evidenced by spiral increases in food prices, continuous and higher import bills.

## *2.2 Technology and Technological Change*

Technology may simply be defined as the systematic application of collective human rationality to the solution of problems through the assertion of control over nature and all kinds of human processes. From this definition, technology can be said to be the application of knowledge for practical ends. It can also be an idea, object or practice and these could be organized by an individual or group(s) to promote an improved way of life or civilization. As such it covers all aspect of material (hoe and cutlasses) and non-material culture (beliefs, norms, values and social organization). However, technological change can, therefore, be viewed as an alteration in the existing traditional technology of a society to bring about improvement in their socio-economic status.

Moreover, technology takes different forms. One of which is agricultural technology that borders on the application of technology for the promotion and development of agriculture through improvement of food production, income, well-being of the farmers and the nation at large. On one hand, appropriate technology comprises a set of techniques that unlocks new resources, increase productivity and generates new capacities to produces goods and services on the farm. It involves enhancing the farmers' potential abilities and the community's cultural values in order to develop the technology that fits the agro-ecological environment and which will also meet the self-need of the farmers. On the other hand, the typology of modern technology include large sophisticated, automated and capital intensive gadgets and technology of modernized large-scale farming.

At this juncture, it seems we are confronted with certain questions. One, of which is: which among the various concepts of technology did the past agricultural development projects promoted? Were the technologies promoted, adopted and adapted to the existing farming systems of the country? Are the farmers capable of paying for the inputs and additional cultivation expenses? Is there appropriate structure for making the inputs available, adequate and at the right time? Is our extension service delivery system effective in communicating the knowledge to farmers? In spite of these glaring questions that beg for answers, agriculture still contributes about 40% to the country's GDP. Then what needs to be done? To proffer a solution it may perhaps be safe to detour into the issue of sustainable approaches to agricultural production in an attempt to attain food security and ultimately development in the agricultural sector.

## *2.3 Sustainable Agricultural Development*

Proper management of natural resources is of central importance to agricultural and economic development of any nation. This is especially true for developing countries, where natural resource depletion has immediate economic and social consequence. Low income countries are typically dependent on agriculture and natural resources, and are thus often most vulnerable to the effects of environmental degradation.

In many developing countries, the combination of poverty, unequal distribution of land and other resources, and rapid population growth are creating avenues for people to overexploit existing resources in order to survive. Exacerbating this is the fact that economic systems do not always contain the automatic self-regulating mechanism for ensuring the perpetual environmental sustainability of current economic development path. Under such conditions, it is no longer possible to address systematic problems through piece-meal action. Increased effort, is therefore, needed to identify appropriate social, economic and other policy measures for sound environmental management (Warford and Partow 1990).

In defining sustainability, 24 different definitions appeared in Blueprint for a Green Economy (Pearce et al. 1989), and many more have been formulated since. Rather than choosing between existing definitions, let us develop one for our purpose. Thus, in a sustainable environment, all the production processes, in this case crop and livestock production, once established should be capable of being carried out unaltered for a long period without causing a progressive damage to any factor of production that they affect or relied upon whether human or environmental. However, by our definition above, the set of production processes by which the needs of most of humankind is currently met, it appears that the world economic system is seriously unstable. A notable reason is the greenhouse effect, causing the climate to change in ways that are unbalanced and almost certainly unfavorable. Another reason is that the world economy is unsustainable because it supports agricultural methods which cause the loss of soil and biodiversity. This leads to increased poverty and growing inequality combined to the increase of the vulnerability of humans and nature. Meeting fundamental human needs, while accelerating today's halting progress in a transition towards sustainability is currently a serious challenge (McCarty and Dickson 2000). In addition, the natural genetic resistance of crops to pests and diseases is neutralized to such an extent that within a few years it could become possible to grow one or more food crops; however, much insecticide or fungicide is applied (Johnson et al. 1991). A third reason is that some of the chemicals it employs mimic human hormones and disrupt the body's endocrine system. As a result, the sperm counts of men have been falling and increases in testicular and breast cancer (Sen and Dreze 1989).

The three above examples are enough to make it clear that the processes by which most of humanity lives have to be changed radically before we can rely on being able to continue upon our heads.

Moreover, as a *sine qua non* for any sustainable agricultural development effort, any increase in the productivity of land for instance, presupposes improvement in fertility or the maintenance of its existing level. The question is: is it possible or rather easy to bring about any increase in the productivity of land, particularly for small-scale producers tilling marginal lands (Soils)? The answer seems far-fetched because in a degraded eco-system for such small-producer, the overriding concern is the survival of the family first. As such, they will tend to deplete the soil, thus further deteriorating the physical environment and adding to their own misery and poverty as evidence by what is obtainable in the Nigerian rural economy.

Therefore, the concept of sustainable development should be a dynamic one since the resources that humankind derives from the biosphere are constantly changing, not only because of population growth, but also of social needs.

Further, in examining the problems associated with sustainable use of natural (oceans, rivers, lakes, soil, forests, air, etc.) and human resources, this chapter draws our attention to the need to first offer the teeming small-holder producers in the country land-use options that are economically viable and socially acceptable. This applies to both crop production and pastoralism, as such calls for a steeped-up effort in applied research with active collaboration and participation of farmers, particularly in areas of alternative choice to traditional agriculture, such as between shifting cultivation and alley cropping, low intensity tillage, cover crops, green manuring, eco-leveling and agro-forestry, etc. Another important area borders on the use of inputs which often poses in the form of a choice or conflict between low- and high-input technologies. In as much as favourable ratio between values of production and costs of inputs is essential for the economics of individual farm units, the question is and will continue to be fundamental. In this instance, low-inputs technology is understood to mean a technology that reduces the use of market bought inputs in favor of farm produced inputs. It also applies to the use of efficient and effective cultural practices that will increase the cost-benefit of purchased inputs. This is capable of freeing up resources which can be channeled into other productive uses by reducing the exorbitant input costs.

Undoubtedly, the solution lies in the choice of technologies to be promoted, instead of promoting large sophisticated, automated and capital intensive gadgets and technology of modernized large-scale farming. Our peculiarity calls for the development and application of technological packages that will associate in appropriate proportions both farm and market produced inputs. In this regard, it may be noted that research on biotechnology, particularly based on genetic manipulation and bio-mass energy, may make a significant contribution to reducing the need for externally produced chemical inputs. The same applies to the area of bio-pest control, such as the control of two cassava pests namely mealy bugs and cassava green mites developed by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. On-farm machinery and equipment, the promotion on a large-scale of traction technology will go a long way in reducing the drudgery of the hoe and cutlass technologies of the traditional agricultural sector.

In dependable agricultural production, hence food security, another critical factor that the country does not manage very well is irrigation. The two main constraints to expansion and efficiency of irrigation, as has been noted, are capital costs and limited managerial capacity. A key element to these problems is participative management which can only provide the communities in question with proper management and maintenance of their own irrigation schemes but, also involves them in the investments needed to bring it into being. Research in participative management could, as well, be strengthened.

It also stressed the need to fill in gaps in research, training and education in the biological potentials of soils, as well as the need to preserve our biodiversity in actions aimed at maintaining the sustainability of basic natural and human resources. In line, special emphasis should be placed on the major role that traditional practices and know-how can play. It was observed that some of the tribal technologies used by natives in the Bauchi plateau in Nigeria for soil conservation could hardly be perfected by science.

Stressing the importance of indigenous knowledge systems for sustainable agricultural development, Samson (2001) pragmatically argued that they deal with many important issues, both social (decentralization, local participation, peasant involvement, self-sufficiency and determination) and technological (low-cost resources, appropriate technology developed out of experience and testing, and technology representing a strong potential for special training and utilization by broad populations of low-resource entrepreneurs, technology and practices that take into account household and national goals, and technology and programs seen as interacting well with the physical, biological and socio-economic environments).

## 3 Conclusion

Currently, it will be a mistake to wave sustainable development as a mere ordinary remark or just a vogue, soon to disappear – like the concern about the "limits to growth" of the nineteenth century. Many of the related-issues (resource depletion, population explosion, soil degradation, loss of habitats and species) are recurrent themes. They threaten the Planet's carrying capacity and the ability of its ecosystems to self-regenerate.

Moreover, by linking rural economy, poverty and environmental degradation, the development needs and aspirations of developing country like Nigeria, appears incorporated. It is also apparent that agricultural development cannot be dealt with in isolation of the environmental issues. They are interdependent parts of a greater whole. Elsewhere, strenuous efforts are being made to define, interpret and introduce sustainable development at local, national and global levels. Sustainable development is already passing from being just a vogue concept to becoming a set of objectives and policies requiring implementation.

As such, this chapter calls for a combined development of various areas of the rural society including agriculture, health, nutrition, rural electrification, water supply and cooperatives, simultaneously. The strategy should aim at improved employment, access to production resources, social services and management of development resources. These can be achieved through increased mobilization and motivation of rural people to participate actively in decision making process concerning their progress and in the development activities. Also, established institutional relationships will facilitate the development of the sector. Otherwise, there is no hope for a better tomorrow for a sustainable working relationship between the country's teeming population in the agricultural sector.

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# Chapter 7
# African Agriculture at Crossroads: Balancing the Needs of Increased Productivity and the Challenges of Sustainability. The Case of Fadama Agriculture in Semi-Arid North-Central Nigeria

**Jake Dan-Azumi**

**Abstract** Africa is threatened by the current global food crisis more than any other region in the world. This has once again raised the question of food security on the continent and increased the call for a change of approach in which smallholders and indigenous knowledge systems will play a pivotal role. The main challenge facing the continent is how to balance the quest for food self-sufficiency and the demands of sustainability. This research assesses the productivity and sustainability of *fadama* (floodplains) farming systems of North-Central Nigeria. Findings reveal a delicate interaction and negotiation across the formal and informal boundaries where traditional agricultural practices, based on an understanding of the particular physical reality and exploitation of natural synergies, are combined with inputs typical of conventional agriculture. African agriculture thus stands poised at crossroads: whether to abandon tradition in favour of entirely 'modern' methods and export markets as often advocated for in certain circles or depend on time tested indigenous knowledge systems and grassroots-defined development vision which combines popular livelihoods with respect for nature's systems. Drawing on Bruno Latour, the metaphor of 'hybridisation' is used to justify a negotiated compromise between official discourses, which promote the use of chemicals, and grassroots reality which relies on nature's systems.

**Keywords** African agriculture • Agricultural sustainability • Fadama • Indigenous knowledge • Smallholders

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_7,

# 1 Introduction

Agriculture remains the most important sector of the African economy. It provides 60% of all employment and contributes the largest share to the gross national income (GNI), making it the biggest source of foreign exchange, and the main generator of savings and tax revenues (Pinstrup-Aderesen 2002). Despite its importance, African agriculture continues to be characterized by poor performance in the last three decades despite a host of policies and programmes (Pinstrup-Aderesen 2002; Rosegrant et al. 2005). Most of the world's one billion poorest people live in Africa. The worst victims of hunger are poor small-holders, the landless and female-headed households (FAO 2008). Hence, not only does sub-Saharan Africa (SSA) has the highest percentage of poor people, most of the poorest households are found in agriculture (Spencer 2002; Alayande and Alayande 2004; Poulton et al. 2005), whereas the proportion of the people living in poverty in small-holder farming is on the decrease in Asia, the proportion has increased in SSA (Johannesburg Summit 2002; Chen and Ravallion 2004; Lipton 2005).

Attempts at improving African agriculture have focussed almost exclusively on technical intervention and policy prescriptions for increasing agricultural productivity centre on the promotion of high input packages that consist of technologies, high yielding varieties, agrochemicals and subsidies (IAC 2004; Eicher 2003). On the whole, little attention is paid to issues of sustainability and the potential of drawing from indigenous agricultural systems to increase productivity. Similarly, the diversity of the ecologies of the continent, local institutions, farmer's inputs, environment and biodiversity are seldom taken into account in agricultural planning. Many agricultural programmes and interventions on the continent lack context and ignore the poverty and weak purchasing power of most small-holders, a problem compounded by weak infrastructural support for sustainable small-holder agriculture (Scoones et al. 2005). The real needs of small-holder farmers, which are often are at variance with 'expert' opinion, have been largely ignored, because these farmers are considered as 'backward'.

Yet, technical intervention in African agriculture has consistently failed to ensure food security on the continent (Cowan and Shenton 1996). Also, the logic and method of the current global food system and its ability to meet global food demands in a sustainable manner have been seriously questioned (Altieri et al. 2001). Opponents of conventional agriculture[1] argue it ignores issues of sustainability, attributes productivity to a single set of factors and fails to acknowledge other possibilities. The growing demand for food for an increasing population in a

[1] Conventional agriculture is used interchangeably with modern agriculture to refer to an "industrialized agricultural system characterized by mechanization, monocultures, and the use of synthetic inputs such as chemical fertilizers and pesticides, with an emphasis on maximizing productivity and profitability. Industrialized agriculture has become "conventional" only within the last 60 or so years (since World War II)."

time of severe biophysical limitations is threatening natural resources as people strive to get most out of land already in production. The result includes the following damages: arable land lost to erosion, salinity, desertification and urban spread, water shortages, disappearing forests and threats to biodiversity as shown above. Findings by the International Assessment of Agriculture Science and Technology for Development (IAASTD) recognize the complexities of the problems facing agriculture throughout the world and show that if the current global food system is to deliver wholesome safe and affordable food without causing long-term harm to the environment in the future, it needs to be overhauled (IAASTD 2009).

## 2 Typology and Importance of *Fadama* Areas and Agriculture

*Fadama* is a Hausa[2] name for irrigable land/floodplains and low lying areas underlined by shallow aquifers found along Nigeria's river system. Typically, floodplains are flat lands or regions which serve as floodways and are usually inundated by lateral overflow of water at some point of the year as a result of their proximity to a water body (stream or a river) (Junk et al. 1989). Floodplains are vibrant systems and important ecological units supporting rich and diverse ecological activities and making important sources of biodiversity. Due to intense engineering and regulation, however, natural floodplains in developed countries have been described as 'functionally extinct' (Graf 1979, 1999; Knox 2001; Tockner and Stanford 2002; Woltemade 1994). However, for centuries, many smallholders in developing countries have relied on small floodplains to harness water for farming and construct feasible ecological systems that were socially controlled (Sandberg 2004).

In many parts of Africa, floodplains support agricultural activities such as recession farming, fishing, grazing and ecotourism. This is also the case in the arid and semi-arid areas like those of Northern Nigeria (Adams 1993). The Rufiji River Floodplains in Tanzania continue to support teeming rural small-holders (approximately 150,000 people) who have developed an elaborate, versatile and risk-minimizing farming systems in the area (Marsland 1938; Sandberg 1974; Havnevik 1993). These systems were mostly based on traditional agricultural methods and indigenous knowledge systems and consisted of the following: shared knowledge of "diversity of flood heights and onset times in various fields; drainage and fertility properties of the various soils; place and timing of vermin attacks; the flood resistance properties of seed varieties, especially rice; traditional land tenure mechanisms" (Sandberg 1974). Hence, floodplains have been used by smallholders in many parts of the developing world both as a system of knowledge and power as well as a source of livelihood.

[2] Hausa is a Chadic language belonging to the Afro-Asiatic language family and it is one of the three major languages spoken mostly in Northern Nigeria and across West Africa.

In Nigeria, there are almost 3,000,000 ha of such fertile soils with residual moisture in the dry-season which offer great opportunities for the arable farmers to grow off-season high value crops. Similarly, livestock keepers depend on the *fadama* areas for water access and dry season fodder. The *fadama* areas are also important inland fisheries areas. The potential of *fadama* land for improved food production in Nigeria is reflected in the fact that of the 550,000 ha of land used for rice cultivation in Nigeria, 35% is under swamp and *fadama*s (Oputa et al. 1985). Thus, *fadama* areas have the largest share of rice area and production, and the highest priority for reduced production cost. Other crops grown in the *fadama* areas are maize, sorghum, guinea corn, yam, cowpea, beans and sugarcane.

## 2.1 Fadama Agriculture in Karshi and Baddeggi

A study was undertaken in two small agrarian communities in North-Central Nigeria (Karshi and Baddeggi) so as to understand the practice of *fadama* agriculture and to ascertain its sustainability. The choice of the study areas was based on the following: both areas demonstrate the role of *fadama* within traditional management practices, and both areas fall within similar geographical setting. They are both examples of *fadama* areas that have not been significantly altered by state intervention. The agricultural practices in these two areas are similar: they consist of a combination of 'traditional' methods of cultivation using 'simple' tools such as hoes and cutlasses, and 'modern' inputs comprising of fertilizer, herbicides, insecticides, hybrid seeds and some level of mechanized methods of land cultivation such as the use of tractors and irrigation pumps.

Over a period of 4 months, 47 people were interviewed in-depth in Karshi and 21 in Baddeggi. The research strategy consisted of mixed techniques led principally by a core interview schedule which was complemented by a follow-up strategy, involving survey techniques used to accurately measure the demographic features of the research participants and the extent of agrochemical use. The research methodology was Grounded Theory (GT) as the chief concern was the understanding of *fadama* agriculture through the identification of its key elements, and then categorizing the relationships of those elements to the context and process of the experiment (Strauss and Corbin 1990, 1994; Glaser 1994, 1999; Charmaz 2000; Parse 2001).

It is particularly suited for the purpose of theory development (Strauss and Corbin 1990, 1994; Glaser 1994, 1999; Charmaz 2000; Parse 2001). Unlike with many methods where the research moves deductively (from the general to the particular), GT research proceeds inductively (from the particular to the general). Theory is generated from data and no effort is made to impose theory on data (Stern 1985). The core of GT research is constant simultaneous comparison and analysis of data which is compared with every other item of data and from which a theory is then generated (Glaser and Strauss 1967). Thus, it combines data collection, analysis and theory formulation all of which are seen as connected in a reciprocal sense.

The data collected was mainly analysed using the qualitative GT technique which helped to achieve a more critical and reflexive interpretation of the statistics generated, and hence helped to avoid the often simple, general and impersonal nature of statistics (Harding 1995; Nelson 1995; Ribbens and Edwards 1998).

## *2.2 Indigenous Resource Management in Fadama Areas of Karshi and Baddeggi*

The main factors affecting the adoption of specific farming practices in relation to soil and water management in both Karshi and Baddeggi are dependent on two factors: biophysical and climatic factors as well as risk management; and the availability and accessibility to technology, farm inputs and the market. Generally, there is an apparent ambivalence or even dualism in the decision making process of *fadama* farmers with regards productivity and sustainability. On the one hand, it appears predicated on long-term considerations for the environment derived from extensive knowledge of the particular ecosystem and millennia of experience in agricultural production, while on the other hand, it seems *ad hoc*, depending on availability and affordability of inputs (agrochemicals) rather than an indication of a sustained effort at agricultural sustainability. In general, however, increased lack of access and high cost of external inputs coupled with knowledge of changing environmental conditions have intensified the desire for more sustainable alternatives which are cheaper and more readily accessible. For instance, increase in price of fertilizer, the bureaucracy and sheer frustration involved in its distribution make the farmers depend more on alternative organic methods of soil improvement.

Traditional resource management techniques in Karshi and Baddeggi derive from indigenous knowledge (IK) which represents a society's information base derived from decades of experimentation and modification. IK is dynamic and guides decisions regarding important aspects of community life such as resource management and agricultural production (Warren 1991; Flavier et al. 1995). Traditional soil management in *fadama* areas is carefully carried out based on an extensive knowledge of the soil type and condition. Soil is carefully profiled based on attributes such as colour, texture, nutrient value and level of acidity. Based on soil attributes and the type of implements available to them (mostly hoes, cutlasses and machetes), the farmers decide on what type of crop is best suited for what soil, the acceptable level of moisture ideal for what crop and the time to do the actual planting. A broad range of soil management techniques are employed by these farming communities, and include among others minimum tillage activities, use of non-inverting implements, use of cover crops and green manure, organic fertilizer, ridge planting, crop rotation, mixed cropping, and effective control and disposal of surface water for use on farm.

Similarly, pest management in Karshi and Baddeggi involves a series of traditional actions planned to deal with a particular pest problem. In addition to methods like crop rotation and mixed cropping which serve to reduce the risk of pests and diseases, the farmers also design means to deal with specific problems such as bird attack on rice fields. These range from the use of simple techniques (such as the erection of insect barriers and the use of scarecrows) to more advanced ones involving the use of medicinal plants and altering of planting/harvesting times.

Correspondingly, water management in both Karshi and Baddeggi involves a variety of traditional irrigation practices such as the use of water containers as in riverside cropping, the channelling of water from rivers/streams through the use of furrows and water canals and the use of ridges and embankments through which the water flows to irrigate their fields. The choice of a given irrigation method (*shaduf* or basin irrigation) depends largely on the soil topography – flat land or land on a slope, soil type, distance from water source and climate. The entire irrigation system is operated and maintained by the small-holder farmers who benefit from it and often involves organized community work ranging from short and light to long and intensive.

The farmers in the *fadama* areas maintain an appreciable level of output through reliance on traditional farming practices such as intercropping/mixed cropping which helps to improve soil fertility and suppress pest/disease as well as increase overall productivity and biodiversity in cropped fields through intensification of the farm system (Vandermeer 1989). Mixed cropping is adopted by farmers for a variety of reasons which include meeting dietary requirements of the family (especially during the dry season), the diversification of production base, maximization of land and generation of cash to meet other social needs (Alegbejo and Uvah 1986a, b; Alegbejo 1994). In several cases, research has documented the benefits of intercropping as done in Karshi and Baddeggi: maize or guinea corn with beans, cowpea, and *egusi* (*Colocynthis citrullus lanatus)* (Agboola 1972; Adetiloye 1980; Ogungbaide et al. 1996); cassava and maize (Zuofa et al. 1991); banana/plantain and maize, cocoyam and vegetables (Wilson 1987; Ikeorgu et al. 1989; Oko et al. 2000).

Also, through integrated animal/fish-crop farming, *fadama* farmers operate a sustainable production system that also ensures increased productivity through maximization of whatever meagre resources is at their disposal. The two systems operated by the farmers are: (1) systems combining crops and ruminants (mainly goat and sheep – and sometimes a few cows); and (2) systems combining crops and non-ruminants/poultry (chickens, grasscutters [*Thryonomys swinderianus*] and fish ponds). There is a mutual symbiosis between crops and animals in a way that reduces risk and increases efficiency of their farming systems. Thus, the farmers benefit from manure from the animals and are able to reduce dependency on external inputs.

Finally, recession farming (dry-season farming) is popular in *fadama* areas as they retain water which is easily accessible to farmers during the dry season. This makes *fadama* a highly valuable asset (Singh 1982). Recession farming is popular in Karshi and Baddeggi for a number of reasons. *Firstly*, it represents a period in the year when there is slack agricultural activity, and hence they are able to pay more attention to it. *Secondly*, there are fewer incidences of pests and diseases at this time of the year. *Thirdly*, most vegetables do better under the cool and dry conditions which prevail in the dry season (Okosun et al. 1996). *Finally*, it serves as an alternative and viable source of income not just for rural dwellers but increasingly in peri-urban and urban areas where *fadama* dry season farming is used for the production of vegetables and cereals (Ladele and Omotesho 2000; Ojo 2000).

However, despite their role in maintaining livelihoods, and indeed their contributions to global knowledge systems in such areas as medicine, indigenous knowledge and practices (such as the ones discussed above) have long been maligned (Jackson 1987; Liebman 1987; Slikkerveer 1989; Warren 1989; Slikkerveer and Adams 1996; Slikkerveer and Quah 2005). IK has also been recognized to be important in the conservation of biodiversity and also achieving sustainable development (Richards 1985; Posey and Balee 1989; Oldfield and Alcorn 1991). Biodiversity conservation itself is a significant risk reduction strategy. For instance, in both Karshi and Baddeggi, traditional knowledge in the area of seed selection helps to preserve genetic information of local varieties and indigenous species. Seed selection is a careful process meant to protect the phenological integrity of traditional seed varieties. The qualities of the seeds which include ear characteristics, presence of insect holes, size, earliness, shape, colour, are all considered important in seed selection. Findings from both Karshi and Baddeggi show structural and institutional neglect of indigenous systems whose potentials have not been fully utilized in the development process. They are often regarded as out-dated and unproductive. Development and agricultural policies mostly stress technology transfer at the expense of local experiences and practices in the exclusive promotion of modern agricultural techniques (e.g. mechanization, pesticides use and monoculture) and agricultural commercialization.

## 3 Mechanization and Agrochemicals Use in *Fadama* Areas of Karshi and Baddeggi

Alongside the sustainable indigenous agricultural techniques, the use of agrochemicals was found to be pervasive in both Karshi and Baddeggi. Generally, the use of farm machinery is very low in both villages mainly due to the prohibitive costs of purchasing or hiring them, and also due to the inaccessibility of *fadama* lands to heavy machinery. The percentage of farmers who use tractors for land preparation is higher in Baddeggi (27%) than in Karshi (less than 10%). Much of the land preparation is done using traditional methods of slashing and hoeing, removal of organic debris and pre-plant burning.

The use of agrochemicals was widespread as shown mainly because government policies and interventions in the past stressed the use of external inputs as the prerequisite for higher yields and often subsidized them. As in many developing countries, Nigeria espouses the principle of agricultural modernization and input supply as the prerequisites for achieving food self-sufficiency. 78.7% of *fadama* users in Karshi and 71.4% in Baddeggi use chemical fertilizer (either by itself or alongside organic fertilizer). The common inorganic types of fertilizer used are Urea and

NPK (nitrogen, phosphorus and potassium). 87% of the farmers use between 100 and 300 kg and none of the respondents used above 300 kg/ha. The average rate of fertilizer use (for most cereals and tuber crops) is mostly less than 200 kg/ha, which is below the rather high level (500 kg) recommended by the Agricultural Extension Research and Liaison Services (AERLS) of Nigeria. For instance, the recommended level for lowland rice is about 300 kg/ha (first application of 200 kg/ha of NPK, 15:15:15 and 100 kg/ha of urea for second application).

Similarly, pesticides use was found to be equally widespread in both villages. The most common herbicides used in the two communities include paraquat, Atrazine, Propanil, Pendimethalin, Glyphosate and 2–4-D Amine. As with fertilizers, the level of herbicide consumption falls way below the recommended levels. For instance, the majority of the farmers are not able to meet the recommended level for most of the crops they grow. The recommended dosage for rice herbicides (Tamarice™, Ronstar™, Risane™) is 3 kg/ha (8 l). Insecticides (fungicide, fumigant, aphicide, acaricide and rodenticide) are also widely used in Karshi and Baddeggi. These include: *Aluminium phosphide* (Justoxin™) is used by some farmers for rodent and mole control; *Monocrotophos*, a contact and systemic insecticide and acaricide, is also used by the farmers for control of pests on crops like rice and maize; and *Piriphos Methyl* 250 g/l (Actellic™ – made by Syngenta and marketed in Nigeria by C. Zard™) used to protect grains in storage.

Many of agrochemicals used in the *fadama* areas are toxic and pose significant threat to the environment as well as human health. The harmful effects of poor or excessive fertilizer use are well studied and documented and range from disturbance of soil mineral ions, depleting of soil organic humus, increased risks of top soil loss, water logging, salinity and decrease in soil porosity among others (Gliessman 1998; Magdoff and van Es 2000). In addition to posing great danger to aquatic life (a sizeable number of *fadama* farmers raise fish in naturally occurring fish ponds on the farm), fertilizer washed into water bodies can increase risk of algae growth and eutrophication (Carpenter et al. 1998). When ingested (in water) fertilizer is toxic and can affect the liver and kidney and increase chances of cancer.

Some of the pesticides used in *fadama* areas are often banned or restricted in developed countries. These include the following: Paraquat dichloride, Atrazine, Aluminium phosphide, Actellic® (an organophosphate). The FAO and the WHO estimate that about 30% of pesticides sold annually in developing countries (totalling $900 million a year) fail to meet international standards and are often mislabelled or entirely unmarked (Africa Recovery 2001). These pesticides are toxic both to humans and animals and have the potential to alter the *fadama* habitat and destroy biodiversity (Freedman 1995; Hayes and Laws 1991). The use of pesticides has eroded cultural methods of weed and pest cultural which include the following: altering the time of planting, crop rotation, mixed cropping, the use of extracts (*magani*) of medicinal plants such as spear grass (*Imperata cylindrica*), and *neem* (*Azadirachta indica*) tree, for pest control, careful selection of seeds, treatment of seeds before planting, the use of tillage to disrupt breeding cycles of insects and the utilization of ploughing and ridging to expose and destroy the development stages of insects. Other methods include weeding (using hoe or by hand) and burning and/or burial of plant residues (e.g. maize stalks) which harbour pests like larvae of stem borers.

Even though pesticides consumption is below the minimum recommendation, it is widespread and continuous/increased use will have many long lasting and dire consequences. Nigeria is said to annually consume about 1.3 million tonnes of pesticides (FMARD 1989). This is particularly a potential threat in *fadama* areas where water retention level (both surface and underground) is high. Excessive use of pesticides could result in water pollution through drainage (UNEP 1992). Similarly, pesticide retained in the soil could accumulate over years and be translocated by arable crops, leading to increased health hazards (Dung and Dung 1999).

The risks associated with agrochemicals use in *fadama* areas are aggravated by the following factors: low literacy level which means farmers cannot read safety instructions on chemical containers; inappropriate and unsafe handling of agrochemicals; non-use of protective clothing; indiscriminate disposal of chemical containers; the use of inappropriate and often poisonous but cheap chemicals; the prevalence of contaminated and adulterated agrochemicals; and weak drug regulation and control in which have centred more on pharmaceutical drugs and not on agrochemicals.

### 3.1 Developing a Conceptual Basis for Agricultural Hybridization

From the above discussion, it appears that African agriculture stands poised at a crossroad. Whereas governments and donors continue to advocate increased use of external inputs, on the global stage, there is a consensus that conventional agriculture in its current form is unsustainable. The challenge centres on how to promote agricultural productivity without jeopardizing the environment. Perhaps the solution to this impasse and the future of agriculture itself can be found in the way small-holders understand agricultural management. Small-holder farmers in developing countries, as shown by findings in Karshi and Baddeggi, straddle the line between “traditional” and “conventional” agriculture in that they mix traditional methods of resource management with inputs typical of conventional agriculture.

In an important work on modernism (*We’ve Never Been Modern*, 1993), Bruno Latour, the French ‘sociologist of science’, offers a dialectical critique of modernism and debunks the ‘myth’ of modernity and argues against the prevalent notion that the rise of science has irrevocably changed the world and separated us ‘the modern’ from our predecessors, ‘the pre-modern’. According to him, modernity has tried to polarize and classify ideas into ‘Nature’ and ‘Culture’, ‘Science’ and ‘Social’, ‘Human’ and ‘Thing’. Thus, it dismisses the inconvenient ‘intermediaries’, the ‘networks’ that exist between these extremes. Latour called the middle point between society and nature the ‘Middle Kingdom’. It is within this sphere, argues Latour, that systems are constructed and ideas crossbred, and where much of the discourses on the modern world actually take place. In this third sector, politics, science, technology, and nature are constantly mixed making the distinction between nature and culture (with each in a separate mental chamber) illusory and difficult to maintain.

In light of the proliferations of such connections (hybrids) between nature and culture, Latour argues for a rethink of the whole modern enterprise and our understanding of modernity. This can be achieved through an alteration of our mental landscape that will enable us to blur the false distinction between ideas, between nature and culture. By doing so, we can keep the best elements in modernity and replace the rest with a broader, fairer, and finer sense of possibility. Once we become engaged in the simultaneous acts of purification and hybridization, we stop being wholly modern and our relation with other natures-cultures becomes transformed in a renewed future (Latour 1993).

When applied to agriculture, Latour’s thinking sheds light on the scientific basis of conventional agricultural practice which from its very foundations ignored the connection between nature and culture and production and the environment. Modern agriculture depicts the false separation and isolation of “science” from “society”. As such, the complex web of translations and interactions that join these two have been completely ignored for the most part leading to the promotion of a system that exploits nature’s resources without consideration of consequences on society and the environment.

Modernity’s critical stance which divides and conquers hybrids through the process of purification and disciplinary ghettoization has shaped much of modern agriculture in which the delicate network that exists in nature and between nature and society (typical of traditional agricultural systems) are ignored through tidy compartmentalization. Modernism encourages us not to mix up knowledge, interest, justice and power (Hicks 1994). Similarly, monoculture sums up modern agriculture’s tendency not to mix. Yet, as argued by Latour, the so-called pre-modern cultures thought and acted through hybrids. For instance, traditional agricultural systems relied on the interrelationships that exist in the natural ecosystem and worked in line with such synergies and not counter to them. For them, the distinction between nature and culture was non-existent. Instead, there is a continuous and inter-dependent relationship between them.

Conventional agriculture has pursued a modernist agenda in focussing mainly on technical innovation and the use of external non-renewable energy sources and inputs for the sake of economic gain. Agricultural commercialization and modernization as promoted by the Nigerian government ignore the social and ecological dimensions of agriculture. Instead of conceptualizing agriculture as *multifunctional*, extending beyond simply food production and economic gain, conventional agriculture construed agriculture as *unifunctional* and so discounted the interconnections between those multiple dimensions.

Rather than anatomize ideas and reality, therefore, agriculture needs to explore and elaborate the relationships between them in what Latour describes as an ethnographic habit that deals calmly with the seamless fabric of 'nature-culture.' Useful elements of both indigenous knowledge systems and elements of modern science can be collected, sorted, elaborated and followed such that they benefit each other. In bridging the great divide in agriculture and development studies, Latour's caution on saving the best of modernity should serve as a guiding principle.

Agricultural hybridization can happen at several levels but this needs to be done dialectically. Firstly, there can be a *hybridization of institutions* whereby traditional institutions such as the ones in the *fadama* communities are hybridized with formal institutions. Traditional institutions are custodians of sustainable resource management practices and indigenous knowledge that could contribute in building more stable global food systems. Thus, 'modern'/formal actors/institutions and customary institutions can result in a collaborative system of resource management in *fadama* areas.

Equally, traditional institutions can benefit from the 'modern' scientific knowledge of the changing environment/climate change and changes in ecology while the latter can also draw from former's repertoire of sustainable farming practices. For long, ignoring traditional institutions has resulted in the promotion of agricultural policies that are ineffective in resource management and the imposition of inappropriate development policies, both of which have negatively impacted the environment and the people's livelihoods (Bromley 1991; Crook 2005). Many of these institutions have survived both colonialism and the post-colonial state and have been reinvigorated in light of increasing social pressures and the failures of many modern institutions. It is these institutions that 'hybrid agriculture' seeks to incorporate in resource management, modern institutions can benefit from the presence and knowledge of rural communities and their institutions. On the other hand, customary institutions can also develop reflexivity and abandon certain anachronistic elements that characterize them.

Secondly, there can be a *hybridization of knowledge* such that IK and modern scientific knowledge can draw from what is good and valuable in both systems. For instance, African agriculture has been known to be very flexible and adaptable as reflected in the adoption and success of the variety of crops that have been introduced onto the continent. Similarly, many traditional farmers not only experiment with new breeds but also combine breeds purposely to develop new strains (Richards 1985). The production of non-traditional fruits and vegetables has intensified since they were introduced to several African countries in the last few decades (Jaffee 1995; Barrett et al. 1997). However, care must be taken in ensuring that commercial and export crops do not take the place of food crops. Crop diffusion should be encouraged where socio-economic benefits are apparent but crops introduced to small-holders in developing countries should find 'their niche' and not replace previously cultivated traditional crops (Blaut 1977). American maize and Asian rice (*Oryza sativa*) varieties have been such successful crop.

According to Richards (1996), the practice of introducing new cultivars into existing traditional cropping systems is a 'repertoire enhancement' and a technique that can lead to local cultivars like millet taking on new roles (from staple food to specialized beer ingredient) within an emergent cropping system (pp: 312–313). For instance, in many parts of Africa (including Nigeria) maize has replaced sorghum and millet as staple food which have become crops for beer brewing (Byerlee and Heisey 1997; Smith et al. 1997). Similarly, the International Institute of Tropical Agriculture (IITA) has recorded successes in developing new and better yielding banana and plantain cultivars (*Musa* crops) through improved breeding techniques (IITA 2008).

In addition, African smallholder agriculture can benefit from technical innovation such as sustainable technologies for better efficiency. In addition to sustainable technology, traditional agricultural systems can benefit from sound agricultural extension on sustainable farming methods. Through such methods and consistent agroecological principles, small-holder traditional agriculture will be able to compete with agri-business. On the other hand, conventional agriculture can draw from indigenous production systems and management strategies for natural resources (soil and water).

In some instances, certain traditional knowledge systems and farming practices themselves need reforming. Traditional knowledge, which has been confined and restricted, can be studied in-depth and some of its elements can be made to benefit other communities. It can equally be enriched in the process. Other reformations encouraged in certain cycles include the use of bio-fertilizers and bio-pesticides alongside compost/manures and biological/cultural methods of pest control. Similarly, traditional agriculture could draw from certain management methods used in conventional agriculture.

Thirdly, there is the possibility of the *hybridization of methods*. This is perhaps the most problematic in the sense that many aspects of the methods of conventional agriculture (such as the use of agrochemicals) are significantly in conflict with the principles of agroecology and sustainability. The effects of modern farming methods have resulted in water pollution, proliferation of susceptible species, increased use of pesticides and soil depletion among others. These effects are undesirable and are therefore incompatible with sustainable agricultural practices. Hence, there is the need for more research in this area on the possibility of combining amenable methods of modern farming with sustainable ones not only to increase food quality and output, but also to encourage a more sustainable use of non-renewable resources, protect soil fertility, reduce pollution, ensure economic viability and exploit natural cycles.

Finally, there can be a *cross-hybridization* of *hybrids* where, for instance, modern farming methods can benefit from traditional knowledge systems. Aspects of traditional farming such as the focus on stability and risk reduction, system diversity and trophic complexity of natural systems can be valuable to conventional agriculture in achieving sustainability. Similarly, agroecology is generally high in net energy yield due to the fact that external energy inputs are relatively low. A careful study of these knowledge systems which are built and modified over centuries, can help in redesigning the food production systems in industrial countries and correct some of the deficiencies that characterize conventional agriculture.

## 4 Conclusion: Balancing Productivity and Sustainability

Despite differences of opinion on what the causes might be, it is widely agreed that the global food economy in its present form is in crisis. It is also unsustainable in the long-term due to its reliance on non-renewable energy, biophysical limitations (climate change) and the untenability of the consumption pattern it promotes. The consequences of the crisis on developing countries, especially in SSA are dire. This has heightened calls for alternative and sustainable systems. There is also a renewed focus on small-holders who provide the food needs of millions in developing countries despite the challenges and changing structure of production. Despite the slow growth in African agriculture (which have been blamed on various factors internal and external) and the prevailing challenges, there is a real possibility for Africa to develop its agricultural sector by harnessing the potential of small-holders and indigenous knowledge systems, rather than imposing structures and systems that are not in tandem with the peoples' socio-cultural values. As shown above, the evidence on the role of small-holder agriculture in ensuring food security and reducing poverty is solid. Enhancing small-holder productivity will entail: (1) *stepping up* – improving investment in infrastructure, sustainable technology and facilitating access to credit and sustainable inputs; (2) *stepping out*– investment in non-farm economy, e.g. education, health care; and (3) *hanging in* – providing social protection and investing in technology for food staples (Dorward 2009).

However, enhancing small-holder productivity needs to be done within a sustainable framework. Agroecology was suggested in this thesis as an integrative approach that combines the ecological, economic and social dimensions of the ecology of the entire food system. As evidenced by findings in the research communities and captured in the substantive theory – *agricultural hybridization*, the focus should not be on the development of exclusives but of linkages and complementarities. The future of agriculture will depend on how much it is able to harness indigenous knowledge on sustainability and combine that with the best stable practices of modern agriculture. Equally important is the need to involve women in agricultural policy planning because of the key role they play in agricultural production in developing countries.

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# Part II
# Governance for Food Security: Key Challenges and Relevant Debates

# Chapter 8
# Food Crisis Mitigation: The Need for an Enhanced Global Food Governance

**Mohamed Behnassi and Sanni Yaya**

**Abstract** As demands for food rise faster than supplies, the resulting food-price inflation puts severe stress on many countries already teetering on the edge of chaos. As a result, almost no country is currently completely immune from the impacts of food shortage. If the food situation continues to deteriorate, entire nations and their social orders will break down at an unprecedented rate because, in geopolitical terms, deeper food crisis will undoubtedly engender more collective insecurity. Paradoxically, widespread hunger exists today in a context of a global food oversupply. Often, people go hungry because they either have no means to produce their own food or earn enough money to buy it, not because of a global shortage of food. Thus, access to food can be identified as the major issue in food security rather than the amounts of food being produced. Therefore, this chapter presumes that the whole issue is more of a governance challenge, promotion of the right to adequate food and the food sovereignty. In other terms, at the root of the failure to effectively reduce hunger, the failure of the global food security governance and architecture is a key factor. So, it is becoming increasingly crucial to develop and implement adequate global food governance arrangements from a North-South redistribution perspective, with the active involvement of major stakeholders and the support of sound scientific evidence.

**Keywords** Food security • Global governance • Food sovereignty • Right to food • MDGs

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_8,

## 1 Introduction

Beyond a billion of the world's poor and vulnerable people – more than 15% of our total population – are in danger because they cannot be sure of getting the required food for healthy and productive lives. Many of them go to bed and wake up hungry. They are unable to enjoy their right to sufficient and adequate food. As was evident during the dramatic food price spikes in recent years, the cost of food is now so volatile as to threaten people's food and nutrition security, and create a multitude of humanitarian, human rights, socio-economic, environmental, developmental, political and security-related challenges. The severe global food crisis our world currently experiencing is exposing existing and potential vulnerabilities of households, governments and the international system to food and nutrition insecurity. Already before the rapid rise in food prices, some 854 million people worldwide were estimated to be undernourished. The crisis has driven other millions more people into poverty and hunger.

So, unless action is taken now, we will see a reversal in the critical gains made in recent years towards reducing poverty and hunger as outlined in the Millennium Development Goals (MDGs). This requires an urgent comprehensive, coherent and coordinated response (HLTF 2008). Indeed, we believe that the food challenge can be seen as a scenario that is compounded by a number of new occurrences, such as global climate change and related catastrophes,[1] rising energy prices, market distortions, regional conflicts and even issues related to food aid programs; and since it is also a scenario that is influenced by local, national and global policies on trade, economics, agriculture and other social/support sectors like health, education, science, technology, transport, engineering and energy among others, any adequate response should be conceived from a governance perspective and a holistic approach.

By reference to this outlook, this chapter aims to deeply analyze the factors behind the current food crisis and the various challenges and unresolved issues facing global governance for food security. Actors and dynamics of this governance regime will be also assessed.

## 2 Research Background and Scope

According to the current scenarios, about 73 million people will be added to the world's population every year between 1995 and 2020, increasing it by 32% to reach 7.5 billion. Meeting the food needs of a growing and urbanizing population with rising incomes will have weighty implications for the world's agricultural

[1] The floods which are severely affecting more than 15 millions people in Pakistan (homeless people with no sufficient food, potable water or medical stuffs), is a relevant example to provide in this sense.

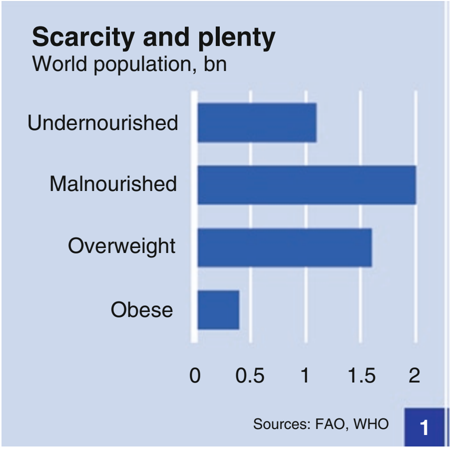



**Fig. 8.1** Scarcity and plenty (Source: FAO and WHO)

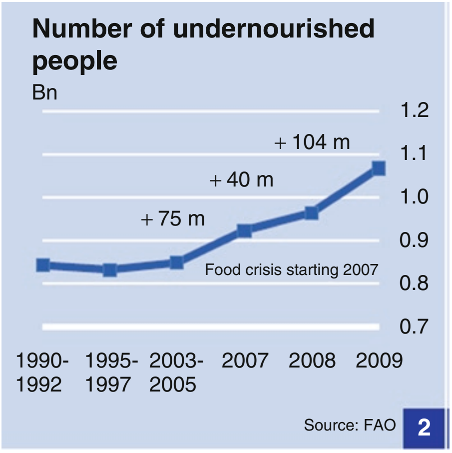
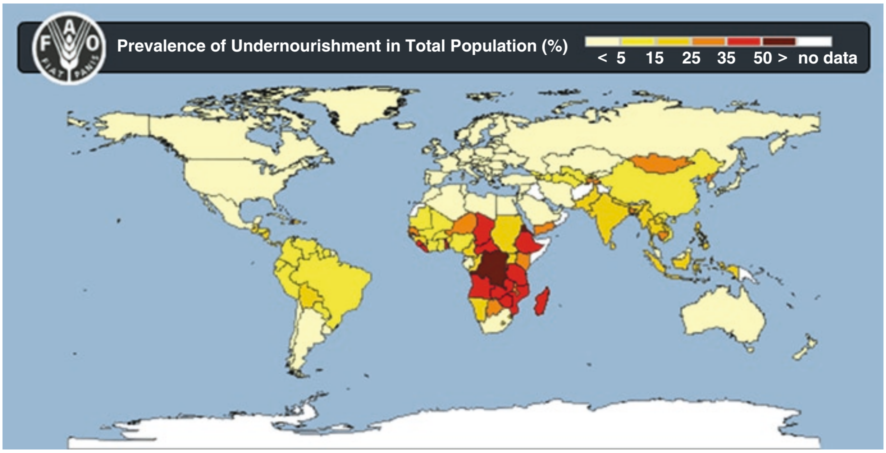



**Fig. 8.2** Number of undernourished people (Source: FAO)

production and trading systems in the coming years. Therefore, the issue of *food security* is paramount. In the 1970s, there was a tendency to understand this issue only from the economic perspective, mainly supply aspect. Today, with more than one billion undernourished people in the world (Figs. 8.1 and 8.2), the dramatic scope of the world food crisis is fully recognized as a growing number of regions are suffering from chronic hunger and its disastrous consequences both in political, economic, social and health terms (see Fig. 8.3).

Moreover, the provision of food is globally undergoing radical transformations and, consequently, conventional governmental and intergovernmental arrangements can no longer adequately respond to emerging food challenges. Meantime, failure to deal efficiently with the environmental declines that are undermining the world food economy – water shortage, eroding soils, climate risks – forces to presume that a global collapse is possible if current trends are not reversed.




Source: FAO (www.fao.org/economic/ess/food-security-statistics/fao-hunger-map/en/)

**Fig. 8.3** FAO hunger map (Source: FAO (www.fao.org/economic/ess/food-security-statistics/fao-hunger-map/en/))

Additionally, as demand for food rises faster than supplies are growing, the resulting food-price inflation puts severe stress on many countries already teetering on the edge of chaos. As a result, almost no country is currently completely immune from the impacts of food shortage. If the food situation continues to deteriorate, entire nations and their social orders will break down at an unprecedented rate because, in geopolitical terms, deeper food crisis will undoubtedly engender more collective insecurity.[2] In the twentieth century, the main threat to international security was superpower conflict; today it is failing and disintegrating states that become an increasing source of terrorism, drugs, weapons and refugees, threatening political stability everywhere. Thus, it is not the concentration of power but its absence that puts the current and future world at risk, thus undermining collective security gains.

Food security is not only about producing more food. It is about "providing physical and economic access to balanced diets and safe drinking water to all people at all times" (Hilary 2001). It can be also achieved "when people, at all times, have physical, social and economic access to sufficient, safe and nutritious food preferences for an active and healthy life" (FAO 2002). In fact, and paradoxically, widespread hunger exists today in a context of a global oversupply of food. Often, people go hungry because they either have no means to produce their own food or earn enough money to buy it, not because of a global shortage of food. Thus, the other half of the main issue is the inequitable access to food, and the FAO has already identified access to food as the major issue in food security rather than

[2] Many regions in Africa and Asia are already experiencing such scenarios.

the amounts of food being produced. Therefore, this analysis presumes that the whole issue is more of a governance challenge, promotion of the right to adequate food and also the food sovereignty.

To be sure, considering the complex connections of food with long-standing and recent developments, addressing food security requires a strong governance of the food production and policy systems of related areas (e.g. economics, agriculture, science and technology). Hence, food security is now viewed not only from a local and national perspective, but also from a global stance. In other terms, strengthening governance may be among the best responses to food challenges. Indeed, it had been identified that "strengthening governance of the food and agriculture system at the global, country and local levels" is one of the key strategies for the achievement of the MDG agenda of reducing hunger and malnutrition (Medrana 2007).

The major challenge therefore for local, national and supra-national actors is how to make governance work for all. It is no longer a question of under whose responsibility does this governance issue falls. The global issues affecting the food scenario have not necessarily shifted the responsibility of ending hunger from the national governments to supra-national/regional authorities. Rather, these global issues have entailed greater importance and increased roles to regional/supra-governmental governance, thereby altering the old paradigm of food security governance which used to be of local and national orientation. Specifically, these global issues have added a more encompassing insight toward the interconnections of food with all these other issues.

So, at the root of the failure to effectively reduce hunger, the failure of the global food security governance and architecture is a key factor. Weak institutions and lack of effective coordination and participation at global, regional and national level impede the implementation of sound food security policies. At the global level, a truly representative, action-oriented body with strong political support, credible scientific basis and adequate financial support is lacking. At national levels, good governance and Right to food principles are not promoted and embraced as key goals in many countries.

Based on these assumptions, we believe that conventional regulation approaches to food security have failed. It is becoming increasingly crucial to develop and implement adequate global food governance arrangements with the active involvement of major stakeholders (inter-governmental organizations, nation-states, private sector, civil society organizations, etc.) and the support of sound scientific evidence. In addition to concerns over food and commodity price variations, attention should also focus on global redistribution mechanisms and long-term threats, such as demographic growth and urbanization, growing demand for bio-energy, land and water, environmental constraints and climate change.

Developing a strong, credible and efficient global governance for food security requires first the assessment of the underlying causes that are converging to move the world towards a global food disaster. The contribution of each factor in the current food crisis already shows the respective roles and strategies of concerned actors within the framework of the global food governance.

# 3 Factors Behind Food Crisis

Food crisis is a highly multifaceted issue. While media reports and policy debates have been concentrating on the immediate causes and consequences, the deeper issues have not been fully discussed. In fact, food crisis is the outcome of numerous factors[3] which are difficult to broadly assess within the scope of this chapter.[4] However, we will try to focus on the underlying causes that we judge important with regards to the current global context and the objective of this analysis.

## *3.1 Climate Change: Critical Implications for Food Security*

Climate change is a major factor redefining the world food equation and having an enormous impact on the food security of poor people. This phenomenon is a ticking time bomb waiting to explode. It is now not only a better-understood scientific fact, but also a phenomenon which is already affecting global temperatures, regional weather patterns and physico-biological systems. Attributed directly or indirectly to human activity, climate change puts additional pressure on already over-exploited natural resources. It negatively affects crop yields, stability of food supplies and the ability of people to access and utilize food in many parts of the developing world. Although rich countries are responsible for most greenhouse gas emissions, with a growing contribution of emerging economies (such as China, India and Brazil), the impact of climate change is expected to be most severe in developing countries and on poor people. The higher vulnerability of the poor is not only due to geography, but also to limited adaptive and capacities. Meantime, since low-income communities depend directly on agriculture, forestry, fisheries, aquaculture and climate-sensitive resources, climate change impacts will adversely affect food supply in the future. While technological advances in agriculture have led to increases in food production, the food production system is still highly dependent on climate and weather conditions. Any slight change in climate can have drastic effects on agricultural production.

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[3] Food crisis results from a combination of factors: lack of "food entitlement" – inequality, appropriation, poor governance, subsidies, the "stork and plow" – struggle between increases in population and food; total (growing) consumer demand combined with proximity to further yield growth of key crops; under-investment in agricultural research; excessive reliance on "Gene Revolution"; conflict and poverty; diversion of food crops for feed and fuel; global environmental change: climate change, plus atmospheric, water and soil factors; global economic failure; rising cost of oil, fertilizer, transport and other inputs.

[4] Among the relevant causes we can mention: energy shortage and prices, biofuels, global warming, fresh water shortage, economic chaos, higher population levels, inefficient agricultural policies, soil degradation and grabbing, loss of crop varieties and genetic contamination, farmer shortages, fish declines, general ignorance of food and inadequate governance.

The effects of climate change are expected to be heterogeneous and region-specific. Some positive effects of climate change[5] – such as $CO_2$ fertilization of plants[6] – could contribute to increasing food production and security. However, impacts – such as rising temperatures and increased frequency of extreme weather events – will put severe pressure on farming, hence food availability, stability, access and utilization. Climate change could lead to increased water stress,[7] decreased biodiversity, damaged ecosystems,[8] rising sea levels and, potentially, to social conflicts due to increased competition over limited natural resources. Smallholder agriculture, pastoralist, forestry, fisheries and aquaculture are among the systems most at risk.

Current policy responses to climate-change threats – particularly those affecting agriculture in developing countries, and hence the majority of the rural poor – still underestimate the gravity of the situation. In the agriculture, climate change adaptation can go hand-in-hand with mitigation, and appropriate measures need to be integrated into the overall development approaches and agenda (Butt et al. 2005).

Although a considerable body of work has studied and projected the adverse consequences of climate change, research on how the negative effects for developing countries and food insecure people could be mitigated is still very limited. Meantime, if the global community does not invest massively to tackle the climate change challenges, the social and economic costs will be disastrous.

[5] For instance, colder agricultural areas like Canada and Northern Europe may experience warmer weather and increased growing seasons which will be a positive factor in the yield equation. But other factors, like increased pest and disease problems, which are predicted to be spurred on by warming, would push back the other way.

[6] The "$CO_2$ as fertilizer" argument is only correct if other required nutrients are also available in increasing quantities. Even where that is partly true, it worth pointing out that weeds tend to outcompete crops in higher-$CO_2$ environments.

[7] Also associated with global warming will be the lower availability of fresh water in some areas. With use of river water in key farming regions already at or near full exploitation, any decrease will not only reduce farm output, it will also make living in concerned regions more than a challenge. Over-pumping of groundwater is another fresh water problem; that is, pumping groundwater resources at a rate greater than their recharge rate. The twentieth century saw a vast expansion of the use of groundwater for agricultural and residential purposes. Globally, up to 80% of potable water is used for irrigation. But now water tables are falling in many countries, including China, India and the United States which together account for nearly 50% of the global grain harvest. Worse, the rate of depletion is accelerating. Not all food production relies on irrigation, of course, but the situation is of serious concern. Also problematic is the contamination of groundwater from polluted surface water and land, leaking underground storage tanks and intentional "dumping" of toxic waste which can eventually find its way to usable groundwater.

[8] Four of five major global climate models project consistent expansion of arid areas in developing countries: such areas home to almost one billion people, and more than 180 million people in Africa alone (see Fischer et al. 2005).

### *3.2 Energy Shortages and Prices*

The risks climate change poses on food security are particularly pressing at a time of high oil prices which make agricultural production more expensive by raising the cost of fertilizers, irrigation and transportation. With high oil prices, calls for increased energy efficiency and government biofuel subsidies, agriculture-based energy production has surged. Farmers have switched massively to production of crops for ethanol and biodiesel. As new linkages and tradeoffs are created between the energy and agriculture sector, energy and food prices are becoming increasingly intertwined. The increased level and volatility of agricultural prices is negatively impacting the purchasing power and the food security of the poor (von Braun 2007).

Modern agriculture is a highly industrialized, highly distributed and petroleum-dependent affair. Farmers are very reliant on diesel-powered farm machinery, and most of the food we eat was produced in places distant from us, processed at some other distant places and shipped to us via terrestrial, marine or air transport. Our local store refrigerates freezes or otherwise stores the food and presents it to consumers in a well lighted, heated and cooled space. Consumers drive their petro-powered cars to the market and make their purchases, then store their food at home in refrigerators and freezers.

All of these processes require huge amounts of fuel and electricity, and makes our food supply very dependent on steady supplies of affordable energy. So, where is the problem? Global petroleum production appears to be peaking, which means tighter oil supplies and higher prices in the future. Higher fuel prices will be reflected in food prices. Similarly, spot shortages of fuel could result in spot shortages of food on store shelves. Few households maintain significant food stocks, so shortages would lead to hoarding (this also usually increases food waste factors), which would further exacerbate the situation. Moreover, petroleum is also the base ingredient in chemical pesticides, and a main ingredient in food packaging. Higher oil prices will mean higher pesticide and packaging prices, and will contribute to higher food prices. The final energy component in our food supply is electricity. As demand for electricity continues to rise and global warming's pressure to phase out coal-fired power plants increases, our electricity system may be gradually more strained to keep up with demand – a situation that will make grid failures occur more frequently.

As everyone is currently looking for global warming solutions, with oil prices risen into the painful range, many countries – such as USA and EU – seem to be ready for action when evoking bio-energy which is considered as a home-grown and climate-friendly energy solution. However, the assessment of the potential benefits and obvious problems of biofuels would require a deeper and separated analysis, and the overall pros and cons of biofuels are not really the point here. The core question is, what effect will biofuels have in term of food security?

Diversion of corn and soybeans from the food stream into biofuels production has already begun to put upward pressure on food prices. In many countries such as United States, farm land, which is currently devoted to other crops, will also be diverted to corn and soybean production in the future to increase the availability of biofuels feed stocks. The voracious biofuels push will also cause marginal, fallow cropland and unplanted buffer zones to be put into production, increasing soil erosion and water pollution and overuse.

Cellulosic ethanol, which can use the inedible part of the corn plant – or other plants that are entirely inedible – is championed as a double-barreled solution that will make the ethanol process more efficient and eliminate the need to use food crops as feed stocks. But this technology is still being worked out, and even if it does come to maturity, unsustainable "clear cut" harvesting of plants from farm fields, range lands and "scrub" areas could degrade these lands to the point where we end up causing the next great *Dust Bowl.*[9]

This is not to say that biofuels have no role to play – they clearly do[10] (see Fig. 8.4 about bio-energy production potential). Local production of biofuels based on sustainable agriculture practices is an excellent and promising option. But this production will not scale up to a nationwide supply that can replace the current amounts of gasoline and petroleum diesel. Certainly, that does not mean the

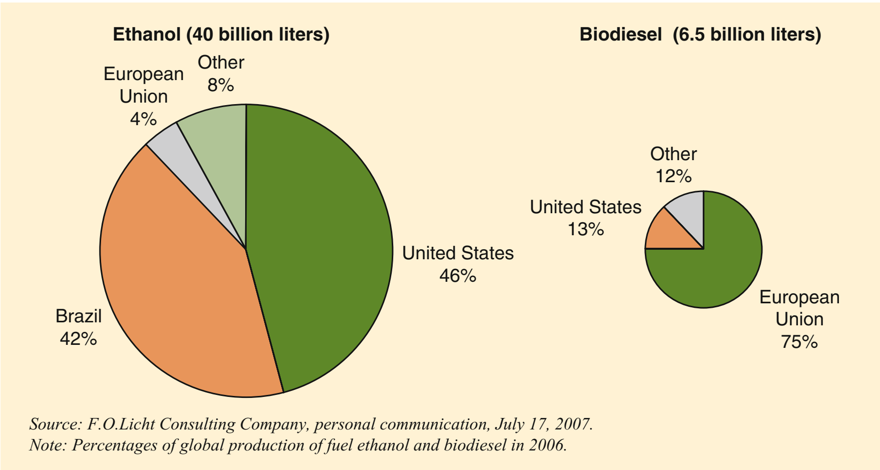


**Fig. 8.4** World bioenergy production share

[9] "Dust Bowl" is a term born in the hard times from the people who lived in the drought-stricken region during the great depression. The "Dust Bowl Days", also known as the "Dirty Thirties", took its toll on Cimarron County. The decade was full of extremes: blizzards, tornadoes, floods, droughts and dirt storms.

[10] Although assessments of the global economic potential of biofuels have just begun, current biofuel policies could, according to some estimates, lead to a fivefold increase of the share of biofuels in global transport—from just over 1% today to around 6% by 2020 (World Bank 2008).

interested countries will not try, impacts on food and soil health are not currently prioritized in policy agendas.

To conclude, biofuels offer a potential source of renewable energy and could lead to large new markets for agricultural producers. However, few current biofuel programs are economically viable, and most have social and environmental costs: upward pressure on food prices, intensified competition for land and water, and possibly deforestation. Based on these facts, national biofuel strategies need to be based on a thorough assessment of those opportunities and costs (World Bank 2008).

## *3.3 Inadequacy of Agricultural and Food Practices and Policies*

### 3.3.1 Global Food and Agriculture System and Food Crisis

Political leaders since Roman times have deeply recognized that widespread hunger is one of the main risks which can undermine the legitimacy of the established power. Therefore, the majority of modern politicians support a policy of cheap and plentiful food. However, what is good for the public and its food supply is not necessarily convenient enough for corporate profits – at least in the minds of corporate executives and shareholders. Corporate lobbying is currently influencing politicians to shape agricultural policies in a way that is favorable to their products, their future plans and their bottom lines. Agriculture research organisms are similarly showered with research funding as long as the research supports and legitimates corporate interests.

These trends have reinforced the reign of industrial or intensive agriculture – a farming system with many negative externalities and unsustainable practices.[11] This rise came at the expense of organic and other agricultural forms and techniques which produce healthier foods and preserve environmental balances, but with less potential for corporate monetization. One emerging problem linked to this trend is the issue of centralized control vs. local control. Farming is an inherently local affair. Weather and soil conditions, which plants grow best, farming tricks and tips are factors that are mainly local in nature. Today, increasingly unwanted corporate-driven policies are being imposed by national and international politicians and bureaucrats. Central planners in many developed countries have generally encouraged a nationalized (even globalized) commodity-based food system at the expense of growing and selling food locally. Via the machinery of the WTO and World Bank, this philosophy has been widely exported to other countries, with unfortunate consequences for local food security.

In global term, fundamental changes have taken place in food systems around the world over the past century. We now have a globally integrated food system that

[11] Overuse and pollution of water resources, degradation of soil, impacts in terms of human and animal health and welfare are among the serious impacts of the intensive agriculture. All these externalities have also impacts in terms of food security.

affects all the regions of the world. The recent volatility in food prices has illustrated the global nature of this food system, highlighting the way development in one part of the world can have multiple and wide-ranging impacts. Transnational corporations (TNCs) have been central actors in the development of this global food system, dominating production, international trade, processing, distribution and retail sectors. Indeed, it is unlikely that the current global food system would exist as it does today without the participation of TNCs. Many of these firms operate in numerous countries, and at more than one level along the global food chain. As food systems around the world become increasingly affected by the corporate-dominated global food system, the consequences of this fundamental change in the provision of food should be considered when analyzing the global governance for food security (Clapp and Fuchs 2009:1).

The governance system is geared towards providing some degree of regulation to put in place safeguards from potential negative socio-economic and ecological consequences of globalized food system. In many instances, these rules govern activities of agri-food corporations because they are pivotal actors in the globalization of the food system. But at the same time, these corporations play a key role in the establishment of the vital rules and regulations by which they themselves are governed. This includes influence over state-based and intergovernmental mechanisms of governance, as well as private form of governance. By doing so, they exercise power over global food and agriculture governance with many consequences in terms of sustainability of the global food system (Clapp and Fuchs 2009:1). Corporate power can be exercised in different ways and generally it has three forms: *instrumental* power, or direct influence; *structural* power, or the broader influence corporations have over setting agendas and rules; and *discursive*, or communicative and persuasive, power.

### 3.3.2 Loss of Crop Varieties and Genetic Contamination

In historical terms, human beings have enjoyed a much wider variety of plants and animals than they do today. Numerous varieties of edible plants and animals existed, each having carved out its own niche based on climate requirements, drought tolerance and resistance to pests and predators. During our era, as agriculture expanded and progressed, human beings are increasingly focusing on a less significant number of crops and animals[12] to exploit positive taste, growing and storage characteristics. During the last century, this trend went into overdrive, first

[12] The FAO has already showed that: (a) of the 4% of the 250,000–300,000 known edible plant species, only 150–200 are used by humans. And just three plants (rice, maize/corn and wheat) contribute nearly 60% of calories and protein obtained by humans from plants; (b) since the 1900s, more than 90% of crop varieties have disappeared from farm fields as farmers worldwide have abandoned their multiple local varieties for genetically uniform, high-yielding varieties. Thirty percent of livestock breeds are at risk of extinction and six breeds are lost each month; (c) today, 75% of the world's food is generated from only 12 plants and 5 animal species.

with selective breeding and hybrid strains, and now with genetically-modified crops and cloning.

What kind of risks we are facing if we take this direction? Genetic concentration is a major risk. To quote the proverb: *genetic concentration is choosing to put just a few eggs in a very large basket*. All species and strains have their own individual resistance (or lack thereof) to specific diseases and pests. Today's modern varieties are no exception. Farmers use copious amounts of pesticides and antibiotics to keep trouble at bay, while there is a constant race between the chemicals and the pests' ability to develop resistance to them.

By relying on a few varieties and producing them in tremendous volume, we increase the chance that extended drought or the sudden onset of uncontrollable disease or pests could decimate a significant portion of the food supply. The Irish Potato Famine of the mid-nineteenth century is a perfect example of what happens when a single, heavily-relied-on variety fails. Since then, genetic concentration in crops has increased far more, raising the stakes still higher. Some farmers and gardeners are recognizing this problem, and are now including in their growing plans a broad variety of plants and vegetables. These varieties are non-hybridized, non-GMO strains that have been around for a long time but fell out of favor during last century's move to fewer varietals based on market characteristics and qualities, other than taste and food security.

However, even these promising efforts face many threats, such as:

– *Genetic Contamination*: genetic material from one plant strain can sometimes end up getting incorporated in the genome of a similar plant strain. This is a natural phenomenon – it is part of how we ended up with so many varieties in the first place. But genetically modified crops, with their inherent risks, are now being grown practically everywhere. Non-genetically modified varieties are at risk of being contaminated with genetic material from genetically-modified and hybrid crops, and could lose their unique characteristics and possibly their safety and survivability.
– *Control of Seeds*: farmers are increasingly suffering from the control of seed, feed, fertilizer and pesticide markets by the agri-business corporations. If it is part of the food producing stream, corporations are trying to monetize it. The biggest threat is to seed saving which has been a part of farm life since the dawn of agriculture. Now, farmers using genetically modified varieties must sign contracts promising not to save seeds from the previous year's crop, but rather to go back to the supplier for a new order. At present, farmers using non- genetically modified varieties can still save seeds – though seeds saved from hybrid crops cannot be used reliably – but farmers saving and using their own seeds is contrary to long-term corporate business plans. In the future, we can presume that seed saving is in jeopardy.

### 3.3.3 Fish Stocks and Marine Biodiversity Decline

Seas cover more than two thirds of the Earth and are critically important for biological diversity, commercial activities (i.e. fishing and tourism) as well as the sea's role in climate regulation. Despite their crucial importance for the survival of Humanity – in terms of food security and ecosystem services – global marine biodiversity and fish stocks are in danger, increasingly pressured by overfishing, environmental degradation and impacts from human-induced climate change. Many scientists have already confirmed that marine fish production is tending to become stagnant, and coastal aquaculture is facing environmental problems (Swaminathan undated).

To supplement the fish available from wild sources, fish farming has increased dramatically in the last decade. Some fish-farming operations are well run, but many are not, polluting the ecosystems near the operations and spreading disease to wild species that pass by. Left to its current trend, fish farming will ultimately become nothing more than the sea-going version of that land-based abomination, industrial agriculture. In the cases of both overharvesting of wild fish and poor management of fish farms, in the end, the bad practices will mean less fish for food.

To reverse this trend, the Johannesburg Plan of Implementation had already called for the establishment of Marine Protected Areas (MPAs). Nonetheless, the magnitude of the current problem of overfishing and environmental pollution is often overlooked, given the competing claims of deforestation, desertification, energy resource exploitation and other biodiversity depletion challenges. The rapid growth in demand for fish and fish products is leading to fast increases in fish prices. As a result, fisheries investments have become more attractive to entrepreneurs and governments – much to the detriment of small-scale fishing and fishing communities around the world, as well as for sustainable marine biodiversity and ecosystems.

### 3.3.4 Farmer Shortages

Twentieth century farming trends were all about efficiency: more machinery, more specialization and more pressure from corporations to keep crop prices low, thus ensuring a relentless push for ever-greater efficiency. One of the results was the move from small- and mid-sized family farms, that grew a wide variety of crops and animals, to mega-farms with a single farm family often growing just one crop on thousands of acres (for example wine farming in many European countries). New high-tech farm machinery and farming systems have greatly reduced the "hours per acre" needed to tend farm fields and produce food.

That sounds good since it certainly has enabled us to keep food prices low. But reframing living systems (farm fields) as industrial systems, with plants and animals acting as mere assembly-line parts in the operation, was a dubious choice. The added pollution from the chemicals, fuels and overcrowded animal conditions are notable disadvantages of the current farming regime. The reduced nutritional value of the food coming from these semi-sterile fields is another. But perhaps the worst negative aspect was the vast reduction in the number of farmers.

Additionally, and since land and water are shrinking resources for agriculture, there is no option except to produce more food and other agricultural commodities from less per capita arable land and irrigation water. In other words, the need for more food has to be met through higher yields per units of land, water, energy and time. It would therefore be useful to examine how science can be mobilized for raising further the ceiling to biological productivity without associated ecological harm. It will be appropriate to refer to the emerging scientific progress on the farms as an "ever-green revolution", to emphasize that the productivity advance is sustainable since it is rooted in the principles of ecology, economics, social and gender equity and employment generation (Swaminathan undated).

For a variety of reasons, we are beginning to see industrial agriculture reach the limits of its "success". As communities increasingly suffer from pollution, as farm yields finally begin to suffer from the years of soil abuse, as consumers begin recognizing the blandness and nutritional insufficiency of conventionally grown food and the dangers of genetically modified foods and pesticide residues, the inevitable shift back to non-chemical agriculture should be promoted. Tightening energy supplies will put further pressure on the current ultra-distributed, fossil-fuel-dependent approach, and we will be seeing more small, local, organic farms again growing a wide variety of crops (many regions in Europe and Asia are rediscovering the virtues of this trend). Small and diverse farms produce a much better overall result, with higher total food yields per acre, but they are more labor intensive. That means we're going to need more farmers. It remains to be seen whether the twentieth century migration from rural to urban life can be reversed in this century.

## *3.4 National and International Policies on Trade, Economics and Agriculture*

In many countries and regions, hunger and poverty persist due to inefficient policies pertaining to trade, economics, agriculture and other support sectors. Where national governments have not responded appropriately to challenges, hunger has persisted or even worsened. Indeed, the reason why many countries fail in their development efforts is the failure of governance to manage policies and initiatives in various areas related to food from an interdependent perspective.

During the previous decades, many countries were satisfied in terms of food security because they were relying on cheaper imports which they thought would be always or usually available. In this context, local food production was not often so necessary as many developing countries have consequently reduced it by reference to international donors instructions. However, the high price of many food items in recent years makes food imports increasingly expensive, and intensifies inflation of food prices in local markets. There have also been cases of shortages, as some countries placing orders – for example for rice – have found that the supply is not guaranteed, sometimes because of export restrictions by the exporters of the food items.

So despite the fact that the factors behind the food crisis are numerous, one of the longer term reasons remains the decline in agricultural production in many developing countries, in most cases due to the structural adjustment policies of the IMF and World Bank. Many countries were asked or advised to: (a) dismantle marketing boards and guaranteed prices for farmers' products; (b) phase out or eliminate subsidies and support such as fertilizer, machines and agricultural infrastructure; and (c) reduce tariffs of food products to low levels. Consequently, many countries that were net exporters or self-sufficient in many food crops have experienced a decline in local production and a rise in imports which had become cheaper because of the tariff reduction. Some of the imports are from developed countries (like United States and European Union) which heavily subsidize their food products. The local farmers' produce were subjected to unfair competition, and in many cases could not survive. The effects of these policies on farm incomes, on human welfare, on national food production and food security were structurally severe.

Many developing countries have suffered from this situation, resulting in street protests as households found it difficult to cope. Given these changes, most of concerned countries rediscovered the relevance of "self-sufficiency" paradigm versus "food security", and started to promote local food production policies and manage all the identified constraints which hamper this option.

Some developments in the trade negotiating arena are also a source of concern. The WTO Doha negotiations were mandated to substantially reduce domestic support in developed countries. However, to date, the offers of the United States and European Union indicate their Overall Trade Distorting Support (OTDS) would be reduced at the bound level, but not at the applied level. A major loophole in the WTO's agriculture agreement is that countries are obliged to reduce their bound levels of domestic support that are deemed "trade distorting", but there are no constraints on the amount of subsidies deemed non distorting or minimally distorting, which are placed in the so-called *Green Box*. Recent studies have shown, however, that many of the Green Box subsidies are also trade distorting. The Doha negotiations process is unlikely to place new effective disciplines on the Green Box. Therefore, the major subsidizing countries can change the type of domestic subsidies they give, while reducing the "trade distorting subsidies" and continue to provide similar levels of farm subsidies.

Meanwhile, the developing countries are being asked to reduce their agricultural tariffs further. The Chair's proposal at the Doha talks is for a maximum 36% tariff cut for developing countries, and 24% for small vulnerable economies. Most developing countries are advocating that the instruments of Special Products (SP) and Special Safeguard Mechanism (SSM) be set up as part of the WTO talks to promote food security and farmers' livelihoods and rural development. In the bilateral or regional Free Trade Agreements (FTAs) involving developed and developing countries, the developing countries are asked to reduce or eliminate their tariffs by even more.

## 3.5 Food for Aid Programs

Many food aid categories have existed: (a) *emergency food aid* is destined to victims of natural or man-made disasters. It is freely distributed to targeted beneficiary groups, and is usually provided on a grant basis. It is channeled multilaterally through NGOs or, sometimes, bilaterally; (b) *project food aid* aims at supporting specific poverty-reduction and disaster-prevention activities. It is provided on a grant basis and delivered through NGOs, multilateral organizations or bilaterally. This kind of food aid can be freely distributed to targeted beneficiary groups, but may also be sold on the open market, usually by NGOs, and is then referred to as "monetized" food aid. (c) The last category is *programme food aid* which is usually supplied on a government-to-government basis as a resource transfer for balance of payments or budgetary support activities. Unlike most of the food aid provided for project or emergency purposes, this kind of food aid is not targeted at specific beneficiary groups. It can be sold by the recipient government on the open market, and is provided either as a grant or a loan.

Regarding the terms of delivery, food aid is usually provided as a grant, but may also be delivered on the basis of concessional terms of sale. The conditions are defined according to the register of food aid transactions of the FAO's Consultative Sub-committee on Surplus Disposal, and are based on the principle that the conditions of the transactions must be more favorable to the "recipient" than are those prevailing on world trade markets. Furthermore, the 1999 Food Aid Convention foresaw, for the first time, a ceiling on each donor's contribution in the form of concessional sales that are provided under the Convention. This ceiling has been fixed at 20% of each member's commitment.

One should recognize that food aid has been essential for saving lives around the world, especially during a crisis or natural disaster[13]; but its value in longer-term development has been controversial. Many development experts believe that the mobilization of food aid to the most vulnerable populations is critical for combating global hunger and malnutrition. Many also believe that regions – such as sub-Saharan Africa – continue to need foreign assistance to help break the cycle of poverty, which they believe is a prerequisite for enabling more agricultural productivity and economic development.[14]

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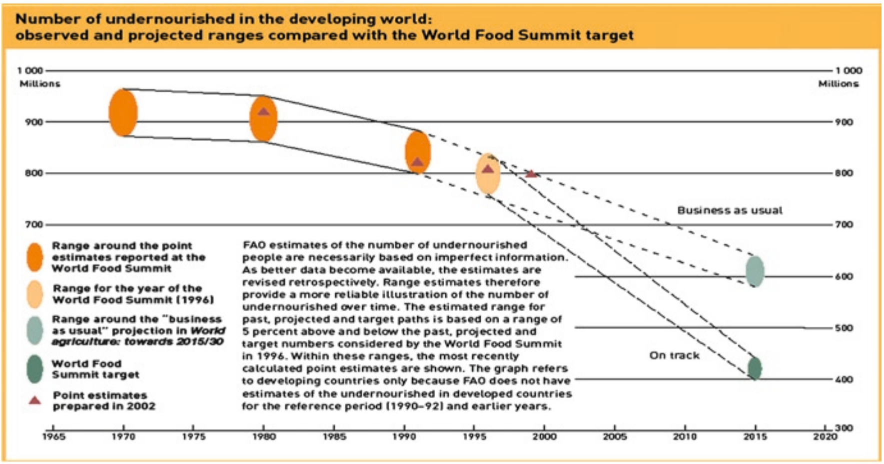
[13] It has been paradoxically noticed that the Global food aid deliveries of 5.7 million mt in 2009 were the lowest since 1961: programme food aid declined by 25%, emergency food aid by 12% and project food aid by 6% (FAO 2009). The decline occurred predominantly in bilateral food aid. Compared with 2008, bilateral food aid deliveries fell by 45%, food aid deliveries channeled through NGOs fell by 18% and multilateral food aid deliveries fell by 4%. This decline occurs in a context marked by the increase of global hunger which currently reaches more than 1.02 billion people – the highest number on record. The global economic crisis and rising food prices have contributed to the surge in world hunger, which was exacerbated by 245 natural disasters affecting 58 million people; extreme weather linked to climate change is likely to increase people's vulnerability (FAO 2009).

[14] Proponents of food aid include Jeffrey Sachs, author of *The End of Poverty* (Penguin Press 2005), and Paul Collier, author of *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It* (Oxford University Press, 2007), among others.




Source: Protecting our health from climate change: A training course for public health professionals (developed by the WHO)[4]

**Fig. 8.5** Number of undernourished in the developing world

But, while the explicit intention of food aid programs is to feed the hungry in the recipient countries, it is being criticized as rather a self-serving strategy of the donor countries.[15] Critics of foreign aid, especially food aid, claim that many well-intentioned foreign aid policies and trillions of dollars spent on foreign aid have done little to help developing countries prosper, especially in Africa.[16] To be sure, no country has meaningfully reduced hunger or poverty and spurred significant and sustainable levels of economic growth by relying on aid (see Fig. 8.5).

Food aid in its current form and function is not uncontroversial. Food aid is often blamed for creating disincentives for small farmers in recipient countries by depressing food prices, distorting markets, discouraging overdue policy reforms and fostering dependency (Barrett and Maxwell 2006). This is because it is frequently supplied 'in-kind' (Murphy and McAfee 2005). Moreover, food aid is often provided when there is a corresponding surplus in the North, and not when there is demand for it in the South. Even in cases in which food aid is not handed out to the population for free, there is often the problem of monetarization by

[15] Critics of foreign aid include William Easterly, author of *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good* (Penguin Press HC, 2006), and Dambisa Moyo, author of *Dead Aid: Why Aid Is Not Working and How There Is Another Way for Africa* (Farrar, Straus and Giroux, 2009), among others.

[16] For example, in the 1970s less than 10% of sub-Saharan Africa's population lived in dire poverty, while today over 70% of sub-Saharan Africa lives with less than US$2 a day.

NGOs or governments that have received the food aid (Murphy 2005). In the case of monetarization, food aid is sold at local markets, often at cheaper prices than local products. In addition, even if the local farmers are not affected because they cannot offer any products to the local markets due to a drought for example, regional markets and accordingly other developing countries' chances for export are affected. The size of this problem becomes clear when we consider that 80% of the global food aid is currently provided '*in kind*' (Fuchs 2006). Another source of controversy concerning food aid is the fact that it is frequently used to open up new markets[17].

Critics also claim that food aid creates dependency on the part of recipients, undermining incentives for local agricultural development and distorting international trade. The challenge therefore for recipient countries is how to ensure that the hungry people are not deprived of any assistance they can get, while also making sure that such aid programs do not distort trade or discourage local food production. Moreover, critics also argue that food aid often results in unintended consequences that can have detrimental effects on the local economy. If aid is open-ended, African governments will have no incentive to look for other, more self-sufficient ways of financing their development. These critics claim that foreign aid often encourages corruption, create dependency, fuel inflation, create debt burdens and disenfranchise Africans from the rest of the world.

In response to many assertions about the pros and cons of foreign aid, external and independent watchdog entities have been created that attempt to provide a transparent and unbiased review of poverty reduction and development assistance. Several organizations have looked at what various nations have donated, how and where funds have been spent, and other issues. Considerable controversy exists among the donor and NGO community over the merits of using food aid as a long-term tool to promote general development objectives. The United Nations World Food Programme (WFP) and some NGOs have used food commodities directly in programs that focus on building human capital in the form of nutrition, health and education. Some argue that the incentive mechanisms established to participate in the program may be as important as the direct impact of food itself, and can have implications for the sustainability and efficiency of the development project over the long term (Ho and Hanrahan 2010).

Based on the evolution of global food insecurity patterns which have changed dramatically over the last decade, with a rise in the number of extreme natural

[17] For example, during the 2002 famine, the United States provided numerous African countries with food aid containing genetically-modified corn. The United States also refused to mill this corn, which would have prevented a mingling with local corn. Some of the affected countries initially rejected the food aid. In the end, only Zambia stuck with this rejection. Still, this is a clear case in which the United States tried to open the affected countries' agriculture for genetically-modified organisms (Fuchs 2006).

disasters, the persistence of conflict in some countries and overall growth in the number of major humanitarian emergencies, the nature of the response has changed as key donors move from in-kind food aid to local and regional procurement. Cash transfers have increased, and social protection and hunger safety nets are playing an increasingly important role. Efforts to reform the humanitarian system and to develop a new food security architecture, including debate around the future of the Food Aid Convention (FAC), are additional areas of change.

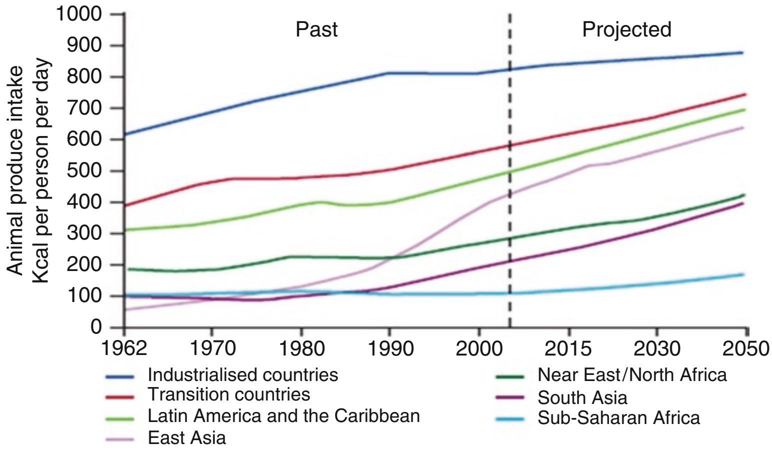
Moreover, donors and aid agencies are increasingly changing their referential by using the term *food assistance* as an alternative to *food aid*. A major reason for the shift in terminology is to include the provision of cash for food-related purposes within definitions of food assistance. However, different stakeholders define food assistance in very different ways. Some definitions embrace all interventions that address food insecurity and nutrition (including in-kind food aid, cash transfers and some forms of production and market support), while others limit food assistance to direct food and cash-based transfers (Harvey et al. 2010).

## *3.6 Population Growth and the Shift in Global Food Production and Consumption*

Population levels are a main driver in many environment and resource problems. Demographic growth rate in Western countries have stabilized, while in many developing nations it is still exploding (the UN projections indicate that the global population may range from eight to ten billion by 2050). Overall, more people to feed means more pressure on food supplies. Even though total global grain production has managed to continue growing, the amount of grain per person has declined since its high rate in the 1980s, and total grain reserves are at their lowest point in decades.

At this point in agricultural history, we have a fixed amount of arable land. Further increases in population will smack up against limits in land availability and stagnating yield gains, thus further reducing the amount of grain per person. Another trend that fits somewhat into this category is the demand for more meat. As average incomes in developing countries rise, there is a tendency for eaters in those countries to add more meat to their diets too (see Fig. 8.6). The amount of meat that can be raised per acre is far less than the amount of vegetable protein that can be raised per acre; thus, the more-meat trend will put further pressure on grain and soybean prices, supplies and reserves.

A focus on the right to nutrient-dense food and conditions that promote healthy lifestyles is currently considered as a key prerequisite to food security. Although a global increase in available calories and energy intake is often assumed to be an indicator of development, a paradox has emerged in that those calories do not seem to be fully nutritious, leading to healthy and active lives or increasing food security.




Source: Protecting our Health from Climate Change: A Training Course for Public Health Professionals (Developed by the WTO)[1]

**Fig. 8.6** Projected global increase in average animal produce consumption (Source: Adapted from FAO 2006 by the WHO)

Clear evidence of a rapid ongoing "nutrition transition"[18] in developing countries supports this claim (Popkin 2006).

As a consequence, the WHO reports that today there are more people overweight than are hungry, and approximately two billion people have some type of micronutrient deficiency due in part to the increased availability of empty calories (foods containing primarily fats and carbohydrates) and a decrease in dietary biodiversity (access to and consumption of a wide variety of food products originating from traditional local and regional food environments). How developing countries combat the problems of obesity and other non-communicable chronic diseases while simultaneously struggling with continued food insecurity, hunger and infectious diseases is a significant challenge for the future.

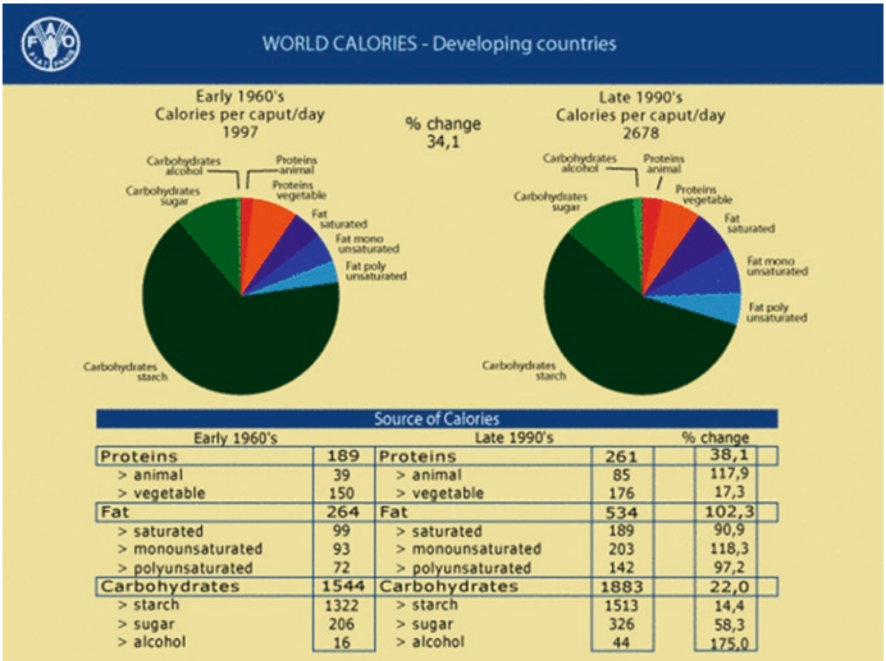
The double disease burden related to world hunger and overnutrition – both forms of "malnutrition" – can be attributed in part to the complex process of

[18] What is the *nutrition transition*? Humankind has faced major shifts in dietary and physical activity patterns and body composition since Paleolithic man emerged on Earth. Human diet and nutritional status have undergone a sequence of major shifts among characteristic states – defined as broad patterns of food use and corresponding nutrition-related disease. Over the past three centuries, the pace of dietary change appears to have accelerated to varying degrees in different regions of the world. The concept of the *nutrition transition* focuses on large shifts in diet and activity patterns, especially their structure and overall composition. These changes are reflected in nutritional outcomes, such as changes in average stature and body composition. Furthermore, dietary and activity pattern changes are paralleled by major changes in health status and by major demographic and socio-economic changes (for more details see Popkin 2006).

globalization and supporting policies that encourage agricultural subsidies and the aggressive marketing of processed foods and agricultural products by transnational corporations (Mendez and Popkin 2005).

Addressing over-consumption as a factor behind the food insecurity does not necessarily exclude the over-consumption of fossil fuels and natural resources, which also contributes to the current global food crisis. However, it is argued that we can no longer continue to look at this paradox and its major impacts on global human health as being separate issues (Brenton and St John's 2008). The world-wide rise in obesity and related non-communicable diseases is part of a large-scale shift in global food production and consumption that is actually contributing to food insecurity and sustaining world hunger by undermining local food environments and production and promoting a loss in dietary biodiversity.

Simply put, the promotion and support of over-consumption is contributing to world food insecurity. Trends in consumption (as measured through caloric intake[19]: see Figs. 8.7 and 8.8) have indicated that shifts in global food and agricultural

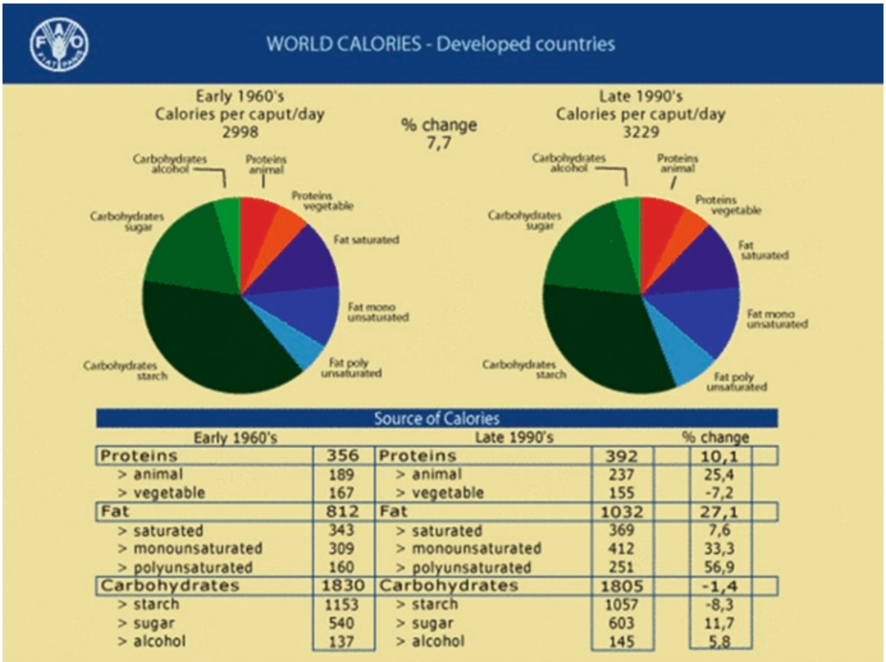



| Early 1960's | | Late 1990's | | % change |
|---|---|---|---|---|
| Proteins | 189 | Proteins | 261 | 38,1 |
| > animal | 39 | > animal | 85 | 117,9 |
| > vegetable | 150 | > vegetable | 176 | 17,3 |
| Fat | 264 | Fat | 534 | 102,3 |
| > saturated | 99 | > saturated | 189 | 90,9 |
| > monounsaturated | 93 | > monounsaturated | 203 | 118,3 |
| > polyunsaturated | 72 | > polyunsaturated | 142 | 97,2 |
| Carbohydrates | 1544 | Carbohydrates | 1883 | 22,0 |
| > starch | 1322 | > starch | 1513 | 14,4 |
| > sugar | 206 | > sugar | 326 | 58,3 |
| > alcohol | 16 | > alcohol | 44 | 175,0 |

Source: FAO website[3]

**Fig. 8.7** World calories-developing countries

[19] Today, the supply of food in developed countries is superabundant – some 3,230 cal per caput/day, with peaks of 3,650–3,750 in various countries. Assuming unrecorded losses and waste in the households at 12% of supply, there still remain 2,842 cal, which is more than enough.




| Early 1960's | | Late 1990's | | % change |
|---|---|---|---|---|
| Proteins | 356 | Proteins | 392 | 10,1 |
| > animal | 189 | > animal | 237 | 25,4 |
| > vegetable | 167 | > vegetable | 155 | -7,2 |
| Fat | 812 | Fat | 1032 | 27,1 |
| > saturated | 343 | > saturated | 369 | 7,6 |
| > monounsaturated | 309 | > monounsaturated | 412 | 33,3 |
| > polyunsaturated | 160 | > polyunsaturated | 251 | 56,9 |
| Carbohydrates | 1830 | Carbohydrates | 1805 | -1,4 |
| > starch | 1153 | > starch | 1057 | -8,3 |
| > sugar | 540 | > sugar | 603 | 11,7 |
| > alcohol | 137 | > alcohol | 145 | 5,8 |

Source: FAO website[1]

**Fig. 8.8** World calories-developed countries

systems have been maintained by international food policies that support agri-business corporations and food conglomerates and disrupt local food production and distribution.[20] This process is exacerbating the double burden of hunger and obesity throughout the world.

So, there is no doubt that we must reconsider how current trade and marketing policies might be restructured to monitor and affect corporate responsibility and accountability to both diet and nutrition, and improve overall global food security. Vital policies that also target lifestyle modifications related to activity and dietary behavior must be placed in combination with sustainable mechanisms for producing both affordable and nutritionally diverse food crops. An emphasis on the interactive and synergistic relationship between agriculture and health in education and community planning initiatives is imperative to their success. Meantime, food policy that will address the current and ongoing food crisis must be sensitive to recognizing shifts in the food environment through which local populations are

[20] To confront the root causes of this problem, Indian scientist and activist Vandana Shiva has called for a movement that promotes food democracy and food sovereignty (growing what one wants to grow) and supports anti-trust actions against agri-business infringing upon growers' and consumers' rights.

transitioning to a global food economy. There is a need to move away from heavily subsidizing agricultural industries whose primary focus is to produce cheap sources, but less nutritious, calories. If anything, subsidies should encourage global consumption of whole grains, fruits and vegetables (Popkin 2006).

## 4 Global Food Governance Regime: Actors, Powers and Dynamics

For the purpose of this analysis, a governance regime is to be understood as a historical and policy field specific organization and control of political decisions resulting from the socio-economic and institutional relationships between state and non-state actors (McMichael 2000). In other terms, this analysis follows the governance approach and defines global governance as a "multi-actor, multi-level political decision-making" (Rosenau and Czempiel 1992). Thus, the core question arises who controls global food governance or rather whose interests are being pursued by it. When trying to answer this question, it had been noticed that a shift in the control of global food politics is currently taking place (Fuchs 2006). It is a shift from a governance regime dominated by powerful states, in addition to their agriculture and food corporations, to a governance regime dominated for the most part by corporations – in this case the food retail companies – which are increasingly independent from governmental power and control. This section will analyze the different actors influencing the shape and functioning of the global food governance regime, and how their respective powers are exercised.

### *4.1 Conflicting Actors and Interests*

It had been presumed that the harmony of interests of involved actors cannot be implied in global governance (Messner and Nuscheler 1996). This means that global governance too is always about competition of potentially conflicting interests in which the relative power of the actors involved can be of vital importance. In other words, if global governance is a multi-actor, multi-level political decision making, one has to ask who decides, how and in whose interests? This in turn shows that an analytical governance approach is used beside a functionalist one that would primarily focus on the effectiveness and the efficiency of predisposed solutions (Fuchs 2005). It is also assumed that actors exercise power, among other things, with institutional resources, and by creating structural constraints as well as with ideas and norms. This means that a power-based approach is pursued. In this perspective, actors exercise power when they influence other actors' decisions. Actors also exercise power by influencing other actors' policy options – i.e. by preventing other actors from having certain options at all. This kind of power is normally called structural power and it can exist as agenda-setting power as well as rule-setting power. And finally, actors exercise power by influencing other actors' perception concerning their own interests, and thereby their preferences. This power is normally referred to as discursive power (Fuchs 2005).

### 4.1.1 Role and Power of Powerful States

As mentioned above, the old governance regime was characterized by the dominance and interdependence of powerful states and companies, and it can be exemplary illustrated with the global food aid. In this sense, one has to explore the extent to which food aid in its current form and function reflect the dominance of powerful states.

On the one hand, these powerful states and their national legislation set the parameters for food aid: they decide the granting and form of food aid. They also determine the agricultural subsidies that are responsible for the surplus production in the North. Furthermore, these states significantly influence the rules set by multilateral organizations. In this context, the Food Aid Convention (FAC), agreed in 1967, reflects visibly the structural power exercised by dominant states. The FAC was supposed to guarantee the international capacity to face food crises by ensuring a stable flow of food aid independently of fluctuations in price or supply. In the context of negotiations and renegotiations (every 5 years) on the FAC, for a long time, the developed countries – particularly the United States – refused to agree about a best practice policy, and to adopt mandatory rules as well as sanctioning mechanisms. Consequently, the renegotiations were completely discontinued in 1999 to await the Doha Round of the WTO (Fuchs 2006).Ultimately, during the Doha negotiations, the United States refused again to approve the necessary food aid reforms – i.e. to base food aid on demand and not on supply or grant financial aid instead of in-kind deliveries. However, it must be recognized that the United States had made their acceptance of these reforms conditional on a further reduction of agricultural subsidies by the EU which, however, reject these conditions.

Beyond this rule-setting power, dominant states also exercise agenda-setting power in the field of food aid. Again, the United States plays an especially prominent role here. On the one hand, this is due to the fact that it currently provides more than 50% of global food aid (Murphy and McAfee 2005), and on the other hand because it increasingly forces concessions from developing countries by offering bilateral trade agreements. Within these agreements, the asymmetry of power between the involved countries is of course clearly larger than in multilateral trade agreements, as for instance in the context of the WTO, where the United States simultaneously faces many developing countries and not just one.

Finally, powerful states also pursue their interests in global food aid governance by exercising discursive power. This takes place for instance, by emphasizing the aspect of aid in food aid.[21]

[21] For instance, the United States had accused the Zambian government as well as the EU (which had criticized the delivery of genetically-modified corn as food aid) of preferring to let millions of people starve rather than being willing to help (Fuchs 2006).

### 4.1.2 Role and Powerful Corporate Influence

After describing briefly the influence of powerful states within the old food governance regime, we will focus now on agro-food corporations' influence. Such an influence reveals itself not only in terms of overwhelming market power[22] (*economic power*), but also in terms of political power (*political influence*).

Global agro-food companies have grown too powerful and are undermining the fight against poverty and hunger in developing countries (as one on the important MDGs). They are draining wealth from rural communities, marginalizing small-scale farming and infringing people's rights. Urgent action is surely needed to re-govern agricultural markets so they benefit poor and hungry people, and to make corporations legally accountable for their impacts on human rights and the environment.

Transnational corporations – such as Monsanto, Cargill, Nestlé and Wal-Mart – managed to dominate supply chains for food and agricultural goods, from seed to supermarket shelf. Two decades of economic liberalization have enabled agro-food TNCs to expand enormously in size, power and influence in developing countries; as a result, they now deal more directly with small-scale farmers. A wave of mergers, acquisitions and business alliances in the agro-food industry has concentrated enormous market power amongst these corporations.[23]

Beside this economic power, agro-food corporations exercise a certain political influence as follows:

- *Lobbying, campaign donations and technical consulting*: in addition to huge donations granted by these corporations to local and national authorities, a disproportionately large presence of corporations' representatives in committees and commissions at the national and international level can be shown. In international negotiations on food standards in the 1990s, more companies than states were present, the delegations of the powerful companies were larger than those of most states, and the total number of many corporations' representatives was five times as large as those of civil society representatives (Sklair 2002).
- *Exercise of structural and discursive power*: corporations exercise rule-setting power in public-private partnerships (PPPs) – i.e. with USAID or the GTZ as well as with the World Bank and local/regional programs. In these PPPs,

[22] Some facts to illustrate this current state: 3 to 6 companies control 80–90% of the global grain market, 85–90% of the global corn and coffee markets, 85% of the global cocoa market, and so on. Monsanto dominates 90% of the global market for genetically-modified seeds. Another figure concerning the agro-chemical industry: in 1992, there were 12 companies in that field, while in 2003 only 6 remained as a result of mergers and acquisition (ActionAid International 2005).

[23] The following facts can prove the current state of art: the top 30 food retailing corporations account for one-third of global grocery sales; one TNC controls 80% of Peru's milk production; five companies control 90% of the world grain trade; and six corporations control three-quarters of the global pesticides market.

corporations take part in setting rules and standards and determining the focus of programs. In addition, They strategically promote scientists from developing countries whom they can offer research funding and research stays abroad, and who in turn become important ambassadors of the companies' interests – for example for the gen-tech industry – in their countries. Discursive power can be also exercised through public relations campaigns in which they engage in the framing of political decisions, actors and social norms, such as the politics of risk. An important aspect of these public relations campaigns is the safeguarding of their own political legitimacy and social acceptance through a self-portrayal as indispensable global provider of food or as good "corporate citizens", which they emphasize for example by the free provision of biotechnology to African research institutes (Fuchs 2006).

According to Fuchs (2006), this regime, characterized by the power of some states and companies from the agriculture and food industry, is radically changing because there is a new development to which little attention has been granted. This development, or this new regime, has serious political implications and is, from a political science perspective, linked to new scientific necessities.

The new governance regime is marked by the dominance and growing autonomy of agro-food corporations. This situation is the outcome of three factors, as well as the favorable position of the food retailers resulting from their proximity to the customer:

– The first factor concerns the development of an oligopoly. For a long time the concentration of the food retail sector, i.e. at the end of the product chain, was lower than in its preceding parts. This situation has changed rapidly in the last 10–15 years. At the moment, we can recognize ten large internationally operating supermarket chains whose market share has constantly increased in the last two decades.
– The second factor is related to a new form of retail company which has been developed, characterized by the control of the product chain from farm to shelf. The underlying complex logistic task is made possible, among other things, by new technologies of supply-chain management, with which shipments are traced by GPS and deliveries are handled in short time windows defined by the minute (Burch and Lawrence 2005).
– The last factor is the development of competition that is not only based on price but also on quality (Konefal et al. 2005). Food scandals and an increased health awareness combined with shrinking time budgets of consumers in the North have led to the emergence of new markets. Although these markets are still referred to as "niche markets," they are the markets where most of the money will be earned in the near future. Thus, the large retail chains have responded to this development by expanding their own products and supply chains.

Again, the market power of agro-food corporations in this new governance regime implies the ability of these retail chains to put pressure on suppliers in terms of prices.[24] Importantly, the ability to exercise this pressure today reaches all the way to farmers in developing countries. For the future, economists predict the existence of six large supermarket chains that will dominate global markets and whose representatives buy on-site and distribute the products to their stores around the world through global networks.

The political power of these corporations is also of special interest, especially their rule-setting and discursive power. The rule-setting power of retail companies is clearly reflected in the development of private standards, i.e. standards of private governance institutions, for instance for food security[25] (Konefal et al. 2005). The standards for food security are *must*-standards, while the standards for sustainability are *should*-standards. Compliance with these standards by the participating agricultural and food companies is certified through independent auditors. This trend is evolving, paradoxically, in a context marked by the long existence of an intergovernmental organization with the task to develop food standards: the Codex Alimentarius Commission founded in 1962 by the FAO and WHO. Moreover, the Codex Alimentarius Commission has developed a multitude of food security standards since its creation (Sklair 2002). In this respect, the retail companies' development of their own standard is a striking strategy. That strategy can be explained if we look at participation and transparency in the development of the EUREP-GAP standards. Here, food companies from the industrialized countries, Europe in particular, dominate. In consequence, there is a clear asymmetry between participation of retail companies and the rest of the product chain, between North and South, and between representatives of business and of civil society interests. If we ignore questions of participation and transparency, we may appreciate the development of private food security standards, especially for consumers in the North since these standards promise a protection of food quality. Yet, these private governance institutions have fundamental implications for global agriculture, and in this respect they are not an unequivocally positive development.

Meantime, food retailers exercise discursive power, for instance, by emphasizing their role as guardians of consumer interests, which they do with respect to both prices and quality. Furthermore, they emphasize their efficiency as market actors in production and distribution, but also in the setting and reviewing of standards (Konefal et al. 2005). The core argument concerning standards is that public actors act too slowly and they do not have the necessary expertise to set the most efficient standards. This is a well-known argument made in many other business sectors in a similar way (i.e. corporate social responsibility standards). Finally, and most fundamentally, retail companies' media presence is fundamental for their discursive

[24] The market share of the respective three largest retail chains in European countries ranges from 40% in Great Britain to over 80% in Finland and Ireland. In USA, the five largest supermarket chains have more than doubled their market share between 1992 and 2000 (Fuchs 2006).

[25] A prominent standard in this connection is the EUREP-GAP standard which was developed by the European food retail association to determine standards for food security and sustainability.

power, both as a medium to constantly communicate with consumers and to adequately present and frame themselves. Within this frame, the question of consumer power seems relevant. According to Fuchs (2006), this power exists, although not to the degree suggested by the phrase "consumer sovereignty," which retailers tend to emphasize in their public communication. Among other things, consumer power is limited by the active manipulation of demand through such corporations (using for instance the media), by information asymmetries concerning products, production processes and actors in the supply chain between consumer and food retailers, and by the high transaction costs, which "political" consumers face. After all, the exercise of market power by consumers does not require just one consumer's decision, but the mobilization of 1,000 consumers. Consumers certainly are not free of liability concerning the economic, social and ethical implications of their consumption decisions. Yet, they clearly are in a weaker position within the political framework of the new governance regime than the retail industry is.

Characteristics and consequences of the new governance regime can be summarized as follows:

- *Firstly*, there is a shift of power within the food industry from agriculture and food processing industry to food retailers;
- *Secondly*, from a political science perspective, it is particularly interesting that there is a shift in power between corporate actors and the state;
- *Thirdly*, there is a shift in the distribution of economic opportunities in global agriculture. This is due to the fact that the implementation and certification costs of the new private standards are so high that NGOs predict that hundreds of thousands of peasants in Africa will lose their livelihood by the implementation of the EUREP-GAP standards (Actionaid International 2005). That in turn means that these farmers will be driven into the subsistence economy, if no new opportunities – for whatever reasons – arise in the local markets. By the way, such a development would also be significant from a gender perspective, as in most developing countries women are responsible for 60–80% of food production, i.e. they will be particularly affected.

Thus, what cannot be expected from the regime change as analyzed above is an automatic improvement of the hunger problem or rather assistance in meeting the MDGs related to the reduction of the proportion of people who suffer from hunger and poverty by 2015. On the contrary, the new regime has the potential to exacerbate these challenges.

## *4.2 Potential of Global Food Regime to Enhance Food Security*

The current food governance regime is fragmented and incoherent and in many ways based on past conditions, practices and understandings of how best to promote food security (Cohen and Clapp 2009). Meantime, it is a regime dominated increasingly by global structures far removed from daily struggles of hungry and poor people. Even the emergent global civil society and advocacy groups have a limited influence on global food policies. Moreover, no area of the current debate on global governance has had such a low profile as food security. This cannot be explained because of irrelevance or lack of genuine interest in the significance of governance to food security. It certainly cannot be explained on the grounds that a "good governance" regime in food security already exists. It clearly does not.

In order to construct a new food regime, governments must address several crucial questions. What position should human food occupy in global trade policy by virtue of its unique biocultural relationship to human health, human culture and human rights? How can we buffer poor food consumers from and semi-subsistence farm sectors in the least developed countries and the poorer farm sectors of other countries? (Ellis and Sunberg 1998).

According to Mohamed Salih (2003), three plausible interpretations could be put forward as to why food security governance remains on the back seat of the debate, although global food governance institutions do exist:

*Firstly*, it can be explained in relation to two competing definitions of security: human security and national security. For most of the post-Second World War period – particularly during the Cold War – security was predominantly defined as national security. Military security was the dominant concern of national security, with its evident economic and political connotations. Cold War architects considered national security the defining element of national sovereignty. Concerns with military expenditure predominated over concerns with human security – defined as "a condition of existence in which basic human needs are met and in which human dignity, including meaningful participation in the life of community, can be realized. At the most basic level, food, shelter, education and health care are essential for the survival of human beings" (Thomas and Wilken 1999:3). So food security is essentially part of human security and as such requires the redefinition of the concept of security. This conceptualization was absent during the Cold War, when the heightened ideological divisions between Western and Eastern blocs in many instances sacrificed human security to achieve national security objectives.

*Secondly*, it was expected that with the end of the Cold War, the emphasis would shift from military to human security. The triumph of multilateralism has contributed to a new and emerging global governance regime, and it was expected that this would foster a new "humanitarian" understanding, and therefore make it possible for humanity to reap the positive outcomes of the democratic peace dividend. Sadly, this has not been the case. Indeed, in some parts of the world, particularly war-torn and famine-stricken countries, the end of the bipolar Cold War has instead "produced new forms of polarization (ethnic, religious, economic, regional, etc.) that have undermined state and societal security alike" (Mohamed Salih 1999).

*Thirdly*, food security governance should entail the accountability of the governors to the governed through binding commitments that most developing countries are probably fearful of subscribing to. The current global mindset is premised on food trade and competitiveness. So commitments to ensuring the food security of potential competitors could deter the largest food producing and exporting countries from making concessions in the areas of subsidies and market access to developing countries. While large food exporting countries and regional entities supply food in complex emergencies – for famine relief and disaster prevention – they are less keen to support long-term food security, including such global visions as food-for-all and a hunger-free world. In short, there are serious food security governance issues at the national, regional and global levels, so the linkages between these issues and the general debate on governance should be closely considered.

According to Mohamed Salih (2003), it is difficult to ensure food security by subsuming it under economic governance, given its particularity and because it is a domain of governance in its own right. All four aspects of food security – availability, access, stability and quality – are matters for a governance regime based on food as an indispensable part of the support system for human life. In this respect, food security encompasses more than the economies of food production, consumption, distribution and marketing. As such food security cannot be guaranteed through economic governance institutions alone or through policy reforms dealing merely with economic regulatory frameworks and instruments. Moreover, in the domain of food security, governance is part of a broader context, linking the physical environment as well as the socio-economic and political aspects of society. This in turn is linked to a global governance regime that has designed policies to respond to global food insecurity. These include buffer stock systems, food price stabilization programmes, food aid, financial food facility schemes, trade policies and food imports. Meantime, although national and global food security policies are important for fostering food security, these are often influenced by other non-food policies such as marketing, trade regimes and transport. Taken on their own, they cannot solve problems associated with food entitlement. Obviously, food policies devoid of real concerns with food security have provided poor answers to urgent and critical food needs. Not only have these policies failed to solve food crises, they have dramatically failed to ensure long-term food security.

How to harness change? It has to be said that the globalization of food, the exponential development in food technology from biotechnology to genetic modification, the global competition for farm animal and plant genetic resources, climate change and bio-energy carry with them immense risks and potential opportunities. They have the potential to transform what is meant by food security for subsistence producers and indigenous peoples. At the same time, it cannot and should not be left to the monopoly of individual states or corporate caprice to maintain minimum standards of sustenance. Certainly, the current regime of governance for global food security addresses some of the current concerns. However, its direct contribution to alleviating food insecurity for the majority of the world's population is questionable. The gap in perception between global, national and household food security governance is too great to be bridged by global conventions and treaties alone. It is also doubtful whether the current regime satisfies the requirements for global food security governance set out above. This regime could, however, be hugely aided by democratic governance that is responsive to the immediate concerns of citizens. As voters, they can influence policies and priorities and can commit public policy to food security targets. So the relationship between democracy and the quest for transparency, accountability and public participation cannot be isolated from the debate about food security and its opposite, food insecurity, shortages and famine.

## 5 Concluding Remarks

As the global food equation is changing as a result of energy shortage and climate change, the world is not only confronted with agriculture and energy policy issues, but also with broader social, environmental and security issues. The needed response involves a combination of science, institutional and policy innovations, which should be taken into account in global, regional and national strategies. Meantime, improved global governance is often assumed to be the greater need, yet in the area of food security the greatest governance deficits are still found at the level of the nation-state. As a consequence, to reduce hunger in an age of globalization, we should first improve governance at the national level. Where national governments have performed well in the developing world, hunger has been significantly reduced. In those regions where hunger is not yet under control, improving governance at the national level is now the highest priority (Paarlberg 2002).

"Think globally, act locally" is an accepted adage. This is a relevant advice for some truly global issues (such as HIV or climate change), but in the area of food security, thinking globally has shown its limits. Despite globalization, most hunger today is still highly localized and locally generated. Local problems, such as poor rural infrastructure, little access to health services or education, gender or ethnic or caste discrimination, landlessness, governmental weakness or corruption and violent internal conflict, are problems difficult to address at the global level. Most of these local problems must be managed through improved governmental performance at the national level.

However, the importance of the global level remains crucial since many external dynamics can influence national ones. As Christiaensen (2009) argues, to safeguard the strengths of the current global food system, four failures in market functioning and policy making must be addressed:

*First*, agriculture in developing countries must undergo a significant transformation in order to meet the related challenges of food security and climate change (FAO 2010). Agricultural policies should increasingly focus on the provision of public goods supporting environmentally sustainable production of food. To increase efficacy and sustain the current shift in financial and political commitment to agriculture, enhanced public accountability through more demand driven and evidence-based agricultural policymaking with agricultural ministries focused on coordination, regulation and facilitation should be also pursued.

*Second*, the world cannot afford to have its food prices determined in the infinitely larger fuel market. The current policy-induced link between food and fuel markets must be broken. This requires removal of US and EU subsidies and import tariffs supporting first generation agro-fuels and a revision of EU and US usage targets to allow production of agro-fuels in economically and environmentally more suitable locations.

*Third*, better sharing of information on food stocks, stricter WTO regulation of export restrictions and some form of globally managed buffer stock will be minimum requirements to prevent the resurgence of inefficient national food self-sufficiency policies.

*Finally*, to more efficiently assist the poorest in accessing food in times of crisis and make a market-based national food policy politically sustainable, countries need to establish effective social safety nets.

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# Chapter 9
# 18,000 Children Die of Starvation Everyday: Cannot We Save Them?

**Md Sirajul Islam Molla**

**Abstract** 18,000 children and 7,000 adults die of starvation everyday and more than one billion people starve at every night throughout the world. Out of them about 65 million are in Bangladesh representing 40% of the total population where 28 million representing 20% of the total population are considered 'ultra poor'. Every human being has right to food and other basic needs. Food is the first basic right of every living being in the world. If the respective governments fail to save hungry people for any reason whatsoever, the world leaders including rich people should come forward to save them. In order to mobilize sufficient resources to feed the starved people the rich countries should enhance their yearly contributions to the UN. They should adopt strict measures to stop food wastage in their countries and definitely should come out of protectionism. In USA and UK, 63 billion-dollar worth foods are wasted every year. Making biofuel is another malpractice which should never be allowed keeping other people hungry. The UN may take initiative to make a special fund to meet this challenge.

**Keywords** Children • Food • Fund • Hunger • Waste

## 1 Introduction

While most of the rich people in developed countries are completely unaware about food deficits and poverty and do not hesitate to waste food, 18,000 children and 7,000 adults totaling 25,000 human beings die of starvation everyday, and more than one billion people starve at every night throughout the world. In the United

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_9,

States of America (USA) and the United Kingdom (UK) alone, people waste US$63 billion worth of foodstuffs every year.[1] Similarly, there are many people in other developed countries who waste food, spend lavishly and do not contribute for charity. They think only for themselves.[2] The time has come for them to come out of such 'so-called' advantaged existences, and work globally to help the poor of all nations. Socio-economically- and environmentally-balanced situations can but only save people from starvation, malnutrition and killer diseases as well as the existence of this beautiful earth.

## 2 Methodology

The paper has been prepared by analyzing secondary data and information from different sources, including newspapers and internet. The main source of information is the website of the Food and Agricultural Organization (FAO) which has plenty of information on hunger and malnutrition derived from their own research programmes conducted in different hunger-prone countries as well as from various sources throughout the world. Their information sources are believed to be dependable and authentic. Other sources of information are also mostly web-based as lots of information on the subject is available in the internet. Some sections of the paper, however, have information from some peer-reviewed journals and books.

As the chapter focuses on saving hungry people, which seems to be possible with the existing food production, emphasis has been also given to curb food wastage. Food wastage is seen everywhere in the world even in the poor countries like Bangladesh. The rich countries' people, however, are more likely to waste food than the poor countries as evident from the information on food wastage in USA and UK. Being two of the richest countries and the leading members of the Group 8 (G8) in the world, the USA and UK have been selected here as examples of food wastage.

The cost of saving hungry people in the short-term plan has been estimated on Bangladesh perspective. The minimum cost of food of an ultra-poor in Bangladesh has been estimated for US$1.0/day and the cost of milk for a child has been estimated for US$0.71/day. The cost of medicine has been estimated for US$ 5.0/month and clothing for US$ 5.0 for 6 months. The housing has not been calculated (Sect. 6.1, Table 9.1).

The long-term plan has been suggested to be bestowed upon the respective countries. They will make their plan best suited for their people based on their own need and socio-economic and climatic conditions. Nevertheless, some suggestions, in addition to the recommendation to stop food wastage, have been indicated below within the framework of a long-term plan. Some probable sources of finance have also been indicated for sustainable solutions in saving hungry people and poverty alleviation.

[1] http://www.soundvision.com/Info/poor/statistics.asp

[2] http://www.soundvision.com/Info/poor/statistics.asp

**Table 9.1** Hypothetical cost of food and clothing for 850 million people and 150 million children in US$

| | Cost/day (US$) | Cost/month (US$) | Cost/6 months (billion US$) |
|---|---|---|---|
| Food for 850 millions people | 850 million ($1 per person/day) | 25.5 billion | 153.0 |
| Medicine for 1.0 billion people | | 5.0 billion | 30.0 |
| Clothing for 1.0 billion people | | | 5.0 |
| Milk for 150 million children | 107 million ($0.71 per child/day) | 3.2 billion | 19.0 |
| Total | | | 207.0 |

## 3 Hungry People

Hunger and malnutrition rank number one risk to human health, worldwide – not Human Immuno-defficiency Virus/Acquired Immuno-defficiency Syndrome (HIV/AIDS), nor malaria nor tuberculosis (TB). As stated above, everyday 18,000 children and 7,000 adults die of starvation throughout the world, and the number of people that starve every night is rising alarmingly. A few years ago, 850 million went to sleep every night hungry (United Nations (AP) 2007).[3] The number of hungry people rose to 963 million at the end of 2008 (see footnote 2). The number is increasing unabated, and now at the end of 2010 they are more than one billion. This reality has been reported by the International Conference on "The integration of sustainable agriculture, rural development and ecosystems in the context of climate change, energy crisis and food insecurity" held in Agadir, Morocco during 12–14 November, 2009 and by the UN Food Summit held in Italy during 15–18 November, 2009. Out of them, about 900 million in the developing world and the rest are in the developed countries. Sixty-five percent live in only seven countries: India, China, the Democratic Republic of Congo, Bangladesh, Indonesia, Pakistan and Ethiopia (see footnote 2).

In sub-Saharan Africa, one in three people – or 236 million in 2007 – were chronically hungry,[4] the highest proportion of undernourished people in the total population. Most of the increase in the number of hungry people occurred in a single country, the Democratic Republic of Congo, as a result of widespread and persistent conflict, from 11 million to 43 million (in 2003–2005), and the proportion of undernourished rose from 29% to 76%.[5]

In America also, there were 33 million hungry people in 2002.[6] In the last 5 years, the number rises to about 38 million (3.7%) out of whom 14 million are

[3] http://www.usatoday.com/news/world/2007-02-17-un-hunger_x.htm

[4] http://www.fao.org/news/story/en/item/8836/

[5] http://www.fao.org/news/story/en/item/8836/

[6] http://www.thenation.com/doc/20021216/sarasohn

children.[7] The US ranks 23rd among industrial nations in infant mortality, and African-American infants die at nearly twice the rate of white infants. One out of every eight children under the age of 12 in the US goes to bed hungry every night.[8] On the contrary, the average net worth in the US amounted to US$143,867 per person in 2000 while it was US$193 in Ethiopia and US$180 in Congo.[9]

In 2008, the number of hungry people in Bangladesh rises to 65 million representing 40% of the total population.[10] The depth of food insecurity has also worsened. Food expenditures are increasingly dominating household budgets, the poor are consuming even less than before and the quality of their diet has deteriorated further. To cope with the situation, the poor have fallen into an even deeper spiral of debt, from which it will take many months to recover. A heavy impact on school enrolment, attendance and dropout was already visible by mid 2008 (see footnote 10). High food prices in 2008 have worsened the already precarious nutritional situation. Nationally, nearly half of under-five children are moderately to severely underweight and 36% suffers from moderate to severe stunting. The rates of wasting increased from 13% in 2004 to 16% in 2007. This is above the World Health Organization emergency threshold.[11]

## 4 Why People Are Hungry?

Protectionism and huge abuse of food, poor quality of food, poor market system, ethnic violence, war between countries, autocratic governance, natural calamities, illiteracy, terrorism, militarization, over-population, killer diseases, environmental degradation, etc. are the major reasons for hunger, malnutrition and death throughout the world. The existing system of global economy and/or non-cooperation of governments of the rich and powerful countries as well as naked trend of profit-making business of international financial institutions may also cause human sufferings from hunger which causes malnutrition, diseases and death.

Foods are wasted unthinkably throughout the world. In USA only, household foods for US$43.0 billion dollar are wasted every year by which 700 million people can be fed right away.[12] In the UK, US$20.0 billion worth of food is wasted every year.[13] One out of three kids in USA has overweight and the total obese is 59 million (31%) now. It is predicted that nearly four out of ten adults will be obese within next 5 years.[14] The expenditure due to obesity related diseases and weight loss is

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[7] http://www.medicalnewstoday.com/articles/32800.php

[8] http://library.thinkquest.org/C002291/high/present/stats.htm

[9] http://www.cbc.ca/money/story/2006/12/05/globalwealth.html

[10] http://www.wfp.org/node/3398

[11] http://www.wfp.org/node/3398

[12] http://www.soundvision.com/Info/poor/statistics.asp

[13] http://www.treehugger.com/files/2008/05/britons-waste-food.php

[14] http://www.annecollins.com/weight_health/obesity-rate.htm

also being increased tremendously. In USA, the daily expenditure due to obesity related diseases is about US$125 million and on weight loss is US$55 million.[15] The irony of fact is, not only in the USA alone, almost all countries of the world have significant number of people with overweight and the total number (perhaps more than one billion) of obese people throughout the world is surprisingly more than the hungry people. More surprisingly the ratio of increase in number of obesity is the highest in Asia[16] which represents the highest percentage of hungry and malnourished people as stated in Sect. 2 above.

Ethnic violence in many parts of the world (including Sudan, Sri Lanka, Serbia and Chechnya) pushed lots of people into poverty and hunger. The US invasion in Iraq and Afghanistan in the name of destroying the weapons of mass destruction and Al-Quaeda/Talibans, and Israel's atrocity in Palestine, also killed many innocent adult people including children and pushed many others into extreme poverty and hunger.

In African countries, drought and armed conflict played a major role in causing low food production resulting in malnutrition and hunger. The problem had been compounded by high rates of HIV/AIDS in countries such as Zambia, Zimbabwe and Malawi. As a consequence of the HIV epidemic, many farms were without economically active adults, leaving orphans and elderly people at risk of hunger and malnutrition. Outside Africa, the number of undernourished people also increased in most of the Asian countries including Bangladesh, Cambodia, India and Pakistan.

## 5 Cannot We Save the Hungry People?

Off course, we can. Although till today we have only one earth in the whole universe, it has sufficient arable lands and other resources yet for all people and other living beings of the world. The problem is that there is no balance of power and fair distribution of resources among the countries, the demarcation of which are created by human being by dint of their powers and privileges.

## 6 How Can We Save Them?

Though it is the primary responsibility of the concerned government to save their own people meeting all of their basic needs, it may not be possible for them for various reasons as stated in Sect. 3 above. In that case, the responsibility lies on the UN and rich countries as well as on the rich people living in the concerned countries and elsewhere in the world.

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[15] http://www.wfp.org/node/3398

[16] http://news.bbc.co.uk/2/hi/health/4793455.stm

If the rich countries and their people, as well as the rich people of the concerned poor countries who have excess to food or money, wish to save the hungry people, it is absolutely possible. Saving hungry people may be compared with the saving of a drowning child. If a baby drowns in a pond in front of a healthy adult person, should not the latter save the baby? Obviously should. To save the hungry people is like that. We have to use our judgment and open our eyes to see the reality that people are dying without food, while many of us are throwing it to the bins and spending money for no good reasons. We have to stop it now with a belief that the riches may also be infected by hunger through the large-scale invasion of the hungry people. Considering the overall socio-economic and political condition of the world, the following short and long-term plans have been hypothesized which may help save people from hunger and malnutrition and make sustainable living conditions.

## *6.1 Short-Term Plan*

Feeding hungry people is the number one obligation for the concerned governments. The feeding plan should be framed out beginning from the period of 6 months up to a couple of years depending on the age and health status of a group of people. Until someone can feed himself/herself and his/her children, he/they should get sufficient supply of food and children should get supply of milk from the specific channel as defined by the concerned government, if necessary with the help of UN. Let us have an estimate for 6 months to feed the hungry people of the world. In Bangladesh perspective, the minimum cost of living is estimated for US$207 billion to feed the world's one billion hungry people including about 150 million children for 6 months (Table 9.1). This includes the cost of medicine and clothing also, but excludes housing and rehabilitation. Based on the UNICEF statistics on Bangladesh, these hypotheses have been made. It said about 50% people of Bangladesh are living below the international poverty line of US$1.25 per day.[17]

The hungry people should continue to be fed until they can meet their own demand. Given the priority to save hungry people, both short and long-term plans should continue simultaneously as appropriate for the governments and their people concerned. Food subsidies for people who can afford to buy it at a considerable lower price should also continue until their income is increased up to a satisfactory level (Besley and Kanbur 1988).

## *6.2 Long-Term Plan*

The governments concerned should design their long-term plans best suited with their socio-economic and environmental conditions to meet their demands. But if

[17] www.unicef.org/infobycountry/bangladesh_bangladesh_statistics.html#69

they are unable to do so for reasons stated above, the UN should help them make such plans, if necessary taking technical and/or financial help from the rich countries. The following long-term plans are suggested here for the concerned government as well as for the UN and rich nations:

### 6.2.1 Increase Agricultural Production

The gravity of the current food crisis is the result of 20 years of negligence and under-investment in the agriculture sector by many countries of the world. As recommended in the Agadir Conference on "The integration of sustainable agriculture, rural development and ecosystems in the context of climate change, energy crisis and food insecurity."[18] (Shabbir et al. 2009), poor countries need to develop their economic and policy tools in order to boost-up their agricultural production. Investment in agriculture must be increased because, for the majority of poor countries, a healthy agricultural sector is essential to overcome hunger and poverty and is a pre-requisite for overall economic growth.[19] Any successful food security policy needs first to identify which commodities are strategic, because it is not possible to provide an ample supply of all food products consumed by a population. Governments' food security policy should focus on four major issues: availability, affordability, nutritional and health value and safety (Maroun et al. 2009). Another important matter is to protect the agricultural lands. All countries of the world must protect their agricultural lands at any cost.

### 6.2.2 Come Out of Protectionism

The protectionism policy is mostly responsible for creating a huge imbalance situation between rich and poor. This situation may even lead to a civil unrest. The American civil war in 1812 can be cited here which basically was due to the huge socio-economic imbalance between the Northern and Southern Americans.[20] Also, protectionism had led to the constant warfare in the seventeenth and eighteenth centuries among European countries whose governments were predominantly mercantilists and protectionists. Many economists, including Nobel Prize winners Milton Friedman and Paul Krugman, have suggested that protectionism, in fact, is an insincere attitude of protecting thyself.[21]

The rich-poor gap must be reduced to a significant level coming out of protectionism. The rich nations should consider that the people who are starving and

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[18] http://nrcs.webnode.com/

[19] http://www.fao.org/wsfs/world-summit/en/ [Cited 2 December 2009].

[20] http://en.wikipedia.org/wiki/Protectionism#References/ http://www.treatyist.com/issue1/protectionismcivilwar.aspx

[21] http://en.wikipedia.org/wiki/Protectionism#Arguments_against_protectionism

dying of hunger do not have adequate opportunities to earn food for them. Their governments concerned are either insincere or autocratic or incapable for any reason whatsoever to feed them or create opportunities for them to work. So the riches should extend their helping hand to the poor keeping in mind that the only Earth is for all people, and everyone has the right to food. While the disastrous financial tsunami has been waving all over the world since 2008, and the countries, particularly the riches, have been more active than ever on the protection of their respective national economies, some of the world leaders, including President Barak H. Obama, have been vocal for the first time against protectionism. At the backlash of the beginning of world financial crisis, the leaders of the G20 countries in their London Summit on April 2nd, 2009 have raised their voices to come out of protectionism and apparently came to a consensus to work together to face the disaster. The people of the world were hopeful to see a significant improvement afterwards in the world leaders' cooperation in eliminating poverty and hunger. But soon after their declaration in London, people's hopes were shattered again when they saw the leaders' negligence toward the implementation of their noble agreement by avoiding the UN Food Summit held in Italy during 15–18 November 2009 (as referred to Sect. 6.2.1). This should not continue anymore. The riches should change their mind-set to help poor. In fact, all countries of the world should be united to ensure food and other basic needs to all people at any cost.

### 6.2.3 Stop Food Wastage

Food wastage begins from planting of food crops to eating. After having plantation, natural calamities and insects can damage the plants which cause losses before the harvest. The use of machinery in harvesting can cause waste, as harvesters may be unable to discern between ripe and immature crops, or collect only part of a crop. Economic factors, such as regulations and standards for quality and appearance, also cause food waste. Food waste then continues in the postharvest stage, but the amounts of postharvest loss involved are relatively unknown and difficult to estimate. The variety of factors that contributes to food waste also includes considerable quantitative losses attributed to pests and microorganisms. This is a particular problem for countries that experience a combination of heat (around 30°C) and ambient humidity (between 70% and 90%), as such conditions encourage the reproduction of insect pests and microorganisms. Losses in the nutritional value, caloric value and edibility of crops by extremes of temperature, humidity or the action of micro-organisms, also account for food waste. These qualitative losses, however, are more difficult to assess than quantitative ones (see footnote 20). Further losses are generated in the food processing which also yet to be assessed.

The next stage of food wastage is just throwing away and over-consumption of consumable foods. This type of wastage is also resulted in from the nature of protectionism. Enormous foods are being wasted in this way in every moment throughout the world. It could be trillion dollar worth foods wasted everywhere in the world, while only USA and UK waste $63 billion worth of food every year as referred to Sect. 3 above. These foods could be more than enough as required for saving people starving and dying for want of food.

The rich people of the poor countries also waste food unthinkably. In Bangladesh also, the riches waste foods at parties, hotels and at their respective homes, while at the same time some people go to sleep on the footpath by the side or close to hotels and apartments without eating any foods, and obviously many more starve at slums and distant rural areas.

Food-throwing is an interesting game in the USA that the kids all over the world watch in their favourite Disney Channel. This is an unethical game, and therefore should be illegal in the countries where such games are in practice. The people should be convinced to give away the money of their additional food to the hungry people. Consumers can reduce their food waste at point-of-purchase and in their home by adopting some simple measures. They should make accurate plan of their needs as far as possible and accordingly they should buy it from the market and should not store it for fear of scarcity. Spontaneous purchases are shown as often the most wasteful; proper knowledge of food storage reduces foods becoming inedible and thrown away. We have to find out appropriate mechanisms to stop food waste beginning from the plantation through food processing. Then, appropriate laws should be promulgated in every country to stop the practice of readymade food waste, and at the same time mass awareness should also be created on this, or otherwise the hungry people may once snatch foods from the riches as the latter are very few. The 25% wealth of the world belongs to only 0.13% people and the rest 75% belongs to 99.87%.[22] Ninety-five percent of developing country population live on less than US$10 a day and according to 2005 population, they were just 79.7%.[23]

### 6.2.4 Obesity Control

Obesity also seems to be a bad effect of the protectionism. The major contributory factors for obesity include the high fat and calorie content of snacks and fastfoods and a growing culture of over-eating. Obesity is a two-way problem – as it is resulted in from the increased consumption of food, it is similar to food wastage and secondly it is a complex health and social problem for which billions of dollars are being spent everyday throughout the world. In USA alone, the daily expenditure due to obesity related diseases is about US$125 million and on weight loss is US$55 million.[24] Obesity has been linked to raised incidence of premature death as well as several serious medical conditions, including type 2 diabetes, insulin

[22] www.globalissues.org/article/590/corruption#RichCountriesinvolvedincorruptionabroad

[23] www.globalissues.org/article/590/corruption#RichCountriesinvolvedincorruptionabroad

[24] http://www.treehugger.com/files/2008/05/britons-waste-food.php

resistance, heart disease, high blood cholesterol, high blood pressure and stroke. It is also a risk factor in higher rates of certain types of cancer, as well as fatty liver disease, vascular disorders, thrombosis, obstructive sleep apnea, musculoskeletal problems and gastroesophageal reflux. Abdominal obesity is associated with insulin resistance syndrome and cardiovascular disease. So giving up high-calorie eating habits and extra food than actual requirement can only help reduce the rate of obesity that ultimately will help save money spent in medication as well as the extra food/food cost which could be contributed to the concerned government to help out the poor in own country or elsewhere in the world through UN.

### 6.2.5 Food Safety

All kinds of food should be 100% pure and safe for consumption. In many developing countries like Bangladesh, food traders are so dishonest that they use harmful chemicals in many food items in order to keep them longer time in the market for maximizing their profits. As for example, in Bangladesh, many traders use formalin in fishes, fruits, vegetables and milk which threat human health (Haque and Mohsin 2009). Such practice is common in other developing countries as well. In January 2009, a Kenyan court ordered to destroy US$8 million worth of maize because it was found positive for unacceptable levels of Alfa-toxin which was unfit for human consumption (Ruth 2009). Mixing unacceptable levels of melamine in milk powder by some unscrupulous Chinese traders caused deaths of some young children with many others ill in their own country as well as in some other areas of the world in recent years (Chen 2009).

### 6.2.6 Well-Planned Market System

A well-planned distribution system may help facilitate the process of getting food delivered equitably across the globe. To maximize the effectiveness of any food security programme, the supply chain must be determined but adaptable to sudden changes both at home and abroad. In order to ensure it, a strong network of monitoring system and surveillance should be built and led by the UN in collaboration with the concerned governments with the focus of ensuring food for all. As the prerequisite in making the supply chain efficient, the transportation cost should be cost-effective and market institutions should be developed accordingly enabling them to meet people's demand (Ruijs et al. 2004). This will help bring equilibrium in the market price beginning from producers to the consumers, which means the producers will have a chance to get fair price for which he will produce more and it will create opportunities for consumers in the short supply areas to purchase the products at a reasonably fair price. For want of these facilities, lots of vegetables are damaged every year in Bangladesh and other developing countries. In 2010 also, Bangladesh has lost tons of potatoes and tomatoes just for want of transportation and storage facilities.

### 6.2.7 No Bio-fuel

When food security has deteriorated since 1995 and 25,000 people are dying without having any food, some developed countries in the name of energy saving are increasingly making fuel from food crops and are arguing in favour it. They said dumping their extra food to the poor countries is not the solution to save hungry people – this is all about trade, if the poor can produce something, they can buy it at a fare price (BBC Radio, 4 Oct 2100BST 2009). But that is only possible when they have that much capacity. If they do not have food to eat for the whole day or have food only for once a day without sufficient nutrition and do not have education, training and/or capital, how can they produce something? They must be saved first and be nourished enough to make them useful to do something. There may be more arguments in favour of making biofuel, but this is one of the major challenges threatening present and future efforts to overcome food insecurity (Tirado et al. 2010). It could be compared with the following situation: a child is drowning in a pond and adults are seen passing through without even thinking of rescuing the child. Can we even imagine this situation? Not at all, and similarly we cannot think of producing oil from our crops particularly from staple food crops keeping millions of people hungry. If, however, it can be made of solid, liquid and gaseous forms of biomass, and the biomass does not contain any food crops and does not degrade environment, it could be an alternative way of subsidizing fossil fuel.

### 6.2.8 Economy Lifestyle

All human beings are not equally talented and cannot earn wealth equally. All countries also do not have equal opportunities for their people to earn money according to their capacity. The manmade discrimination has made the Earth divided into so many groups, and hence some people are making huge money and spending lavishly beyond their needs, and on the other hand some are not even getting food to survive. If the lavish lifestyle is changed to economy style, and the extra income is given away for the people who are unable to earn for any reason, there will be no hungry people in the world. This is our holy duty to see if anyone of our neighbours is hungry. We people have conscience and capacity to judge right and wrong, and as human beings we should always choose the right. Maintaining luxurious life is never good while other people of our surroundings need food to survive. The religious books, like Quran, also have clear guidelines to help others, and as many people of the world believe in religion they should follow those guidelines. As for example, some verses of Al-Quran maybe cited here – ‘Give to the near of kin his due, and also to the needy and the wayfarers’. ‘Do not squander your wealth wastefully; for those who squander wastefully are Satan’s brothers, and Satan is ever ungrateful to his Lord’ (Al-Quran, 17:26–27). But what do we see in the motherlands of Islam – Saudi Arabia and other Arabian countries – just opposite to the verses of Al-Quran. We see when a Mercedes Benz is made of gold or an excursion boat is made of luxurious metals, those are perhaps bought by an

Arabian Sheikh,[25] while their neighbours in Sudan, Ethiopia, Somalia and other countries are dying for want of food. If and when guidelines of religious books and good advices cannot make changes of our minds always to choose the right, all countries should make and enforce some rules to make changes in the lifestyles of rich people and impose heavy taxes, a certain percentage of which could be put into the fund to save poor people. Or, a separate tax could be imposed particularly for the poor fund.

### 6.2.9 No War

War is the enemy of all living beings. When there is a war between two or more countries, not only living beings, everything is destroyed, especially in the land of the defeated country. Their men are killed, women are raped, animals are either killed or looted, infrastructures are damaged and wealth is looted. And thus, the children and aged who survive suffer a serious setback and cannot stand on their foot without the help of others. Let us look at the casualties in the World War I. This War affected all people of the world and about 16 million people were killed and another 21 million were wounded. The deaths included 9.7 million military personnel and about 6.8 million civilian. The estimates of the total casualties, however, vary due to the fact that many deaths went unrecorded. According to many other sources, some 60 million people died in the War, including 20 million soldiers and 40 million civilians. Many civilians died of disease, starvation, massacres, bombing and deliberate genocide as per the report.[26] The Soviet Union alone lost around 27 million and this figure is almost half of all deaths in the World War II.[27]

So, the Security Council of the UN should come to a consensus against war and should take stringent measures against the country responsible for war. If a member of the Security Council is responsible, other member-countries must boycott him and that very country should severely be penalized and isolated from the world. Reducing military expenditure alone can also feed all hungry people of the world. We have known that US$1.4 trillion spent a year for military[28] which can feed one billion hungry people for about 4 years (one dollar/person/day). Iraq war spends $2.0 trillion, whereas Mr. Bush fired his economic adviser Lawrence Lindsey who predicted that the actual costs might be closer to US$100 billion or even US$200 billion. The White House called those figures grossly exaggerated and swiftly fired Mr. Lindsay.[29] The amount of money spent in Iraq War could feed one billion people for 5 years.

[25] http://friendfeed.com/shey/159bc3ee/mercedes-fully-built-in-white-gold-body-abu

[26] http://en.wikipedia.org/wiki/World_War_I_casualties

[27] http://en.wikipedia.org/wiki/World_War_I_casualties

[28] http://harvardmagazine.com/2006/05/the-2-trillion-war.html

[29] http://harvardmagazine.com/2006/05/the-2-trillion-war.html

### 6.2.10 No Ethnic Violence

Ethnic violence is another major cause of poverty and hunger. From the very beginning of the existence of human beings in the Earth, the strong groups of people tend to dominate the weak ones. This human nature is no different than animal. Though we claim ourselves civilized, but in true sense we are not. We still dominate over the weak and it persists everywhere in the world in one hand, and the rich and powers are dominating even outside their territory. Till 12 May, 2009 thousands of innocent people have been killed both by Tamil Rebels and the Sri Lankan troops as reported by different newspapers.[30] This may result in poverty and hunger for lots of people in the violence-prone Northern region of Sri Lanka. Sudan is another example where ethnic violence made lots of people homeless, landless and foodless which led many to die. This violence has to be stopped everywhere at any cost. The UN can play a vital role to stop it everywhere in the world. If any country represses its own people, the UN should apply force to get them out of repression.

### 6.2.11 Population Control/Management

Most of the poor countries have over-population. More particularly in developing countries, most poor families have more people than they can feed. In poor Muslim countries, the situation perhaps is the worst. In case of Bangladesh, this is the root cause of hunger, malnutrition, chronic diseases, illiteracy, social unrest and corruption. In accordance with the UNICEF's 2008 statistics, the total population of Bangladesh was 160 million. The size of the country is about 55,000 square miles area which is equivalent to the size of Wisconsin of the USA. The annual growth rate was still 1.6 which must be reduced to the replacement level. The overarching strategy of family planning programmes is to offer clients easy access to a wide range of affordable contraceptive methods through multiple service delivery channels in a good quality reliable fashion. It would be more effective if demand-based reproductive health commodity could be delivered (Gazi 2010). So population control is a necessity for the poor countries to fight against hunger. On the other hand, the rich countries with less population like Singapore, Australia, Canada and USA should allow people to migrate from the over-populated countries like Bangladesh and others.

### 6.2.12 Corruption Control

Corruption is also a major cause of poverty and hunger throughout the world as it reduces the net income of the poor, and damages programmes related to their basic needs. Corruption is a serious impediment to overall development of a country. The

[30] http://www.thedailystar.net/newDesign/news-details.php?nid=87872

risk and threats of corruption are increasingly taken into account in the design of national development programmes. In the developing countries, particularly in Asia and Africa, it is like a chronic infectious disease. Though the invasiveness of corruption in Bangladesh has been reducing slightly in the recent years, it may still be the biggest barrier in all development activities here. The country ranked number one in the list of corrupt countries of the world for five consecutive years from 2001 to 2005, but thereafter a slight improvement has been in effect. The Corruption Perceptions Index (CPI 2009) prepared by the Transparency International (TI) showed that Bangladesh ranked 13 in 2009 together with Belarus, Pakistan and the Philippines (139th among 180 countries).[31] But the improvement is not significant yet. In order to make further improvement the government needs to pay special attention to the effectiveness of key institutions like the Parliament, Anti-corruption Commission, Election Commission, Public Service Commission, Information Commission, Judiciary, law enforcement agencies and the Human Rights Commission. Other countries enlisted in the CPI of TI should also need to make such institutions of their respective countries effective to wipe out their corruptions.

The countries enlisted in the CPI of TI as most corrupt, however, alone are not responsible for their own corruption. In order to involve with business and make money, sometimes developed countries farms inject corruption into those countries through their local agents and it is inflicted all levels of the society from local to national government, civil society, judiciary, business and military. International financial institutions lending systems are also responsible for creating corruption in a poor country.[32] Thus, the respective rich countries should have control over their farms and business conglomerates to refrain them from doing any malpractice elsewhere, and they should also have strong commitment to their people to minimize the corruption with a mission to eliminate corruption from all over the world.

### 6.2.13 No Military Administration

Military administration is another major cause of corruption that resulted in poverty and hunger. As they are not responsible to the people, they usually tend to resort corruption in every sphere of government institutions. In military administration, democracy is locked into the cantonment, right to information is looted, justice is denied and humanity is killed. They always seize state power in the name of controlling corruption of the civilian government, but at the end of the day, they rather institutionalize the corruption as they do not need to face public. Bangladesh is an example of it where military administration took over the power several times soon after its independence in 1971. Myanmar is the current example where many people are struggling to survive when the rulers are maintaining lavish lifestyle. According to the CPI survey of TI in 2009, Somalia, Iraq, Afghanistan and Myanmar ranked number one corrupt countries

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[31] http://www.transparency.org/publications/publications

[32] http://www.globalissues.org/article/590/corruption#RichCountriesinvolvedincorruptionabroad

in the world with scores under 1.5 out of 10.[33] This indicates that the military ruling also inflict corruption as in the war-torn countries like Iraq and Afghanistan. So, all countries of the world should non-cooperate the militarization. The UN, with support of the rich and powerful countries, should create tremendous pressure on the military governments to bring back democracy in their respective countries.

### 6.2.14 Fight Diseases

Though poverty itself is the most strongest and widespread killer disease, other major killer diseases, such as HIV/AIDS, TB and malaria significantly contributes to poverty and hunger. These diseases are either keeping enormous people out of work or killing healthy earners of so many families in the world. Massive intensive programmes led by WHO can improve the situation significantly. The concerned countries should also have their own plan to eradicate those killer diseases.

### 6.2.15 Proper Education and Training

Education is the backbone of a nation for its development. But it must be appropriate and pragmatic. After taking care of other basic needs, proper education is the most important resource for a person that can help him/her earn food and other basic amenities. Education is one of the five basic human rights set by UN in its convention, and the concerned government must ensure it for its people. If it is unable to do so, the UN should take the responsibility to guide/help that particular government. If people are trained and educated and guided properly for employment or income generation, they can survive by virtue of their own merit. We should remember that if opportunities and skills match, people can earn more than they need.

### 6.2.16 Right to Migration

This should be the basic right number six after food, clothes, health, housing and education as defined by the UN Charter of Human Rights. No one should be refrained from migrating to his/her choice of destination. If the restriction imposed by the rich countries is withdrawn, it will create a balance of population throughout the world and through providing right to work and fair distribution of wealth in the migrated land, poor people can change their lot with minimum help from the state concerned. The UN should take the lead to allow sufficient number of migrants to the countries like Australia, Canada, France, Germany, Italy, Japan, Singapore, Switzerland, UK, USA, and elsewhere who have plenty of arable lands kept unused for want of sufficient population. Not only in arable lands, the developed countries

[33] http://www.transparency.org/publications/publications

should create more jobs taking care of the environment and invite people from the developing countries to employ. It will help not only survive the poor people, but also the economy of the concerned countries. The countries, however, must be fair in providing the basic amenities including justice to the migrants.

### 6.2.17 Industrialisation and Job Creation

Planned industrialization in phases keeping environment in mind could help develop the economy of a poor country, and fair distribution of wealth can lead to improve the lot of poor and hungry people. It will help create new jobs for more people to earn. Jobs should also be created by installing sustainable development projects. The concerned countries should make their own plans best suited for their people and environment. They should also make such a congenial atmosphere so foreign direct investors are attracted to invest their money for industrialization. The UN should also have panels of experts in various fields, and they should extend cooperation to the countries concerned according to their need of industrialization and job creation. The process of industrialization may continue simultaneously with the implementation of the short-term plan of saving hungry people.

### 6.2.18 Reduce Greenhouse Gas (GHG) Emissions

Naked competition by the developed countries in boosting their economies through unplanned industrialization and ultra-modern lifestyle of their people contributed heavily to greenhouse gas emissions which resulted in climate change threatening to the existence of lower lands of the world due to sea-level rise caused by melting glaciers. The climate change is fast changing the total environment of the globe, particularly the countries like Bangladesh, the Maldives, India, Nepal, Sri Lanka, Indonesia, the Philippines and others close to sea-level. Scientists predict that about 30–40 million people of Bangladesh's coastal areas will be homeless by 2050 due to sea-level rise, frequent storm, loss of cropland, impossibility of farming domestic animals, poultry, etc. as a result of climate change, and the whole Maldives will probably be submerged. But unfortunately, these countries are seldom responsible for greenhouse gas emissions. Bangladesh contributes only about 0.1 percentage point, whereas this poor country will possibly be the victim number one of climate change as pointed in the Climate Conference in Poznan, Poland in December 2008[34] as well as in the UN Climate Conference in Copenhagen in early December 2009.[35]

It maybe mentioned here that food production in South Asian countries is already being disrupted by flooding more frequently and more severely than before

[34] http://www.thedailystar.net/story.php?nid=66215

[35] http://www.prothom-alo.com/detail/date/2009-12-07/news/23764

due to climate change. The situation is likely to be worse than now in future as predicted by researchers worldwide (Douglas 2009). Measures of adaptation in one hand, and global commitment to reduce greenhouse gases by half by 2050 on the other hand, should continue simultaneously. Adaptation programme must be supported by the rich countries as poor countries are negligibly responsible for green house gas effect.

### 6.2.19 Root Out Terrorism

Terrorism has been emerged throughout the world over the years. Many workable people have been the victims of terrorist attacks compelling their families in falling in poverty. It may be widespread in the coming days if the world leaders do not understand the root causes of its evolution and do not hit that point. Some groups of Muslims are meant for international terrorists. But they should be brought to the table of discussion and the world leaders through UN should listen to them, and try to address their lawful demands. Israel's invasion into the land of Palestine and their repression on Palestinians, US and their allies' invasion into the land of Iraq and their repression on the fellow countrymen, fighting with Talibans in Afghanistan, both India and Pakistan's ruling of Kashmir, repression on Burmese Muslims by the autocratic Junta ruler, and same or more severe nature of repression, including genocide in some other areas of the world like Serbia, might have created some reasons of the emergence of some groups of terrorists among hardcore Muslims. So, in order to eliminate terrorism we have to identify the root causes, and effective steps should be taken to root it out from the society. The UN should take effective and sincere steps with support from the world powers to make a fair judgment for all parties. Strictest measures should also be taken to stop weapon sale to unauthorized groups or individuals other than the state concerned.

## 7 Finance

If the abovementioned challenges can be addressed, nobody will die of starvation. Though lots of funds will be required to save the hungry people of the world, money is never a problem for doing any good work. About a couple of years ago, a US national namely Randy aged 50 said 'If all my fellow Americans gave US$25 per household per month we could supply sanitary water and basic food provision for all starving people in the low-income countries. Most people say "It's not my fault!", and they are right; but basic humanitarianism says that if you can help, you should. Just like if you sea a child drowning in a pond. It's not your fault but you would certainly try to rescue the child unless you're heartless'![36]

[36] http://www.youtube.com/watch?v=1QA0MzAirpo

**Table 9.2** Collection of contribution[a]

| Source | Rate of contribution (US$) | Total (billion US$) |
|---|---|---|
| 5% of six billion people | 100 | 30.0 |
| G8 countries | 10.0 billion | 80.0 |
| 50 developed countries | 2.0 billion | 100.0 |
| Others | – | 10.0 |
| Total | – | 220.0 |

[a] It could be multiplied with the increased rate of contribution

In order to mobilize resources, the rich countries should enhance their yearly contributions to the UN which they can easily do by adopting stringent measures to save food and money from their respective countries. If necessary they can send a SOS (save our souls) message to all inhabitants of their respective countries, even the UN can send the same message to all people of the world. If only 5% out of the total six billion people contribute US$100 each, US$30.0 billion could be earned and if the G8 countries contributes at the rate of US$10.0 billion each, another $80.0 billion would come, if the next 50 developed countries each would come with US$2.0 billion that would total another US$100.0 billion and if Bill Gates, Ted Turner and some other billionaires would come forward to contribute another US$10.0 billion, the total would be US$220.0 (US$30bn+US$80bn+$100bn+ US$10bn) billion (Table 9.2). This US$220 billion can feed one billion people at least for 6 months.

However, the long-term plan cannot be initiated with a small amount of money. In order to streamline the long-term plan for survival of all hungry people, the rich countries should contribute a significant amount of money to the UN fund to make several hundred trillion dollars, and with the help of world renowned economists and planners, the long-term sustainable development projects should be initiated. Then, the money should be spent plan-wise through short-term planning by providing relief to malnourished until they are able to join the workforce and through long-term planning by establishing small, medium and large-scale industries, enhancing arable lands, increasing food production, creating jobs, allowing sufficient number of migrants to the countries like USA, Canada, Australia, UK, Germany and elsewhere who have plenty of arable lands kept unused, fighting killer diseases as well as meeting all challenges mentioned above.

In the implementation of the long-term plan, money should be given to the respective governments as contribution to a certain level particularly for the small-scale home-based industries like poultry farms and interest-free loan for large-scale industries taken care of by the concerned government. As stated in Sect. 6.2.15 of this article, proper guidance and training must be given to the people before giving away any capital to them for small-scale investment. There should also be a proper monitoring and evaluation system all through the process starting from providing training to the investment, production and marketing.

The governments will start refunding the loan once benefit will come out of their respective investments. The so-called microcredit programme with high rates of interest may not eliminate poverty and hunger from the world. Nobel Laureate Professor Muhammad Yunus' challenge to put the poverty into museums may not be possible unless the ultra-poor people are given relief up to a certain period of time, and investment is made for them plan-wise with strictest monitoring and evaluation system by their respective government who will be supervised by the UN. If Professor Yunus' formula were so pragmatic, Bangladesh would not have any poor in its land – Grameen Bank, Bangladesh Rural Advancement Committee popularly known as BRAC and other big non-governmental organizations (NGOs) working here would have eliminated the poverty by now. Anyway, this is another debate which can be made clear in a separate monograph.

The rich countries should also create more jobs and the migration policy should be made easier to allow people to go elsewhere according to their choice and expertise. Such a drive may help the UN meeting deadline of MDG targets by 2015, and dramatically change the world scenario of poverty and saving people from dying of starvation and malnutrition.

## 8 Conclusion

We have no choice but to save all the hungry people of the world. We have to join our hands and take oath to save them. As stated earlier, if any government cannot feed their hungry people for any reason, the rich countries individually or in any combination should come forward to feed them. This content of universal human rights has been strongly supported by Brian Barry in his article *Why Social Justice Matters* published in Polity Press, London in 2005 as quoted by the Nobel Laureate Amartya Sen in his book, *The Idea of Justice* (Sen 2009). All human beings have every right to live in this beautiful Earth fulfilling their basic needs. If we cannot help them survive, maybe we are not civilized. Because we preserve foods more than we need, we waste foods without thinking of others who need it to survive. If we do not change our mindset and behaviour and continue to do so, the rich nations may also be infected by hunger in the near future through large-scale invasions of hungry people into their countries. As stated above, the riches are very few and the 25% wealth of the world belongs to only 0.13% people and the rest 75% belongs to 99.87%.

Though leaders of the G20 countries in their London meeting in April 2009 pledged to come out of protectionism and vowed to help the developing countries, they could not prove their sincerity in doing so. The UN Food Summit held in Rome in the middle of November 2009 seemed to be a flop as none but only one-third of the world leaders including the host country attended it. Nevertheless, they unanimously adopted a declaration pledging renewed commitment to eradicate hunger from the face of the Earth sustainably and at the earliest date. We have to be stick on to this commitment to save hungry people of the world and to make a beautiful Earth for all people.

**Acknowledgments** The author gratefully acknowledges the contribution of Ms. Joanna Grzelinska, immediate past Senior Associate, Communications Unit, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) for her suggestions in literature citation as well as some micro-editing and rearrangement of the paper. The author also profusely acknowledges Mr. Md. Al Mamun, Senior Information Officer, ICDDR, B for his contribution to organize the references in accordance with the style suggested by the Publisher.

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# Chapter 10
# The Self-Reliant Country: Sustainable Agricultural Policy for Australia?

**Jane Shepherd**

**Abstract** Contemporary Australian agricultural and food policy is strongly neo-liberal, with market forces as the basis for resource production, consumption and distribution. The national policy framework endorses continually increased levels and scales of production by a self-reliant farming sector that is highly responsive to market signals. Insufficient consideration is given to the unpaid environmental, social, community and human-health costs resulting from industrial-scale agriculture. This chapter examines how neo-liberalism has shaped *Creating our future: Agriculture and food policy for the next generation* (2006): the key Australian Government policy document on these topics. The report was developed to ensure the profitability, competitiveness and sustainability of future Australian agriculture and food production. The chapter will consider how pervasive neoliberal ideology determines many facets of agricultural policy, from attitudes to production, the development and expansion of markets and use and abuse of natural resources. Attention will be paid to the absence of a clear definition of 'sustainability' and 'sustainable agriculture', and the implications for future management and stewardship of the Australian environment. A conclusion is reached that the neo-liberal agenda is too limited to underpin policy designed to address the significant environmental, health and social future needs of the Australian agricultural environment.

**Keywords** Agricultural policy • Australia • Neoliberalism • Sustainable agriculture

## 1 Introduction

The limiting effects of neo-liberal ideology on sustainable agricultural policy and practice in Australia warrant attention. This chapter, therefore, analyses two of the four sections of the 2006 Australian national policy document *Creating our*

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_10,

*future: Agriculture and food policy for the next generation* [COF] (AFPRG 2006). It examines how the language of 'sustainability' is used and the policy expectations that result. Also, it questions whether that platform can lead to the development of sustainable agriculture. First, however, the historical background the document ultimately addresses is sketched.

## 1.1 Historical Background

Australia has a developed economy with the export profile of a peripheral economy. Agriculture and agricultural related services contributes 3% to gross domestic product. In addition, agriculture occupies approximately two-thirds of the continent's landmass. Yet more than 60% of that land is arid and semi-arid rangeland, much of it used for marginal sheep- and cattle-grazing. Even so, Australia currently exports around two-thirds of its farm output (AFPRG 2006:37). With a population exceeding 22 million (ABS 2010), our agricultural industries produce food for an estimated 55 million (Hamblin 2009:1195).

Also, Australia is the only continent not to have experienced a period of agrarian agriculture. From the late eighteenth century, land management by indigenous Australian hunter-gatherers was directly replaced by industrial agriculture: first, wool-producing pastoral 'runs', and later grain production (Symons 2007: 6, 7). Large-scale farming methods developed in the English agricultural revolution, used in the eighteenth and nineteenth century, continued in the twentieth. As was typical for countries with developed economies, Australian farmers were subsidized to increase production after World War II and throughout the 1950s and 1960s. By the end of this period, agricultural supply exceeded demand. The policies that subsidized increased production encouraged farmers to push the productive and ecological capacities of their land to the limit (Lawrence 1987:58–66).

Neo-liberal agricultural policy developed from 1972. It was part of a 'widespread push for deregulation' commensurate with the 'abandonment of a Keynesian policy regime in advanced capitalist economies' (Higgins 1999:136). As a political economic theory, neoliberalism 'proposes that human well-being can best be advanced by liberating individual entrepreneurial freedoms and skills within an institutional framework characterized by strong property rights, free markets and free trade' (Harvey 2005:2). Market reform – including the removal of subsidies and protection – were important components of integration into a deregulated global economy (Vanclay 2003:81). The role of government moved from state sponsorship to the promotion of high-productivity agriculture achieved by increased economies of scale and greater efficiency (Dibden and Cocklin 2005:136). But lower produce prices and rising input costs left farmers, who could not afford the capital investments necessary to increase efficiency, struggling to remain profitable (Higgins 1999:135). Rural reconstruction schemes, therefore, supported 'productive' farmers to increase landholdings and restructure debts, providing assistance for 'un-productive' farmers to leave the land (Vanclay 2003:84; Higgins 1999:135).

This continued through the 1980s. Such policies led to reduced numbers of small and medium sized farms (Thomas 2008:51). It encouraged large, corporate industrial agriculture, characterized by 'horizontal and vertical integration… [into a] total food system' (Lawrence 1987:139). New contractual arrangements for growers also set quantitative and qualitative targets that led to excessive use of agricultural chemicals (Vanclay 2003: 86).

Now, the neo-liberal agenda that has transformed global capitalism in the last 30 years (Harvey 2005:5) is deeply embedded in Australian agricultural policy. It has become hegemonic at home and it dictates Australia's negotiating position abroad. At the World Trade Organization (WTO), for example – itself a neo-liberal institution – our position 'unlike the US stance, appears to accurately reflect a domestic situation in which market liberalism has attained almost unchallenged hegemony' (Tilzey 2006:9). Pressures on the environmental health of farm-land have continued to increase where farmers must produce in a highly competitive global economy against heavily subsidized produce from other countries, particularly the European Union (EU) and the United States. This is a significant issue in Australia where many of the ecosystems are fragile, and 'droughts and overstocking caused enormous erosion losses' (Hamblin 2009:1203).

## 2 Sustainable Agriculture and Food Production

For the last three centuries, global expansion of large-scale industrial farming has substantially increased food production, reduced food insecurity and improved health for many populations (McMichael et al. 2007:1253). Australia has played a significant role in this. But industrial agriculture has negative environmental, social, human health and animal welfare effects (Jacobson 2006; Singer and Mason 2006). Rising food prices reduce food security for poor populations (Nellemann et al. 2009; FAO 2008; Holt-Giménez and Peabody 2008; Gardner and Halweil 2000). Excessive calorie consumption elsewhere leads to pandemic levels of obesity (WHO 2007; FOA 2002; WHO 2000; Gardner and Halweil 2000) with high future health costs (Access Economics 2008, 2006; HOCHC 2004:122–130). By contributing to the low-cost of calorie-rich food, subsidized industrial agriculture has exacerbated obesity (IATP 2007b, 2006). Also, there are global relationships between food production, energy consumption, emissions and climate change outcomes (Nellemann et al. 2009; McMichael et al. 2007:1253). Worldwide, agriculture therefore faces immense challenges in the immediate future (McMichael et al. 2007; Patel 2007; Pretty 2002; Wirzba 2003).

Powerful economic and political forces support existing systems (Robbins 2008; Patel 2007; Tilzey 2006:6, 7; Vanclay 2003:82, 83). But emerging and divergent social movements, farming practices and government policies provide alternatives that are generally referred to as 'sustainable agriculture'. Definitions of the term are grounded in spatial, temporal, cultural and economic specificities. Frameworks employed for definitions of sustainable agriculture are divergent (Pearson 2007:410).

Usage of related terminology and concepts, such as 'sustainability', are diverse, overlapping and frequently contested (Benton and Short 1999:132). Sustainable agriculture requires multiple outcomes, many of which are not specific to agricultural production itself (Pannell and Schilizzi 1999:57).

Some positions incorporate theories from broader sustainability discourses. Ideas of justice – some biocentric, others anthropocentric – can also be used. Environmental concerns can be combined with human, social, and economic interests, or with the protection of non-human species and their rights (Dobson 2003). Intergenerational equity and opportunity as a core principle of sustainable development, established by the Brundtland Report (WCED 1987), is also a common theme. But in definitions of sustainable agriculture, intergenerational equity and opportunity occurs more frequently for developing than for developed economies (for example: Via Campesina 2007; Haroon Akram-Lodhi 2007; Rosset 2003).

For developed economies, the term 'sustainable development' is often used without definition, as an intellectually empty catch-cry (Luke 2005:228). An implicit environmental moralism may generate 'sustainability' policies and programs, but these are 'only vaguely attached to its core concept' (Yanarella and Bartilow 2000:123). Moreover, 'sustainability' is rarely defined in statements and policies on sustainable agriculture. The word 'sustainable' is simply used as a qualifying adjective that apparently speaks for itself. Thus, what is being sustained and for whom must be inferred from the type of agriculture described or proposed. Despite such complexity, 'sustainable agriculture' is considered a useful term and an 'emblem or banner that represents a broad range of related and important influences' (Pannell and Schilizzi 1999:57).

Many principles for sustainable agriculture, especially multifunctionality, are shared by activists and policy makers in developed and developing economies alike. Multifunctionality refers to a number of roles, other than economics and trade, that agriculture might play, including: food security, land tenure, the environment and rural social and community issues (Forge 2000). In the developed economies of the global North, multifunctional definitions of sustainable agriculture emphasize environmental, social and cultural components. Over the last 15 years, policy reforms by the European Economic Community, then the EU, and their member-states, including England, have endorsed multifunctionality (for a discussion concerning Europe see, Thomas 2008:50, 51; Rozin 2005:627; Schmid and Sinabell 2007; for England see DEFRA 2005). Bastian and Lütz (2006) offer a characteristic set of new principles for European agriculture:

> minimise input of production means from outside a given farming system;
> as far as possible, controls pests and disease by internal regulation;
> guarantee food quality and animal welfare;
> ensure agricultural landscape diversity and multifunctionality, including ecological, economic and social values and functions (2006:15).

By contrast, Australia has no sustainable-agriculture policy. The Department of Agriculture, Fisheries and Forestry does, however, have 'an environmentally sustainable Australia', and 'promoting and maintaining good health' as two of its four national and rural research priorities (AFPRG 2006:79).

## 3 Analysis: Creating Our Future. Agriculture and Food Policy for the Next Generation

The report was released in February 2006. Its terms of reference required 'broad recommendations to improve the profitability, competitiveness and sustainability of the Australian agricultural and food sector' (AFPRG 2006:198). The Reference Group was required to consult widely with industry stakeholders; '[to] identify the major issues and challenges facing the sector'; and '[to] identify outcomes necessary to enhance the profitable and sustainable growth of the sector' (AFPRG 2006:198). 111 submissions were received: 99 from organizations and 12 from individuals.

At its heart was the financial well-being of Australian agriculture. Natural resource management, environmental impact and climate change mitigation and adaptation were considered with reference to that goal. Thus, the report's introduction notes that:

> Despite its impressive performance, the agriculture and food sector faces ongoing pressure. Businesses are challenged by variable seasons, the difficult international trading environment, increasing constraints on the use of natural resources, and strong competition for labour and capital (AFPRG 2006:35).

The Reference Group reviewed current agricultural and food policies to establish which policies would enable 'the sector to perform strongly over the next one to two decades' (AFPRG 2006:35). The four substantive sections of the Report were as follows: markets, competitiveness, natural resources and adapting to change. This analysis discusses the markets and natural resources sections.

### *3.1 Markets Section*

Current barriers to global markets and free trade faced by Australian agriculture are the first issues discussed. Australia has supported the WTO since its formation in 1995. Its mandate is to liberalize trade, and reduce tariffs and restrictions impeding global multilateral free trade. The Report endorses the removal of market distortions created by subsidized commodities, noting that 'the protectionist measures of the United States, Japan and the European Union distort global markets far more than those of developing countries' (AFPRG 2006:51). COF details Australia's need to pursue new, and to open existing global to regional markets. Tilzey (2006:5) describes this determination as 'introducing new discourses in the agricultural policy debate which emphasize international competitiveness and improved overseas market access'.

Throughout its discussion of markets and free trade, the COF report reveals a clear, albeit implicit, position on sustainable agriculture. It separates the sale of agricultural commodities, from negative social, economic or ecological effects resulting from the methods of production. COF supports and reinforces the WTO where human labour efficiency, not ecological or energy efficiency, 'constitutes the sole arbiter of economic viability in agricultural production' (Tilzey 2006:7). Indeed, the Reference Group explicitly endorses the WTO's neoliberalism under the sub-title 'Protectionist forces are stubborn'.

> Some WTO members and non-government organizations have also attempted to overload the WTO with non-trade issues that are not directly relevant to its objectives. These include environmental, animal welfare and labour standards, as well as the so-called multifunctional aspects of agriculture, such as landscape management, food security and the socio-economic viability of rural areas. These attempts to expand the WTO's mandate risk distracting the organization and weakening its capacity to deliver on trade liberalization (AFPRG 2006: 54).

However, not all WTO members believe that international agriculture should be understood exclusively in terms of free trade. Advocates of alternative, and especially multifunctional, models of sustainable agriculture do not believe the WTO is acting legitimately (Tilzey 2006: 9). Nations that support multifunctionality as part of agro-environmental governance therefore contest the WTO, even from within (Tilzey 2006:2). Australia, however, is opposed to broadening the discussion.

The Report brief considers the reluctance some developing countries have to accelerating free trade and open market as detailed by another neoliberal global institution: the World Bank. In 2002, the latter maintained that developing countries only stand to gain from free trade (AFPRG 2006:54). This is, in itself, a highly contentious – even tendentious – claim (IATP 2007a; Madeley 2002:115–128), especially given global statistical estimates that 1.1 billion people were underfed by 2000 (Gardner and Halweil 2000).

Since COF's terms of reference require policy to ensure 'the profitability, competitiveness and sustainability of the Australian agricultural and food sector' (AFPRG 2006: 198), it is not surprising that the document places such a high priority on markets and free trade. Nor is it surprising that sustainability is linked with profitability throughout the document (AFPRG 2006:1, 2, 21, 34, 68, 76, 82, 107, 140, 142,162, 176, 198, 201). That profitability will also be achieved through competition.

> The best protection against the development of excessive margins in the marketplace is vigorous competition. Competition is enhanced where there are no artificial barriers to new businesses entering a market, and when participants can turn to alternative suppliers of raw materials or customers for their product (AFPRG 2006:71).

## *3.2 Natural Resources Section*

The environment and its associated ecosystems are central to sustainable agriculture. This section of the Report describes the Australian agriculture-environment relationship in this way.

> Australia has a unique natural environment that supports some of the world's most efficient agricultural industries. Farmers are custodians of almost two-thirds of Australia's landmass, and their management of the environment will have a direct bearing on the future sustainability and profitability of the agriculture and food sector (AFPRG 2006:140).

The section concentrates on government and community intervention in natural resource management. Three key areas are identified: future government resource management, public support for farmers to produce ecosystem services and water use. The terms 'sustainable agriculture', 'sustainable farming practice' and 'sustainable land management' used throughout this section, are nowhere defined (AFPRG 2006:140–144, 146, 147). This can fairly be called a major oversight, given (a) the contested meanings of 'sustainability', inside and outside government and (b) the scale and significance of the Report's topic. Without specification, terms become actively problematic. The Report may be used to justify what is, by world standards, unsustainable practice.

The Report notes that agriculture and the environment are interdependent foundations for effective resource management. Yet, it fails to provide any information on that interdependence. The participation of farming enterprises in larger ecological systems is not discussed. Nor are the positive or negative contributions that farms can have on those systems. Similarly, the buffering and enabling that ecological systems provide for farming is ignored [ground water control, pollination, shelter, and so on]. No framework links the [agricultural] use, management and productivity of natural resources with government agendas for land, water and biodiversity. Approaches that maximize outputs while protecting and enhancing the very ecosystems that support farming are absent (for comparison see DEFRA 2005, 2002a, b). Each of these gaps is sizable. Together, they are very substantial, especially in policy discussions on agriculture and food for the next generation.

Altogether, the Natural Resources section provides no broad, coherent policy for supporting eco-agriculture systems together with healthy soil, biodiversity and primary commodity diversity. Scant regard for salinity, climate change and landholder responsibilities – not only their interests – limit the document's potential for guiding discussion on Australia's food and agriculture policy. Here, as throughout, the 'environment' is clearly subject to neo-liberal demands for productivity and profitability. The multifunctional underpinnings of sustainable agriculture are outside discussion. The environment provides no more than 'natural resources' and 'the ability of farmers to reflect environmental factors in their decision making is largely driven by profitability' (AFPRG 2006:141). As Hamblin explains, agricultural policies of this type 'maintain the productivity of the sector, but are ineffective in stemming associated environmental degradation, biodiversity loss and rural population decline' (Hamblin 2009:1195). A range of broader policy thinking had been publicly available by this time (for example see Phillips and Lowe 2005).

## 4 Limitations of the Current Agricultural and Food Policy Framework

This market-driven approach to Australian policy has particular implications for future land management, farming and rural communities. As Australia has endorsed the WTO's free-trade regime, the Report excludes any issues arising from multifunctional approaches that underpin the development of sustainable agriculture in other countries. As previously discussed, policy therefore emphasises ever-increasing levels of production, through the ability to manoeuvre in competitive markets with fluctuating commodity prices, while absorbing the escalating input costs of non-renewable resources. The platform pays scant attention to the fragility of the landscape systems that support agricultural production or alternative approaches for the future (Campbell 2008:56, 57; Larsen et al. 2008:37–55; Phillips 2006). For over quarter of a century, concerns have been raised about the consequences of industrial production methods where agriculture is seen only as a form of manufacturing (Berry 1996; Newby 1983:44).

Compared with this high-input/high-output model, multifunctional approaches developing in England and the EU emphasise strategies that enhance both human and environmental health. While they accept the ongoing role of market dynamics in the agricultural economy, such approaches seek to ameliorate the undesirable outcomes of subsidized, high-production agricultures. Multifunctional strategies establish environmental, social and economic practices that encourage diversity in food production, a healthy diet for all populations, ensuring good food quality and animal welfare (DEFRA 2002a, b, 2005, 2006; Lang et al. 2002; Lang and Rayner 2002).

The current Australian framework seriously constrains the development of approaches that would enable states and regions to coordinate and collaborate on land management, thereby protecting water quality, soil health and biodiversity. It does not examine the displaced costs associated with current and past agricultural practices. Political, social and market-related impediments – repeated and embodied in current policy – thwart Australia's progress to sustainable, policy-led stewardship and use of natural resources. As a matter of some urgency, climate change has emerged as a significant challenge for future policy-making. Australia has many agricultural industries and associated ecosystem types that are particularly vulnerable. The scale and uncertainty surrounding regional climate-change effects will require integrated, regional responses.

## 5 Conclusion

The neoliberal ideology informing current Australian agricultural and food policy inherently limits progress toward sustainable agricultural practices for Australia. This ideology has persistent and deep assumptions about the positive benefits of free trade, open markets and private property rights, normative assumptions that are now accepted throughout the world (Lamy 2008:131; Hobden and Jones 2008:152). Indeed, they are written into the terms of reference for *Creating our future: Agriculture and food policy for the next generation*: to 'improve profitability, competitiveness and sustainability' of the sector (AFPRG 2006:198). The platform is firmly focused on the first two terms: 'profitability' and 'competitiveness'. Neither the meanings nor the intentions of 'sustainability' and 'sustainable agriculture' are specified. The current framework does not actively support environmental and social sustainability in rural Australia (Tilzey 2006:12). Eventually, this will affect even the economic sustainability of the sector. If sustainability is to become a meaningful term in the future, Australia will need to embed ecological, economic, social and health considerations into agricultural policy (Pearson 2007; Tilzey 2006:19; McMichael 2005). Moving from neoliberalism to multifunctionality could be a liberating first step.

**Acknowledgements** Thanks to Alistair Phillips, Department of Sustainability and Environment, Victorian State Government for assistance with the Natural Resources section; and to Dr. Jonathan Carter for advice on the original conference paper.

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# Chapter 11
# LCA Potentials and Limits Within a Sustainable Agri-food Statutory Framework

**Geneviève Parent and Sophie Lavallée**

**Abstract** The Life Cycle Analysis (LCA) of products and services is a tool created to assess the environmental impact of a product, process, services or system by taking into account every step in its life cycle. Mainly used for the analysis of environmental impacts of products and industrial services, a growing number of studies incorporating LCA are focusing on the agri-food production sector. At a time when the agri-food statutory framework must take into account the environmental impacts of the activities that it encompasses, it seems worthwhile to question whether or not LCA may contribute to a sustainable agri-food statutory framework, especially by promoting agriculture more friendly to the environment and those who work in this area.

**Keywords** LCA • Sustainable development • Sustainable food security • Agri-food law • Agri-food statutory framework • Environment

## 1 Introduction

The “agri-food statutory framework” is, by its very nature, intimately related to the environment and its protection. It springs from how the environment, the earth and its abundances, animal resources and their derivatives, are used. This legally-oriented designation is more all-embracing than traditional “rural law”, “agrarian law”

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_11,

or "agricultural law". It extends not only beyond the contractual relationships of farm operators, but also beyond standards for production and processing as well as the related sanitation issues. This also includes product packaging and labelling, marketing and transportation, agricultural land resources management and market consumption.

As such, an "agri-food statutory framework" has been conceived as a social factor in making the concept of food security operational as set forth at the *World Food Summit* (FAO 1996). It encompasses in its broadest conception the three components inherent in sustainable development: the economy, the environment and the social factors (Parent 2005; Duhaime and Godmaire 2002).

The agri-food statutory framework should also take these constituents into account so as to participate in food security that is sustainable and not only punctual or conceived in a fragmented manner.

While the existence of a "statutory framework for sustainable development" is still uncertain, the issue of questioning "sustainable development within a statutory framework" remains pertinent, and even more so within the agri-food statutory framework when one considers the close relationship it has with environmental issues. It is from this standpoint that we approach environmental methodology that underlies "the life cycle analysis of products and services" (LCA).

Is it conceivable that an agri-food statutory framework might play an even more important role in sustainable food security? May it contribute to the promoting of agriculture that is more respectful with regard to the environment and the people working in this field? What potentials and limits can be found in this tool? We shall attempt to address these issues from an essentially legal approach, yet one that necessarily remains open to all other sciences owing to the subject matter at hand. The first part of this chapter analyzes LCA as a method for the development of a more sustainable agri-food statutory framework. The second part reviews current LCA applications in agricultural production and food processing. Finally, the third part deals with the intrinsic and extrinsic limits of LCA owing to the challenges brought on by the specificity of the agri-food sector and the legal framework governing it.

## 2 LCA as a Tool for the Development of a Sustainable Agri-food Statutory Framework

LCA is a tool developed for the purpose of operationalizing "life-cycle thinking" (Sect. 2.1). Its methodology sets it apart from other analytical methods used on environmental impacts. Its understanding is essential in order to analyze its potentials within the agri-food statutory framework (Sect. 2.2).

### *2.1 "Life-Cycle Thinking" Within LCA*

"Life-cycle thinking" implies, as in the case of human beings, that any product, processes or production system comes into existence, lives its life, then dies and in doing so, evolves from one phase to the next while generating social, economic and environmental impacts (Desjardins 2007; PNUE/SETAC 2005). This vision necessarily leads to an overall encompassing of products, processes or production systems. It implies that the responsibility of those who interact in the production and consumption of goods extends beyond the life phase of the product with which they are involved. As such, the life-cycle viewpoint stands in contrast to a sectoral or piecemeal approach to environmental challenges, and thereby makes it possible to sidestep the shifting of environmental impacts to other phases in the life of a product (Lavallée and Normandin 2003).

LCA assesses the environmental impact of a product, process, service or system by taking into account all phases in the life cycle of the product. While its origin in time does not meet with general consensus, the number of references to this tool in international texts that appeared following the year 2000 bear witness to the escalation that LCA has experienced during the previous decade (Desjardins 2007). This growth has in fact brought about the drafting of international standards, namely the series of ISO 14040 standards and sequentia, in order to harmonize the various methodologies that have been used to perform LCAs.

## *2.2 The LCA Methodology*

Since LCA has proven its worth by assisting decision making related to the production of goods or the proposing of a service, it therefore offers a promising avenue for the constitution of a national or even international legislative environment.

A short presentation of the different steps leading up to the materialization of an LCA is essential for analyzing the potentials and limits of this tool for the development of a sustainable agri-food statutory framework.

Distinct phases are taken into account when performing an LCA. These include the extracting of raw materials, production or manufacturing, packaging, distribution, consumption, use, disposal or recycling (Lavallée and Normandin 2003).

A fully developed LCA is carried out in four steps. The *first* one defines objectives, stakes out assessment boundaries, identifies designated parties as well as the targeted public. Its purpose is to determine "the functional unit" to which emissions and extractions will then be assigned (Jolliet et al. 2005; Lavallée and Normandin 2003). The *second* step consists of quantifying all input and output flows from the system under study, on the basis of detailed data from private, governmental and university sources. This step encompasses the inventory of input and output quantities, which makes it possible to answer the following questions: *What quantity of energy is required to produce, distribute and use the product? What substances are used during the life phases of the product? What are the derivative products, waste and pollutants released into the environment (water, air and earth)?*

The *third* step involves the assessment of impacts from various input and output flows and quantities of energy estimated in the previous phase in order to determine what stages and constituents generate the most impacts and how they may be characterized (Lavallée and Normandin 2003). According to ISO standard 14042, ten impact categories are generally taken into account in an LCA: global warming, stratospheric ozone destruction, formation of photo-oxidizing (smog) agents, acidification, eutrophication, ecotoxicological impacts, toxicological impact on human beings, uses of abiotic resources, uses of biotic resources and uses of land. Many of these impacts relate directly to food quality and the concepts of sustainable food security, and even sustainable agriculture.

The *fourth* and last step involves the interpretation of data collected during the previous three steps. In addition to evaluating the quality of results, this step makes it possible to analyze the opportunities in terms of reducing environmental impacts and increasing the economic return of a product or service by a "more efficient use of energy and a reduction or replacement of raw and secondary materials" (Lavallée and Normandin 2003). Herein lays the opportunity to propose alternative solutions.

## 3 LCA Possibilities Leading to the Generation of a More Sustainable Agri-food Statutory Framework

LCA is a decision making tool assistant because it contributes to the analysis of environmental impacts of products and services throughout their life cycle. It enables decision makers to find alternatives so that their products are more respectful of the environment.

An ever increasing number of analyses use LCA in the agri-food sector. Since a complete nomenclature of all applications is beyond the scope of this chapter, a succinct review of agri-production (Sect. 3.1) and food processing (Sect. 3.2) applications is presented in order to assess the potentials for designing a more sustainable agri-food statutory framework.

### *3.1 Current Applications of LCA in Agricultural Production*

The first LCA applications in agricultural production targeted renewable energies such as biofuels, which were compared with, among other things, traditional fuels (Hayashi et al. 2005; Puppan 2002). In its role as a producer of raw material required for bio-energies, the farming sector is including these studies only as one of the targeted publics, as are the producers of biofuels and the oil industry.

However, since the mid 1990s, a large number of research projects, mainly conducted in Europe, have been applying LCA to agricultural production (Hayashi et al. 2005). They notably target dairy production (Cederberg and Mattsson 2000), sugar beet production (Brentrup et al. 2001; Bennett et al. 2004), cereal production (Hayashi et al. 2005) and tomato production (Antón et al. 2005; Van Woerden 2001), then focus their attention more generally on horticulture and biological production (Hayashi et al. 2005).

Some studies establish comparisons between agricultural production systems, whether they be conventional, biological or biotechnological (Bennett et al. 2004), while others compare the use of different fertilizers in the production of beets or wheat (Brentrup et al. 2001). Still others draw a parallel between biologic production and methods recognized and used in an agricultural environment, such as the "Good Agricultural Practices" (GAP) developed and defined by the FAO as "practices which concretely contribute to environmental, economic and social sustainability of on-farm production resulting in safe and healthy food and non-food agricultural products" (Agriculture Committee 2003; Bassett-Mens and Van Der Werf 2005).

Nonetheless, little does the field of interest of these studies matter, it may be noted that they rarely examine agricultural production in its entirety, but only some specific aspects of it (Hayashi et al. 2005).

## *3.2 Current Applications of LCA in Food Processing*

LCAs carried out in areas of food processing activity such as milk, bread, beer and tomato ketchup (Hayashi et al. 2005; Andersson and Ohlsson 1999) indicates which phases of processing and production generate the most impacts on the environment and stimulate research seeking optimal solutions (Roy et al. 2009).

Some studies target processing and packaging as having the most significant environmental impact, especially in the case of the tomato ketchup industry (Andersson and Ohlsson 1999; Andersson et al. 1998). Other analyses, for instance dairy farming studies, demonstrate that the environmental impact is most negative in the stage of primary production (Roy et al. 2009).

LCA can also serve as a basis for "eco-labels" development (Lavallée and Plouffe 2004; Lavallée and Bartenstein 2004; Lampron 2005) or it may be useful for ecological labelling programs (as stated in ISO standard 14020) but, even if its use remains optional, LCA can contribute by providing a competitive edge advantage for businesses whose practices are more environment friendly (Lavallée and Bartenstein 2004; Desjardins 2007).

LCA contributes to government legislative and statutory activity in agri-food issues seeking to promote better environmental protection. It can help governments measuring the net environmental impact of existing rules as well as the ones they plan to adopt or amend in order to optimize overall environmental progress.

As for extended producer responsibility (EPR), LCA can direct private and public decision makers towards effective management of residual matters or help them to choose materials (packaging and the like) that generate the least negative environmental impacts in a given region (Lavallée and Normandin 2003). LCA is in fact recognized by OECD as an indispensable approach to EPR.

Be that as it may, in food processing LCA has proven to be a tool to be privileged over others when it comes to implementing an array of voluntary, negotiated or statutory agri-food programs. Nonetheless, it has its limits that must be overcome so that LCA may really be used to create a more sustainable agri-food statutory framework.

# 4 Challenges Facing LCA for a More Sustainable Agri-food Statutory Framework

Agriculture and agri-food activities are not limited to the production of marketable foodstuffs, they also engage in the production of non marketable goods and services under the heading of cultivation, environment, territorial management and rural development. When seen from this angle, LCA should be able to take into account the specific nature of the agri-food sector that many deem to be multifunctional (Sect. 4.1). Its use in agri-food sector legislative and statutory activity also comes with its share of challenges (Sect. 4.2).

## *4.1 Challenges Facing the Specific Nature of the Agri-food Sector*

The specific nature of agricultural and agri-food activity, when set up against the production of industrial goods, leads some to say that the classical type of LCA, often qualified as a "cradle-to-grave" approach, does not apply easily to agricultural reality (Hass et al. 2000). Actually, the often reproducible character of "self-produced" cultures, along with the widely documented impacts of agriculture on the environment, confirms this assertion (OCDE 2004). Nevertheless, it confirms our hypothesis according to which the development of an LCA closer to the agri-food reality is necessary and implies arising, among other things, to the following challenges.

First, by taking into account the multifunctionality of agriculture. This means that in order to conduct an LCA closer to the agri-food reality, one must resort to the simultaneous use of several functional units or a broader functional equivalence (Hayashi et al. 2005; Roy et al. 2009). For example, the animal unit, the farm and the product as such are examples of three different functional units or of a broader functional equivalence. It seems that this way of proceeding is unavoidable in seeking a comprehensive analysis of the environmental, social and economic impacts on a scale of entire agri-food production. Author Hayashi (Hayashi et al. 2005) also suggest analyzing the results originating from these various units under the light of production intensity. Contrary to all expectations, this factor is rarely used in LCAs despite the fact that it is directly linked to the agri-food sector and doubtlessly exercises a major impact on the environment.

It is appropriate to bear in mind that most all studies applying LCA to agriculture and agri-food processing make a point of expressing a European reality. Note that the farming sector and products issuing from there, are intimately related to their region of production. The nature and the quality of the land, weather conditions in the production zone, agricultural practices and agricultural territory management will have a direct impact on products issuing from this agriculture, and the impact that this production will have on the environment.

These close relationships and the environmental impacts should also play their part in the choice of "indicators". Different indicators, more appropriate to the agri-food industry and in accord with ISO standard 14042, should be privileged. One must especially consider the impact on land properties after production, the loss of biodiversity or the intensity of the production (Carlsson-Kanyama 2003; Roy et al. 2009). ISO standard 14042 indeed provides that the choice of categories must "reflect a vast range of environmental considerations related to the system of the product under study, and in doing so, consider the purpose and scope of the study" (Desjardins 2007).

Finally, the social aspect underlying agricultural and agri-food production, as well as the economic impacts of production choices, deserve further consideration. The important part played by agriculture in societal organization would be further enhanced by adding the sustainability concept to LCA (Andersson 2000) or moreover, if it were to borrow various elements from "Good Agricultural Practices". Agricultural workers' health and security, compromised by pesticides, could thereby be integrated into the decision making process. The consideration of economic consequences of alternative solutions proposed by an LCA could perhaps be made by integrating the LCA and the "Life Cycle Cost Analysis" (Norris 2001). These possibilities for adapting the LCA into the agri-food sector would make it possible to further assess the social and economic impact of measures that are proving to be more desirable for the environment.

The works of many researchers are at this time worthy of mention, namely (Bellem et al. 2005; Hendrickson et al. 1998; Hunkeler and Rebitzer 2003; Shapiro 2001; Finsterbusch 1995; Cernea and Kudat 1997) as well as the recent publication of the first *Guidelines for Social Life Cycle Assessment of Products (ASCV)* (UNEP 2009) whose contributions give hope for an improved assessment of social-economic impacts of product life cycles.

## *4.2 Challenges Facing an Agri-food Statutory Framework*

The agri-food statutory framework offers many challenges for anyone seeking to adapt LCA to the agri-food sector in order to use it within a standardized and regulated environment. First of all, despite recent efforts in agricultural production and environmental protection, the drafting of an agri-food statutory framework in Canada has generally been carried out sector-by-sector. The time has come, however, to forge ahead in crafting an agri-food statutory framework in the most coherent manner possible. Such coherence must be verifiable both internally, i.e. between the various constituents of agri-food law, and externally with all other branches of the law. This holistic approach to constructing the rule of law would make possible the most optimal use of LCA.

Second, various methods of risk analysis relating to the health of humans, animals and vegetables are already well integrated into the agri-food statutory framework. These are methods for specifying referential toxicological values, statistical evaluation of risk exposure and the *"Hazard Analysis Critical Control Point" (HACCP)* method, which are all founded upon scientific bases (Feinberg et al. 2006). These elements should be part of the mental building blocks leading to the use of LCA as the one best adapted to agri-food production. This complementarity could prove to be most interesting for authorities entrusted with the drafting, regulatory and normative reviewing of agri-food necessities.

One last challenge that must be well underscored emanates from an intrinsic characteristic of the law, namely, its stability (Boy et al. 2008; Desjardins 2007). The law, in its role as a social tool, is intended in principle only to be amended very rarely, thereby contributing to social tranquillity founded upon the stability of the rule of law. Yet, scientific knowledge pertaining to environmental and public health impacts resulting from agri-food production and services, is in never ending evolution. Furthermore, the solutions making it possible to set forth the most well-adapted LCA to agri-food specificities must continuously be verified and amended as needs arise.

As such, this reality means that agri-food law must be adaptable. Several solutions bearing the adequate adaptability needed to accomplish this goal are at the disposal of agri-food law. This is found, for example, in legislation by reference to a standard, a standard that may be frequently amended without having to change the law (Organic Products Regulations 2009). Whatever the solution may be, flexibility is the most appropriate means for sustainable agri-food law in order to avoid an agri-food statutory deadlock where solutions set forth by an LCA could cause harm greater than such solutions are intended to prevent.

## 5 Conclusion

In the light of this analysis, we conclude that the use of LCA appropriately adapted to the specificity of the agri-food sector could contribute to the framing of an agri-food law that would participate more fully in sustainable food security and, more extensively, in sustainable development.

The studies that have applied LCA to the agri-food industry – while they shed light on this tool's potentials in this sphere of activities – nonetheless lead us to underscore its limits. All the limits come from the specificity of the agri-food sector and the law that regulates it. The development of databases and the importance of regional analyses of agriculture figure among the challenges facing the development of a better adapted LCA to the specificity of the agri-food industry.

If there can be no doubt that LCA may contribute to the promotion of a more environmental friendly agriculture, it is presently less obvious that in its current form it may contribute to the development of an agri-food statutory framework that takes into account the importance of agriculture in rural society, the health and security of agricultural workers and consumers, or even the socio-economic impacts of the proposed alternatives.

These elements could be more carefully honed by combining the concept of sustainability with LCA or even by borrowing various elements from "Good agricultural practices", and by reflecting upon the best way of making LCA coexist with the methods and methodologies associated with the risk analysis in terms of humans and animals health and plant life. These methods are already well implanted in the agri-food statutory framework but they put little emphasis on environmental protection. There can be no doubt that the very first *Guidelines for Social Life Cycle Assessment of Products* (ASCV) will contribute to this on-going inspiration.

As previously mentioned, the development of a sustainable agri-food statutory framework requires an overall approach touching upon agri-food activities and services that must remain open to other sciences and involve all participants, which will contribute to an LCA better adapted to the agri-food sector.

**Acknowledgements** The authors would like to express their gratitude to the Social Sciences and Humanities Research Council of Canada (SSHRC) for its financial assistance that has made possible this research project and the drafting of this chapter. Special thanks are also addressed to Ms. Marie-Claude Desjardins, PhD Student at the Laval University Faculty of Law, who contributed by her research to the drafting of this text, as well as Ms. Sonya Morales, PhD Student at the Laval University Faculty of Law, for her precious assistance as text editor.

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# Chapter 12
# Risk Communication at the Hungarian Guar-Gum Scandal

**Gyula Kasza, Judith Szigeti, Szilárd Podruzsik, and Krisztián Keszthelyi**

**Abstract** Millions of people have no access to healthy and safe food due to food insecurity that may occur at household, regional or national levels. National policies, insufficient agricultural development and low levels of education may lead to food insecurity. Furthermore, food quality and food safety is a major benchmark of economic development. Food borne risks to human health can arise from biological, chemical or physical hazards. Risk analysis is a key discipline for reducing food borne diseases and food insecurity, and for strengthening food safety systems. Food safety risk analysis is used for assessing and managing risks associated with food hazards. The risk analysis process contains three elements: risk assessment, risk management and risk communication. This paper focuses on risk communication and summarizes the results and findings of the case study for official food safety communicators. The preliminary descriptive study intends to present the reaction of Hungarian consumers to a crisis that affected a wide range of society. In 2007, the guar gum scandal caused panic among consumers when dioxin-contaminated guar gum entered the food chain. This food contamination scare followed previous occasions such as production of intoxicated paprika powder, re-labelling of overdue meat packages and the Bovine spongiform encephalopathy (BSE) crisis in Hungary. To analyze risk perception and consumer behavior, a primary research was conducted with a sample size of 1,577.

**Keywords** Consumer behaviour • Food quality • Guar gum • Risk communication • Risk perception

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_12,

# 1 Introduction

Around 852 million people worldwide starve due to extreme poverty, while up to two billion people lack food security intermittently due to varying degrees of poverty (FAO 2005). Food security exists when there is assured physical and economical access to food at all times to all citizens and non-citizens. Food insecurity is mentioned when people do not have enough food for normal health and physical activities (Unklesbay 1992). Beyond food security, food safety is an important aspect of provisioning. Food safety involves the handling, preparation, and storage of food in ways that prevent food borne illnesses. It includes a number of routines that should be followed to avoid potentially severe health hazards (Henson 2003). Hazard is an act or phenomenon posing potential harm to some persons or things; the magnitude of the hazard is the amount of harm that might result, including the seriousness of the harm and the number of people exposed. Food safety risk analysis is used for assessing and managing risks associated with food hazards. The risk analysis process contains three separate elements: risk assessment, risk management and risk communication. Risk assessment comprises four steps: hazard identification, hazard characterization, exposure assessment and risk characterization. Risk assessment thus provides an objective scientific basis for decision making in ensuring the safety of the food supply. Furthermore, a detailed risk assessment can be used to identify critical gaps in the knowledge base, characterize the most important risk factors in the production-to-consumption food chain, help identify strategies for risk reduction, and provide guidance for determining priorities in public health and food safety research programs (Lammerding 1997).

The primary goal of the management of risks associated with food is to protect public health by controlling such risks as effectively as possible through the selection and implementation of appropriate measures. According to Powell and Leiss (1997) almost all of us are or will be involved in risk communication. There is a great divide that often separates two evaluations of risks. The two broad capacities are the professionals (scientists, engineers, business managers, etc.) and the consumers or citizens. Good risk communication practice seeks to bridge the divide by ensuring that the meaning of scientific risk assessment is presented in understandable terms to the public and ensuring that public concerns are known by risk managers.

## *1.1 What Is Guar Gum?*

Guar gum is a galactomannan that is the ground endosperm of guar beans. In order to obtain guar gum guar seeds must be dehusked, milled and screened. Chemically, guar gum is a polysaccharide composed of the sugars galactose and mannose. Guar gum has industrial application: sizing, finishing and printing in textile industry, folding and denser surface for printing in paper industry, binder or as disintegrator in tablets for pharmacies, etc. The largest market for guar gum is in the food industry: guar gum increases dough yield in baked goods, thickens milk, yogurt, kefir and liquid cheese products; helps maintain homogeneity and texture of ice creams and sherbets, functions as lubricant and binder in meat products. In Europe, guar gum has EU food additive code E412. Guar gum is a natural food thickener and stabilizer with no health threat. In 2007 however, contaminated guar gum entered the food chain causing panic and another food scandal. Dioxin-contaminated guar gum can cause a series of health problems such as cancer and nervous system disorders. It may be presented in soil, air and water. This is generated due to incineration, combustion and geological processes. The high dioxin levels are linked to contamination of the guar gum with pentachlorophenol (PCP), a fungicide banned from use in food and feed.

### *1.2 The Process of the Contamination*

A serious contamination by dioxins and pentachlorophenol in guar gum originated from India. India produces approximately 80% of the world's total production of guar beans, about two hundred thousands tons per year. The contamination levels of dioxins and pentachlorophenol found in July 2007 in certain batches of guar gum were very high. A Swiss company Unipektin AG, which supplies guar gum products to EU markets, recalled batches of food additives containing guar gum exported by India Glycols. Few of the EU's 27 member states were unaffected by the contamination, while many others – at least 16 countries – reported recalls of either guar gum or food products. Foods have been recalled from supermarket shelves in France and Germany. The Swiss retail chain has also withdrawn products. Hungary has already blocked the sale of several items from a wide range of food, feed and drug products after finding dioxin levels that exceeded the EU's permitted maximum.

The guar gum case in 2007 was not the first incident when Hungary had to face food scares due to global food risks. In 1996, the Hungarian beef market almost collapsed due to the BSE crisis in spite that no diseased animals were found in the country. In 2004, aflatoxin was found in national staple spice paprika. In 2006, birds suffering from avian flu appeared in Hungary, causing fortunately no human infections. The Hungarian dioxin scare in 2007 shows that the question of food safety is not only a problem confined to one country, but is the result of globalization.

## 2 Objective

The study intends to present the reaction of the Hungarian consumers to a crisis that can affect a wide range of the society. In 2007, the guar gum scandal caused panic among consumers when dioxin-contaminated guar gum entered the food chain.

A primary research to analyze risk perception and consumer behaviour was conducted with a sample size of 1,577. The paper focuses on risk communication as the guar gum crisis was intensively communicated through the media. The survey tried to measure consumer reactions, awareness, shopping habits and mentality after the crisis.

## 3 Materials and Methods

The analysis started with secondary research. This type of research is based on information gleaned from studies previously performed by government agencies, chambers of commerce, trade associations and other organizations. This kind of information was obtained from the web, publications, magazines and newspapers. After the analyses of secondary resources, primary information was gathered by directly contacting the customers. The primary research delivered more specific results. The research involved the collection of new information by conducting questionnaires (Hajdu and Lakner 1999). To prove the applicability of the data collected from the surveys, appropriate software and evaluation of the given problem were required. In order to evaluate the questionnaires, SPSS 14.0 for Windows program was used.

## 4 Results and Discussion

Between January and September 2008, over 1,500 questionnaires were returned. The processing procedure is still in progress. Until April 2009, 38% of the questionnaires were processed. In that phase of the study, 591 processed questionnaires were presented. The answers were sorted out into four bunches.

The *first* bunch relates to demographical information about the food consumers. All respondents were more than 18 years old. One quarter of them was between 18 and 25, 21% between 26, and 35, 35% between 36 and 50, 16% between 50 and 65 and only 1% was more than 65. Sixty percent of the respondents are female, and 40% are male in the sample. More than half of them (55%) have children. One third of the respondents live in the capital of Hungary, Budapest. Almost half of them are from cities or towns, one quarter from villages. According to their education, half of the respondents have accomplished grammar school, 10% completed primary school and 36% graduated from colleges or universities. The profession of 76% of the sample is not related to food industry or agriculture, but 24% of them work in the afore-mentioned fields.

The *second* bunch relates to the knowledge and information about guar gum. The main object of the study was to examine the consumers' risk-perception in connection with the contaminated guar gum products. An emphasis was put on how and what the consumers remembered from the crisis and the concerned food products.

According to the results, 93% of the respondents have heard about the guar gum crisis in 2007 (Table 12.1). The high ratio can be explained by the effects of media, the crisis was head news for several weeks.

In this context, it is considered important to examine consumers' awareness of the exact circumstances. The crisis occurred 0.5–1 year before the study, so consumers' memory was also tested. Table 12.2 shows the evaluation of the answers.

Almost three-fourth of the consumers remembered well, that the scandal was caused by the infected guar gum that entered the food chain. Twenty percent believed that the guar gum itself caused the hazard. Only 60% of the consumers considered guar gum as safe as other often used aggregates in food products. The rest of the consumers (26%) could not give an answer or defined guar gum as a contaminant. The distribution of the answers is summarized in Table 12.3.

Only three-fourth of the consumers answered the question related to the level of the guar gum hazard. The results in Table 12.4 show that the majority did not know or believed that guar gum is hazardous. According to the minority's opinion, guar gum is not hazardous at all.

**Table 12.1** Have you heard about the guar gum crisis in 2007?

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| Yes | 543 | 91.9 | 93.1 |
| No | 40 | 6.8 | 6.9 |
| No answer | 8 | 1.4 | – |
| Total | 591 | 100 | 100 |

**Table 12.2** What caused the crisis in 2007?

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| Guar gum contaminated the food | 117 | 19.8 | 21.5 |
| Infected guar gum contaminated the food | 391 | 66.2 | 71.9 |
| I don't know | 36 | 6.1 | 6.6 |
| No answer | 47 | 8 | – |
| Total | 591 | 100 | 100 |

**Table 12.3** Is guar gum an aggregate or contaminant?

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| Aggregate | 356 | 60.2 | 65.3 |
| Contaminant | 154 | 26.1 | 28.3 |
| I do not know | 35 | 5.9 | 6.4 |
| No answer | 46 | 7.8 | – |
| Total | 591 | 100 | 100 |

**Table 12.4** How hazardous is guar gum?

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| Not hazardous at all | 49 | 8.3 | 10.9 |
| Not hazardous | 79 | 13.4 | 17.5 |
| I do not know | 150 | 25.4 | 33.3 |
| Hazardous | 67 | 11.3 | 14.9 |
| Very hazardous | 106 | 17.9 | 23.5 |
| No answer | 140 | 23.7 | – |
| Total | 591 | 100 | 100 |

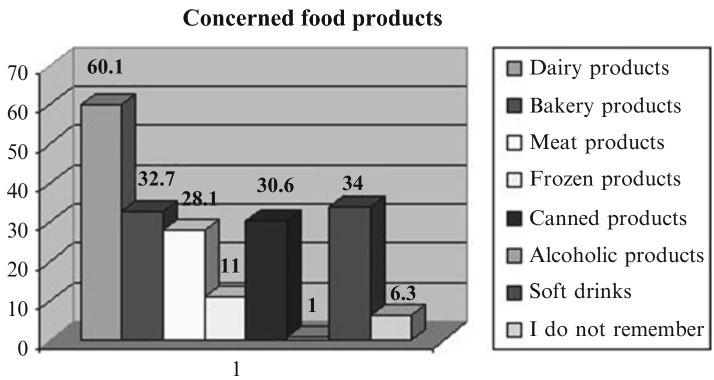


**Fig. 12.1** Concerned food products

The consumers were also interviewed about the guar gum concerned food products. Food manufacturers add guar gum – amongst others – in small quantities to meat-, dairy-, dessert- or delicatessen products. Respondents could choose from eight given answers. Figure 12.1 shows the results of the question.

In the first figure, it is obvious that according to most of the consumers the dairy products were mainly affected in the crisis. The distribution of bakery-, meat-, canned products and soft drinks is about 30%, thus significant difference may not be observed. Answers concerning frozen products and alcoholic drinks were irrelevant.

The survey also wanted to find out what the consumers knew about the health impacts of the contaminated food products. Dioxin infected guar gum may cause cancer and nervous system symptoms. According to 35% of the consumers, the health effects of the concerned food products are diarrhea and puke. Twenty two percent was sure that the real health effects are not known by scientists either. More answers could be chosen; the results are shown on Fig. 12.2.

Figure 12.3 presents that a vast proportion of the consumers (68%) had information on the contaminated food products from television, while the minority (14%) from the radio. Internet attendance exceeded the reading of printed newspapers

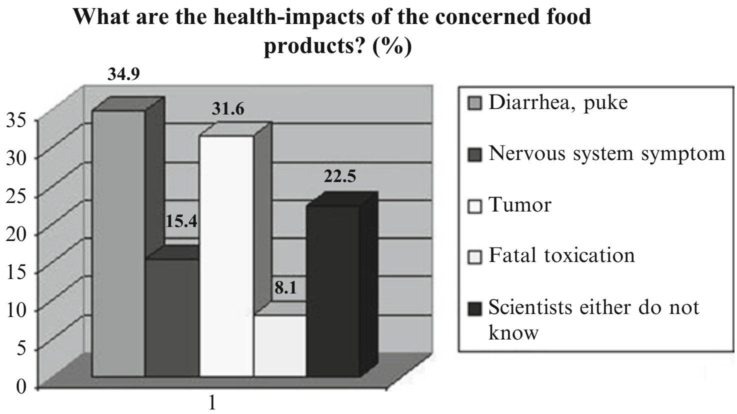


**Fig. 12.2** What are the health-impacts of the concerned food products?

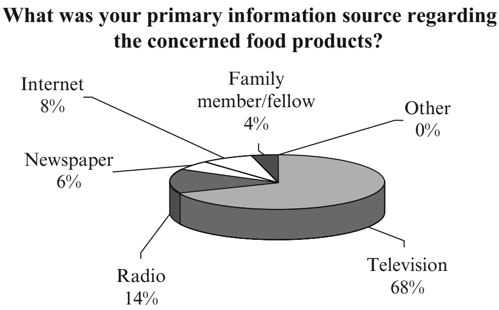


**Fig. 12.3** What was your primary information source regarding the concerned food products?

about this question. Only 4% of the consumers were informed personally by a fellow or family member.

Finally, the survey inquired about the latest news on food contamination the consumers remembered. The hazard was ultimately eliminated according to 55% of the consumers. The correct answer, i.e. we have eaten one ton of infected food products was known only by 6% (Fig. 12.4).

In the *third* bunch, the survey questioned consumers about their food shopping habits. The questions tried to reveal whether their practices changed due to the crisis and if so, how careful they became. As Table 12.5 shows, almost half of the consumers did not check the food products they bought during the crisis. A negligible number of the consumers (1.7%) took back the products to the shops. Sixteen percent immediately threw them away. A quarter of the consumers checked the concerned food products, and put back the ones with guar gum content on the shelves.

Out of the sample, 547 consumers reflected on the question of "shopping habits influenced by the crisis" (Table 12.6). More than half of the consumers (63%)

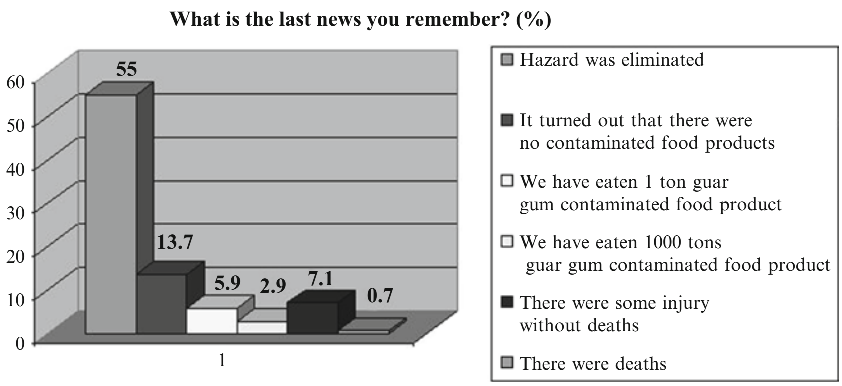


**Fig. 12.4** What is the last news you remember?

**Table 12.5** During the crisis, have you checked whether the already shopped food-products contain guar gum?

| Answer | Prevalence | Percentage |
|---|---|---|
| I checked and waited for information | 146 | 24.7 |
| I have thrown away the food containing guar gum | 95 | 15.9 |
| I have taken back the food containing guar gum | 10 | 1.7 |
| I did not care about it | 284 | 48.1 |
| No answer | 55 | 9.3 |
| Total | 591 | 100 |

**Table 12.6** Did the crisis affect your shopping habits?

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| I was careful and avoided the concerned products | 344 | 58.2 | 62.9 |
| The news did not affect me at all | 200 | 33.8 | 36.6 |
| I bought more price-reduced products | 3 | 0.5 | 0.5 |
| No answer | 44 | 7.4 | – |
| Total | 591 | 100 | 100 |

definitely avoided the concerned products. One-third of them (37%) was not affected while only half percent benefited from the crisis by purchasing the said products with price reduction.

The ratio of the careful consumers who checked the ingredients of products more deliberately is indicated by Fig. 12.5. Consumers could choose from five alternatives and could score the answers between 1 and 5. Mark 5 means more awareness, mark 1 no awareness. Almost half of the consumers have chosen answers 4 or 5 which mean that they behaved more carefully than before. Thirty percent of them did not care at all, or cared less about the ingredients.

The last bunch of the survey focuses on the consumers' opinion regarding the reaction of Hungarian authorities. A little more than half of the consumers were

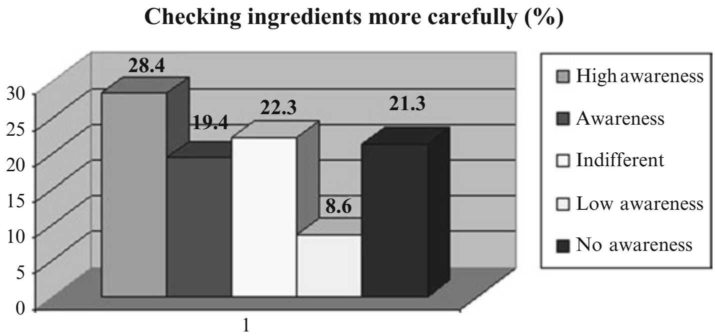


**Fig. 12.5** Checking ingredients more carefully

**Fig. 12.6** How did the Hungarian authorities react?

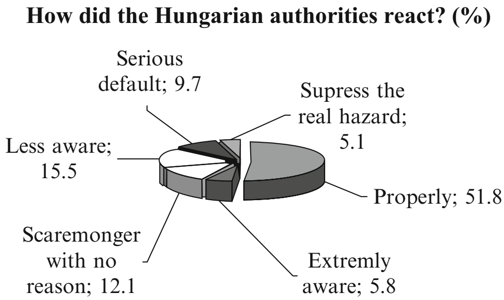


**Table 12.7** Post-crisis opinion about authorities

| Answer | Prevalence | Percent | Positive percent |
|---|---|---|---|
| Significantly better | 9 | 1.5 | 1.7 |
| Better | 88 | 14.9 | 16.3 |
| No change | 398 | 67.3 | 73.9 |
| Declined | 35 | 5.9 | 6.5 |
| Significantly declined | 11 | 1.9 | 2 |
| No answer | 50 | 8.5 | – |
| Total | 591 | 100 | 100 |

satisfied with the authorities' actions. About 30% was extremely negative, they think that the authorities were not aware enough, made serious default and wanted to suppress the real hazard (Fig. 12.6).

From Table 12.7, it can be concluded that 8.5% of the consumers did not answer the question: "How did your opinion on the Hungarian authorities change after the crisis occurred?" It can be said, that the view of three quarter of the consumers did not change at all. In connection with the authorities' activity 18% was more positive but 8.5% was less negative than before the crisis.

Figure 12.7 presents the results of the final phase of the survey. The inquiry related to the source of information regarding food-safety. The significant majority

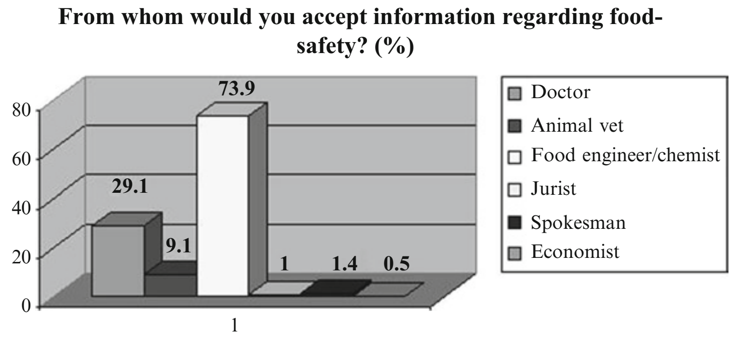


**Fig. 12.7** From whom would you accept information regarding food safety?

of the consumers would like to receive information about food-safety issues from a food engineer. A high ratio of "doctor answers" was prospective; while a low ratio of "animal veterinary surgeon (vet)" answers was surprising. Traditionally, measurements and monitoring are performed by vets; control of authority system is also achieved by the main vet. From Fig. 12.7, it also can be seen that consumers would not accept information from a person with no linkage to food safety.

## 5 Conclusion

This paper discusses the Hungarian food consumers' relation to the guar gum crisis in 2007. As a result of the preliminary survey it can be declared that the Hungarian consumers reacted sensitively to the guar gum crisis. The most food consumers already had knowledge about the guar gum crisis, and more than half of them had information about the causes of the food crisis. Among the consumers, the same proportion considers guar gum as aggregate. Only one quarter of the food consumers thinks about guar gum is a contaminant. The minority of the food consumers evaluated that guar gum is not hazardous at all. Most of the consumers associated the crisis with dairy products. The majority of the food consumers had information of the health impact of the contaminated food products. The source of information was mainly the electronic media. Despite the intensive media communication, many misconceptions remained unclear for the consumers. Many of them were not able to recognise relevant information, while some others seemed to react in a different way than authorities expected.

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# Chapter 13
# The Environmental Challenges and Its Security Implications for South Asia

**Abhaya Kumar Singh**

**Abstract** The South Asian region's volatile geological situation and high degree of mutual mistrust, and the potential for environmental degradation to trigger events means environmental factors could become a major cause of instability and threat to regional security. The attention demanded by increasing domestic problems and struggling political, economic and social interests between South Asian countries confine environmental problems primarily to the realm of low politics. This is also because the complexity of environmental problems and the intricate linkages between development, population, poverty, ethnic conflict and mass migration to the natural environment are often indirect or difficult to understand. The present paper is an attempt to analyze whether the social and economic impacts of climate change could result in or exacerbate conflict in the region, with particular attention to the likelihood of intra-state conflict and unrest in South Asia.

**Keywords** Environment and security • Global warming • Population growth • Agricultural land and production • Population displacement or migration

## 1 Introduction

The fast depletion of natural resources, resulting in the scarcity of resources and the degradation of the environment, and the growing conflict over resources within and between the states have given rise to a gearing concern for environmental security

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_13,

all over the world. It is being widely accepted that the environmental scarcity and the environmental degradation pose a threat to the national security. Hence, there is a close linkage between the environmental degradation and the national security (Riftin 1991). In the recent years, it has been widely accepted that environmental security is a significant dimension of the national and regional security frameworks of the nation-states.

Environmental issues often have a direct impact on armed forces and national security as well. A number of scholars have recently asserted that large-scale human-induced environmental pressures may seriously affect national and international security. Environmental change is a serious and long term challenge that has the potential to affect each and every one of us. It is one of the biggest issues facing the world today that no nation can resolve alone.

The South Asian region's volatile geological situation and high degree of mutual mistrust, and the potential for environmental degradation to trigger events means environmental factors could become a major cause of instability and threat to South Asian security. This region is composed of seven adjacent countries: India, Pakistan, Sri Lanka, Bhutan, Nepal, Maldives and Bangladesh. The region has many interstate rivers and common sea coastline extending from Pakistan in the West to Bangladesh in the East. Five of them share land borders with India except the island nations of Sri Lanka and Maldives. Bhutan and Nepal are land locked nation. This geographic contiguity is separated by geo-political rivalries and security concerns between the different political units, whose political system run from a well established and deeply rooted democracy in India, to an inexperienced one in Bangladesh, uncertainty in Nepal, thorough monarchy in Bhutan and to military unstable democracy in Pakistan. Above all, these nations are struggling with their own internal problems.

South Asia is a compact geographic unit, and it is one ecological zone with several geographical variations ranging between high Himalayan regions to maritime zones. The South Asian states are not in synchrony with the eco-geographical region due to the artificial division of the state into different regions. India, Pakistan and Bangladesh emerged as independent countries out of one geographic unit. As a result, these independent states share a common geography. Therefore, mutual sharing and conflict over resources are obvious. It also necessitates the development of a common approach to environmental security. The three major river systems of South Asia – The Indus, the Ganges and the Brahmaputra are shared by most of the countries of the region. It is, therefore, obvious that they also share the hazards emanating out of these river systems.

Nepal and Bhutan are land locked, while Sri Lanka and Maldives are island countries. This asymmetrical incongruity between the states of the region accounts for many of the disputes and conflicts (Upreti 2004).

On the basis of the above overview, it may be observed that the very nature of South Asian region is prone to various kinds of environmental issues and problems, and these problems are threats to regional peace, security and stability of the region.

## 2 Environment and Security: A Conceptual Understanding

The environmental changes may shift the balance of power between states either regionally or globally, producing instabilities that could lead to war (Wirth 1989). Homer Dixon suggests that environmental decline has the potential to exacerbate existing disputes between the rich and poor countries – developed countries versus developing countries – as well as between rich and poor people in what he describes as 'relative deprivation conflicts' (Homer-Dixon 1991). DuPont shifts the debate from the 'environmental-induced conflicts' to what constitutes 'environmental security' by focusing on environmental warfare "the explicit targeting of an adversary's resources or physical environment aimed at degrading or destroying the capacity to prosecute war", and the use of defense forces to monitor environmental changes and to assist in protecting the environment (DuPont 1998).

After the end of the Cold War, there has been an urge to redefine the national security and build up a comprehensive view of it (Buzan 1997; Weston 1990; Powers and Sommers 1990). The thrust of the comprehensive view of security has been to secure social, economic and environmental dimensions along with securing the boundaries of the state (Buzan 1992). The traditional concept of security surrounded along defending territory and political integrity of a country. The state was responsible for defending its sovereignty and integrity, and armed forces were assigned to this duty (Leffer 1984). With the end of Cold War and the decreasing importance of geo-strategic considerations, the national security is being viewed in a comprehensive perspective. While there is no denying of the fact that the military dimensions of security are still relevant, there is an added emphasis on the non-military dimensions of security. Now it is not sufficient only to secure the territory and the sovereignty of the State, but it is equally important to secure the people and their surroundings. It is in this perspective that a comprehensive view of national security has emerged which includes social, economic and environmental security along with the security of the state. Thus, both the military and non-military dimensions have become important in the changed framework of national security.

The environmental security has become an important dimension of the comprehensive national security. The indiscriminate attitudes of the people and the governments towards the environment, their self-interests, over-exploitation of resources, etc., have resulted in scarcity of resources as well as degradation of the environment. This has caused conflicts and violence among and between the states (Homer Dixon 1999; Diehl and Gleditsch 2001; Dobkowski and Wallimann 2002). The scarcity of resources may give rise to a conflict for the remaining resources. Therefore, there is a need to secure the environment. The security of the environment needs a positive attitude towards it. Thus, environmental security may be defined as avoidance of negative linkages between human activities and the environment. It encompasses the establishment of a proper human-nature relationship.

Environmental security reflects the ability of a nation or a society to withstand environmental asset scarcity, environmental risks or adverse changes, or environment-related tensions or conflicts. Thus, environmental security means ordering and managing the resources and the biosphere activities.

## 3 Global Warming: A Major Environmental Threat for South Asia

Global warming is the increase in the average temperature of the Earth and the oceans in the recent times, and the likelihood of a continued increase in temperature in future. Gases – like carbon dioxide, methane, ozone, nitrous oxide, sulpher hexafluoride HFCs and PFCs as well as water vapor-called greenhouse gases – collect in the atmosphere like a blanket trapping the Sun's heat that is radiated off the Earth's surface. These emissions of carbon dioxide and other greenhouse gases into the atmosphere help trap heat and lead to global warming. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) clearly established that warming of the climate system was 'unequivocal', and if the annual emission of greenhouse gases (GHGs) remains at today's levels, by 2050 it will be 550 ppm. This means a potentially catastrophic mean global temperature increase of 5°C. That would imply seas rising and submerging half of Bangladesh. Glaciers would melt, leading first to floods and then droughts as river run dry. There would be more dengue, more malaria and more diarrheas (Homer-Dixon 1991).

Global warming is sure to become one of the most pressing security issues of this century. This could reverse decades of social and economic progress across South Asia, where food shortages loom, and more than half the continent's 4 billion people live along vulnerable coasts, a new report issued by Oxfam and Greenpeace in its document "Asia-Up in Smoke". It reports on the growing scientific consensus that all of South Asia will warm during this century, and the result could be less predictable rainfall and monsoons affecting the food supply (The Times of India, December 2007). Most scientists agree that temperature will rise by between 2°C and 6°C this century due to carbon emissions from burning fossil fuels for power and transport. They say this will cause melting at the polar ice caps and weather patterns to change bringing floods, famines and violent storms, putting billions of lives at risk (The Times of India, November 2007). A temperature rise of between 3°C and 4°C would displace 340 million people through flooding, droughts would diminish farm output, and retreating glaciers would cut drinking water from as many as 1.8 billion people (The Times of India, January 2007). It will reorder the political map by submerging some nations, flooding others and creating refugees from rising waters. All of Maldives and large parts of Bangladesh are among the South Asian regions estimated to go under water (The Times of India, November 2007). In the case of Bangladesh, it is said that one third of the country may be submerged by 2050 due to the rise of sea level. It has been estimated that the one-meter rise in sea level would cover 14% land area of the country and thereby displacing 10% of its total population (The Times of India, February 2007). The IPCC estimates that sea-level will rise 9–88 cm by the year of 2100 with a 50% probability of sea-level rising to 45 cm (Khan 2001). The NASA scientists are projecting that the Arctic sea ice was melting so rapidly that it could be disappear entirely by the summer of 2040 (Sinha 2006). A NASA scientist Jay Zwally said that if the melting of Arctic ice is so rapid, the Arctic Ocean could be nearly ice-free at the end of summer by 2012 much faster than previous prediction (The Times of India, December 2007).

In the monsoon season, one-third of the Bangladesh's land is submerged in water. This would mean a significant displacement of Bangladeshi people internally and externally. India could face severe problems in case of large scale migration if such a situation arises, complicating its already worse security situation. The global warming may also worsen the crisis in agricultural production. While a 2–3°C mean global warming might not seem too significant for agricultural production, it may produce a large increase in crop-devastating droughts, floods, heat waves and storms.

## 4 Social Effects of Environmental Degradation

The environmental effects may cause social effects, that in turn could lead to conflict. It is also assumed that environmental effects do sometimes lead directly to conflicts. They tend to produce and will increasingly produce several casually interrelated social effects. That does not play down the significance of other intervening variables – population growth, demographic structure, the effects of ideational factors like family, community and beliefs – and the South's economic structure and pattern of development in the context of the dominant and mimetic Western frontiers model of economics. Without an understanding of these intervening factors, the causative linkage between environmental degradation and conflict can not be easily formulated.

There are four main interrelated social effects in South Asian region:

- Population growth;
- Reduced agricultural land and agricultural production;
- Population displacement or migration;
- Disrupted institutions and social relations.

These social effects, in turn, may cause several specific types of conflict, including scarcity disputes between countries, clashes between ethnic groups and civil strife and insurgency, each with potentially serious repercussions for the security interests of the South Asia.

### *4.1 Population Growth*

One of the main drivers behind environmental scarcity in South Asia is population growth. The region is among the most densely populated in the world. Population growth and increasing population density represent demographic forms of social change. Population growth may lead to geographic expansion of a society, military conflicts and the intermingling of cultures. Increasing population density may stimulate technological innovations, which in turn may increase the division of labor, social differentiation, commercialization and urbanization. As population increased, farm land sizes started getting smaller. People found it difficult to survive on such small land holdings. On the other hand, population growth may contribute to economic stagnation and increasing poverty, as may be witnessed in several South Asian countries today.

In the South Asian region, three countries – India, Pakistan and Bangladesh – are among the world's ten most populous countries. India's current population is 1.10 billion and by 2050 it is predicted to overtake China; Pakistan current population of 159 million will reach 295 by 2050; and Bangladesh with a population of 141 million will have twice that number by 2050 (WRI 1990–1991). High population growth rates lead to more intense use of resources, exacerbating existing scarcities and over-exploitation (Sinha 2006). The region's population growth will have a direct bearing on its renewable resource system such as forest, land and water as well as on energy demand. The renewable resources are being subjected to significant pressures. Some important factors like deforestation, land degradation and water crisis indicates a high level of stress on the South Asia region's renewable ecosystem.

On account of industrial and agricultural expansion as well as trade in forestry products, deforestation remains a major concern in South Asia. Bangladesh and Pakistan are the countries with the highest rates of deforestation. In Nepal too, over 75% of population depends on fuel wood for energy needs, which puts tremendous pressure on the country's forest resources. Landslides and soil erosion increase the sediment loads in rivers and cause sedimentation and flooding downstream. Areas with most extensive degradation, already, include the cultivated Himalayan belt in India and Nepal, the Western Ghats of India and watershed areas of Sri Lanka. The FAO predicts that at exiting rate of deforestation, Bangladesh and Pakistan will completely loose their forests by 2011 and 2015 respectively.[1] It is very alarming for the South Asian countries.

In the continuing struggle to provide food and other basic needs of the South Asian region's burgeoning populace, land degradation has emerged as an important issue. Soils suffer from varying degrees of degradation on account of rapid deforestation, poor irrigation and drainage practices, and overgrazing. The depletion of land resources through desertification, and the loss of nutrient-rich topsoil through water and wind erosion threaten the livelihood of countless millions throughout the region. The per capita unit land resources are below the world average of 0.26 ha in South Asian countries. Population increase and unsustainable agricultural practices are primary contributors to land shortage and land degradation. Another cause

[1] http://www.un.org/popin/cenasia/faotex3.htm

of land degradation common to the countries in the region is mining, which is typically unorganized and unscientific, without any defined environmental management and land reclamation plans. In some cases, there are clear trans-boundary impacts. Poor mining practices in the dolomite mining areas of Bhutan, adjoining the state of West Bengal in India.

Depletion of aquifers in many parts of the South Asian countries and growing demand for water will bring agricultural, industrial and urban use of water into conflict. This shortage will force water-usage restrictions and will increase the cost of water consumption. Water could become the "energy crisis" of the early twenty-first century. Conflicts over water will grow over the coming decades as growing populations demand more and climate change affects supply. With the overwhelming majority of the world's rivers shared by two or more nations, these challenges will test diplomats and political leaders worldwide.[2] Some South Asian countries are in water crisis. They may fight over dwindling supplies of water and the effects of upstream pollution.

### *4.2 Agricultural Land and Agricultural Production*

Land constitutes the most important natural resource of South Asia, and agriculture is the most important activity using this resource. Industrialization, agricultural expansion and a large dependence on forest products for meeting the energy needs have resulted in large-scale deforestation in most countries of the region, and this situation remains a major concern in South Asia. In an effort to increase agricultural production, farmers have encroached upon forests and other environmentally fragile areas. Increased industrialization and agricultural production, means increased run off of the fertile soil, decline the arable land resulting in food scarcity, atmosphere and water pollution and health hazards stemming from industrial accidents. For South Asian countries, cropland grew at just 0.26% during the 1980s, less than half the rate of the 1970s. More importantly, in these countries per capita arable land is dropped by 1.9% a year (Sinha 2006). In the absence of a major increase in arable land in South Asian countries, experts expect that the per capita world average of 0.28 ha of cropland will decline to 0.17 ha by the year 2025 (Sadik 1990), given 73% of all rural households in developing countries are either landless or nearly landless. In the case of Bangladesh and Bhutan, per capita unit land resources are well below the world average of 0.26 ha. Population increase and unsustainable agricultural practices are primarily contributors to land shortage and land degradation. For example, in India, the intensive agriculture has degraded 125 million hectares of land owing to monoculture, salinity and water logging with a result many fertile lands are now wastelands (WRI 1990–1991).

[2] http://www.un.org/popin/cenasia/faotex3.htm

Decreased agricultural production is often mentioned as potentially the most worrisome consequence of environmental change. The effects of this change causing greenhouse gases, global warming and climate change which affect the agricultural production. Coastal cropland in countries such as Bangladesh is extremely vulnerable to storm surges. Such events could become more common and devastating because global warming will cause sea levels to rise and might intensify storms. Thus, the scarcity of productive agricultural land and decline in agricultural production seem to be two important reasons for inducing cross border migration in South Asia. One study suggests that the number of people crossing over to India increases during periods of environmental disaster (Warrick et al. 1986). If these situations continue unabated, the volume of migration from affected countries will increase in the future and sheer dictates of history, geography and economy will encourage their movements to India and other countries.

In South Asian countries, a sharp drop in food crop production could lead to internal strife across urban-rural and nomadic-sedentary cleavages (Alam 2003). If environmental degradation makes food supplies increasingly tight, exporters may be tempted to use 'food as a weapon' (Wallenstein 1986).

The changes in rainfall pattern and distribution owing to climatic change can lead to the shifting of agricultural lands, and may also force intensive cultivation of marginal lands which in turn will exacerbate deforestation in future. Environmental change could ultimately cause the gradual impoverishment of societies in this region, which could aggravate class and ethnic cleavages, undermine liberal regimes and spawn insurgencies (The Times of India, November 2007).

### *4.3 Population Displacement or Migration*

Environmental crisis in the rural areas of developing countries has increasingly become an important cause of cross-border migration of population, and South Asia is no exception of this phenomenon. There are many aspects of the migration-security link. According to Anioł, international migration impacts on regional and international security in three distinct ways (Anioł 1992):

- International migration can be a consequence of other security threats like human rights violation, ethnic conflict and internal war;
- International migration can by itself constitute a threat to international security when it is of massive and uncontrolled character;
- International migration can result in other security threats-racial violence.

Large scale migration in South Asia has continued unabated for last five decades. This gravest problem has been faced by India from last 30 years. In 2003, India has about 20 million Bangladeshi migrants to neighboring West Bengal and Assam and various part of India (Gurr 1985), 2.2 million Nepalese, 70,000 Sri Lankan Tamils and about 100,000 Tibetans (Jacobson 1988). Presently, this migration is limited not only to Assam, Tripura and West Bengal but is to far-off states like Tamil Nadu, Maharashtra, Gujarat and Delhi (Sinha 2006). This phenomenon has generated a host of destabilizing political, social, economic, ethnic and communal tensions in many states and union territories of India.

Issues of migration or population displacement, refugee repatriation and alleged state support for insurgent groups have become a point of tension between India and Bangladesh. It is alleged that this migration has not only environmental base, instead they are induced to cause premeditated population imbalance on religion line. Assam's ethnic strife over the last decade has apparently been provoked by the migration of Bangladesh. The migrants have also been regarded as a security threat by the intelligence agencies in India for their susceptibility to getting involved in information gathering activities for extremist groups both on the India – Bangladesh border and on the frontier with Pakistan.

The migrants have become a part of the local political struggle in many areas, with a potential for violent conflict. To some political parties in India, the migrants have been a tool to enlarge the political base either by winning their support or by mobilizing the native Hindu population against the Muslim immigrants. Within Bangladesh, in the Chittagong Hill Tracts, South of the North-Eastern Indian state of Tripura, an ethnic conflict rages between the Bengali speaking Muslim population and the native Buddhist and Christian tribal population of the thinly populated, but densely forested area. The ensuing clashes have transformed into insurgency operations involving the Bangladeshi military forces (Vasudeva 2000).

On the other hand, the subversive elements are being pushed by ISI in the garb of environmental migrants to implement its sinister design of 'Greater Bangladesh' (Kishore 2005). It is a challenge for India to manage its borders. In this situation, it is the first and foremost duty of our leadership to take concrete action to secure our frontiers and sub-serve the best interests of the country.

### *4.4 Disrupted Institutions and Social Relations*

The environmental change and acute conflict result in the disruption of many legitimized political institutions and social relations. The economic deprivation and frustration among people result in overthrowing of established authority. One authority points out that "any event or broad social process that serves to undermine the calculations and assumptions on which the political establishment is structured occasions a shift in political opportunities" (McAdam 1982). Thus, it is a matter of great concern that the seriousness of the environmental crisis as a threat to security escapes the attention of the policy makers of the region. The governments of the region should come forward to check the menace before it becomes too late.

## 5 Need for a Regional Approach on Environmental Crisis

Climate change presents a collective challenge to the international community. Meeting that challenge is necessarily a collective endeavor. No other environmental threat has such a universal quality. In no other field can activity in one location potentially have such a direct impact across the globe. So it is no surprise that the world is turning to collective and collaborative initiatives to address climate change mitigation and adaptation.

The environment related problems and their implications are regional issues as the countries of the South Asian region in most of the cases share them. It is true that there is a growing awareness on environmental issues in almost all the countries of South Asia in the last few years. The individual countries have persuaded environment friendly policies in certain sectors. Attempts have been made towards reforestation, flood control, controlling desertification, etc.

A common approach to securing the environment at the regional level may involve the following aspects:

## *5.1 Deep Cuts in Carbon Emissions*

It must lead to deep cuts in Carbon emissions by developed and South Asian countries. The International Panel of Climate Change (IPCC) has warned that irreversible catastrophe would be caused by global warming if GHGs are not rapidly reduced. Industrialized countries should reduce their greenhouse emissions by between 25% and 40% compared with 1990 levels by 2020. South Asian countries need to arrest or slow down deforestation, and the industrialized countries must take actions to mitigate climate changing greenhouse gases and gives poor and developing countries the carbon space to grow economically.

The policy shift needs to stop encouraging the waste of natural resources, hard as it is politically. The world spends a quarter of a trillion dollars a year on energy subsidies, draining the public purse, promoting energy waste and locking the polluting infrastructure for decades. In many South Asian countries, ware for agriculture is undervalued, while globally the overuse of freshwater is estimated at 5–25%. Even when intended for the poor, these energy and water subsidies are not well-targeted anyway, be in it South Asia.

## *5.2 Population Control*

Unabated population growth, as at present, not only adds to the economic burden for all developmental activities, but also reduces the impact of economic growth on our society. Therefore, for the success of our planning, population control becomes the most urgent necessity. A comprehensive program, with strong political backing and appropriate socio – economic measures, fully utilizing the available scientific know – how, simultaneously making efforts for developing new methodologies, and supported by modern communication technology and managerial and organizational skills, is essential for success in this most difficult area. Population control should be a national mission for the next decade.

### 5.3 Strengthening Institutions and Legislation

Among the institutional mechanisms for regional cooperation on the environment, the most significant one is South Asia Cooperative Environment Programme (SACEP), established in 1982 under the aegis of the United Nations. Its membership consists of nine countries: seven member nations of South Asian Association for Regional Cooperation (SAARC), Afghanistan and Iran. SACEP's Council, consisting of the ministers of environment and forests in member countries, meets once in 2 years. Its secretariat is in Colombo, Sri Lanka. The organization implements projects funded by the UN and other multilateral or bilateral agencies. Given the gravity of common concerns in the region, there is an urgent need for an agenda to implement remedial action among countries of the region. The establishment of SACEP and efforts within the framework of SAARC are clearly steps in the right direction. In view of extensive loss of life and colossal damage to property, as a result of earthquake and tsunami and other natural disasters in South Asia, the Heads of States underscored the urgency to put in place a permanent regional response mechanism dedicated to disaster preparedness, emergency relief and rehabilitation to ensure immediate response. They underlined the need for collaborating action in the area of environment to promote sustainable development. They proclaimed the year 2007 as the "Year of Green South Asia," devoted to a region-wide a-forestation campaign (Strategic Digest 2005). However; translating broad principles into concrete action will need the coordinated efforts of many institutions within governments, public sector organizations and private institutions. While efforts within SACEP and SAARC may take some time before they lead to any action, there are other avenues for regional cooperation to be explored.

It will require the strengthening of existing institutions at different levels. It will need a close linkage among the compartmentalized sectors which have been historically dealt with by separate organizations. It will call for a change in the institutional – mechanism for enlisting public participation. It will necessitate quick decision making on development projects based on assessment of their potential of rendering long term sustainable benefits to the society at large, particularly vulnerable sections. It will be also require effective implementation of laws and regulations for environmental protection through strengthening of and closer interaction among the regulatory bodies and administrative machinery. Existing laws and enforcement mechanisms should be subjected to periodic review to evaluate their adequacy and efficacy in the light of changed circumstances and experience.

### 5.4 Accounting and Cooperative Management of Natural Resources

Given that the economic policies form the framework for a range of sectoral development, it will be necessary to consider how these policies affect the quality and productivity of environmental resources. This will require a system of resource accounting along with the other exercises of cost-benefit analyses. The Government should prepare, each year, a natural resources budget which will reflect the state and availability of resources like land, forests, water, etc. and which will rationally allocate these resources in keeping with the principles of conservation and sustainable development.

## 5.5 Training and Orientation Programs in Environmental Management

Formal education and training program in specialized areas of pollution control and environmental management will be a continuing need. For this purpose, intensive programs for education and training will need to be introduced in the universities, IITs and other professional institutions. Environmental education at the school level, including training of teachers, shall be an important component of educational programs.

## 5.6 Promoting Environmental Awareness

To raise public awareness and involvement in environmental activities, the mass media ranging from local folklores to electronic media should serve as a vital role. To raise public awareness on environmental issues and to promote people's participation, in environmental activities and conservation of natural resources, development of environmental education resource material, and use of traditional and modern media need to be strengthened.

## 5.7 Promoting Appropriate Environmental Technologies

Existing research and development efforts need to be strengthened to develop the appropriate low cost technologies considering the possibilities, opened up by biotechnology, genetic engineering, information and material technologies and remote sensing, tailored to the local environmental and socio – economic conditions.

Above all, it requires a strong political will on the part of regional governments. The political environment of South Asian nations is not very much encouraging. The political initiative obligatory to implement the suggestions is not coming forth. Governments of the region should come forward and should take concrete action to comprehend the emerging threats of the environmental mismanagement. All these measures can be covered within the framework of a Regional Environmental Security Treaty.

## 6 Conclusion

After the end of Cold War, there has been much debate on the comprehensive approach to national security. It is widely accepted that the national security has to be viewed in a wider perspective. The environmental security constitutes a significant dimension of the comprehensive national security. The environment has to be viewed in a wider perspective where human and non-human living beings are also important along with the nature. The environment and the living organs are closely interlinked. Hence, environmental security must take into consideration a balanced and sustained inter-relationship between the two. In South Asia, environmental issues have become significant in the overall framework of security due to high population growth, excessive dependence on nature, uneven infra-structural development, poverty, under-development and fragile ecology. While there is an urgent need to take measures for environmental protection, a regional approach alone can be fruit bearing because of eco-geographical inter-linkages and interdependence in the region. Therefore, along with the strengthening of SAARC, a Regional Environment Security Treaty can be suggestive. Such a treaty will provide an institutional basis for the growth of a common approach to environmental protection and management in South Asia.

We owe it to the world's poor and to future generations to act with resolve and urgency to stop dangerous climate change. The good news is that it is not too late. There is still a window of opportunity, but let's be clear: the clock is ticking and time is running out. Above all, it can be said that "Either we act quickly, or prepare to join the dinosaurs. Alternatively, find another planet."

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# Part III
# Climate Change and Energy as New Major Factors Redefining the World Food Equation

# Chapter 14
# Climate Change, Seasonality and Hunger: The South Asian Experience

**Nira Ramachandran**

**Abstract** Seasonality remains a prime cause of food scarcity and hunger in the rural areas of South Asia with millions facing recurring food insecurity each year. With the impacts of climate change becoming apparent, the probability of sharpening food insecurity is high. Climate change brings with it increasing uncertainty. It is no longer a specific season which the farmer must gear up to face, but also the uncertainty regarding the advent of the season, its duration and the intensity of impact in terms of drought, rainfall, flooding, etc. To equip the small and marginal farmer to cope with the additional burden of seasonal uncertainty, agriculture policy and welfare measures need to be tailored to fit the changing situation. This paper reviews the impacts of seasonality on food security in the rural areas of South Asia, and projects the scenario which is likely to result with climate change. Existing policies/interventions to provide food security and secure livelihoods are assessed and recommendations are made to effectively co-ordinate government policies, public-private partnerships, corporate and voluntary initiatives to build resilience to climate change and ensure food security in the region.

**Keywords** Food security • Seasonality • Climate change • Climate proofing • South Asia

## 1 Backdrop

The South Asian economy remains heavily dependent on agriculture which employs 60% of the labour force, and contributes 22% of the region's GDP. With an annual growth rate of 1.5% in the rural areas, landlessness is increasing and the pressure on rural jobs is high with the result that as much as 25% of the active male

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_14,

population in rural areas is employed as agricultural labour (World Bank 2008). Productivity and stability of agricultural output in the region is largely determined by the availability of water, but only 39% of the cropped area is irrigated. In fact, in the rural areas of the region, the fine edge between survival and destitution hinges on the advent of the monsoons. Not for nothing are these countries classified as the "monsoon countries" of South Asia. The wide ranging impact of the seasons can be gauged by the fact that even the failure of a single monsoon can result in indebtedness and starvation at household level, and deplete buffer stocks at country level turning food surplus countries into food importers within a single season. India with its successive ups and downs in food production, imports and exports over the last few decades is a case in point. Added to this is the fact that increasing urbanisation and decreasing proportions of the population engaged in agriculture do not necessarily translate into lesser numbers being subjected to climatic vagaries. In terms of actual numbers, millions of people remain directly dependent on agriculture, and thus on climate, both for food and wage income.

Undisputedly, the impacts of climate are more severely felt by the poor. Whether, these are physical impacts in terms of flooded villages, contaminated water supplies, outbreaks of disease, collapse of poorly constructed homes, loss of crops, livestock and personal belongings in the case of unusually heavy rainfall, or enforced migration with loss of assets during prolonged drought, and/or economic shocks brought on by rising food prices and loss of jobs, the poor have neither the assets nor the support system, which protect those with more assured incomes. And South Asia is home to 39% of the world's poor living on less than US$1 a day. In fact, it is estimated that the number of rural poor in South Asia will likely exceed the number of urban poor until 2040 (World Bank 2008).

A delay in the monsoons, a prolonged drought, un-seasonal rainfall or flooding due to exceptionally heavy monsoons can all wreak havoc on livelihoods and food security and impact even urban populations because of rising food prices and scarcity of produce. In this background, the fast emerging impacts of climate change in terms of heightened uncertainty, increased occurrence of extreme events and the accompanying risks of proliferating pests and disease may well undo all earlier efforts to bring a measure of food security to the poor in rural areas.

## 2 Seasonality and Hunger

Life in rural areas is largely governed by the seasons. Seasonality impacts not only food production, but also the availability of wage income from farm or off-farm jobs. For the subsistence farmers of South Asia practising rain-fed mono-cropping, food production from their marginal holdings provide only a few months of food security. The cash income which comes with the harvest barely suffices to meet immediate pressing needs. Thus, the seasonal cycle brings into operation a set of coping strategies, the first of which is a steady decline in food consumption reducing both the number of meals per day and the amounts consumed. Intra household, the impact of this reduced intake is severest on women and girls, and the fallout can be seen in the statistics on undernourished women and children. South Asia has the highest proportions of underweight and anaemic women and children in the world. The reduction of daily intake from three meals to two begins within 3–4 months of harvest depending on the size of landholding and family size, and reaches a single meal a day towards the end of summer and through the monsoons, often culminating in hunger, starvation and even death in the case of the most vulnerable. In fact, the large numbers of children succumbing to infections like ARI[1] and diarrhoea in South Asia is largely a consequence of their malnourished status. Exacerbating the shortfall in food stocks, the peak hunger season of the monsoons also coincides with the unavailability of opportunities for employment as farm labour or construction workers. This holds true not only in the open market, but also with regard to government sponsored Food for Work programmes, which focus on construction projects often untenable in the wet season (Ramachandran 2004).

The vicious cycle of seasonal food distress does not, however, end with the hunger season but casts its shadow over the entire year. As Messer writes, "specifically it is during the peak season when tasks, such as harvesting, require sustained expenditure of human energy that reduced calorie intake has its greatest negative impact on worker productivity. Thus, the household that experiences seasonal shortages of food in one year faces the prospect that low levels of food energy intake will impair work performance in the future. A possible consequence is a ratcheting effect, whereby reduced performance leads to a lower wage offer and farm profits, and thus to even lower food intake in the following year. Similarly, distress sales, placing children with relatives or friends or migration are strategies employed by households to cope with a period of seasonal dearth. These strategies of coping with the lean season may in fact result in a household having to mortgage land, human capital and part of its productive assets" (Messer 1989). Even the food crisis in Africa may be attributed to the cumulative impacts of seasonality. As Vatla writes, "The famines in Malawi (2001) and Ethiopia (2003) were not simply the result of a catastrophic once off agricultural production failure as is commonly thought but were also underpinned by years of seasonal hunger that eroded household resilience to such production failures" (Vatla 2008).

There is little doubt that certain technologies, especially water control and management, change the seasonal pattern of food production. Longhurst and Lipton (1989) argue that abandoning traditional crops (e.g., roots and tubers) and cultivation practices (e.g., diversification) exacerbates seasonal variability in food supplies – causing increased seasonal stress in parts of Africa. Furthermore, legumes, fruits, green leafy vegetables may be the major suppliers of micro-nutrients and protein and play a vital role in the diets of the poor, especially during the pre-harvest period.

Another important factor that determines the seasonality of food availability is the effectiveness of storage operations. Regardless of when crops are harvested the ability to store inter temporally can smooth out seasonal food availability. This also suggests that the availability of storage infrastructure and the functioning of markets are essential components in reducing seasonal fluctuations in food availability.

[1]Acute Respiratory Infections.

## 3 The Controlling of Climate in South Asia

Of the South Asian countries, Bangladesh is perhaps, the most vulnerable to extreme climate events. Floods, typhoons and cyclones strike the country almost every year wiping out standing crops and rendering millions homeless. The high population density of 1,218 persons per sq. km (2007) – one of the highest in the world – and the concentration of population in the fertile, but low lying, flood prone Ganges delta extenuate the risk factor. In 1998, flood waters covered two-thirds of the land area of Bangladesh, leading to major crop losses. Despite the massive social and economic impact, the government was successful in avoiding a major food crisis through a mix of public interventions, private market trade flows and an extensive system of private borrowing (Del Ninno et al. 2001).

Bangladesh is also heavily dependent on agriculture which provides employment to 52% of the country's workers (Table 14.1). Thus, food security is integrally linked with agricultural production. While foodgrain production has doubled since independence in 1971 with the aid of improved varieties and technology, the increase has served to support the large population base rather than enhance living standards (FAO 2005a).

About 41% of Bangladesh's population is classified as extremely poor living on less than US$1 per day (WDR 2008), indicating deep problems of chronic poverty and also of access to food. Like the other South Asian countries, Bangladesh also ranks among those with the highest malnutrition rates in the world. Over 48% of children under 5 years old are underweight (WDR 2008).

In the decades since the 1974 famine, Bangladesh has moved from being chronically food-deficit to the brink of food self-sufficiency. The focus of food policy has shifted perceptibly in recent years. The government has liberalized grain trade and dismantled the public food rationing system. Instead of using public distribution as an outlet for public food procurement and price support, the emphasis has shifted toward strengthening social safety nets and disaster mitigation programmes, and procurement and stocking are now being carried out up to the level necessary to sustain these programmes.

Despite these positive changes in food policy and progress in economic growth, pervasive poverty and undernutrition persist. The most disturbing consequence of

**Table.14.1** Agricultural indicators: Country comparisons (Source: World Development Report 2009. Data in Cols. 5 and 6 are from FAO 2007)

| Country | % Arable to total land (2007) | Population density per km$^2$ (2007) | % Rural population (2000) | % Population in agriculture (2005) | % GDP from agriculture (2006) |
|---|---|---|---|---|---|
| Bangladesh | 61.1 | 1,218 | 76.8 | 47.0 | 20.1 |
| Bhutan | 3.4 | | 90.4 | 69.1 | 24.1 |
| India | 53.7 | 378 | 72.3 | 49.9 | 18.3 |
| Nepal | 16.5 | 197 | 86.6 | 93.1 | 38.2 |
| Pakistan | 27.6 | 211 | 66.8 | 48.2 | 21.6 |
| Sri Lanka | 14.2 | 309 | 84.3 | 48.6 | 16.8 |

widespread poverty is that over 140 million people cannot afford an adequate diet. Furthermore, 41% of the country's population remains seriously underfed due to inadequate purchasing power. Chronically food insecure and highly vulnerable, these people remain largely without assets (other than their own labour power) to cushion lean-season hunger or the crushing blows of illness, flooding and other calamities. The government has shown a remarkable willingness to evaluate programme effectiveness, confront shortcomings and cancel or modify programmes as a result. However, income seasonality remains unaddressed by the existing safety nets. A consumption credit programme for the poor to mitigate transitory food insecurity during the lean season has been proposed. It has been understood that relief is needed immediately after a disaster, but to restart the development process, the provision of credit becomes very important. BRAC[2] is targeting the ultra poor with various development oriented safety-net programmes.

India stands on the verge of achieving middle income country status with an average annual economic growth rate averaging 7.7% (2007), one of the highest rates in the world. Yet seasonal food shortages persist, and as much as 79.8% of the rural population is estimated to consume less than the standard norm of 2,400 kcal on a daily basis (Deaton and Dreze 2008). IFPRI (2008) ranks India in the category of nations where hunger remains at "alarming" levels. One third of the adult population have BMIs below 18.5, while 47% of children below the age of 5 years are underweight (Planning Commission 2008).

Despite technological advance, the heavy dependence of Indian agriculture on climate may be gauged from the fact that within a period of just 1 year (1998–1999), agricultural growth declined sharply, from 8% to 1% due to below-normal monsoon rains and serious damage from a cyclone that hit the Orissa coast. Exacerbating the impact, two major tropical cyclones left approximately 10 million people homeless, with millions losing their crops and at the same time, there was deficit rainfall in 8 of the country's 29 states (Bandyophadhyay 1999).

The focus of the country's agricultural policy has been on promoting production through input subsidies and support prices, which tend to benefit the large farmer. Thus, the production base has shifted from low cost to high cost regions. With the sharp rise in the use of private capital, small farmers are forced to sell part of their produce to pay off loans incurred on purchased seeds, water, fertilizers and other inputs. In addition, the proportion of total bank credit for agriculture has fallen from 18% in the mid-1980s to just 10% in 2005–2006. Also groundwater has become the main source of irrigation resulting in nearly 30% of the blocks in the country being classified as semi-critical or critical as groundwater use exceeds the rate of recharge. The result of this combination of factors has been increasing landlessness, sharpened inequalities and stagnation in production (Saxena 2008).

Sri Lanka has the best social development indicators among the six South Asian countries, and has maintained healthy economic growth despite a 20-year-long ethnic conflict. In comparison with the other countries of the region, only 6.6% of Sri Lanka's

[2] Bangladesh Rural Advance Commission.

population lives below US$1 per day (HDI 2008). However, the food energy deficiency prevalence of 57% is on par with India and Bangladesh (IFPRI 2007) (Table 14.2). This may be attributable to the fact that the proportion of people living on less than US$2 per day is quite high, at 45% (World Bank 2005), indicating that while poverty is not severe on a widespread basis, it remains an issue in the country. Furthermore, the majority of poor households, mostly small-scale farmers and landless labourers, experience seasonal food shortages despite the country's achievement of near self-sufficiency in rice. Their food security is highly dependent on rainfall patterns and due to irregular rainfall, recurrent drought and neglect of irrigation infrastructure, agricultural productivity in small-scale farming has been declining since the mid-1990s (FAO 2005b).

Pakistan with a poverty rate of only 13.4% has a lower rate of food energy deficiency and a lower child malnutrition rate than either Bangladesh or India. Nevertheless, an estimated 44% of the population is not consuming sufficient dietary energy for maintaining light activity levels. This may be partially attributable to a considerable slowdown in economic growth in the latter part of the 1990s, due to the poor performance of the manufacturing, service and agricultural sectors. The decade of the 1990s is characterized by a "deteriorating socioeconomic situation", increases in poverty and inequality, stagnating food production and the "re-emergence of food poverty and insecurity as an issue" (World Bank 2002b).

Nepal is a small landlocked country with a population of 29 million (2008). Compared to other Asian countries such as India or Bangladesh, it has a relatively low population density. However, the population is overwhelmingly rural, with only 13% living in urban areas (World Bank 2002a). Consequently, rural population density is relatively high at 686 people per square kilometre, a figure that exceeds that for most low income countries (World Bank 2002a). It is also one of the poorest countries in the world, with 24% of the population living below an income of US$1 per day (HDI 2008). As per the National Population Census of 2001, 87% of the people of Nepal live in rural areas, where even two square meals a day are unaffordable. Agriculture is the mainstay of the country's economy. Over 81% of the population is engaged in agricultural and allied activities, but the seasonality of agricultural work and inadequate availability of off-farm employment have compounded the poor living conditions of the farmers. Besides, old-fashioned agricultural methods, lack of improved farming inputs and poor irrigation facilities are a great stumbling-block to agricultural development (Maharjan 2003). The contribution of agriculture to the country's Gross Domestic Product (GDP) is only 38%.

Bhutan, despite its small population, is also prone to food insecurity, especially in the remote villages of the Eastern and Southern regions. With a mountainous

**Table 14.2** Key indicators of food insecurity based on household economic surveys (Source: IFPRI 2007)

| Country | Year of survey | Food energy deficiency (%) | Severe food energy deficiency (%) | % of energy from staples |
|---|---|---|---|---|
| Bangladesh | 2000 | 53.7 | 29.4 | 82.4 |
| India | 1999 | 52.4 | 34.2 | 66.5 |
| Pakistan | 1998 | 44.1 | 31.2 | 56.2 |
| Sri Lanka | 1999 | 56.7 | 42.1 | 59.9 |

terrain and large tracts of forest area, Bhutan has only 7.7% of its total land area available for cultivation. While the country is self-sufficient in coarse cereal production, fine cereals are imported from India. The agricultural system is traditionally of a subsistence and integrated nature with crop farming, livestock rearing and forestry. More than 85% of the population is dependent on agriculture, and the sector remains the single largest one contributing 35% of the country's GDP (1998). The two major factors affecting food security are:

- Size of land holdings; and
- Poor infrastructure both in terms of road connectivity and storage facilities.

Fifty-five per cent of the farm households own less than 2 ha of land, and 27% own less than 1 ha with as many as 40,000 people (9%) owning less than 0.5 ha. With a growth rate of 3.1% per annum, it is estimated that the current per capita land holding size of 0.51 ha will be halved within two decades. The undeveloped road network leaves much of the rural area isolated with no opportunity to market farm produce. Hence, crops are limited to coarse cereals for home consumption.

Lack of proper storage facilities leads to high post harvest losses, and seasonal food insecurity is common (United Nations CCA Bhutan 2000).

Thus food insecurity in the South Asia region is largely driven by chronic poverty and exacerbated by the overwhelming role of seasonality, which often brings in its wake crushing natural disasters. While economic and, in particular, agricultural growth has fueled an increasing potential to meet the food needs of populations, there have been some setbacks, especially with respect to agricultural productivity growth (IFPRI 2007).

## 4 The Heightened Impacts of Climate Change

The effects of climate change are heterogeneous and region specific. Some positive effects of climate change such as $CO_2$ fertilisation of plants could contribute to increasing food production and security. However, impacts such as rising temperatures and increased frequency of extreme weather events put severe pressure on food availability, stability, access and utilisation. Climate change could lead to increased water stress, decreased biodiversity, damaged ecosystems, rising sea levels and potentially to social conflict due to increased competition over limited natural resources. Small-holder agriculture, pastoralist, forestry and fisheries and aquaculture are among the systems most at risk (FAO 2008).

While socioeconomic determinants of food security, such as markets for agricultural products, might be important in the short term, the long term stability and availability of food production are closely linked with environmental factors. The impact of climate change on food security can be summarized as follows:

- *Availability of food* will be reduced as a result of crop losses linked to extreme climate events.
- *Access to food* will be made more difficult by the destruction of infrastructure and loss of income from climate-related disasters.

- *Stability of food supplies* will be influenced by price fluctuations and heavy dependence on imports and food aid.
- *Utilization of food* may be affected indirectly by food safety hazards associated with pests and animal diseases as well as the increased incidence of climate-sensitive human diseases (IDRC, CDRI, DFID 2008).

Pest and disease occurrences often coincide with extreme weather events and with anomalous weather conditions such as early or late rains and decreased or increased humidity, which by themselves can alter agricultural output. Recent climate trends, such as increased night time and winter temperature, may be contributing to the greater prevalence of crop pests. Expected temperature increases are likely to hasten the maturation of annual crop plants, thereby reducing their total yield potential, with extremely high temperatures causing more severe losses.

Climate change projections include an increased likelihood of both floods and droughts. Variability of precipitation in time, space and intensity will make agriculture increasingly unstable and make it more difficult for farmers to plan what crops to plant and when. Climate affects not just agricultural crops but their associated pests as well. In the wake of floods and heavy rains in Bengal in 1942, for example, rice leaf blight caused the great famine in which 2 million people lost their lives (Rosenzweig et al. 2000). In June 2009, the tribal district of Ukhrul in the state of Manipur in North East India reported over 10,000 people facing severe food scarcity due to delayed rains in the previous year followed by a massive pest invasion. Not only were the tribal people unable to begin their *Jhum* (slash and burn) cultivation in time, but the grasshopper invasion destroyed the remaining crops (Indian express and New Delhi. 10 June 2009).

Geography, coupled with high levels of poverty and high population densities, has rendered South Asia especially vulnerable to the impacts of climate change. These impacts in the form of higher temperatures, more variable precipitation and more extreme weather events are already being felt in the region. It has been projected that these will intensify. Over 50% of South Asians – more than 750 million people – have been affected by at least one natural disaster in the past two decades. The human and economic toll has been high with almost 230,000 deaths and about US$45 billion in damages (World Bank 2009).

High population levels translate into increased resource demands on an already stressed natural resource base. By 2050, South Asia's population is likely to exceed 2.2 billion from the current level of 1.5 billion. With an estimated 600 million people subsisting on less than US$1.25 a day in South Asia, even small climate shocks can cause irreversible losses and tip a large number of people into destitution (Damania 2008).

Collaborative studies carried out by IRRI and US-EPA for rice production in Asia, report that using process-based crop simulation models, increasing temperature may decrease rice potential yield up to 7.4% per degree increment of temperature. When climate scenarios predicted by GCMs are applied, it has been demonstrated that rice production in Asia may decline by 3.8% under the climates of the next century. Moreover, changes in rainfall pattern and distribution have also been found suggesting the possible shift of agricultural lands in the region. Shifts in rice-growing areas are likely to be constrained by land-use changes occurring for other developmental reasons, which may force greater cultivation of marginal lands and further deforestation. This should be taken into account and lead to more integrated assessment, especially in developing countries where land-use change is more a top-down policy rather than farmers' decision. A key question is: To what extent will improving the ability of societies to cope with current climatic variability through changing design of agricultural systems and practices help the same societies cope with the likely changes in climate? (Iglesias et al. 1996).

During the last few decades, a large number of climate change impact studies on agriculture have been conducted qualitatively and quantitatively in many regions of the Asia-Pacific. Changes in average climate conditions and climate variability will have a significant consequence on crop yields in many parts of the Asia-Pacific. Crop yield and productivity changes will vary considerably across the region. As mentioned earlier, vulnerability to climate change depends not only on physical and biological response but also on socioeconomic characteristics. Adaptation strategies that consider changes in crop varieties or in the timing of agricultural activities imply low costs and, if readily undertaken, can compensate for some of the yield loss simulated with the climate change scenarios. Studies suggest that the regions of Tropical Asia appear to be among the more vulnerable (Luo and Lin 1999).

Cline expects that of all potential damages which could occur from climate change, the damage to agriculture could be among the most devastating. Since agriculture constitutes a much larger fraction of GDP in developing countries, even a small percentage loss in agricultural productivity would impose a larger proportionate income loss in a developing country than in an industrial country (Cline 2008).

The Himalayan system shapes the critical and often unpredictable monsoon dynamics in South Asia. It acts as a natural reservoir for sustaining crops and providing groundwater recharge. The Himalayan ecosystem sustains some 1.5 billion people who live directly in the floodplains of its many rivers (e.g., the Brahmaputra, Ganges, Indus and Meghna). There is general agreement that the widespread retreat of the global ice cover has been occurring since at least the early 1800s. "With rising temperatures the ice mass of the Himalayan-Hindu Kush is retreating more rapidly than the global average in some locations". The Gangotri glacier is the source of the Ganges and is one of the largest in the Himalayas. The Gangotri has been receding since 1780, and in recent years the pace of retreat has accelerated. The receding trends of glacier masses threaten water supplies, livelihoods and the economy of the region. With melting glaciers, flood risks would increase in the near future. In the long term, there can be no replacement for the water provided by glaciers, and this could result in water shortages at an unparalleled scale (Damania 2008).

Various scenarios and predictions have been made by scientists and experts: Himalayan snow and glacial ice may decline by 20% by 2030; Bhutan will be more frequently hit by floods, landslides and droughts; Nepal's Yaks will have to find new forage lands; irrigation in the Indus basin and Ganges-Brahmaputra delta will be at risk due to salinity, increased flooding and sea level rise; food deficits in Bangladesh may rise from the current 2.8–3 mt to 4.7 million tonnes in two decades time; a temperature rise of 0.5°C will reduce rice production in Sri Lanka by 5.9%; and a temperature rise of about 2°C may have substantial impacts on the distribution, growth and reproduction of fish stock. These are not science fiction scenarios; rather, some are already a reality: two monsoon floods and Cyclone Sidr that struck

Bangladesh in 2007 led to significant food losses, with Aman rice losses alone estimated at 2 million tonnes, causing panic in the rice market.

## 5 Climate Proofing the Farmer to Ensure Food Security

Farming activities revolve around the climate, a seasonal phenomena over which human beings exert little control. While weather events (e.g., levels of solar radiation, precipitation) are given exogenously, the interaction of the natural ecology with technology and markets determines the seasonal pattern of food production. Although some periodicity in food production is inevitable, there are a number of policy and research issues that are important. These revolve around how farmers can control or respond to climatic events (Sahn 1989). Mongkolsmai and Rosegrant (1989) in their study of Thailand find that irrigation stabilizes the seasonal demand for labour, boosts wages for hired workers and reduces out-migration. The poor, by adjusting production techniques and management practices, face a dilemma when saving confronted by the choice of saving for the next season, even if anticipated to be a period of stress, in the face of hunger in the present. The uncertainty of the seasonal cycles makes more complex, albeit more important, a household's inter-temporal budgeting of scarce resources (Sahn 1989).

National farm policy can be a critical determinant in the adaptation of the farming sector to changing conditions. Farm subsidies may either help or hinder necessary adaptation to the eventuality of a changing climate. An important policy consideration is the assessment of risk due to weather anomalies. If flood and drought frequencies increase as projected, the need for emergency allocations will also increase. Anticipating the probability and potential magnitude of such anomalies can help make timely adjustments that may reduce social costs. Coping with disasters often diverts government efforts and resources away from long-term development priorities and into short-term crisis management. It becomes necessary for governments to adopt more holistic approaches to cover all aspects of vulnerability and risk management, both existing and anticipated. Specific codes must be developed to address cyclones, floods, drought, famine and other extreme climate events, on the one hand, and gradual reduction/increase in precipitation, temperatures, desertification, glacial melt, changes in sea level or forest cover, on the other.

As Vatla (2008) states, planning for seasonality is an important, though often ignored, principle of smart development. Most of the world's poor families live in rural areas and work in agricultural and livestock economies. For these households, poverty, hunger and illness are highly dynamic phenomena changing dramatically over the course of the year in response to production, price and climatic cycles. As a result, most of the world's acute hunger occurs not in conflicts and natural disasters but in that annually recurring time of the year called the "hunger season".

Despite the importance of seasonal cycles throughout the rural developing world, development response is often homogenous in type and amount throughout the year with the result that assistance is inadequate to meet needs during some periods, while resources are underutilized during other periods. Not only does this reduce the efficiency of development spending, but it also suppresses economic growth.

South Asia is home to numerous successful examples of targeted food and nutrition intervention programmes. India's Integrated Child Development Services (ICDS), the largest child nutrition intervention programme in the world, the Food for Education programme in Bangladesh which transfers food to poor households through targeted interventions focused on schoolgirls, Pakistan's Food Support Programme and the food-based nutrition intervention programme Triposha in Sri Lanka aimed at reducing child malnutrition are just a few. Additionally, livelihood promotion programmes such as India's National Rural Employment Guarantee Act (NREGA), which provides 100 days of employment to one member of each household seeking work, and Bangladesh's Grameen Bank which provides small loans, issued without formal collateral, to enable the poor to set up small income-generating businesses and climb out of poverty are being implemented.

While some programmes are already thinking seasonally like India's NREGA or the Productive Safety Nets Programme (PSNP) in Ethiopia which provides 6 months of employment during the hunger season for those who can work, as well as direct assistance for those who cannot, most others ignore seasonality altogether. Seasonality-based approaches often utilize seasonal calendars to improve humanitarian assistance efforts. NGOs in many states of India (Jharkhand, Orissa, Andhra Pradesh and Madhya Pradesh) are reviving traditional grain banks in tribal communities. Banks are set up with grain collected during the harvest festival or with grain grants from government agencies. The banks are managed by the community, which lends out grain for food or seed as needed and recovers loans at minimal interest rates. Most such experiments have met with considerable success ensuring food security during the hunger season, preventing forced migration and creating additional funds for development activities through the sale of surplus grain. The Government of India has been implementing a grain bank scheme in rural areas from 2005 onwards covering 16,478 villages to date. During droughts, school feeding programmes are extended through the long school vacations to ensure that all school-going children receive at least one square meal a day. However, despite the impacts and cost effectiveness of seasonal programmes providing resources during the most difficult time of the year – other than supplementary feeding during the hunger period – all other programmes function on a year round basis. And, despite year after year predictability of the hunger season, "seasonal thinking" has yet to become the norm in development planning (Vatla 2009).

## 6 Summing Up

Undoubtedly, climate change exacerbates the impacts of seasonality and, all too often, these are negative effects. Seasonality is a major factor underlying the uncertainty of agricultural output, and preventing the South Asian farmer from breaking through the poverty barrier. Vatla (2009) suggests specific action points to combat the effects of seasonality on small farmers:

- Pre-positioning of resources, health and nutritional in the months preceding the hunger season, with early warning systems to indicate deteriorating food and nutritional situation, including therapeutic food to ensure that moderate malnutrition does not become severe;

- Seasonal approach to safety nets such as India's National Rural Employment Guarantee Act (NREGA), which can protect family health and assets during the hunger season;
- Price indexing: indexing cash transfers to price trends to protect against food price volatility.

However, in view of the exacerbating impacts of climate change, these measures may not suffice to safeguard farmers and protect rural populations against hunger. There is a need for better linkages between agricultural research and technology transfer in the region. The extension systems that were successful in transferring technology to the farmers during the Green Revolution period have declined, both in terms of quantity and quality (Suresh 2005). Unless the extension systems of the South Asian region are revived to equip farmers with the required know-how on flexible cropping patterns, crop varieties suited to early/late sowing or shortened growth periods, changes in temperature or rainfall, etc., farmers will be unable to face the challenge of climate change. The process of technology transfer in itself implies empowerment at the grassroots level, through the strengthening of self-help groups and local governance structures. There is no reason why community driven initiatives cannot work with government or planned initiatives.

Listed below is a three-pronged strategy that needs be set in place, on a priority basis, to safeguard the South Asian countries from backsliding into the hunger trap (Fig. 14.1):

1. Communication

   - Effective early warning systems to be set in place with quick communication links to grassroots institutions/representatives.
   - Village level warning systems to be installed and made effective by conducting of regular drills.
   - Easy access to information and inputs for adapting cropping patterns to unexpected weather changes to be created.

2. Empowerment

   - Grassroots self-help groups and local governance structures to be strengthened.
   - Local banks for food-grain, fodder and seed to be set up with the involvement of the village population, and equipped with stocks sufficient to tide over at least a minimum period of 2 weeks, before the government machinery steps in.
   - Regular monitoring of these banks/supplies and recycling of contents to ensure that these essential items remain in usable condition.

3. Asset/livelihood protection

   - Apart from traditional crop insurance, weather-indexed insurance can help farmers avoid major downfalls in their overall income due to adverse weather related events, and reduce their overall vulnerability to climate variability. Unlike traditional crop insurance where claim settlement may take up to a

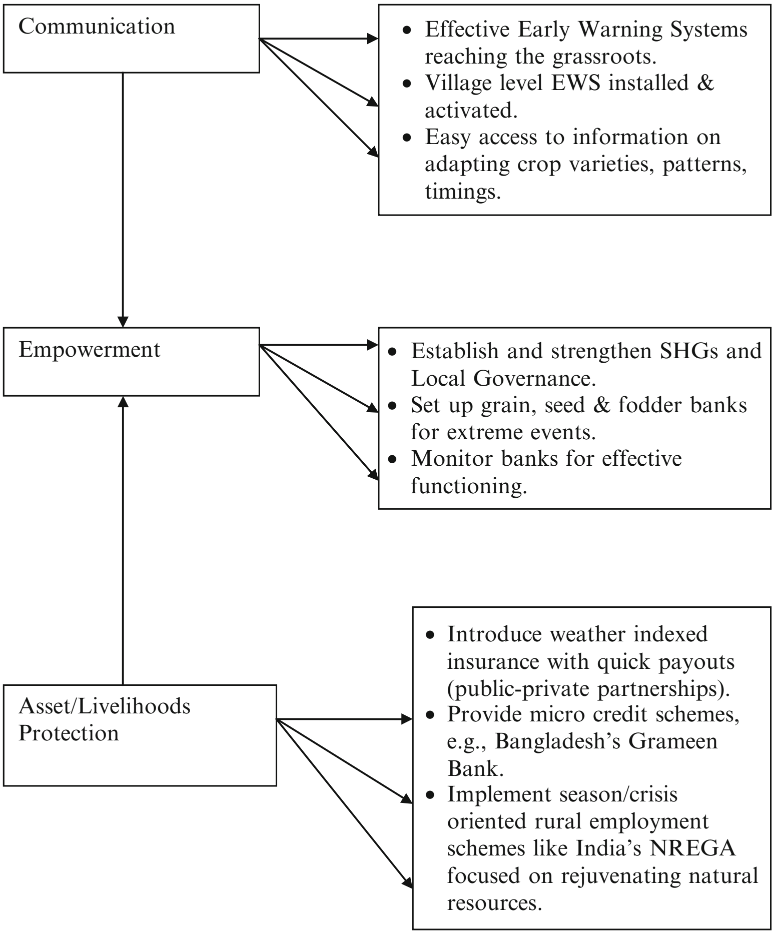


**Fig. 14.1** Climate proofing the farmer – a model

year, quick payouts in private weather insurance contracts can improve recovery times and thus enhance farmers' coping capacity. In this context, there is a role for public private partnerships in the provision of financial services in rural areas (Kelkar and Bhadwal 2007).

- Micro-credit schemes like Bangladesh's *Grameen* Bank to be promoted with a view to providing alternative income choices and rebuilding livelihoods after disaster strikes.
- Rural employment schemes on the lines of India's National Rural Employment Act (NREGA) to be set up in all the South Asian countries to safeguard the livelihoods of landless rural workers and others who need support.
- Activities undertaken by the beneficiaries could additionally be focussed on the rejuvenation of the natural resource base through water conservation, land development and aforestation, as is the case in India.

To conclude, the challenge of the hour is to ensure that government policies, public-private partnerships, corporate and voluntary initiatives – all work in tandem to build resilience to climate change and ensure food security in the region.

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# Chapter 15
# Effects of Climate Change on Food and Human Security in Nigeria

**Abiodun Elijah Obayelu**

**Abstract** Climate change is not just an environmental problem but a threat to food and human security. This study reviewed the known and suspected causes of climate change, extents and effects of climate change on food and human security, mitigation and adaptation strategies. The findings revealed that many different communities, including fishermen, farmers and herdsmen are now confronted with the difficulties of climate change in Nigeria than ever before. Climate change affects agriculture through erratic rainfall patterns, occurrence of greater weather extremes (temperature), rising sea levels, erosion, droughts and flooding. The extreme weather like thunderstorms, heavy winds and floods devastate farmlands and lead to crop failure. Pests and diseases migrate in response to climate change and threaten livestock in the drier Northern area. On human, Nigeria has more cases of cerebro-spinal meningitis in Northern states because of high temperature. Malaria, yellow fever, cholera and sleeping sickness are among notable diseases emanating from climate change.

**Keywords** Climate change • Food security • Global warming • Human security • Nigeria

## 1 Introduction

In many parts of the world, climate change poses significant threats and challenges to social and ecological systems, international stability, and ultimately to human security. Yet the linkages between climate change and human security are poorly understood and require further research. Climate change is being increasingly viewed as the foremost defining human development problem of the twenty-first

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_15,

century (UNDP 2007). It is a new threat to water, agricultural production and public health (Ludi 2009) in countries with low capacity to effectively cope (CSIS 2007; Dupont and Pearman 2006; Nellemann et al. 2009; Shah et al. 2008). Climate change is the latest in a series of environmental drivers of human conflict in recent decades (Brown et al. 2007; IIDSA 2008). The problem of climate change therefore is not one in which a single nation or community is facing in isolation, but a global issue which is a consequence of the fact that the atmosphere is common to the entire mankind. The risks posed by climate change are real (HRECEC 2008) and the dangers have been likened to those posed by a world war to all of humanity (Nicholls et al. 2007).

The main objective of this study therefore is to analyze the effects of climate change on food and human security in Nigeria. This study is motivated by what we perceive to be an important gap in literature on the relationship between climate change, food and human security, and lack of proper attention on the effects of climate change on human and food security.

The first section of this chapter gives the background. The second section, presents the theoretical and conceptual frameworks on climate change, food and human security. The third section states the methodology, while the fourth section presents the results of the findings. The last and the fifth section talk about the summary of findings, conclusion and recommendations.

## 2 Theoretical and Conceptual Frameworks on Climate Change and Human Security

The basis of this study is that climate change is a threat to both food and human security. This section addresses the basic concepts of climate, climate change, food security and the much-debated human security.

### *2.1 What Is Climates and Climate Change?*

*Climate* refers to the long time (about 35 years) average weather conditions of a region including typical weather patterns, the frequency and intensity of storms, cold spells and hot weather (Zabbey 2007). *Climate change* is the departure from the expected average weather. It is any change in climate overtime, whether due to natural variability or as a result of intense human activities in the environment. *Global warming* is an important aspect of climate change that is primarily a consequence of accumulation of greenhouse gases in the atmosphere or the observed increase in the average temperature of the air near the Earth's surface. *Weather* is the daily fluctuating state of the atmosphere around us, and it is characterized by temperature, wind, precipitation (rainfall), clouds and other weather elements. The primary characteristic of climate is variability.

## *2.2 Meaning and Dimensions of Food Security*

Food security is defined as physical and economic access to sufficient, safe and nutritious food to meet dietary needs (FAO 1996). Ensuring food security is currently one of the greatest challenges facing the world community because global food prices continue to soar. The concept of food security also has spatial and temporal dimensions. The spatial dimension refers to the degree of aggregation at which food security is being considered. This implies the possibility of analyzing food security at the global, continental, national, sub-national, village, household, or individual level. The temporal dimension refers to the time frame over which food security is being considered. In much of the food security literature, a distinction is drawn between chronic food insecurity (the inability to meet food needs on an ongoing basis), and transitory food insecurity when the inability to meet food needs is of a temporary nature (Maxwell and Frankenberger 1992). Transitory food insecurity is sometimes divided into two subcategories: *cyclical* (where there is a regular pattern to food insecurity, for example, the 'lean season' that often occurs in the period just before harvest); and *temporary* (which is the result of a short-term, exogenous shock such as droughts or floods).

Food security encompasses food availability (with elements related to production, distribution and exchange); food access (with elements related to affordability, allocation and preference) and food utilization (with elements related to nutritional value, social value and food safety (Latham 1997).

## *2.3 The Concepts and Meaning of Human Security*

Human security has many useful definitions and characterizations (Bajpai 2000; Edson 2001; Hampson et al. 2002; Heinbecker 2000; Kilgour 2000; Leaning and Arie 2000; Newman and Richmond 2001; Ogata 2001; McRae and Hubert 2001; Paris 2001; Sen 2000). Human security is a function of multiple processes operating across space, over time and at multiple scales. It is a concept that links together different issues and allows one to look at power, politics and the contextual factors that create insecurities. Human security takes its shape from the human being (the vital core that is to be protected). It is considered an emerging theme among international institutions, encompassing issues related to human development, human rights and environmental sustainability (Gasper 2005). The concept was first introduced by the United Nations Development Programme in 1994 (UNDP 1994), and then developed further in a report by the Human Security Commission, co-chaired by Sadako Ogata and Amartya Sen (Commission on Human Security 2003; Brauch 2005). Recently, environmental dimension of human security has been addressed by an international team working on Global Environmental Change and Human Security (GECHS) and by the United Nations University Institute for Environment and Human Security (UNU-EHS) (Bogardi and Brauch 2005). Alkire (2003) offers a useful conceptual approach to human security with her term "vital core", which implies that although institutions and interventions that undertake to protect human security will not be able to protect all aspects of human security, they will at least protect the vital core, such as survival (freedom from premature death), livelihood (basic material needs) and dignity.

Human security is people-centered, not threat-centered. It is a condition that results from an effective political, economic, social, cultural and natural environment, and not from executing a set of administrative procedures. It is the protection of the individual from sudden violent attack or property. It means protecting vital freedoms (Owen 2004). Human security connects different types of freedoms (freedom from want, freedom from fear and freedom to take action on one's own behalf). The seven components of human security are economic, food, health, environmental, personal, community and political security (UNDP 1994), while the elements include: the environment (Homer-Dixon 1994), health (Matsumae and Chen 1995), education and protection from natural disasters.

## 2.4 Relationship Between Climate Change, Food Security and Human Security

Literatures have shown a number of recent studies showing the relationship between climate change and human security. The linkages are often both complex and context-dependent. Climate change causes human insecurity which in turn increases the risk of violent conflict (Barnett and Adger 2007). Climate change affects food security in both medium- and long-terms by creating greater needs for emergency food aid (Cohen 2007). 'Human security' and 'state security' are not mutually exclusive concepts: without human security, traditional state security cannot be achieved, and vice versa. Using human security in relation to climate change stresses that the proper referent for security should be the individual as part of a wider community rather than the state as an entity of itself.

Food security in most countries is closely tied to agricultural productivity and agricultural productivity is a function of climate change. Framing climate change as a human security issue has led to the problem of vulnerability, equity, conflict and cooperation, and sustainability (Barnett and Adger 2007).

To further stress the relationship between food and human security, the two key dimensions to human security needs to be explained. The first is equity dimension, and the second is a connectivity dimension. Equity is considered an important prerequisite for both social development and human security (O'Brien and Leichenko 2006; Held and Kaya 2007). It is associated with the freedom from bias or favoritism, and entails outcomes that are perceived as fair to all concerned. Equity has a temporal dimension, such that outcomes of future generations can be treated with the same consideration as outcomes in the present (O'Brien and Leichenko 2006).

The connectivity dimension of human security is becoming more and more visible and important in a globalizing world that is characterized by transformative changes.

This dimension emphasizes that humans are part of a larger "global system," with linkages between people and places that are reinforced and accentuated through large-scale processes of global environmental change and globalization (O'Brien and Leichenko 2008). The conclusion therefore is that human security is closely linked to the development of human capabilities in the face of change and uncertainty. Lack of sufficient and timely progress in so many areas, such as in the area of achieving food and water security, poverty reduction, protection of biodiversity, sustaining the environment or resolving human conflict is reminiscent of the failure to build and establish trust, and to create the commitment and provide the means to achieve human security (Shah 2002).

## *2.5 Mitigation and Adaptation Strategies Against Climate Change*

This section explains the interrelations between adaptation and mitigation to climate change. *Adaptation* is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Bates et al. 2008; IPCC 2007; Smit and Pilifosova 2001; Parry et al. 2008). The main objective of adaptation is to reduce the vulnerability of society to changes in the climate system. Adaptation may be spontaneous, anticipatory autonomous, private, public, reactive or planned (IPCC 2001). Anticipatory adaptation refers to adaptation that takes place before climate changes occur. This form of adaptation anticipates potential changes in climate and prepares accordingly. Reactive adaptation takes place following the observation and analysis of changes in climate. Autonomous adaptation is a spontaneous adaptation that does not constitute a conscious response to climate stimuli. It is triggered by both ecological changes in natural systems and market or welfare changes in human systems. This contrasts with planned adaptation which results from a deliberate policy decision. Planned adaptation is based on an awareness that conditions have changed or are about to change. Action is taken to ensure that a desired state is achieved, maintained or revisited. Private adaptation is initiated and implemented by individuals, household or private companies for the purpose of serving some self-interest. While public adaptation is initiated and implemented by a public body and directed at serving a collective public need. In temperate regions, farm-level adaptations include changes in planting and harvest dates, tillage and rotational practices, substitution of crop varieties or species that are more appropriate to the changing climate regime, increased fertilizer or pesticide applications, and improved irrigation and drainage systems.

*Mitigation* with respect to climate change on the other hand, is defined as human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs), or the means of implementing policies to reduce GHGs.

# 3 Methodology

## 3.1 Study Area: Nature of Climate Change in Nigeria

The climate of Nigeria is tropical in nature that is occasionally subjected to variations, depending on the rainfall patterns (Obioha 2005). During summers, major portion of the country comes under the influence of moisture-laden tropical maritime air. The mean temperatures are determined by the location of a particular place in question. Observation indicates that mean maximum temperatures increase from the coast northward. The highest monthly mean temperature is 32.2°C for the coastal region and a mean of 40.6°C in the extreme North. The amount of sunshine ranges from a minimum of 1,300 h in the Niger Delta at the coastline to over 3,200 h in the extreme North East. Rainfall decreases from the coast to the interior with some exceptions in areas with topographic influences, such as the Jos Plateau area of the North Central plateau and highlands. Mean annual rainfall varies from about 2,500 mm to above 4,000 mm in the Southern mangrove swamp near the coast, 1,500–2,500 mm in the rainforest zone, 1,200–1,500 mm in the Guinea savannah, 760–1,020 mm in the Sudan savannah and between 380 and 700 mm in the Sahel. The inter-annual variability of rainfall, particularly in the Northern parts is large; often result in climate hazards, especially floods and droughts with their devastating effects on food production and associated calamities and sufferings (Adejuwon 2004). The mean daily relative humidity and number of rainy days also decrease from the coast to the interior. The highland of Jos has the lowest mean annual temperature of about 21°C. The mean daily hours of bright sunshine generally increases from the coast to the hinterland.

## 3.2 Types and Methods of Data Collection

The thrust of this study require information on climate change, environmental change and food security in Nigeria. Information are collected mainly from secondary sources. Data on climate change and its effects were also collected from Nigerian Meteorological Agency (NIMET). The sourced data were thereafter analyzed through narrative and descriptive statistics.

# 4 Results and Discussion of Findings

Findings from this study have shown that Nigeria is not immune from the effects of climate change. Climate change affects the environment, agriculture and quality of life of many Nigerians.

### 4.1 Factors Influencing Climate Change in Nigeria

The climate of Nigeria, just like the world climate, is changing due mainly to human activities, changes in temperature, decline in rainfall pattern, oceanic heat and gradual increase in sea level caused by accumulation of GHG in the atmosphere. The periodic overflow of the Atlantic across the bar beach bank is an indication of a phenomenon that accelerate climate change as sea level rise further.

On human activities, rich forests in many parts (especially the Southwest) of the country have been mowed down in pursuit of timber, farming, firewood, etc. As observed from available statistics, Nigeria destroys close to 600,000 ha of her forests annually in order to feed the industries.[1] The illegal logging without replacement has exacerbated the decline in both density and floristic richness of the forests, as well as led to reduction in rainfall which has consequently encouraged desertification. The high rate of deforestation is also a major contributor to GHG accumulation. Fewer trees lead to less carbon dioxide ($CO_2$) uptake for organic energy and oxygen production.

Higher temperatures and humidity are also found to have resulted from climate change leading to high incident of pests and diseases in Nigeria. There is no regular pattern of rainfall values in Nigeria except for some dry and wet years, which alternates every 2–3 years. The global increased in $CO_2$ levels from 280 ppm by volume to 370 ppm by volume has exacerbated the heating effects of the greenhouse effect by reducing the re-radiation of heat from the sun leading to increasing the temperature in the atmosphere.

### 4.2 Effects of Climate Change

The effects of climate change in Nigeria runs the entire sector of the country's economic, social and environmental landscape. The resultant challenges include shortages of water and food grains, loss of biodiversity, collapse of ecosystems and frequent disasters and migration. Climate change have the tendency of rolling back human development and undermining international cooperation aimed at achieving the Millennium Development Goals (MDGs) (UNDP 2007).

#### 4.2.1 Economic Effects of Climate Change

On the economic front, the projected effects of climate change on electricity generation and hydroelectric dams stands to cause severe disruptions to economic activity in Nigeria. This threat arises because climate change is expected to bring about a shift in climatic belts resulting in greater aridity in the tropics with huge impacts on

[1] http://www.nestinteractive.org/climate_change_docs/factsheet1pdf.pdf

energy production and supply. This threat is made more important by the fact that Nigeria relies heavily on hydroelectricity which accounts for over 36% share of its electricity energy sources. The resulting interruptions in power supply due to limitations in available generation capacity in the hydro-stations has not only resulted in waste of national resources and disruption of industrial/manufacturing sector of the economy, but affected the commercial and social activities of the nation as well.

### 4.2.2 Social Effects of Climate Change

The social implication of climate change for Nigeria is multidimensional. Climate change leads to increase aridity, desertification (in Northern Nigeria and in the Southern part, especially in the coastal regions) and flooding. With a 1 m rise in sea level, up to 600 km$^2$ of land would be at risk. Flood and erosion remove topsoil, destroy roads, affect fresh water resources and threaten lives and properties. Floods have rendered many people in the Eastern parts of Nigeria homeless, and several roads have been made impassable. Based on the projection by Awosika et al. (1992), a 1 m rise in sea level, now put more than 3 million people at risk due to the country population. The changes in vegetation in many parts of Nigeria are also observed to have great implication for biological productivity and biomass production. Decrease of biological productivity leads to fuel wood shortages. The definite shift in the long-term mean rainfall towards more arid conditions is also having an adverse effect on water resources availability, power generation and agriculture.

### 4.2.3 Effects of Climate Change on Agriculture and Food Security

All the dimensions of food security in Nigeria are affected by climate change in line with Schmidhuber and Tubiello (2007) (Table 15.1). Climate change is intrinsically linked to food security as food shortage and access to food generally confront many households in Nigeria today. A drop in agricultural productivity as a result of climate change is leading to worsen food-insecurity and an unsustainable increase in food prices across the country. Extreme weather events such as thunderstorms, heavy winds, floods, increased land degradation, soil erosion, changes in water availability, biodiversity loss, pest and disease outbreaks thereby leading to crop, livestock, forestry as well as fisheries failure. Due to uncertainties in the onset of farming season in most parts of Nigeria, farmers' plant after the first or second rain and in many years run into huge loss when the rains are delayed beyond the usual. In such situation, crops planted are smothered by heat waves leading to an unusual sequence of replanting and harvest failure and food shortage. Pests (e.g. the tsetse fly) and diseases migrate in response to climate changes and variations northward, and potentially pose a threat to livestock in the drier northern areas. The proliferation of pests and crop diseases originating with climatic change is also hindering agricultural crops storage when the need arises in Nigeria. The current warming trend hinders livestock production by reducing animal weight gain and dairy production.

**Table 15.1** Effects of climate change on food security in Nigeria (Source: Computed by the author)

| Dimensions of food security | Effects of climate change |
|---|---|
| Food production and availability | Climate affects food production directly through changes in agro-ecological conditions and indirectly on growth and distribution of incomes and demand for agricultural produce. Increase in the rate of desertification and flooding in the Northern Nigeria, coastal erosion and oil spillage in Niger Delta region make the land unsuitable for crop production |
| Stability of food supplies | Weather conditions are expected to vary than what Nigeria is experiencing with increasing frequency and severity of extreme events. This has led to greater fluctuation in crop yields and stability of food supplies. Climatic fluctuations are most pronounced in semi-arid and sub-humid regions. It has also led to reduction in livestock numbers and productivity |
| Access to food | Access to food refers to the ability of individuals, communities and countries to purchase food in sufficient quantities and quality. The rising prices of food as a result of supply less than demand and the reduction in real incomes of many households in Nigeria have led to lack of access to food |
| Food utilization | Climate change, such as high temperature, fluctuation in rainfall, exploration and exploitation of oil, is causing a vicious circle in Nigeria. High numbers of people in the Northern and Niger Delta are susceptible to air, water-borne diseases and hunger. This indirectly has led to the decline in labour productivity and increase in poverty, morbidity and mortality in the affected areas |

Warming affects the growth of grain crops such as maize, guinea corn, millet and rice, and makes storage of root crops and vegetables difficult. Livestock are usually subjected to long treks to find water and grass in the more southerly areas of the country during the dry seasons.

A report has shown that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4% of GDP due to climate change (Mendelsohn et al. 2000). Parts of the country that experienced soil erosion and operate rain-fed agriculture has also been predicted to decline in agricultural yield of up to 50% between 2000 and 2020 due to increasing impact of climate change (Agoumi 2003; IPCC 2007). Crops like cocoa, coffees that are highly sensitive to climate change sometimes suffer heavily from the hours of sunshine, to rainfall, soil conditions and temperature.

### 4.2.4 Human Consequences of Climate Change

Researching to the ways in which climate change affect human security is a daunting task (Barnett and Adger 2005). A number of direct and indirect impacts of climate change on human security have been identified in Nigeria. Finding has shown that an approximately 1,350 sq. miles of Nigerian land are annually turns to desert, forcing both farmers and herdsmen to abandon their homes in order to survive (forced migration) (McCarthy 2006). The pattern of communal clashes in the Nigeria is not unconnected with climate change (Fasona and Omojola 2005). People in the Southeast Nigeria have inter-community struggle for dominance and control of land resources, and the Niger Delta people are into combine struggle for control of land, environment and oil activities. The people of the Niger Delta are faced with myriads of environmental problems caused by climate change and the activities of multinational oil companies operating in the region. The current rise in the sea level in the Niger Delta due to oil exploration is observed to have increased the salinity of both surface and underground water, leading to the death of aquatic plants and animals that cannot tolerate high salinity. The results of the negative influence of climate change and destruction of natural resources in Niger Delta region is found as one of the reason behind the present Movement for the Emancipation of the Niger Delta in carrying out their successful campaign of armed attacks, sabotage, and kidnappings leading to shutting down of the country's oil output (Mouawad 2007).

The existence of environmental induced conflicts is also observed in the North-East (NE) Nigeria. We have conflicts over grazing land, over cattle, over water points and over cultivable land. In the NE, decrease in rainfall with increase in surface temperature over the years had resulted in pressure on land in the Guinea savannah zone and the rainforest belt. Most of these pressures have led to the long range trans-humance of the Fulani cattle rearers from Sahel and Sudan savannah to the Guinea savannah and now the rainforest belt.

In addition, climate change induced by increasing incidences of heat waves leads to more cases of cerebro-spinal meningitis (CSM) in most Northern parts of Nigeria like Kano and Adamawa. CSM correlate positively with the highest maximum temperature of the Northern winter season, and inversely absolute humidity to a lesser. There is the occurrence of skin cancer from direct ultra-violet radiation with increase incidences of cardiovascular respiration disorders. Other direct effects of climate change in the Southern part of Nigeria include various types of water-related disease such as malaria (mosquitoes), dengue fever and schistosomiasis (a parasitic disease), dysentery, cholera, sleeping sickness (tsetse fly) and diarrhea. Trauma resulting from the problem of climate change also leads to non-pathogenic diseases such as hypertension and diabetes.

Water shortage in many parts of the country is causing civil unrest and significant economic losses. Many parts of central and North-Eastern Nigeria have recorded many violent disputes between indigenous farming communities and nomads in recent years due to increasing desertification and consequent population pressure over land.

### 4.2.5 Adaptation and Mitigation Strategies to Reduce Climate Change Effects in Nigeria

There are two responses that have been taken against climate change in Nigeria. These are adaptation and mitigation. A series of studies on the effects of climate change have systematically shown that the older literature overestimated climate damages by failing to allow for adaptation and for climate benefits (Tol 2002).

**Table 15.2** Coping strategies by pastoralists at times of environmental stress in Nigeria (Source: Computed by the author)

| Condition | Coping strategy | Implication |
|---|---|---|
| **Pastoralists** | | |
| If rains fail | Pastoralists move to dry season ranges | Storage not a key concern |
| If no dry season range available | Pastoralist consume cultivated crops(purchased or exchanged) | Storage to mitigate deterioration terms of trade |
| If crops are unavailable | Pastoralist sell small -stock, purchase grains, grow cereals | Storage to mitigate terms of trade, retain own harvest for later consumption |
| If there are no markets or if prices fall too low | Pastoralist slaughter small stock, breed large stock, gather more wild food | Decentralised storage systems to distribute food, storage of wild food |
| If above sources are exhausted | pastoralist seek famine relief, wholesale emigration. | Decentalised storage system for famine relief |
| If no relief is available and emigration not possible | Famine ensues | Storage system impracticable |

In Nigeria, climate change affects a large array of systems of which forage and livestock production are not excluded. Nigerian pastoralists have a diversity of strategies to sustain production which is important for their own livelihoods and for their national economies, as pastoralists are responsible for providing a large share of livestock to markets in the country. Some of the employed strategies include changes in livestock and grazing management. These include moving livestock according to vegetation needs and water availability, keeping species-specific herds to take advantage of the heterogeneous nature of the environment. Some other adaptation initiatives against pests and diseases include the development of vaccines against emerging diseases, public education programs aimed at reducing the risk of disease exposure and transmission, and improvement of disaster management plans so as to enhance emergency preparedness (Table 15.2).

Among the mitigation technologies that have been adopted in Nigeria are: improvement in crop and grazing land management to increase soil carbon storage; improvement in nitrogen fertilizer application techniques to reduce Nitrous oxide ($N_2O$) emissions; mulch farming, conservation tillage and cover cropping; and tree species improvement to increase biomass productivity and carbon sequestration.

### *4.3 Government Responses to Climate Change and Constraining Factors*

Nigeria is a large African country highly vulnerable to flood, erosion, drought, desertification and other hazards directly and indirectly linked to climate. The country is associated with international efforts at combating the adverse effects of climate change and at ensuring the availability and adequacy of climatic data. Thus, Nigeria has established various agencies and institutions which are setting up a number of programs as a reflection of the country's concerns. Among the agencies are the National Institute for Freshwater Fisheries Research, the National Centre for Arid Zone Studies, the National Centre for Climate Change, the Nigerian Meteorological Agency (NIMET), the Nigerian Institute for Marine Research (NIMR), the Hydropower Development Department, the Nigeria Power Holding Company (formally known as the National Electric Power Authority-NEPA) and the Universities.

Government effort at combating climate change in Nigeria is not without some constraints. Some of the constraints are: lack of infrastructure (e.g. storm walls, water storage), lack of information (awareness) and knowledge (education) about the effects of climate change, lack of public policy, government preparedness and commitment to promoting climate change adaptation strategies. Added to these is lack of dedicated research institutions which is making it difficult to comprehensively study the growing negative effects of climate change in the country. It has become difficult for Nigeria government to legislate against the use of firewood and other fossil-based sources of fuel where natural gas resources are being flared due to high rate of corruption.

## 5 Conclusion and Recommendations

Climate change and its interactions with human security have become one of the major challenges facing humanity today. Climate change poses many hard security challenges without hard security solutions. The effects of climate change are being felt now in Nigeria more than ever before as temperatures rising and extreme weather events becoming more frequent and more intense with unpredictable rainfall. Climate change does not only affect animals and plants, but also humans. This chapter concludes with the fact that impact of climate change on food and human security is not a problem of the future, but already in existence and will stay with us. New evidence of the effects of climate change shows that, climate change now leads to change in the nature of many types of hazards, not only hydro-meteorological events (such as floods, windstorms and droughts) but also heat waves and disease outbreaks.

In Nigeria, climate change is threatening the basic elements of life such as access to water, food, health and use of land and the environment. It threatens to reverse the progress made in fighting diseases, poverty and food security. Climate change is undermining government efforts at ensuring food and human security with increasing cases of violence and conflicts.

Battle against climate change can be won through global action. It is also critical to mainstream climate change into sustainable development policies and plans in Nigeria. There is the need for proper land management. Individual community needs to adopt behaviours geared at restoring and conserving the environment by avoiding unregulated forest exploitation, planting appropriate tree species and protecting watersheds. Government should also provide farmers' information needed to assist them on suitable planting periods.

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# Chapter 16
# Quantitative Assessment of Climate Change by Weather Generation Models and Downscaling GCM Data in Tehran, Iran

**Majid Habibi Nokhandan, Nafise Haghtalab, Sharare Malboosi, Fateme Abasi, and Mohsen Goodarzi**

**Abstract** Human activities have changed the composition of the Earth's atmosphere. Increasing levels of greenhouse gases like carbon dioxide in the atmosphere since pre-industrial era are well-documented and understood. These negative effects cause considerable changes in weather condition at several parts of the Earth. Scientists believe that most regions will continue to warm, although some areas will be likely warmer than others. It is difficult to predict which region will become wetter or drier, but scientists generally anticipate increasing precipitation and evaporation, and drier soil in the middle of the century. Assessing the climate change in future needs to introduce climate scenarios, like "Ocean – Atmosphere 3D Linked Global Circulation Model". In this chapter, a stochastic weather generator (LARS-WG) was employed to generate daily climate change scenarios. The simulated results were fed into Arc/View to produce regional impact maps for visual assessment and spatial analysis under A1 scenario from ECHO-G model.

Simulated results show that in 2010–2039: (1) yearly mean rain decrease almost 0.5 mm and yearly mean temperature increase around 0.1°C. (2) Number of hot days decrease almost 2 days per year and number of glacial days decrease around 8 days in mean. (3) Dry days increase into 5 days and wet days decrease into 8 days. Heavy rain will increase about 8%. In the contrary with previous data (1982–2005), it is predicted that adverse torrent will increase. (4) Generally, in 2020s we have warmer and drier weather, with torrent rains which can destroy land cover and soils.

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**Keywords** A1 scenario • Arc/view • Climate change • ECHO-G • LARS-WG model

# 1 Introduction

The Earth's climate has changed many times during the Planet's history, with events ranging from ice ages to long periods of warmth. Historically, natural factors such as volcanic eruptions, changes in the Earth's orbit and the amount of energy released from the Sun have affected the Earth's climate. Beginning late in the eighteenth century, human activities associated with the Industrial Revolution have also changed the composition of the atmosphere, and therefore very likely are influencing the Earth's climate (NRC[1] 2006).

For over the past 200 years, the burning of fossil fuels, such as coal and oil, and deforestation have caused the concentrations of heat-trapping "greenhouse gases" to increase significantly in our atmosphere. These gases prevent heat from escaping to space, somewhat like the glass panels of a greenhouse.

Greenhouse gases are necessary to life as we know it, because they keep the Earth's surface warmer than it otherwise would be. But, as the concentrations of these gases continue to increase in the atmosphere, the Earth's temperature is climbing above past levels. According to National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration's (NASA) data, the Earth's average surface temperature has increased by about 1.2–1.4°F in the last 100 years. The eight warmest years on record (since 1850) have all occurred since 1998, with the warmest year being 2005. Most of the warming in recent decades is very likely the result of human activities. Other aspects of the climate are also changing such as rainfall patterns, snow and ice cover, and sea level (IPCC[2] 2007).

According to the NOAA 2007 State of the Climate Report and the NASA 2007 Surface Temperature Analysis:

- Since the mid 1970s, the average surface temperature has warmed about 1°F;
- The Earth's surface is currently warming at a rate of about 0.32°F/decade or 3.2°F/century;
- The eight warmest years on record (since 1850) have all occurred since 1998, with the warmest year being 2005.

Additionally:

- The warming trend is seen in both daily maximum and minimum temperatures, with minimum temperatures increasing at a faster rate than maximum temperatures;
- Land areas have tended to warm faster than ocean areas, and the winter months have warmed faster than summer months;

[1] National Research Council.

[2] International Panel of Climate Change.

- Widespread reductions in the number of days below freezing occurred during the latter half of the twentieth century in the United States, as well as most land areas of the Northern Hemisphere and areas of the Southern Hemisphere;
- Average temperatures in the Arctic have increased at almost twice the global rate in the past 100 years (IPCC 2007).

The IPCC has concluded that most of the observed warming in global average surface temperature that has occurred since the mid-twentieth century is very likely a result of human activities. During the first half of the last century, there was likely less human impact on the observed warming and natural variations, such as changes in the amount of radiation received from the sun, likely played a more significant role (IPCC 2007).

LARS-WG[3] is a stochastic weather generator which can be used for the simulation of weather data at a single site, under both current and future climate conditions. These data are in the form of daily time-series for a suite of climate variables, namely precipitation (mm), maximum and minimum temperature (°C) and solar radiation (MJm-2 day-1) (Semenov et al. 1998).

The first version of the LARS-WG weather generator was developed in Budapest in 1990 as part of Assessment of Agricultural Risk in Hungary, a project funded by the Hungarian Academy of Sciences. Stochastic weather generators were originally developed for two main purposes:

- To provide a means of simulating synthetic weather time-series with statistical characteristics corresponding to the observed statistics at a site, but which were long enough to be used in an assessment of risk in hydrological or agricultural applications.
- To provide a means of extending the simulation of weather time-series to unobserved locations, through the interpolation of the weather generator parameters obtained from running the models at neighboring sites (Mikhail 2002).

## 2 Study Area

Tehran Province is 1 of the 30 provinces of Iran. It covers on area of 18.909 km$^2$, and is located to the North of the central plateau of Iran.

Tehran Province borders Māzandarān Province in the North, Qom Province in the South, Semnān Province in the East and Qazvīn Province in the West. The metropolis of Tehran is the capital city of the province and of Iran. As of June 2005[update], this province includes 13 townships, 43 municipalities, and 1.358 villages.

Tehran province is the richest province of Iran as it contributes approximately 29% of the country's Gross Domestic Product (GDP). Furthermore, it houses approximately 18% of the country's population. Tehran Province is the most

[3] Long Ashton Research Station Weather Generator.

**Table 16.1** Geographical position and statistical period of Synop Stations in Tehran (www. irimo.ir)

| No. | Station | Latitude | Longitude | Elevation | Statistical period |
|---|---|---|---|---|---|
| 1 | Abali | 35:45 | 51:53 | 2,465.2 | 1988–2005 |
| 2 | Doshantape | 35:42 | 51:20 | 1,209 | 1988–2005 |
| 3 | Karaj | 35:55 | 50:54 | 1,312.5 | 1988–2005 |
| 4 | Tehran | 35:41 | 51:19 | 1,190.8 | 1988–2005 |
| 5 | Tehran-Shomal | 35:47 | 51:37 | 1,548.2 | 1988–2005 |

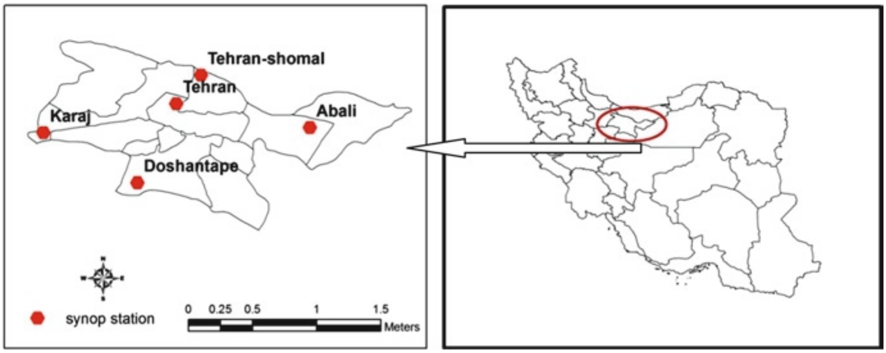


**Fig 16.1** Geographical position of Tehran Province in Iran and the Synop Stations in Tehran Province

industrialized province in Iran and 86.5% of its population resides in urban areas while only 13.5% resides in rural areas.

The province gained importance when Tehran was claimed the capital by the Qajar dynasty in 1778. Today, Tehran, with a population of more than seven million, is ranked amongst the 20 most populous metropolitan cities of the world (Table 16.1, Fig 16.1).

Environmentally speaking, the climate of Tehran province in the Southern areas is warm and dry, but in the mountain vicinity is cold and semi-humid, and in the higher regions is cold with long winters. The hottest months of the year are from mid-July to mid-September when temperatures range from 28°C to 30°C, and the coldest months experience 1°C around December–January, but at certain times in winter it can reach −15°C. Tehran city has moderate winters and hot summers. Average annual rainfall is approximately 200 mm, the maximum being during the winter season. On the whole the province has a semi-arid, stepped climate in the South and an alpine climate in the North (Fisher 2005).

## 3 Methodology

The first version of the LARS-WG weather generator was developed in Budapest in 1990 as a part of the Assessment of Agricultural Risk in Hungary, a project funded by the Hungarian Academy of Sciences. The main focus of this work was to overcome the limitations of the Markov chain model of precipitation occurrence. This widely used method of modeling precipitation occurrence (which generally considers two precipitation states, wet or dry, and considers conditions on the previous day only) is not always able to correctly simulate the maximum dry spell length, which is crucial for a realistic assessment of agricultural production in some regions of the world, Hungary included. This resulted in the new 'series' approach, in which the simulation of dry and wet spell length is the first step in the weather generation process (Mc kague et al. 2003).

A modified version of this weather generator, was used in the construction of the climate change scenarios used in two major European Union-funded research projects examining the impacts of climate change on agricultural potential in Europe, i.e., CLAIRE (Harrison et al. 1997) and CLIVARA (Downing et al. 2000).

LARS-WG utilizes semi-empirical distributions for the lengths of wet and dry day series, daily precipitation and daily solar radiation. The semi-empirical distribution Emp = {a0, ai; hi, i = 1,….,10} is a histogram with ten intervals, [ai − 1, ai], where ai − 1 < ai, and hi denotes the number of events from the observed data in the i-th interval. Random values from the semi-empirical distributions are chosen by first selecting one of the intervals (using the proportion of events in each interval as the selection probability), and then selecting a value within that interval from the uniform distribution. Such a distribution is flexible and can approximate a wide variety of shapes by adjusting the intervals [ai − 1, ai].

The intervals [ai-1, ai] are chosen based on the expected properties of the weather variables. For solar radiation, the intervals [ai − 1, ai] are equally spaced between the minimum and maximum values of the observed data for the month, whereas for the lengths of dry and wet series and for precipitation, the interval size gradually increases as i increases. In the latter two cases, there are typically many small values but also a few very large ones, and this choice of interval structure prevents a very coarse resolution being used for the small values (Mikhai et al. 2002).

In this study, observed daily data (1988–2005) in synop stations was employed for simulating weather condition in the future (2010–1039).

## *3.1 Model Calibration*

Once LARS-WG has been calibrated using observed station data, the next step in the process is to determine how well the model performs, i.e., to assess the ability of LARS-WG to simulate the climate at the chosen site, in order to determine whether or not it is suitable for use in application.

The QTest option carries out a statistical comparison of synthetic weather data (2010–2039) generated using LARS-WG with the parameters derived from observed weather data (1988–2005). In order to ensure that the simulated data probability distributions are close to the true long-term observed distributions for the site in question, a large number of years of simulated weather data should be generated (in this study 30 years was generated). Figure 16.2 shows comparison between observed data and synthetic data that is modeled. For this purpose, t-test and f-test

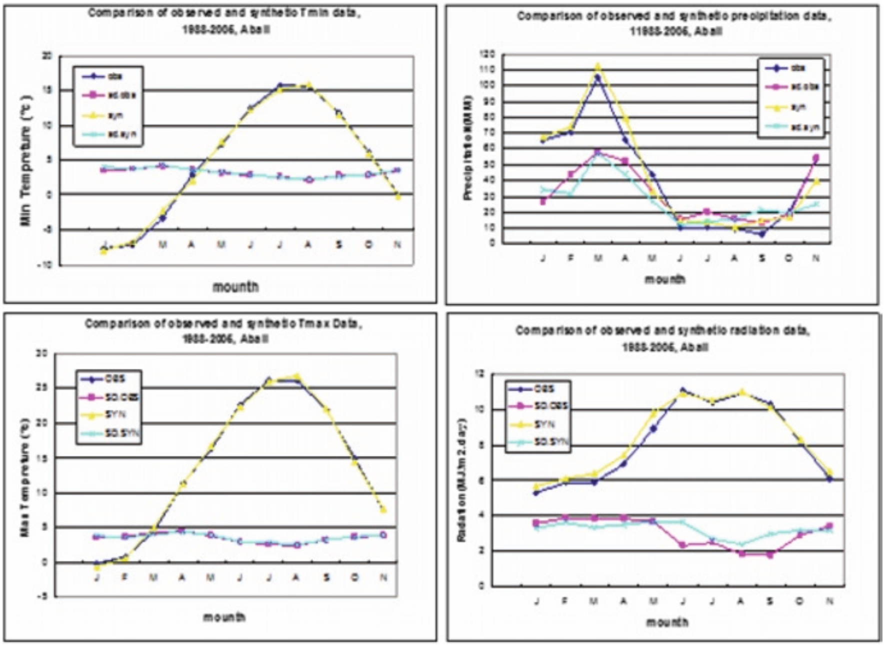


**Fig. 16.2** A statistical comparison of synthetic weather data generated (2010–2039) with the parameters derived from observed weather data (1988–2005) in Abali synop station. *obs* observation data, *sd.obs* standard division observed data, *syn* synthetic data, *sd.syn* Standard division synthetic data

in Microsoft excel was employed to assess the accuracy of modeling. As a result this model has a good ability to model min temperature, max temperature, solar radiation and precipitation. In Fig. 16.2, for an example in one station, comparison between observed data and synthetic data is shown.

# 4 Modeling Results

## *4.1 Precipitation*

According to the model results, monthly precipitation decrease about 4.8 mm in mean (Fig. 16.3). Maximum growth will be in spring nearly 11%, and minimum decrease will be in winter nearly 33% in mean. Annual precipitation will increase about 129 mm in analogy with past (Fig. 16.4).

## *4.2 Major and Extreme Rainfall*

Major rainfall is rain falls with 5 year recurrence Periods, and extreme rainfall is rain fall with 15 year recurrence Periods. In the study area, major rainfall increase

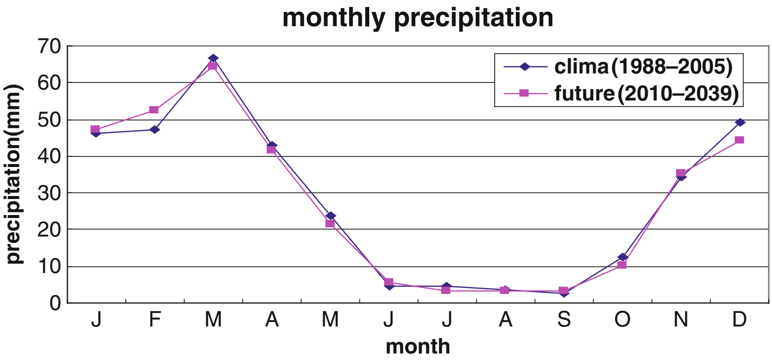


Fig. 16.3 Monthly precipitation in mean at 2010–2039 and compare it with past climate

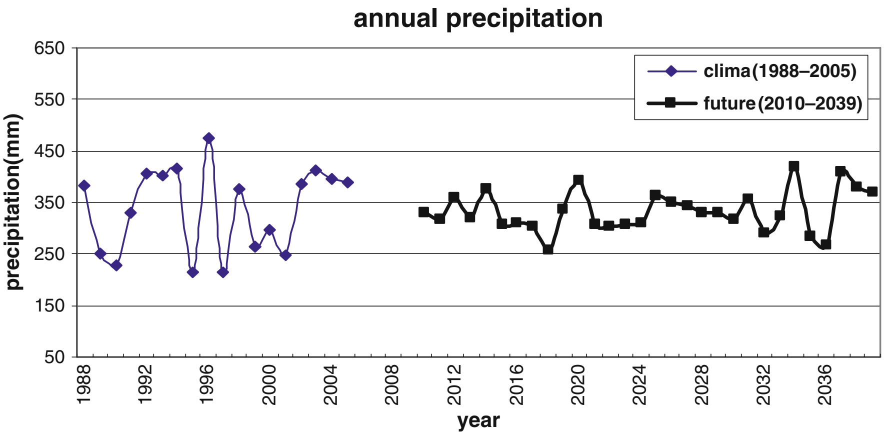


Fig. 16.4 Annual precipitation in mean at 2010–2039 and compare it with past climate

about 7.8%, threshold of this rain is grown from 54 to 58.2 mm but extreme rainfall will decrease, whereas that threshold will come from 69 to 65.3 mm and will decline about 5.35% (Fig. 16.5).

## 4.3 Temperature

In Tehran province, monthly mean temperature will grow up about 0.2°C. maximum increase is in January near 0.8°C that is 41% and monthly temperature will decrease about 0.6°C in April (Fig. 16.6).

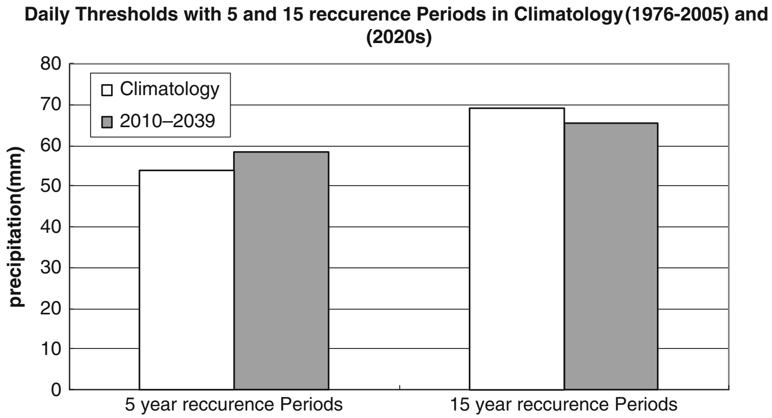


**Fig. 16.5** Daily thresholds with 5 and 15 recurrence periods in climatology (1976–2005) and (2020s)

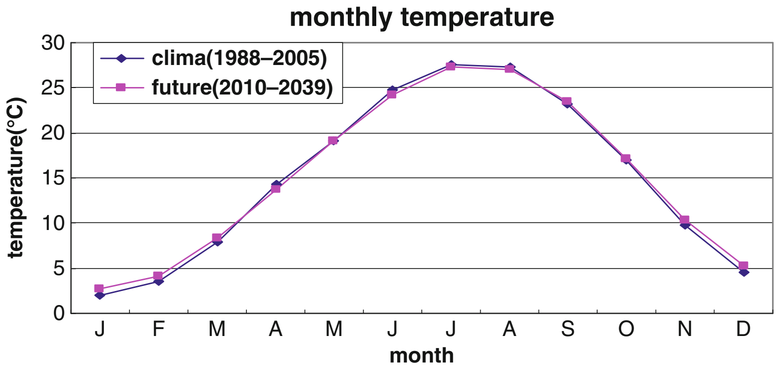


**Fig. 16.6** Monthly temperature in climatology (1976–2005) and (2020s)

## *4.4 Number of Hot and Icy Days*

Hot day is the day that maximum temperature is upper than 30°C. totally in the study area, number of hot days will decrease, utmost decrease is in June about 1.5 days in year, and in September this number increase about 0.5 day in year. Most decrease of number of hot days is about 5 days in year in Karaj station, and least decrease is about 0.7 days in year in Tehran station (Figs. 16.7–9).

Icy day is a day that temperature is equal 0°C or less than 0°C. In the future number of icy days decreases. This number decrease about 0.7 days in month that most decrease is in Jun and Feb and in 2014 is about 37.4 days in year (Fig. 16.10–12).

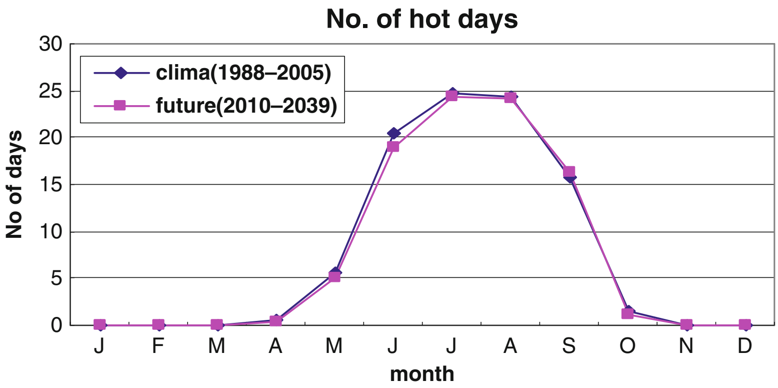


**Fig. 16.7** Number of monthly hot days in climatology (1976–2005) and (2020s)

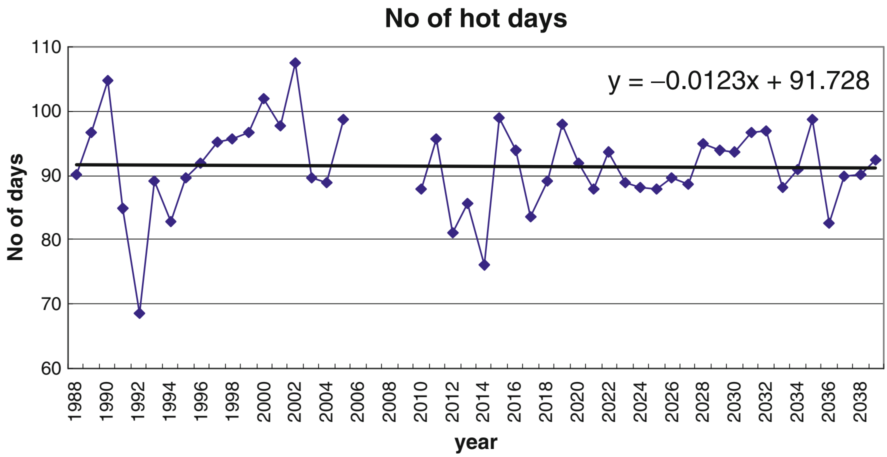


**Fig. 16.8** Number of annual hot days in climatology (1976–2005) and (2020s)

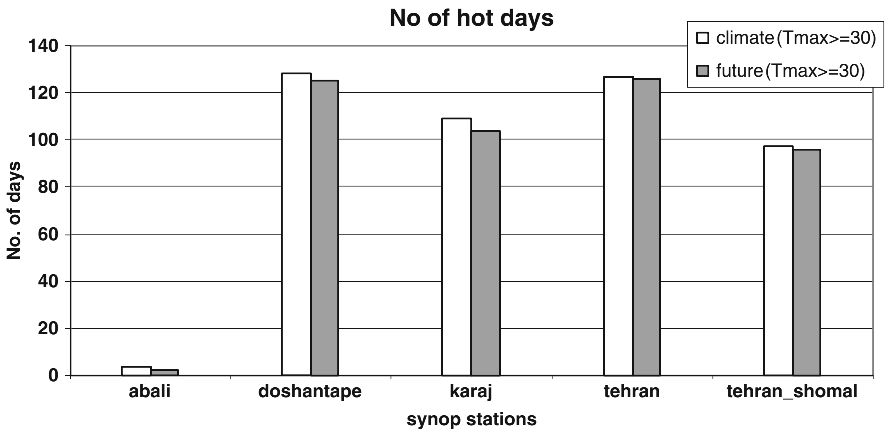


**Fig. 16.9** Number of hot days in synop stations in climatology (1976–2005) and (2020s)

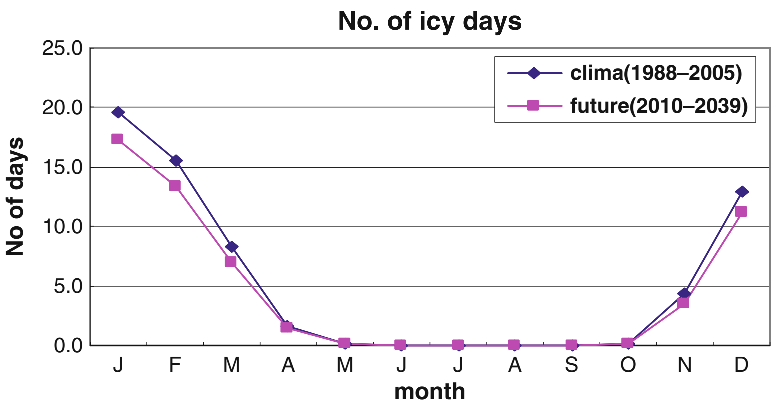


**Fig. 16.10** Number of monthly icy days in climatology (1976–2005) and (2020s)

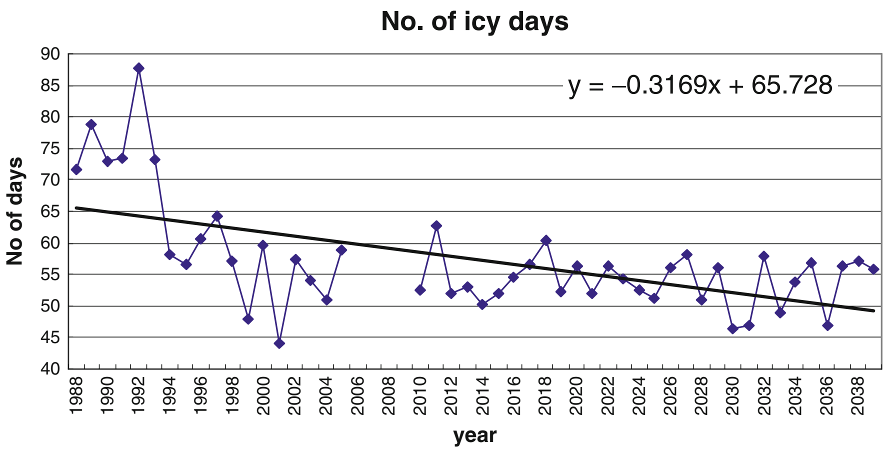


**Fig. 16.11** Number of annual icy days in climatology (1976–2005) and (2020s)

## 5 Conclusions

In this research, daily weather data in synop stations was employed for modeling and simulating the future weather condition in Tehran Province. Results from modeling show that:

- Generally, according to the modeling results, precipitation decrease in the future in the study area. This parameter will increase in winter about 11%, and will decrease in summer near 33% in comparison with observed data.
- Mean monthly temperature will have utmost increase in January about 0.7°C, and it will decrease in April around 0.8°C.

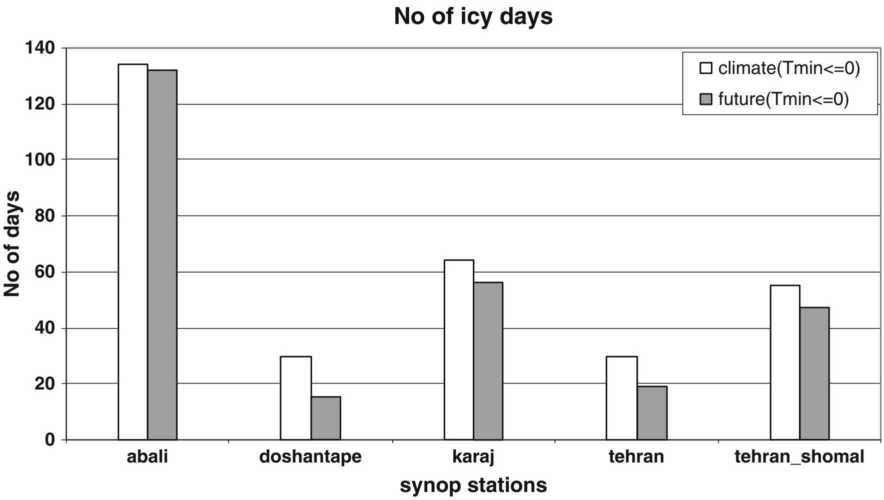


**Fig. 16.12** Number of icy days in synop stations in climatology (1976–2005) and (2020s)

- In Tehran province, number of hot days may grow up at 2020s. Most increase will be in January near 1.5 days in a year, whereas in September it may increase about 0.5 day in a year.
- Number of icy days will decrease in the future. Utmost decrease is in January about 0.7 days in a year.
- Monthly mean temperature will grow up about 0.2°C. so that dissertation will be rating.
- In the study area, major rainfall increase about 7.8%, threshold of this rain is grown from 54 to 58.2 mm. but extreme rainfall will decrease, whereas that threshold will come from 69 to 65.3 mm and will decline about 5.35%.

This results show that dissertation rating will increase in Tehran province at 2020s, because of reduction in rainfall and growth in temperature. And probability of torrent will increase.

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# Chapter 17
# The Role of Biofuels in the Sustainability of the Environment

**Peter Karácsony, Anzelm Kiss, and József Orbán**

**Abstract** The protection of the environment and the preservation of nature's gifts have become a determining part of our social-economic life nowadays. The basic reason for this is, on the one part, the ever quicker utilization of natural resources, and on the other part the increasing amount of polluting materials emitted into the environment. As a result of all these, the quality of the soils has deteriorated, as has the purity of the waters above and sub-terrain; the natural habitats have decreased and have been damaged as well. In the wake of the environmental aspect's moving to the forefront today, biofuels are playing an increased role and they may turn out to play an important role in the fight against global warming. The biofuels are plant or animal derived resources, and we differentiate between two main types: bioethanol and biodiesel. In this study, we wish to deal with utilization and the future of the plant derived biofuels in the EU. The governing principle of the EU pertaining to biofuel specifies a 5.75%, and its agreement dated March 2007 specifies a 10% component of biofuel component for 2020 within total fuel consumption. According to calculations in order to achieve a 10% organic component in engine fuel by 2020, the basic ingredients will have to be cultivated on 38% of cultivation soil area. The remaining area would be shared between plant cultivation for food and fodder purposes. It is obvious that if biofuel, food and fodder will battle over cultivation area, the smallness of the area could cause produce prices to rise, which in turn causes a significant rise in food prices. The study tries to find an answer to the question as to what extent the EU's biofuel production and utilization, and as to how it can contribute to the sustainable development of our environment, as well as what the long term economic and social effects the production of biofuels may be.

**Keywords** Cereals • Competitiveness • Energy • Environment • Food

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_17,

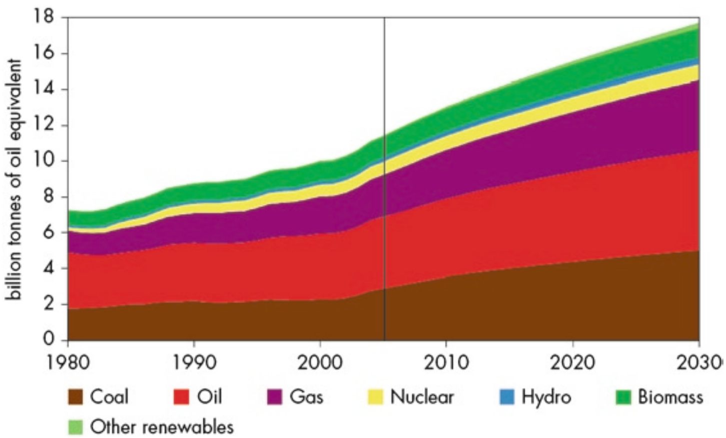
## 1 Introduction

In the last past years, the sustainable development has become part of our life. Ensuring the future development, the protection of resources and the environment elements are required. According to the United Nations's 1987 Brundtland Report, sustainable development is a process which satisfies the needs of the present without decreasing the ability of the future generations to supply their own demand (World Commission on Environment and Development, 1987). The conception of sustainable development gives a new framework for the history of human civilization. The three pillars of sustainable development are: environment, society and importance balanced treatment of economy (Gáthy 2005).

The renewable energy sources are among to the most essential tools aiming at sustainable development. Several years ago, there were fewer cars running on the roads, in the households fewer energy-guzzler equipments were operating, no or hardly spreaded the air-conditioners, wide-screen television, etc. The increasing standard of living goes hand in hand with growing energy usage. All these things indicate into that way that in the following one to two decades, the energy demand of the world will continue to increase, thus maximizing crude oil and natural gas utilization as well as carbon dioxide emission.

## 2 Features of Energy Consumption

Fossil fuels – oil, natural gas and coal – remain the dominant sources of primary energy worldwide (Fig. 17.1). They account for 84% of the overall increase in energy demand between 2005 and 2030. Their share of world demand rises from 81% in 2005 to 82% in 2030. Oil remains the single largest fuel, though its share




Source: World Energy Outlook, 2007 (IEA, 2007)

**Fig. 17.1** World primary energy demand

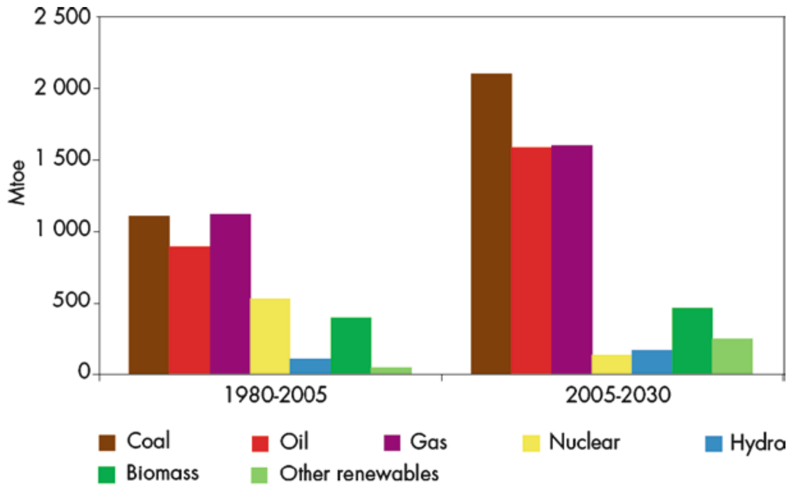



**Fig. 17.2** Increase in world primary energy demand by fuel

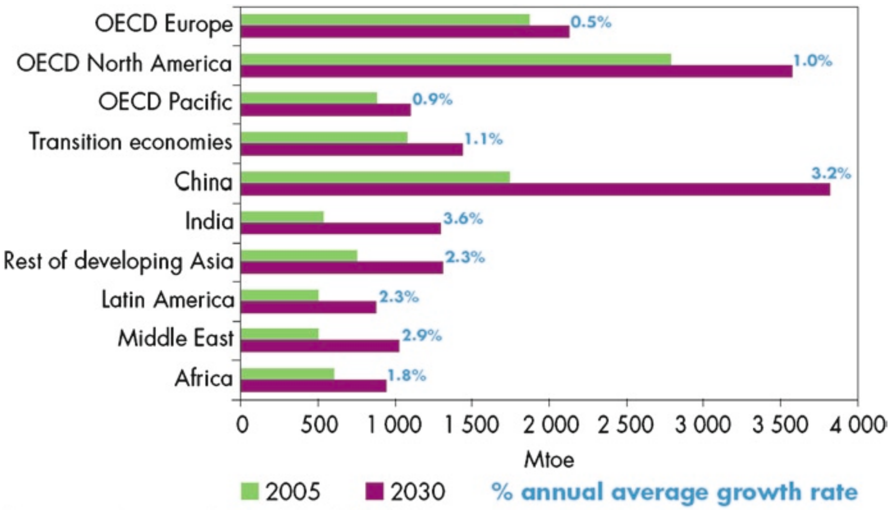
falls from 35% to 32%. The share of coal rises from 25% to 28%, and that of natural gas from 21% to 22%. The rise in fossil-energy use drives up related emissions of carbon dioxide by 57% between 2005 and 2030.

Coal sees the biggest increase in demand among all primary energy sources in absolute terms between 2005 and 2030, closely followed by natural gas and oil (Fig. 17.2). Coal demand jumps by 38% between 2005 and 2015, and 73% by 2030. Nuclear power accounts for most of the fall in the share of non-fossil primary fuels, dropping from 6% of total primary energy demand in 2005 to 5% in 2030. There is no change in the share of hydropower, at 2%, and the share of biomass and waste falls slightly, from 10% to 9%. The share of other renewables, a category that includes wind, solar, geothermal, tidal and wave energy, rises from less than 1% to about 2%.

Developing countries are projected to contribute around 74% of the increase in global primary energy consumption between 2005 and 2030 (Fig. 17.3). Their economies and populations grow much faster than those of the industrialized countries, pushing up their energy use. China and India alone account for 45% of the increase in energy use.

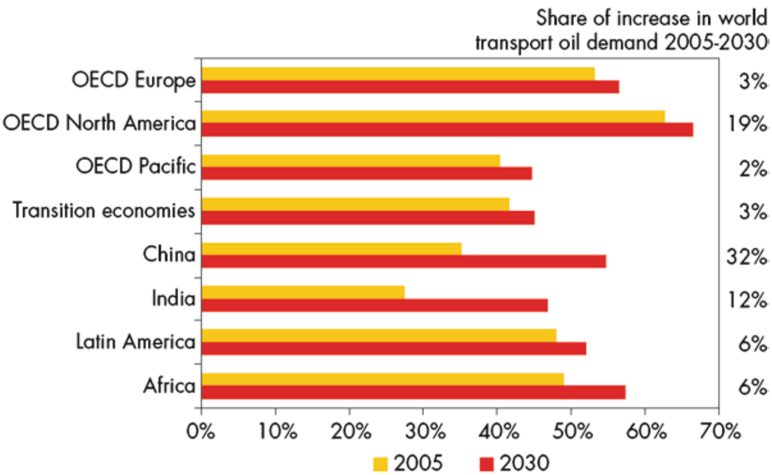
China is projected to overtake the United States soon after 2010 to become the world's largest energy-consuming country. In 2005, US demand was 34% larger than Chinese demand. In aggregate, developing countries make up 47% of the global energy market in 2015 and more than half in 2030, compared with only 41% today. The OECD's share falls from 48% now to 43% in 2015, and to 38% in 2030.

The transport sector is the principal driver of oil demand in most regions (Fig. 17.4). Globally, transport's share of total primary oil use rises from 47% in 2005 to 52% in 2030. Although biofuels take an increasing share of the market for road-transport fuels, oil-based fuels continue to dominate, their share of transport




Source: World Energy Outlook, 2007 (IEA, 2007)

**Fig. 17.3** Primary energy demand by region




Source: World Energy Outlook, 2007 (IEA, 2007)

**Fig. 17.4** Share of transport in primary oil demand by region

demand falling from 94% to 92% over the projection period. Worldwide, consumption of oil for transport is projected to grow by 1.7% per year over 2005–2030. Demand grows fastest in the developing regions, in line with rising incomes and investment in infrastructure. Today, there are about 900 million vehicles on the world's roads (excluding two-wheelers); by 2030, their number is expected to pass 2.1 billion. Most of the extra vehicles are destined to be used in Asia (OECD, 2007).

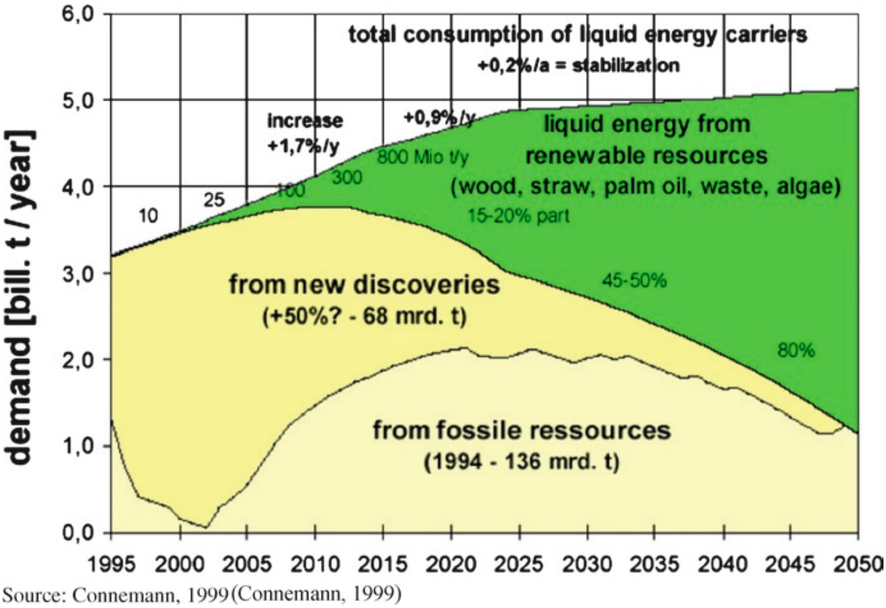


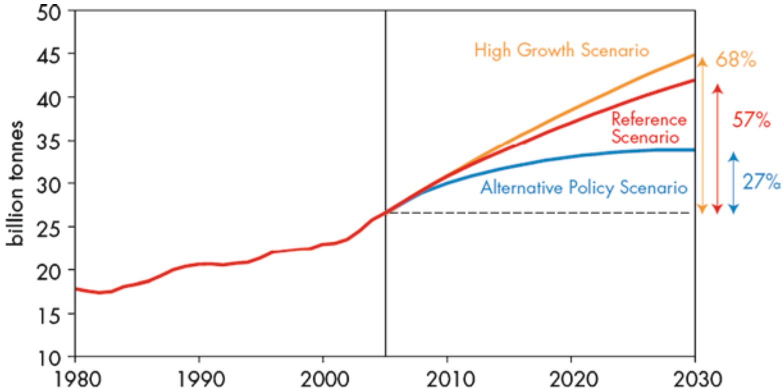

**Fig. 17.5** Demand and supply of mineral oil in coming decades

The world's oil reserves nowadays are still enough, and we won't need to count with oil shortage, but humankinds have to be ready for that as the end of the oil era is inevitable. Meanwhile, the fact cannot be forgotten that exploitation of the fossil energy resources and their consumption has significant impact on the environment.

The estimated resources of today have worldwide distribution which implies possible difficulties in future, besides the fact that they are limited, while yearly consumption still rises. Since at least 5 years, the safe resources are estimated at approximately 140 billion tonnes of fossil oils, the uncertainties in behind with additional 50% (Fig. 17.5), and thus the resulting gap must be filled with biomass (biodiesel, ethanol, etc.).

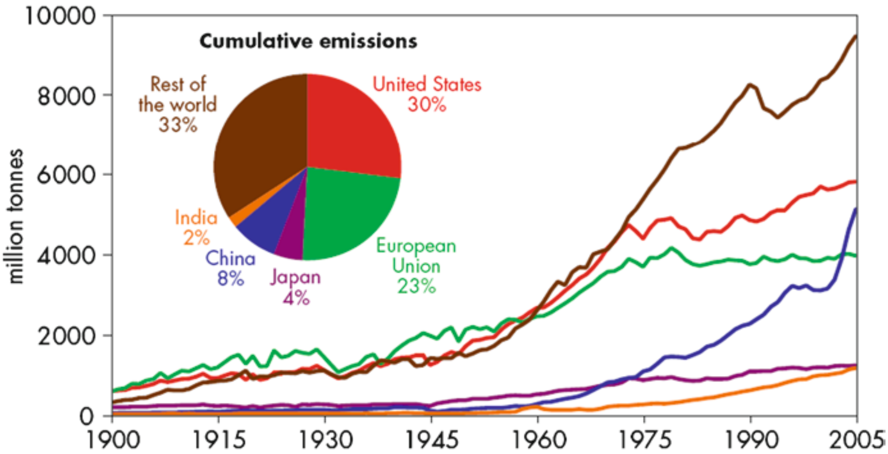
## 3 The Environmental Protection Problem of the Increasing Energy Consumption

Rising global fossil energy use will continue to drive up energy-related $CO_2$ emissions over the projection period (Fig. 17.6). A range of government policies, including those intended to address climate change, air pollution and energy security, have helped to slow the rate of growth in emissions in some countries in recent years, but have not stopped it. In the Reference Scenario, which examines the implications of governments adopting no new policies, world emissions jump by 57%




Source: World Energy Outlook, 2007 (IEA, 2007)

**Fig. 17.6** Energy-related $CO_2$ emissions by scenario




Source: World Energy Outlook, 2007 (IEA, 2007)

**Fig. 17.7** Energy-related $CO_2$ emissions by regions, 1900–2005

between 2005 and 2030 to 41.9 gigatonnes, an average rate of growth of 1.8% per year. The increase is 27% in the Alternative Policy Scenario (1.0% per year) and 68% (2.1% per year) in the High Growth Scenario. By comparison, emissions grew by 1.7% per year over 1990–2005.

The strong increase in emissions in both China and India over the past few years, their historical share in cumulative emissions, measured over the period 1900–2005, amounted to only 8% for China and 2% for India. By comparison, the United States and the EU countries combined accounted for just over half of all cumulative emissions (Fig. 17.7).

## 4 The International Situation of Utilization of Biofuels

The among first generation biofuel, the two wide spreaded are bioethanol and biodiesel. The production of bioethanol is based on the alcohol fermentation technology, of which industrial realized version. The well-prepared sugar or starch contained raw materials – mainly corn, wheat, sugarcane or sugar beet – are converted into alcohol through digestion and fermentation process. This is followed by distillation, refinement, water release multistep process, and finally, at the end of the process, bioethanol with the suitable quality is produced.

In the case of biodiesel, different plant oils, cooking oil or animal fats are used as raw materials. Beside, mostly – (around 80%) – the rapeseed oil utilized in Europe, and in USA for biodiesel production chiefly sunflower, soy or palmoil can be suitable. The plant-based diesel oil production starts with riddling and extrusion of oil contained seeds. Then the plant oil is separated from the small oil containing breeze which is not appropriate for utilization in diesel engines as it tends to make resin due to its unsaturated carbohydrates content, combustion incomplete and it can cause crust in the engine. That's why following a suitable pre-treatment, the plant oil is esterificatened by utilizing small carbon number alcohol.

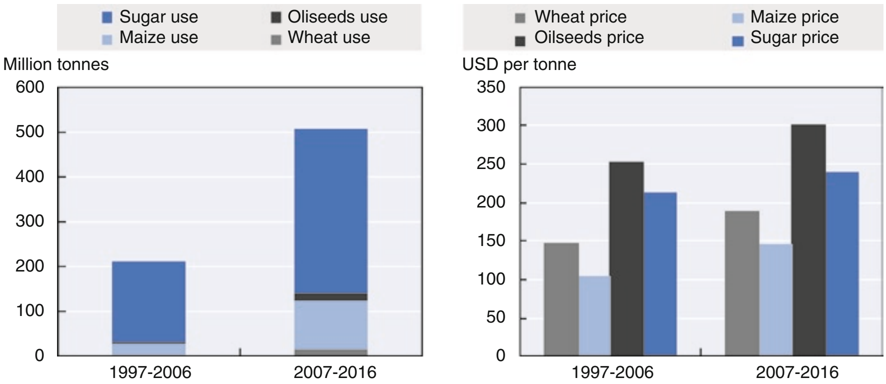
Public and private interest in the area of biofuels is also stronger than it has ever been, for a number of reasons:

*First*, continued rapid economic expansion in Asia has led to increased oil demand and, combined with limited expansion in oil refinery capacity worldwide, has driven up energy prices. At the same time, the notion is increasingly taking hold that fossil fuel supplies are finite and that other forms of energy need to be developed. Bioenergy is one of the alternatives, and its development is seen as enhancing energy security in oil importing countries.

*Second*, with growing evidence of global climate change, it is becoming increasingly urgent to develop sources of energy that have lower greenhouse gas emissions than fossil sources. Bioenergy is seen by many as a "clean" form of energy: the amount of $CO_2$ released when it is burned is generally equivalent to the amount of $CO_2$ captured during the growth of the crop that produced it.

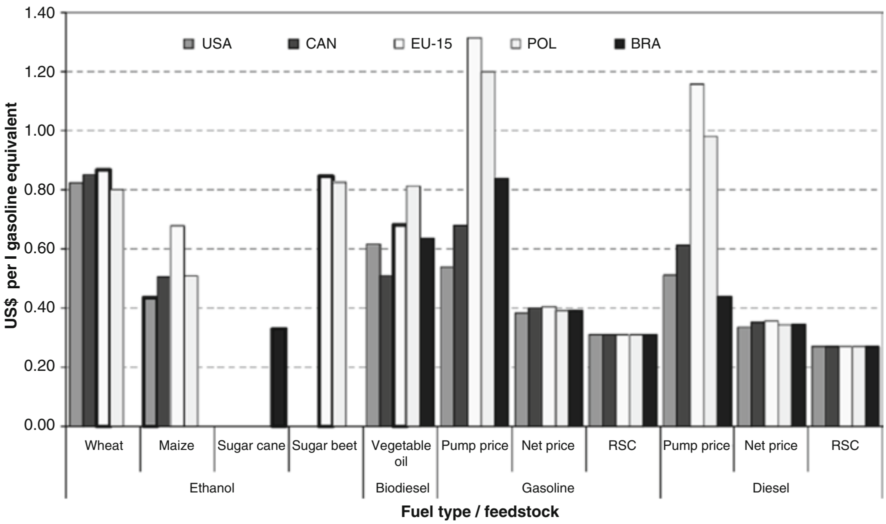
*Third*, with current technologies, biofuels are mostly produced from crops such as sugar, cereals and oilseeds. Demand for these crops is thus likely to grow in line with the expected increase in demand for biofuels. Consequently, prices of these crops are expected to remain above their average values that prevailed during the past decade, with positive impacts on overall farm income levels and possibly beneficial spin-offs for many rural communities (Fig. 17.8).

Figure 17.9 compares costs and prices across fuel types, feedstocks and regions for the year 2004. Costs and prices for all fuels (including biodiesel and diesel) are expressed in US$ per litre of gasoline equivalent to take into account the differences in the energy content of various fuel types. The data supports the hypothesis that Brazil is by far the most cost-effective producer of fuel ethanol – with production costs of about US$ 0.22/l of ethanol or US$ 0.33/l of gasoline equivalent, ethanol is produced at a cost lower than the price of gasoline net of tax, and at comparable costs to the regional supply costs of gasoline.




Source: OECD-FAO Agricultural Outlook, 2007-2016 (OECD-FAO, 2007)

**Fig. 17.8** Biofuel production: crop use and prices

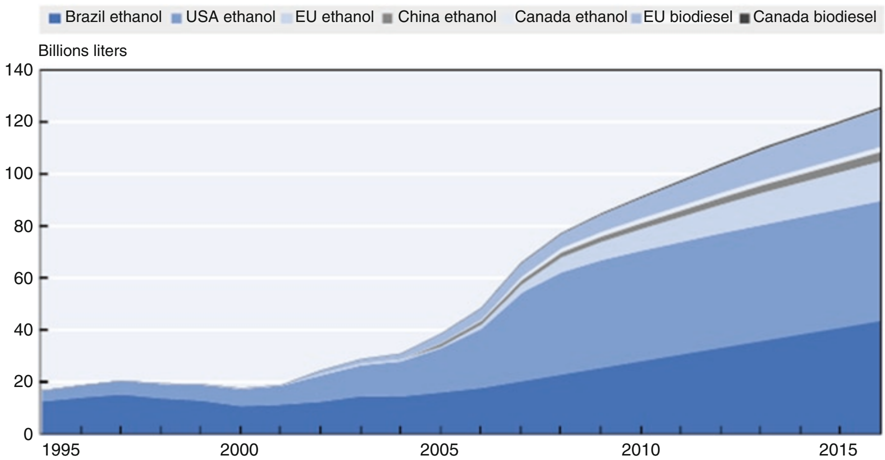



Source: OECD, 2006 (OECD, 2006)

**Fig. 17.9** Production costs of ethanol and biodiesel and petrol-based fuel prices in major biofuel-producing countries, 2004, US$ per litre of gasoline equivalent

Beside production costs, it is also relevant to analyse the energy balance of bioethanol production based on corn and sugarcane. In the case of corn, and regarding the energy input/energy output, only 1.1 can be realized for 1 ha, in the meantime 1 ha of sugarcane can reach 3.7 rate. From economical and environmental protection aspect, the bioethanol based on sugar cane has the best results (de Oliveira et al. 2005).

*Fourth*, bioenergy production is seen as a potential driver for economic growth in developing countries. In some countries, biofuel production could reduce dependence on imported fossil energy. Also, farmers in these countries could benefit from the expected higher crop prices, which could help raise rural incomes and aidpoverty reduction.



Source: OECD-FAO Agricultural Outlook, 2007-2016 (OECD-FAO, 2007)

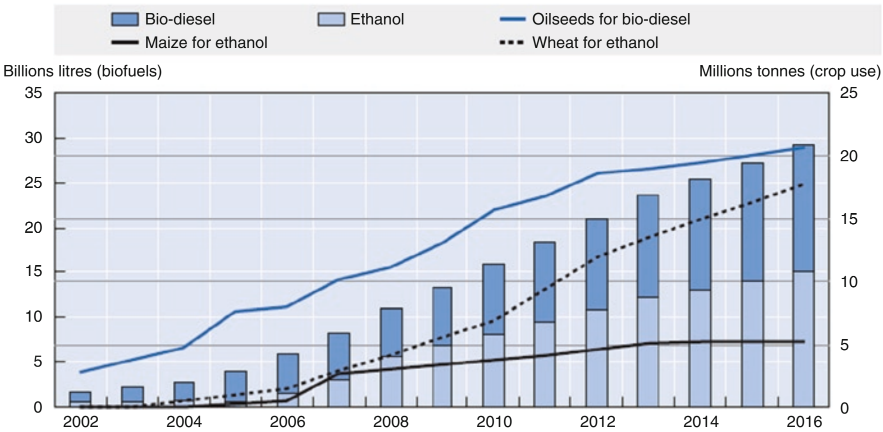
**Fig. 17.10** Biofuel production in selected countries – projections to 2016

The production of biofuels is growing rapidly in many countries. In OECD countries, this growth is most evident in the United States, the European Union and Canada. Outside the OECD area, the main producer by far is Brazil, but production is also increasing in China, as well as in a number of other countries in South and East Asia (Fig. 17.10).

In accordance with the FAO-OECD data in 2008, the global bioethanol production reached 78 billion litres. The biggest amount was produced by USA (38 billion litres) last year, overtaking Brazil (22 billion litres). On the third place – significant gap – is China (6.6 billion litres), meanwhile on the fourth place the European Union stands (4.4 billion litres). Out of these countries, Canada, India, South-Africa and Middle-America have to be mentioned where the production started and has been growing.

Biodiesel production and consumption nowadays are concentrated mainly in Europe – slightly in the USA – although in the past few years an increasing number of countries can be recognized which joined the biodiesel production. According to estimates in 2008, the biodiesel production achieved 35 billion litres, of which 17 billion litres is produced in the EU. Due to the prediction from the developing countries, in Brazil and India significant development can be expected. Beside this, Malaysia, Indonesia and Philippines can show relevant increase in this sphere, where the main raw materials are palm and coco oil.

Biofuel production and use in the EU was historically for bio-diesel based on oilseeds, mostly rapeseed. Increasingly, it is assumed that ethanol, made mostly from wheat and maize, will become important on EU markets. Despite growth in total biofuel use by some 170% between 2006 and 2010, however, it is assumed that the share of biofuels in total transport fuel consumption will not exceed 3.3% in energy terms, rather than the 5.75% target envisaged by the EU Biofuels Directive (Fig. 17.11).




Source: EU Commission, OECD-FAO Agricultural Outlook, 2007–2016 (OECD-FAO, 2007)

**Fig. 17.11** Ethanol and bio-diesel use in the EU to increase – based on wheat, rapeseed and imports

The EU's Biofuel Directive (2003/30/EC) sets blinding rate by 2010 5.75%, the 2007 agreement sets 10% by 2020 based on all types of fuel consumption (Kiss and Karácsony 2008).

According to calculation in the EU, reaching the 5.75% target requires 16–18 million hectares field, and this represents 18% of the cultivated area in EU. Reaching 10% by 2020 will requires 38% of the cultivated area (IEA 2004).

## 5 Connection Between Food Supply, Biofuel Production and Environmental Protection

The food supply, biofuel industry and the environmental protection influence each other tightly. Among these three factors, the most important is the safe supply of food. The food supply is influenced by food prices, customer's purchasing power and the availability of food. The most relevant problem is caused by imbalance distribution of resources in the world. There are places in the world where people can get the cheaper plant-based food due to the high poverty in case there is supply on the market. Due to this, in the world's poorest countries, rate of cereals and goods produced from cereals can reach 80% (Popp and Potori 2008).

The increase of cereals price has a direct impact on these countries as these play a significant role in food supply of inhabitants. Meanwhile, in developed countries, where mainly the higher added valued animal goods are more consumed, the impact of increase in cereals' price results later in the price of food.

The second important question is the energy supply. In global term, there are few countries which are capable to produce fossil energy, thus these countries have competitive advantage comparing with energy import required countries. The fossil energy production capable countries, such as Russia, often use the energy export in order to achieve their political aims, as well as making the energy import demanding countries (member states of EU) more dependent. Nowadays, the decrease of energy import dependence plays an important role which includes the importance of biofuel production, and its requirements can be set up in the developed agriculture owning countries.

The third factor is the environmental protection. The food and energy production means a significant threat to the environment's status. The aim is to produce energy and food with the least environmental load. The most fundamental reason behind the promotion of biofuel production nowadays is that it can reduce the environmental load, as their utilization can contribute to the reduction of greenhouse gas emissions.

## 6 Doubts of Biofuel Utilization

In the above-mentioned connection system, the factors compete with each other. The most disputed issue is "Fuel or food" which means that world's cereal store is used for fuel or food production more. According to Gallagher Report, the biofuel production deteriorates food market in three ways:

On one hand, the utilization of cereals pushes from food production to fuels (30% of USA's corn production is turned into bioethanol production; meanwhile in the EU 50% of the produced plant oil is used for biodiesel).

On the other hand, the agricultural producers are encouraged to use the relevant part of their lands for biofuels. Furthermore, the cereals price has been increased by market speculation. According to the Report, since 2002 the biofuel production has been raised 75% the global food price level (Renewable Fuels Agency 2008).

The decrease rate of the carbon dioxide and other greenhouse gases (GHGs) by using biofuel depends on raw materials, applied agricultural and production technology. According to IEA Biofuels for Transport's Life Cycle Assessment, the best result was reached by the cellulose-based, second generation bioethanol (60–100% GHG saving compared with conventional fuel), meanwhile among the first generation technologies the sugarcane has the best result (80–90% GHG reduction). Contrarily, the cereal-based bioethanol in Europe can reach 20–50% GHG saving, for rapeseed oil based biodiesel is 40–60%.

## 7 Conclusions

In European Union, the road transport is responsible for 30% of GHG emissions, and therefore the first aim in the EU behind biofuel production is providing an environmental friendly alternative to the fossil-based petrol and diesel oil. It has to be mentioned that the biofuel production is not completely carbon dioxide neutral because the production, transport and processing of raw materials require significant amount of fossil energy, taking into consideration the fertilizers and pesticide production, and not to mention the energy need of biofuel production.

Beside the reduction of atmosphere reaching carbon dioxide surplus, the other reason which is supporting the spreading of biofuel is that it can decrease significantly the oil dependence of the given country as less oil has to be imported.

The sugarcane, sugar beet, rapeseed, sunflower, corn and wheat based biofuels can result in a well-planned market for the agriculture sphere, therefore this will generate balancing impact on products' price and influence the production costs. For the farmers, it can be an important advantage since the production of energy plants will support their income, especially that there is currently a high demand for the raw materials of biofuel production in the world market.

The biofuels without support, tax exemption cannot effectively compete with fossil energy resources. By reference to the experience of USA and EU, several methods have been promoted aiming at boosting the biofuel consumption of which one of the most possible tools is the obligatory blinding rate determination.

There are many reasons for producing and consuming biofuels and against them, meanwhile the political, economical and scientific life's persons often, in order to reach their goals, use their reasons by not telling the truth. As far as we know, in the future an important role will come for the authentic communication because we face more and more problems (famine, climate change, population growth, etc.).

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# Chapter 18
# Energy Efficiency, Methane Output, Required Carbon Sequestration Area and Water Productivity in Extensive and Semi-intensive Beef Production in South America – A Comparison of Ecological Currencies

**Horst Juergen Schwartz, Cristian Rodolfo Feldkamp, and Davi Jose Bungenstab**

**Abstract** Beef is one of the most important food commodities. This is reflected in the high international trade volume. Global demand for beef has been rising consistently over the past 5 decades. About one third of all agricultural land on the globe is wholly or partially occupied by beef production systems. Beef production systems have a bad reputation in terms of environmental impacts, from land area and total water requirements to greenhouse gas (GHG) emissions. The paper examines three different evaluation tools applied to extensive and semi-intensive beef production systems in South America. System behaviour was tested for the impact of interventions on energy efficiency and methane output by using simulation models. Compensatory carbon sequestration area was calculated for 31 beef production enterprises with three levels of production intensity using a "carbon footprint" type of accounting. Evaluation of water productivity was carried out by estimating "virtual water contents" for three levels of production intensity typically found in South America. Results were conflicting. Energy efficiency was not improved through intensifying interventions. Likewise there was no reduction in methane outputs when yield enhancing interventions were applied. On the other hand, intensification had a marked positive effect on carbon footprint, i.e. a significant reduction of the required carbon sequestration area. Yield enhancing measures had no effect in either way on water productivity with the exception of increasing

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_18,

nutrient densities in the diet, which were found to improve water productivity but not energetic and or economic efficiency. The complexity of the findings points to the necessity to develop an evaluation system which takes into account conflicting responses by weighted assessment of the different environmental impacts against different economic and political backgrounds.

**Keywords** Beef production • Environmental impact • Greenhouse gases • South America • Water footprint

## 1 Introduction

Beef production, predominant among other ruminant production systems, is uniquely suited to convert biomass with low nutrient density from natural and agricultural ecosystems into high nutrient density food for humans. Vast quantities of low nutrient density biomass are available from natural and derived pastures, in form of crop residues, and as agro-industrial by-products. This feed base is augmented by forage crops and concentrate feeds, especially in the intensive production systems prevalent in Europe and North America.

Along with the growing human population, the world cattle herd has grown from 1 billion to 1.4 billion head since 1965, now representing a total live biomass which is more than twice the biomass of the human population. The annual international trade volume in beef exceeds 18 billion US$ (FAO Statistics Division 2009). Growing global demand for beef, particularly in the emerging economies of Asia, will promote further expansion of the industry. However, there are rising concerns over the environmental impact of beef production. Reputedly beef production causes approximately 20% of all greenhouse gases (GHG), it occupies more than one third of all agricultural land worldwide, and it is the biggest agricultural water user after crop irrigation. Furthermore, beef production is blamed for the destruction of the Amazon rainforest, loss of biodiversity by overgrazing and wasteful use of natural resources in general. Against this background, the authors have investigated three different environmental indicators, i.e. energy efficiency, GHG output and water footprint of beef production within the regional limit of South America, or rather in Argentina and Brazil.

The Brazilian and Argentine beef cattle herds comprise 75% of South American stock and 81% of beef produced (FAO Statistics Division 2009). Both countries have strong beef industries and are largely export-oriented. In the last 2 decades, the cattle industry in Brazil has shown substantial improvement. With a current herd of around 200 million head, numbers have grown mainly in the Central-Northern areas, i.e. in the Amazon agricultural frontier. In Argentina, with about 50 million head of cattle, beef production was traditionally performed mainly in regions with good soils and 700–1,200 mm of yearly rainfall. Cow-calf operations were located in areas with lower quality soils and fattening was performed mainly on artificial pastures, with up to 30% of grain supplement. These pastures were grown in rotation with cash crops.

During the last 15 years, high soybean prices and the availability of new technologies enabled a significant increase of the area under this crop. This made it attractive to replace other annual crops like maize or sunflower, and to replace partly artificial pastures previously used for beef production (Rearte 2003) with soybeans. As agricultural commodity prices, in particular soybean prices, have stabilised at high levels, it is expected that soybean cultivation will continue influencing land use in Argentina and Brazil. Consequently, it is expected that in the near future cow-calf operations will be reallocated to more marginal areas, and fattening operations will intensify the use of grains. These trends emphasize the necessity of detecting interventions in cow-calf operations to improve weaning rates, and in fattening operations to compensate for the reduction in area available for cattle.

## 2 General Approach and Methods

### 2.1 Energy Efficiency and Methane Emissions

Energy efficiency is an important system property influenced by intensification. While in extensive systems sunlight is almost exclusively the source of energy, industrial systems rely heavily on fossil fuel energy. Intensification inevitably includes more external inputs into the production process. This implies an increasing use of external energy. It is expected that a higher use of external energy will have a synergetic effect on current flows of solar energy, resulting in overall higher energy efficiency in beef production.

Cow-calf operations in Argentina are mainly low-input extensive systems which are under pressure to improve their productivity. If the diminishing returns principle applies, first increments in external energy use would have a highly positive influence on energy efficiency. Consequently, intensifying cow-calf operations would improve significantly the energy efficiency.

Together with paddy rice production, enteric fermentation is the main source of methane from the agricultural sector (Watson et al. 1992). Enteric methane is produced by bacteria in the rumen as a natural part of their fermentation of plant fibres. Methane production during digestion is positively correlated to crude fibre contents. Therefore, when intensification includes feeding concentrates, with low fibre content, a significant reduction of methane output would be expected.

To test system behaviour for the impact of these interventions on energy efficiency and enteric methane output, the simulation model developed and validated by Feldkamp (2004) was used. This model is dynamic and simulates the functioning of a cow-calf system. Parameters of the model were set for a typical cow-calf region of Argentina.

Treatments include a combination of stocking rates, age of heifer at first mating (15 months-old with concentrate feeding, 27 months-old without concentrate feeding), and weaning strategy. Weaning could be: traditional (7 months-old calves), early weaning of cows in low body condition score, and systematic early weaning for all cows. Early weaning takes place when calves are 2-months old. Subsequently, they are put on a native pasture with a daily concentrate ration of 1% of their body weight. These are typical interventions proposed in Argentina to improve cow-calf operation output (Feldkamp 2004).

## 2.2 Shadow Area

While intensification reduces demand for land, causing displacement of natural biomes, it represents also other environmental impacts such as greenhouse gas emissions, associated with the industrial inputs added to the process. When comparing intensive and extensive cattle systems taking into consideration both aspects, these indicators react in opposite directions. However, it is possible to attribute the same importance to both in a single analysis by converting emissions into area of land.

The method developed by Bungenstab (2005) is related to what was used in the original Ecological Footprint method (Wackernagel and Rees 1996), but it is focused on what a ranch consumes to produce a given amount of beef in 1 year. It estimates the area of forest that would be needed to sequester equivalent carbon emissions from every external input used in the production unit in a year. For electric power inputs it takes into account the flooded area needed to produce hydroelectricity according to the Brazilian energy grid for the inputs that corresponds to 20%.

This extra area is here denominated "shadow area". The adopted emission conversion rate is 1.8 t C·ha$^{-1}$·yr$^{-1}$ what is equivalent to 6.6 t $CO_2$·ha$^{-1}$·yr$^{-1}$. This is a central value referred to in the literature regarding $CO_2$ sequestration (Fearnside 1999). In the ecological footprint method and in other applications of it, the sequestration rate adopted has also been 1.8 t C·ha$^{-1}$·yr$^{-1}$.

The basic formula for calculating the total area of a production unit for 1 year is:

$$AT = \sum_{i=1}^{n} \left[ \frac{Qi \cdot EEi \cdot \left( \sum_{j=1}^{5} Ki \cdot Gj \right)}{R} + 0.8 \cdot EEi \cdot Ki \cdot H \right] + U + \sum_{k=1}^{m} \frac{Qm}{Ym}$$

*AT*: Area total (ha); *n*: Total number of manufactured inputs; $Q_i$: Quantity of the ith input used (kg, l, m², m³); $EE_i$: Embodied energy of the i$^{th}$ input (MJ·unit$^{-1}$); $K_i$: Proportion of the *j*th source of energy in the energy grid of the *i*th input industrial sector (%); *H*: Hydroelectricity area appropriation rate (ha·MJ$^{-1}$); *m*: Total number of imported feedstuffs; $Q_m$: Quantity of the *m*th feedstuff (kg); $Y_m$: Yield of the *m*th feedstuff (kg·ha$^{-1}$) including its shadow area; $G_j$: Emission rate of the jth fuel (kg$CO_2$ · MJ$^{-1}$); *R*: Conversion rate (kg $CO_2$ · ha$^{-1}$); *U*: Area used in the production unit (ha).

For the same single item of external input, many different values for embodied energy were found in the literature, likewise many different values for $CO_2$ emissions from different fuels and shadow areas of the various hydropower plants. For this reason, these values were randomly combined through a Monte-Carlo-process.

Real land used and shadow areas within ranches and outside of them allocated to grain feeds production were computed together. Comparisons were made among 31 production units, being 16 standard systems and 15 surveyed ranches classified as extensive (only pastures); intermediate intensification (pasture fertilization and supplementary feed on pastures) and intensive (fertilization, supplementary feeds on pastures and finishing in feedlots). These levels of intensification have been recognized as the most common by the scientific community in the area (Correa et al. 2000).

Therefore, if intensification was to be proposed as an alternative to keeping regional beef production stable while avoiding further original biomes displacement, the question would remain which this study proposed to answer: Do local intensive cattle systems, because of shadow areas, appropriate more area than the extensive ones producing similar amounts of meat?

## *2.3 Water Footprint*

Beef production is, next to crop irrigation, probably the largest water consumer of all food production systems. It is also reputed to have severe environmental impacts through water depletion, contamination and negative effects on local and regional hydrology.

It is well established that the daily drinking water demand of cattle ranges between 10% and 20% of the live body weight. Different ambient temperatures, high moisture content in the forage, activity levels of the animals, breed, performance and physiological status of the animals, feed intake, water quality and other factors may lead to higher or lower values. A mature cow of 250 kg live weight in the tropics (1 TLU) will need between 9 and 18 $m^3$ drinking water per year; her counterpart in the temperate zones weighing twice as much will consume 18–36 $m^3$.

Water used for the production of feeds and forages is much greater than the drinking water volumes. Peden et al. (2006) reckon that 1 TLU cattle under tropical conditions ingests about 2% (5 kg) of their live body weight for maintenance, and another 2% (5 kg) for nutrient demands relating to thermoregulation, reproduction, parasite infection, growth and motor activity. Following Peden et al. (2006) in their argument that an average 1 $m^3$ of water is needed to produce 4 kg DM of feed, water for feed production will vary at maintenance level from 1,200 to 2,400 l/day or 440–880 $m^3$ per year. Including a moderate production level into the calculation would double these values.

Adding water needed for drinking, for feed production, and for management of the animals, which is another smaller amount, and relating the sum to a unit of product, i.e. 1 kg of beef, a whole beef carcass, 1 litre of milk or one unit of animal work will allow us to calculate the water cost or water footprint of that particular product. Chapagain and Hoekstra (2003) and Hoekstra and Chapagain (2007) have done this in great detail and found beef to be the food commodity with the highest Virtual Water Content (VWC), i.e. the highest water cost per unit product. Depending on the feed base, the production systems, the cattle breeds involved and numerous other factors they arrived at a range of values from 11.7 $m^3$/kg beef for Netherlands conditions to 37.8 $m^3$/kg beef for Mexico. They also reported global average VWC for live beef cattle 13,824 $m^3$/ton, 11,857 $m^3$/ton, and 8,999 $m^3$/ton for animals originating from grazing systems, mixed systems and industrial systems respectively, accounting for the decreasing proportion of fibre rich components in the base rations common in those systems. This approach, however, needs to be contested.

Agricultural water use is commonly divided into blue and green water use. Blue water, i.e. free surface water or water in accessible underground aquifers, is used for crop irrigation, as drinking water for livestock and as service water in production units. Green water, i.e. water stored in unsaturated soils, is the major source for plant growth through evapo-transpiration. Blue water is highly mobile, can be transported over long distances and has many alternative uses. Green water is immobile and has no alternative uses. Blue water use carries costs, green water use is free. Natural and near-natural pastures, as well as the bulk of derived pastures world wide, use only green water. The same applies to rain fed agriculture. Plant growth under these land use systems relies on large-scale evapo-transpiration, which occurs irrespective of whether the resulting biomass is harvested by man and his livestock or not. Evapo-transpiration does not lead to depletion of water but is part of the global hydrological cycle.

If a land area has no potential for rain fed agriculture due to aridity, poor soils, low temperatures, or other factors, no opportunity costs can be claimed and the green water costs of pastoral livestock need to be set to zero. This applies worldwide to more than 3.3 billion ha of permanent pastures. Approximately, 75% of all cattle are kept in the less developed countries of Africa, South America and Asia. Here, the feed base is primarily unimproved natural pastures and derived pastures, followed by crop residues in mixed farming systems, domestic and agro-industrial by-products, and forage crops in that order of importance. All these have no to very low virtual water contents, therefore a revision of the current approach is urgently required.

# 3 Results and Discussion

## *3.1 Energetic Efficiency and Methane Production*

The main results of the simulation runs are presented in Table 18.1, which shows that regardless of the intervention, the mean productivity in terms of kg of body weight sold yearly per hectare remains similar. There are some differences though.

**Table 18.1** Simulated efficiency of cow-calf operations under different strategies

| Stocking rate [heads $ha^{-1}$] | Age of heifer[a] [month] | Weaning[b] | Efficiency kg BW $ha^{-1}$ $year^{-1}$ | MJ $MJ^{-1}$ | kg BW kg $CH_4^{-1}$ |
|---|---|---|---|---|---|
| 0.5 | 15 | T | 79 (26) | 0.0377 (0.018) | 1.51 (0.51) |
| 0.5 | 15 | Sel | 79 (23) | 0.0398 (0.017) | 1.55 (0.47) |
| 0.5 | 15 | Sys | 74 (37) | 0.0380 (0.023) | 1.58 (0.78) |
| 0.5 | 27 | T | 75 (25) | 0.0377 (0.018) | 1.37 (0.51) |
| 0.5 | 27 | Sel | 78 (34) | 0.0398 (0.020) | 1.40 (0.62) |
| 0.5 | 27 | Sys | 79 (38) | 0.0308 (0.018) | 1.47 (0.63) |
| 0.7 | 15 | T | 81 (29) | 0.0325 (0.013) | 1.21 (0.41) |
| 0.7 | 15 | Sel | 80 (29) | 0.0331 (0.015) | 1.23 (0.45) |
| 0.7 | 15 | Sys | 87 (36) | 0.0347 (0.017) | 1.39 (0.57) |
| 0.7 | 27 | T | 80 (26) | 0.0331 (0.015) | 1.14 (0.38) |
| 0.7 | 27 | Sel | 81 (40) | 0.0320 (0.018) | 1.12 (0.55) |
| 0.7 | 27 | Sys | 79 (38) | 0.0308 (0.018) | 1.13 (0.56) |

Production efficiency (kg of body weight sold per year per hectare), energy efficiency (MJ in product sold per MJ uptake) and methane emissions (kg of body weight sold per kg of enteric methane produced). Results are the mean (standard deviation) of 30 years

[a]Age of heifer at first mating

[b]*T* traditional weaning (7 months-old), *Sel* Selective early weaning, *Sys* Systematic early weaning

The highest productivity is achieved with the higher stocking rate, feeding concentrates to mate a younger heifer and applying early weaning to the whole herd. However, this higher productivity is accompanied by a rather high standard deviation implying an unstable system. The lowest productivity is achieved by the system feeding concentrates to earlier mating and applying early weaning to the whole herd, but with a lower stocking rate.

Higher energy efficiency is achieved with lower stocking rates. The most efficient systems have low stocking rates, wean early, and use cows with low body condition score. This is expected because a lower stocking rate reduces the fraction of non-pregnant cows per year and consequently the efficiency of energy use improves. Additionally, early weaning implies feeding concentrates to weaned calves, but improves the probability of pregnancy of the dam.

Emissions of enteric methane per unit of kg sold, increases with higher stocking rates. Lowest emissions are achieved by the system with low stocking rate, feeding concentrates to heifers and applying early weaning to the whole herd. This allows a combination of adequate pregnancy rate, due to low stocking rate and early weaning, and a higher fraction of concentrate use due to feeding of heifers and calves.

In average, productivity increases with stocking rate, but it is not significantly influenced either by age of heifer at first mating nor by weaning. Energy efficiency is higher for low stocking rate, feeding concentrates to heifers, and traditional weaning. Methane emissions per unit of beef sold declines with stocking rate, feeding concentrates to heifers, and with a selective early weaning.

**Table 18.2** Range and average ( ) of total areas appropriated[a] in hectares per tonne of beef produced by beef cattle production systems in Central Brazil under three different levels of intensification

| Intensification level | Finishing systems | Cow-calf and whole cycle systems |
|---|---|---|
| Intensive | 2.6–5.5 (3.4) | 6.9–8.5 (7.5) |
| Intermediate | 5.8–8.4 (7.0) | 3.5–13.0 (9.2) |
| Extensive | 12.2–15.3 (13.2) | 10.9–15.7 (13.9) |

[a]Used areas plus shadow areas

## 3.2 Shadow Area

Results on Table 18.2 show that even with the inclusion of shadow areas on estimates of total areas appropriated, intensification of feeding systems for beef cattle in Central-Brazil reduces the area necessary to produce beef. The proportion of shadow area increases with increasing levels of intensification, but total appropriated area declines simultaneously. Finishing systems show a tendency to be the most efficient in terms of area appropriation under higher levels of intensification. The use of technologies, such as pasture fertilization and supplementary feed, substantially reduces total area appropriated causing a small shadow area.

Regarding single inputs, nitrogen fertilizers have a major influence on shadow areas. Authors performing environmental auditing of intensified agricultural systems also found similar results (Pervanchon et al. 2002). The shadow area of facilities and machinery together is usually less than 2% of the total area for extensive systems. In intensive systems, it can range from 6% to 30% according to the size of the operation linked to economy of scale.

## 3.3 Water Footprint

Chapagain and Hoekstra (2003) reported 19.3 $m^3$/kg and 21.9 $m^3$/kg of beef carcass and 27.2 $m^3$/kg and 30.9 $m^3$/kg of boneless beef cuts for Argentina and Brazil respectively. These values resulted from the assumption that tropical pastures have an average specific water demand of 445 $m^3$/ton of biomass produced which was then included fully in the VWC calculation for beef cattle. As stated earlier in this paper, natural and derived pastures carry no true water cost. Consequently, VWC of South American beef can only include life time drinking water, service water and water content of feed as far as blue water had to be used in growing, processing and ration preparation.

Additional feed water components will be negligible at present, since less than 10% of all cattle in Argentina and Brazil are finished in all-grain systems (i.e. feedlots). Even though there are no figures to support this, there are probably another 20–30% of beef cattle in Argentina receiving grain-based supplements. These will not exceed 40% of the feed intake in the finishing period. In Brazil, this will certainly be a smaller proportion. Table 18.3 gives an indicative overview of the changing importance of various components of the virtual water content of beef with changing intensity of the production system.

**Table 18.3** Expected contribution of water categories to Virtual Water Content of beef cattle under three different levels of intensification

| Intensification level | Drinking water | Service water | Processing water | Virtual water in feed |
|---|---|---|---|---|
| Intensive | +++ | ++ | + | + |
| Intermediate | ++ | −/+ | −/+ | ++ |
| Extensive | + | − | − | +++ |

To date only the drinking water component can be estimated with any degree of accuracy since data on the other components are lacking for the given conditions and need further investigation. Based on age at slaughter, lifetime drinking water consumption for a steer of 400 kg will amount to approximately 18 $m^3$, 25 $m^3$, and 33 $m^3$ at 30 (intensive), 39 (intermediate), and 48 months (extensive) at slaughter respectively. Under extensive pastoral conditions, where drinking water is the only factor to be considered, this will result in a virtual water content of only ~0.22 $m^3$/kg of boneless beef.

## 4 Conclusions and Implications

From the simulation results, it can be concluded that intensification does not necessarily improve system behaviour. Contrary to expectations, feeding concentrates neither led to a reduction of enteric methane per kg of beef sold nor to improved energy efficiency. Slight improvements in productivity are made at the cost of increasing enteric methane emissions and reducing energy efficiency. The results demonstrate the existence of trade-offs between system properties.

Even when accounting for shadow areas, beef cattle systems using higher levels of intensification in Central Brazil do not appropriate as much area as the traditional system to produce the same amount of beef. Supplementary concentrate feeding on pastures contributes to reducing total areas appropriated for finishing animals as well as for other categories. Quantifying the amounts of nitrogen used for intensive systems can be a good proxy for estimating shadow areas. As machinery, fuels and facilities were the other categories with more influence on shadow areas, it should be useful to study the correlations between intensity of nitrogen use and these inputs.

Current calculations of VWC, which are generally accepted within the scientific community, of ruminants, in particular of beef cattle, burden production with high amounts of green water costs. The highest burden is allocated to pastoral systems on marginal lands. However, green water is immobile, permanent pastures in marginal areas have no alternative uses, and green water is not depleted through evapo-transpiration but rather returned into the global hydrological cycle. Consequently, green water costs in pastoral systems need to be set at zero. This reduces VWC or water footprint considerably. When considering only drinking water costs, extensive systems have the highest water footprint, intensification leads to lower values.

Accounting for other factors like service water, water for ration preparation and water cost of supplementary feeds, intensification will lead to higher water footprints. The main factor affecting the increase is the increasing nutrient density in the rations fed. In certain circumstances, this increased water footprint from intensification may not exceed the one from extensive systems, though.

This work examined three aspects of the environmental impact of beef production at different production intensities in the regional context of Argentina and Brazil. The results were not mutually supportive. Energy efficiency and enteric methane output were not favourably influenced by intensification interventions which are common in the region. The sequestration area was considerably reduced with increasing intensification and with the scale of operations. The drinking water cost of production decrease with increasing production intensity, but this trend may be attenuated or even reversed if other factors determining water footprint are included in the calculations.

In summary, there is no clear advantage in intensification. Using different indicators leads to incompatible conclusions. Consolidating the results into recommendations will require a trade-off analysis of the different environmental objectives which were targeted. Generalized recommendations on intensification will not be possible without considerations of the environment where the system is going to be inserted.

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# Chapter 19
# Biogas Energy From Agricultural By-Products: Energy Yields and Effects on Organic Farming Systems Compared with Energy Maize Cropping

**Arno Deuker, Walter Stinner, and Günter Leithold**

**Abstract** Organic farming systems produce large amounts of organic residues suitable for biogas production. Two organic farming systems were investigated in field trials. In the dairy production system liquid manure, fodder residues, straw and cover crops were fermented. In the tested stockless farming system clover grass, straw, cover crops and in this case non marketable potatoes were used. The biogas yield potential of the stockless farming system averaged 1,742 cubic meters of methane per hectare and year, respectively 1,015 cubic meters in the tested dairy farm system. The utilisation of crop residues can replace (non-organiv) maize cropping on more than 27% of the farmland without using extra land in the stockless farming system. In the investigated dairy system, these residues correspond to approximately 16% of the farmland used for maize cropping. The energy yields and additional positive effects (higher dry matter yields of non-legume maincrops, lower nitrogen losses and a reduction of trace gas emissions) can promote the use of crop residues for digestion and the implementation of biogas plants in organically managed farms. There are some technical and economical problems regarding the implementation of the recommended systems, but the solution of these problems seems to be very profitable.

**Keywords** Biogas • Crop rotation • Agricultural residues • Maize alternative

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_19,

**Abbreviations**

| | |
|---|---|
| a | Year |
| $CH_4$ | Methane |
| NaOH | Sodium Hydroxide |
| N, $N_2$ | Nitrogen, Atmospheric Nitrogen |
| $N_{min}$ | soil mineral nitrogen |
| $NH_3$ | Ammonia |
| $N_2O$ | Nitrous Oxide |
| $m^3\ CH_{4,N}$ | (Normalized) cubic meter methane at standard conditions for temperature and pressure |
| P | Phosphorus |
| TS | Total Solid (equivalent: dry matter) |
| UAA | Farmland defined as agricultural area in use: the total area of arable land, permanent pastures and meadows, land under permanent crops and kitchen gardens |
| VS | Volatile Solid: the weight of organic solids burned off when heated to about 538°C is defined as volatile solids. |

## 1 Introduction and Goals

Agriculture can contribute to the solving of current problems of global warming and energy supply providing biomass for energy use. Especially biogas digestion is interesting because: (a) it allows the use of raw materials with no or small market alternatives (slurry, fodder residues, biomass of cover crops, crop residues); (b) essential nutrients remain nearly lossless in the production cycle; (c) this technology can help to enhance the nitrogen efficiency; (d) the use of such biomass can reduce trace gas emissions (nitrous oxide – $N_2O$ and methane – $CH_4$) from agriculture (Schauß 2006); (e) this technology works relatively decentralized which enables closed nutrient cycles; (f) biogas is a multi-tasking energy source that can be utilized for almost all applications replacing fossil fuels. At the moment most of the plant biomass used as a source for biogas production in Germany is dedicated energy maize (Schauß 2008). Being a main crop, its cultivation competes with other crops for food and fodder production. Another problem of nearly solely using maize as biogas substrate is a high risk of failure: compare the introduction of the Western Corn Rootworm (*Diabrotica virgifera virgifera*) in Europe 1992 and in Germany 2003 (Hummel et al. 2009). The following text estimates firstly the possible energy yields, and in a second step discusses the effects of introduction of biogas digestion in farming systems.

## 2 Material and Methods

### 2.1 Field Trial: Setting, Location, Climate

Within a multidisciplinary project, the attainable energy yields from digestion of residues like stable wastes, crop residues and cover crops of two organic crop rotations were studied. The trials were installed in the year 2001 and ended in 2005. The results of the years 2003 and 2004 were considered for this paper. The field trials were carried out at the experimental farm of the University of Giessen “Gladbacherhof” (50° 23′44″N, 08° 1446″ E temperature Ø9.3°C, precipitation Ø670 mm).

## 2.2 Digestion

Anaerobic digestion took place in two different digesters: slurry has been fermented in a one stage fully mixed digester (Möller et al. 2006). Plant materials were digested in a two stage prototype reactor (Edelmann et al. 1996). In the first stage, the substrate was hydrolyzed, and then the liquid phase pumped to a methanisation reactor from where it was recycled via a buffer container.

## 2.3 Crop Rotations

### 2.3.1 Stockless Organic Farming

1. clover grass (*Trifolium pratense* at 7.5 kg $ha^{-1}$, *Medicago sativa* at 7.5 kg $ha^{-1}$, *Lolium perenne* at 5 kg $ha^{-1}$, *Phleum pratense* at 5 kg $ha^{-1}$ and *Festuca pratensis* at 5 kg $ha^{-1}$)
2. potatoes (*Solanum tuberosum*)
3. winter wheat (*Triticum aestivum*)
4. grain peas (*Pisum sativum*)
5. winter wheat
6. spring wheat (*Triticum aestivum*) with undersown clover grass

### 2.3.2 Organic Dairy Farming

Grassland on 30% of farmland area, Arable land on 70% of farmland, stocking rate 0.8 livestock units per hectare farmland.

(1) Clover grass (2) clover grass (3) winter wheat (4) potatoes (5) winter rye (*Secale cereale*) (6) grain peas (7) spelt (*Triticum spelta*) (8) spring wheat with undersown clover grass;

Cover crops (common vetch: *Vicia sativa* at 90 kg $ha^{-1}$ and oil radish: *Raphanus sativus* at 5 kg $ha^{-1}$) were cultivated after winter cereals and peas in both crop rotations.

Results of both crop rotations were compared with literature data (Amon et al. 2005; Eder et al. 2005; Gaudchau et al. 2005) for dedicated energy maize (*Zea mays*).

### 2.4 Calculation of Attainable Energy Yields

In the stockless organic farming system, the energy yield from digestion of clover grass, straw (peas and wheat) cover crops and non-market potatoes was calculated with measured crop yields of the years 2003–2004, and with the help of data from literature about the methane production of these substrates. In the organic dairy farming system, the measured quantities of straw (cereals and peas; litter deducted), cover crops and the calculated amount of slurry were taken in account to calculate the gross energy yield with the help of literature data regarding methane yields (Deuker et al. 2008). To calculate the amount of slurry available for anaerobic digestion, the phosphorous (P) content of fodder and litter (0.17 t of total solids per hectare farmland – t TS (ha UAA)$^{-1}$) was used. Available fodder was calculated by the yields of: grassland, clover grass, rye, spring wheat, 50% of peas and 10% of potatoes. It is known that the excrements of bovines contain 82% of fed P (Fleischer 1998; Steinshamn et al. 2004).

Therefore, the amount of slurry available is defined by its P content. The total P available for fertilization was the calculated sum of 82% of fodder P plus the P in litter. Both systems were compared with an estimated dedicated energy maize production on 25% of the farmland (Table 19.3). As values for methane yields firstly KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft) values were used (KTBL 2005) (The data set of KTBL has been established in collaboration with leading German biogas researchers in order to determine a scientifically-based calculation instrument to be used by enterprises and authorities). If no values were found for special substrates, the energy yield was estimated with values of similar materials (e.g. mean of different crucifer cover crops for oil radish). The energy yield is expressed in standard cubic meters of methane per hectare farmland ($m^3$ $CH_{4,N}$ (ha UAA a)$^{-1}$). One $m^3$ $CH_{4,N}$ is equivalent to about one litre diesel fuel. All results are gross values.

## 3 Results

### 3.1 Substrates for Anaerobic Digestion

#### 3.1.1 Stockless Organic Farming

The total dry matter yields of clover grass (the sum of four cuts) varied between 14.5 and 15.8 t.[1] The cut of under-shown clover grass following spring wheat in autumn reached 1.0–2.0 t. The yield of potatoes was between 8.6 and 6.3 t (80% of the yield sold, 1.3–1.7 t remain for digestion). The wheat straw yields varied from

[1] Tons of total solids per hectare farmland (t TS (ha UAA)$^{-1}$ ). See Abreviations.

3.0 to 8.8 t. Pea straw yields were between 2.2 and 3.3 t and the cover crop yields ranged from 1.8 to 3.1. The volatile solid yields of all fermentable by-products referring to one hectare farmland are shown in Table 19.1.

### 3.1.2 Organic Dairy Farming

The calculated amount of slurry (based on the fodder yields of grassland 4.3–8.3 t, of clover grass 12.8–13.4 t, of rye 4.4–4.7 t, of spring wheat 3.8–3.0 t, of peas (50% used) 2.2–4.0 t and of potatoes (10% used) 5.4–6.4 t varied between 2.23 and 3.11 t. The cereal straw yields ranged from 3.5 to 10.0 and the pea straw ranged from 4.9 to 5.1 t. Cover crop yields varied from 1.9 to 4.0 t. The volatile solid yields of all digestible by-products referring to 1 ha farmland (t vs $ha^{-1}$)[2] are shown in Table 19.2.

**Table 19.1** Energy yields for the stockless organic farming system

| Substrate | Yields | | Methane potential[a] | | Area | Energy yield | |
|---|---|---|---|---|---|---|---|
| – | t VS $ha^{-1}$ | | $m^3$ $CH_{4,N}$ $(t\ VS)^{-1}$ | | % | $m^3$ $CH_{4,N}$ $(ha\ UAA\ a)^{-1}$ | |
| – | From–to | Ø | From–to | Ø[b] | – | From–to | Ø |
| Clover grass | 13.0–14.1 | 13.6 | 186–390 | 307 | 16.6 | 660–913 | 691 |
| Wheat straw | 4.0–7.5 | 5.7 | 154–327 | 198 | 50 | 307–1,220 | 566 |
| Pea straw | 2.1–3.1 | 2.6 | 184–276 | 230 | 16.6 | 64–141 | 99 |
| Intercrops | 1.9–2.0 | 2.0 | 231–376 | 325 | 50 | 222–376 | 319 |
| Potatoes[c] | 1.2–1.6 | 1.2 | 258–430 | 280 | 16.6 | 52–116 | 67 |
| – | | | | | | 645–2,766 | 1,742 |

[a]Deuker et al. (2008)
[b]Average or KTBL value
[c]Non market potatoes 20% of gross yield

**Table 19.2** Average energy yields for the organic dairy farming system

| Substrate | Yields | | Methane potential[a] | | Area | Energy yield | |
|---|---|---|---|---|---|---|---|
| – | t VS $ha^{-1}$ | | $m^3$ $CH_{4,N}$ $(t\ VS)^{-1}$ | | % | $m^3$ $CH_{4,N}$ $(ha\ UAA\ a)^{-1}$ | |
| – | from–to | Ø | from–to | Ø[b] | – | from–to | Ø |
| Slurry | 1.64–2.06 | 1.85 | 103–267 | 154 | 100 | 165–549 | 285 |
| Wheat straw | 3.9–6.6 | 5.3 | 154–327 | 198 | 17.5 | 109–387 | 188 |
| Rye straw | 6.3–8.3 | 7.3 | 170–409 | 179 | 8.75 | 99–281 | 114 |
| Spelt straw[c] | 4.7–7.0 | 5.8 | 154–327 | 189 | 8.75 | 63–144 | 96 |
| Pea straw | 4.6–4.7 | 4.6 | 184–276 | 230 | 8.75 | 74–117 | 95 |
| Intercrops | 2.0–2.1 | 2.1 | 231–376 | 325 | 35 | 164–280 | 237 |
| – | | | | | | 674–1,758 | 1,015 |

[a]Deuker et al. (2008)
[b]Average or KTBL value
[c]1.94 t TS * $ha^{-1}$ deduced for Litter use

[2]Tons of volatile solids per hectare (t VS $ha^{-1}$). See Abreviations.

**Table 19.3** Literature data for methane yield from dedicated energy maize (Amon et al. 2005; Eder et al. 2005; Gaudchau et al. 2005)

| Substrate | Yields | | Methane potential | | Area | Energy yield | |
|---|---|---|---|---|---|---|---|
| – | t VS $ha^{-1}$ | | $m^3$ $CH_{4,N}$ (t VS $)^{-1}$ | | % | $m^3$ $CH_{4,N}$ (ha UAA a$)^{-1}$ | |
| – | from–to | Ø | from–to | Ø | – | from–to | Ø |
| Maize | 11.3–34.4 | 17.8 | 297–383 | 350 | 25 | 1,000–2,355 | 1,557 |

### 3.2 Energy Content of Substrates

The range of given data about the yields of methane is relatively large (Deuker et al. 2008), while different methods of determination were used (calculation, batch digestion trial, continuous digestion trial). Specific factors as particle size, duration of digestion and pre-treatment (green material, silage) influence the methane yield.

### 3.3 Energy Yield Potential of the Whole Crop Rotations

An average total energy yield of 1,742 $m^3$ $CH_{4N}$ (ha UAA a$)^{-1}$ could be estimated for the stockless farming system (Table 19.1). Clover grass contributed with 40%, followed by straw with 38% and cover crops with 18%. Other production residues (4%) took a relatively small part of the energy yield.

The total energy yield reached 1,015 $m^3$ $CH_{4N}$ (ha UAA a$)^{-1}$ in the dairy farming system (Table 19.2). The repartition was 28% for slurry, 23% for cover crops and 49% for straw.

Compared with literature values for cropping dedicated energy maize (Table 19.3), it can be observed that the energy yield of the stockless organic system reaches about 27% of the methane yield of dedicated energy maize; the organic dairy farming system reached about 16% of this energy yield potential (both without using extra farmland and mineral fertilizer).

## 4 Discussion

### 4.1 Trial Results of Energy Yields

The results show remarkable potentials of biomass for biogas production just by using residues, without depletion of food production (Möller et al. 2008a). As farmland is limited and other demands for biomass (food, other biofuels, and renewable raw materials from biomass) are also rising up (WBGU 2009), it seems to be necessary for biogas industry to solve the problems of using this biomass. Additionally to energy yields, the effects and possibilities of the biogas technology influencing farming systems as a whole (not only in organic farming) need to be discussed.

## 4.2 *Effects of Biogas Digestion on Farming Systems*

### 4.2.1 Recovery of Nitrogen Derived from the Atmosphere by Symbiotic $N_2$ Fixation

It is possible to use legumes alone or in mixture with non-legumes for cover cropping. Clover grass leys are also important crops to enhance soil fertility. After digestion, the nitrogen derived from atmosphere by symbiotic nitrogen ($N_2$) fixation can be reallocated to the N demanding crops via the biogas slurry (Deuker et al. 2005; Stinner et al. 2008).

### 4.2.2 Decreasing of Nitrate Leaching Risk

The harvest of cover crops for anaerobic digestion in autumn leads to a decrease of the nitrate leaching potential in winter. Data from organic dairy farming in 2001–2003 show that the average nitrogen uptake by sprout of catch crops was 110 kg of nitrogen per hectare. In autumn 2001 and 2002 for the ploughed field with following winter-seeds, we found significant by higher soil mineral nitrogen ($N_{min}$) levels (approx. one third) for non-harvested variants in 0–90 cm depth. The non ploughed variants had low $N_{min}$ contents with slightly higher values for the harvested variants. In spring 2002 and 2003, the non-harvested spring seeds showed significantly higher $N_{min}$ values in all soil-horizons (Deuker et al. 2004; Möller et al. 2008b).

### 4.2.3 Reduction of Trace Gas Emissions

Trace gas emissions from the soil were measured in situ by Schauß (2006). Results showed that $N_2O$ emissions from the winter wheat fields during wintertime could be reduced by 25–44% for the stockless organic farming system (compared to the same crop rotation without using anaerobic digestion) (Möller and Stinner 2009). The spelt fields of the organic dairy farming crop rotation showed a reduction of 40–60%. It seems that the yield of pea straw and particularly the harvest of cover crops for energy producing purposes in autumn reduced the $N_2O$ emissions. Nevertheless, this observation could only be made when ploughing and sowing took place in October (for winter cereal), and could not be repeated in the case of following spring crops (spring wheat, potatoes).

### 4.2.4 Diversification of Crop Rotations by Cover Crops

The use of cover crops and second main crops (as green maize) is getting more attractive by using anaerobic digestion. This technique allows the use of crops that otherwise would not have a direct economic benefit. Nevertheless, the humus reproduction capacity of the organic matter of these crops is also to be considered and is probably not reduced by the anaerobic fermentation (Leithold 2009; Möller 2009). The here mentioned crops are also often advantageous for the crop rotation. As weeds are harvested with the cover crops before maturation, the weed pressure can be reduced. Also common diseases and pests of a crop rotation can be partly reduced by using appropriate cover crops.

### 4.2.5 Use of By-Products

The use of crop residues (straw, etc.) does not only offer an extra energy potential, but can also reduce the risk of disease infection, because pathogens can be dislocated and fermented. Especially, if winter wheat is following grain maize, the risk of infestation with *Fusarium spp*. is reduced. Notably, straw harvest allows having extra time for cultivation operations. Under German climatic conditions, it can be possible to seed rape (*Brassica napus*) following winter wheat because no time is needed for straw decomposition in the soil. The repeated soil tillage to enhance straw rotting can be minimized.

### 4.2.6 Use of Problematic Biomass

The possibility of green plants usage with an economic benefit opens possibilities to reduce the intensity of marked crop production. That mean, problematic growths from: (a) fields with insufficient density of specific cultures (in which weeds are spreading and have to be combated costly in the following crop); and (b) pest or disease infested cultures can be harvested earlier and used for biogas digestion. By this strategy, weeds can be eliminated before seeding and diseases and pests before switching to survival or dissemination status.

On the cleaned fields spring crops such as maize (*Zea mays*), sunflowers (*Helianthus annuus*), sudan grass (*Sorghum sudanense*), hemp (*Cannabis sativa*) or amaranth (*Amaranthus spp*.) can be established for anaerobic digestion. This way the pressure of weeds, pests and diseases can be reduced step by step on the entire farmland (which reduces the need for chemical crop protection for non-organically managed farms). As only the best parts of cash crops are harvested, their yields can be stabilized or augmented. As the digester always needs sufficient material to feed, it is possible to harvest for biogas fermentation the worst 30% of cereal and rape growths in May.

## *4.3 Outlook: Factors Influencing the Future Development*

### 4.3.1 Economic Points of View

Compared to the harvest of maize for silage (about 20 t of dry matter can be harvested in one harvesting operation), the costs of the repeated harvest of cover crops, green cereals or clover grass are usually much higher. But there are some aspects that make this strategy attractive to be an economically viable alternative or complement to energy maize cropping:

- The substrates can be produced without occupying extra land that is necessary for food production. (b) Because of the subdivided harvest dates a part of the silage capacity can be used several times a year.
- More diverse crop rotations give additionally possibilities of fertilizing with digestion residues. That can reduce the stock capacity and the demand of machinery for bringing out the manure.
- As the demonstrated operations have a positive impact on the main problems of minimum tillage (weed and pest pressure), strategies to reduce the tillage intensity can be promoted.
- Throughout the use of legumes (cover crops) for anaerobic digestion also non – organically managed farms can reduce their mineral fertilizer costs

### 4.3.2 Obstacles for Implementation

To implement the shown strategy for the use of residues, a strong need for research and development exists. These substrates (mainly straw) have a high fibre content. Therefore, the hydrolysis is relatively slow. This leads to longer retention times in the digester, and higher requirements for pumping and mixing equipment, when the “standard system” of liquid digestion is used. Solutions that should be combined to improve the efficiency of fermentation are:

- Optimization of hydrolysis by mechanical and/or physical treatments (e.g. extrusion, hammer or ball mills, wet milling).
- Optimization of hydrolysis by biological, biochemical and/or chemical treatments (enzymes, ammonia). For use in organic agriculture the legitimacy of the used ingredients must be considered. By the treatment of straw with ammonia ($NH_3$) or sodium hydroxide (NaOH) for non-organic farms the methane yields can be raised up considerably. Keymer (2006) indicates an augmentation of methane yield of 19% for $NH_3$ treatment and 30% for NaOH treatment of wheat straw.
- Optimization of hydrolysis by the use of appropriate substrate mixtures (important: the sufficient nutrition of microbes and as possible the use of easily degradable substrates such as beets, potato, cereals, topinambur (*Helianthus tuberosus*)).

– Developing of anaerobic digestion technologies, that demand no or very low pumping- and mixing-energy and that avoid the pumping of substrates with high fibre content. Additionally, the new technologies should provide cheap digester space to assure a sufficient retention time in hydrolysis.
– The harvest of cover crops in (late) autumn often depends on the weather conditions. In that time, soil conditions can be quite problematic. Cropping systems have to be developed that shift the harvest of intercrops in a less problematic season or that raise up the carrying capacity of the soils.
– The use of by-products and cover crops as co-ferments can cause a disadvantage sediment input into the digester. Cost efficient methods in order to avoid sinking layers are to be developed.
– Throughout the year, the availability of the cited vegetal by-products is unbalanced in quality and quantity. Including energy cropping of main crops, cropping strategies are to be developed which provide substrates with equal quantity and quality for the fermenter in order to limit storage costs.

## 5 Conclusion

The considerable energy potentials and the described advantages for the environment and cropping systems show that the use of residues, as shown, is an interesting option for biogas digestion. These possibilities also justify additionally efforts to solve technical and agronomical problems.

**Acknowledgements** For funding: Deutsche Bundesstiftung Umwelt (DBU) Osnabrück, Germany

For developing the overall research concept, project coordination and helpful comments: Dr. Kurt Möller

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# Part IV
# Sustainable Agriculture and Food Security: Relevant Experiences

# Chapter 20
# Sustainable Agriculture and Food Crisis in Sub-Sahara Africa

**Olubunmi Lawrence Balogun**

**Abstract** Agriculture was the foundation of economic growth and prosperity in most developed countries. Poverty and food insecurity are high in Sub-Sahara African (SSA). It is therefore unlikely that the time-bound Millennium Development Goals to reduce world hunger and poverty by half by 2015, committed to by governments worldwide, will actually be achieved in SSA. To address the issues of sustainable agriculture and rural development, Food insecurity and poverty must first be tackled. The increasing population's need for food poses a threat to natural resources, with people further exploiting land that is already being cultivated or encroaching upon untouched land for agricultural use. Climate change has significant international and intergenerational implications in the context of equity and sustainable agricultural development, and therefore needs to be at the core of comprehensive policy planning and an integrated resource allocation and implementation strategy, both spatially and temporally.

**Keywords** Sustainable agriculture • Natural resources • Poverty • Food insecurity • Climate change

## 1 Introduction

The word "*sustain*", from the Latin sustinere (sus-, from below and tenere, to hold), to keep in existence or maintain, implies long-term support or permanence. As it pertains to agriculture, sustainable describes farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely". Sustainable agriculture integrates three main goals – environmental health, economic profitability,

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_20,

and social and economic equity. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable agriculture is defined as agricultural practices that are economically viable, socially acceptable, environmental friendly and technically appropriate.

Sub-Sahara Africa (SSA) accounts for 25% of the global figure of chronically undernourished. In 2001, the total population of SSA was estimated at 667 million with 436 million rural, of which 92% (400 million) are agricultural (FAO 2003). The number of undernourished has risen from 170 million in 1990–1992 to 204 million in 2000–2002. According to the Hunger Task Force of the UN Millennium Project (2005) analysis, 80% of the chronically undernourished are rural households. The agricultural sector supports the employment of more than 70% of the economically active population in the region (FAO 2003). In developing countries as a whole, per capita agricultural production increased by about 40% in the last two decades; but in SSA it actually fell by 5%. DFID's Research Funding Framework (2004) identified sustainable agriculture, especially in Africa, as one of the crucial research areas for achievement of the Millennium Development Goals (MDGs).

Despite national and international efforts, a third of the African households are still exposed to the risks of food shortages and hunger. At current level of progress, Africa will miss achieving the key MDGs (UN Millennium Project 2005). Progress towards meeting the MDGs will require comprehensive programmes that aim to simultaneously address: (a) declines in the productivity of the agricultural sector in Africa; (b) meeting people's immediate food needs when exposed to natural and man-made disasters; and (c) expanding the scope of livelihood opportunities for poor and food insecure households so that they are able to better manage the risks associated with natural and man-made emergencies. The International Monetary Fund (IMF) said that the current global crisis or melt down in economy is the biggest financial shock since the great depression of the 1930s, and suggested that a world-wide recession was possible.

Recently, the World Bank published a report showing increased income inequality in 44 of 59 developing countries it surveyed, and concluded that countries in SSA would not reach the MDGs in spite of recent strong economic growth in the region. Behind much of the growth figures has been the further hollowing out of domestic agricultural production, laying the grounds for the current crisis. Though, other regions in the developing world are lagging in achieving the MDGs on child and maternal mortality, education, nutrition and sanitation. In SSA as a whole, most people's livelihoods are tied to agriculture. Although two-thirds live on small-scale farms and produce their own food, nearly a third of them are undernourished (FAO 2001). The region simply does not produce enough food to adequately feed its population, and food production per capita is declining.

Although land is relatively plentiful in comparison to other parts of the world, soil fertility, a key factor in productivity, is declining, leading to devastating infestations of the parasitic weed. Drought and its partner, crop failure, are regular visitors in SSA. In the past, with all these constraints facing farmers, the one thing they could rely on was family labor. But with AIDS and the migration of the younger generation to urban areas, even this is no longer assured. Times are tough for small-holders in Africa, and it is also tough for the farmers of other part of the developing countries for instance, South Asia before the Green Revolution – a revolution in agricultural production that bypassed Africa. Today, we in Africa are looking for our own Green Revolution to bring us to a new era of food security. But our Green Revolution will probably entail a range of agricultural advances on a number of fronts rather than the introduction of a new plant variety supported by a specific technology package. One thing is clear: biotechnology will play a central role in Africa's agricultural revolution (Conway and Toenniessen 2003; Toenniessen et al. 2003).

The need in increasing food production to meet the food and nutritional demands of the ever growing population has necessitated this attempt to unveil the strategies of fostering subsistence agriculture in SSA. To achieve this, the concept of subsistence agriculture, its place in a national economy and impact on poverty and health prevention, the various models and strategies were examined. Its intensity and dimensions are revealed in the role it plays not only in providing food with nutritional value, immediately available to the rural people, but also in creating the basis and formation stages for commercial agriculture. The farmers, governments, extensions and other instruments involved in subsistence agriculture are the focal point of change.

In response to the deepening global food crisis, the International Trade Centre (ITC) has called on governments and world institutions to take far-reaching measures to guarantee food security for all. The worsening crisis comes against a background of bleak announcements on the world economic slowdown. The World Food Summit in 1996 produced the Rome Declaration on World Food Security. This was reaffirmed by the Millennium Declaration of the United Nations Millennium Summit in September 2000, where world leaders adopted the MDGs, which set clear targets for reducing poverty, hunger, disease, illiteracy and discrimination against women by 2015. Subsequently, the Johannesburg Declaration on Sustainable Development, September 2002, affirmed the objectives set by the World Food Summit and recognized that sustainable agriculture and rural development are essential for increasing food production and enhancing food security and food safety in an environmentally sustainable way. The current global crisis of high food prices, and of shortages in some countries, has given prominence once again to food security concerns. Stagnating agricultural yields and continuing soil degradation are structural obstacles to poverty reduction in rural areas of SSA. The reliance on extensive methods of land use leads to declining labour productivity, while existing market imperfections provide limited incentives to farmers for investing in improved and more intensive methods of agriculture and stock breeding (Sanders et al. 1996).

In recent years, there was complacency about food security and national self-sufficiency, as it was thought that cheaper imports would be always or usually available, and local food production was not so necessary as previously thought. Many developing countries reduced food production, many of them under advice of the international financial institutions. The rising world prices of many food items in the past couple of years have meant more expensive imports, and inflation of food prices in local markets. Many developing countries have been caught in situation of food shortage found it difficult to cope. Because of this new situation, the paradigm of "food security" has suddenly shifted back to the traditional concept of greater self-sufficiency, instead of prioritizing the option of relying on cheaper imports to take care of emergency needs. This raises the question of what constitute the barriers to local production and how to remove these barriers. Factors for this crisis include climatic factors (such as drought for example affecting wheat production in Australia), the rising cost of inputs especially oil and oil-based products, and the switch of land use from production of food to biofuels.

## 2 Challenges of Food Security in Sub-Saharan Africa

Indeed, Africa not only has the world's highest proportion of its population living below the international poverty line, but also experienced an increase in this proportion from 47.4% in 1990 to 49% by 2000 (World Bank MDG database). Meeting the first MDG target requires Africa to achieve an annual GDP growth rate of 7% (AFDB 2003). Yet, according to Table 20.1, only 10 out of 37 African countries have achieved a 5% or higher average GDP growth rate between 1997 and 2003. As a whole, Africa is growing at about 3% and if it continues according to this trend, projections indicate that 42.3% of the population will remain in poverty by 2015 rather than the target of 23.7% (World Bank MDG database). Agriculture is the primary source of livelihood for approximately 65% of Africans, and it represents between 30% and 40% of African GDP and accounts for almost 60% of Africa's export income. Reducing high levels of poverty and hunger in Africa will require greater agricultural and rural development (IFAD 2003).

Though there have been some pockets of success in African agriculture such as NERICA Rice, high yielding cassava varieties, etc., the goal of food security in Africa has remained elusive for many decades. While agriculture is transforming economies across much of Latin America and Asia, the transformation has not been the same for Africa. For example, during the period 1993–2003, Africa's rate of population growth has been higher than the rate of food production, while the

**Table 20.1** Comparisons of annual GDP growth rate across Sub Region in Sub-Sahara Africa (Source: IMF World Economic Outlook Data Base 2004)

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Region | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 1999–2003 |
| Africa | 3.9 | 2.4 | 2.7 | 3.2 | 3.7 | 3.5 | 3.5 | 3.3 |
| South Africa | 5.0 | 3.1 | 2.8 | 2.1 | 2.3 | 3.4 | 2.4 | 3.0 |
| West Africa | 3.5 | 3.0 | 2.1 | 2.7 | 4.5 | 2.7 | 3.8 | 3.2 |
| East Africa | 3.4 | 3.1 | 3.3 | 2.5 | 4.1 | 2.5 | 2.9 | 3.1 |

continent's share of world trade declined for nine of ten of its major agricultural exports during the period. African agricultural production has to increase by at least 4–6% per annum on a sustained basis to meet the food needs of a rapidly growing population.

African governments face difficult challenges as they strive to achieve food security and reduce poverty. These challenges include but are not necessarily limited to: high poverty rates and high income inequality; resurgent conflicts and political upheavals; poor infrastructure; the HIV/AIDS pandemic and other debilitating diseases such as malaria; high external debts; soil degradation; increasing water scarcity and poor water use management; desertification; and climate change. In addition, Africa is plagued by a high prevalence of HIV/AIDS, which, among other things, decreases labor productivity, erodes assets and blocks the transfer of knowledge from one generation to the next. According to the FAO, the pandemic has already reduced national economic growth rates across Africa by about 2–4% a year (FAO 2003).

Soaring food prices are raising new questions of whether the world will be able to feed itself at a time when energy costs are increasing, the climate is changing, and arable land and water resources are declining due to poor management practices and rapid urbanization. The rapidly escalating crisis of food availability around the world has reached emergency proportions. According to United Nations Secretary-General Ban Ki moon, it is the poorest people, people living on one dollar a day or less, who are hit the hardest. When people are that poor and inflation erodes their meager earnings, they generally do one of two things: They buy less food, or they buy cheaper, less nutritious food. The result is the same - more hunger and less chance of a healthy future.

Food insecurity is greatest in SSA countries compared to other developing countries. The major reasons include: low agricultural productivity, lack of agricultural policies, poor infrastructure and high-transport costs, lack of appropriate marketing strategies, frequent extreme weather events, high-disease burden including malaria and HIV/AIDS, weak financial support systems, lack of safety net systems and political conflicts (the UN Millennium Project 2005; the Commission for Africa report 2005; Reducing Disaster Risk UNDP 2004). The underlying crisis of child malnutrition and under-education undermines the potential of Africa's future generation. Food insecurity is most severe for communities living in remote areas of the continent. Access to markets and utilities is constrained due to the lack of infrastructure and prohibitive high-transport costs. Compared to other parts of the world, transport costs are highest in SSA. In a typical sub-Saharan country, the cost of a local transport can be as high as US$800 per metric tonne compared to USD300 in Asia (Millennium Project 2005). Farmers cannot get their produce to markets at a competitive price due to the high-transport costs. Lack of appropriate storage facilities in remote areas also contributes to high-post harvest agricultural loses. Access to agricultural inputs, such as fertilizers and seeds, becomes too expensive for farmers to afford.

Household food security is also influenced by social vulnerability factors such as household health, composition, household head (female, child) and availability of labour, and social standing in the community and culture. The HIV/AIDS pandemic is contributing to increased food insecurity and vulnerability of households as summarized in Gillespie and Kadiyala (2005). In the agricultural sector, HIV/AIDS reduces households' ability to produce their own food leading to food insecurity (Barnett 1994; Guerny 2002). In addition, the financial cost of looking after the chronically sick is puts a heavy burden on the economic situation of households, the community and the country (Gillespie et al. 2001; Barnett and Topouzis 2003; De Waal and Whiteside 2003). Also, climate variability and extreme weather events in SSA, such as droughts, excessive rains and floods, are among the main risks affecting agricultural productivity, and hence rural household food security. A failure of the rainy season is directly linked to agricultural failure reducing food availability at household level, as well as limiting rural employment possibilities. In recent years, the largest food crises in Africa that required large-scale external food aid have been attributed fully or partially to extreme weather events (Dilley et al. 2005). The food crises of 1974, 1984/1985, 1992 and 2002 that affected the lives and livelihoods of millions of rural households have been mainly caused by droughts. Recovery from such huge drought events could take several years as shown in Dercon (2004). Often the poorest in rural areas occupy the most marginal lands that are vulnerable to disaster risks (UNDP 2004). Natural disasters and economic shocks, if not addressed properly, could lead to increased environmental degradation, deforestation and possible conflicts over resources triggering political instability and food and energy crisis. Many developing countries lack the necessary emergency response and preparedness capacities and financial means to protect their populations from natural disasters and economic shocks.

In response, the African Union and the New Partnership for African Development (NEPAD) have developed a Comprehensive African Agricultural Development Programme which calls for sustained agricultural growth of 6% annually. National statistics from developing countries show that increasing agricultural productivity is closely related with the speed of poverty reduction. The direct effects through lower food prices, increased farm incomes and more jobs on farms are well understood. Furthermore, the sustainable management and use of renewable natural resources is important for achievement of growth and livelihoods for poor people. This is through their direct productive use (e.g. forestry and fisheries), and also in terms of this impact on the environment – such as on water and energy, on which growth in other sectors is dependent.

## 3 Trend in Food Consumption in Sub-Sahara Africa

Africa has the world's highest percentage (33%) of undernourished people, and this proportion has only improved by 3% since 1990. Children are particularly vulnerable with an average of 24% underweight and 35% stunted by 2000 (UNSCN 2004).

Per capita calorie consumption at the global level has increased 0.4% per year since 1992, and in 2002 was roughly 2,800 cal. Consumption in developed countries grew at a slower rate during that time, but was still significantly higher than the world average, measuring over 3,300 cal in 2002. While growth in consumption in the developing world exceeded that at the world level, absolute intake levels were still lower than the global average, equaling about 2,660 cal in 2002. SSA has by far the lowest intake levels of consumption in comparison with other regions of the world. Per capita consumption in the region averaged only 2,200 cal in 2000–2002. Within this region, there are large variations. Eritrea, Burundi and the Democratic Republic of Congo have an average per capita consumption of less than 1,700 cal, which indicates severe food insecurity. Nigeria and Mauritania, on the other hand, have surpassed 2,700 cal. Grains account for the largest share of the diet in SSA, this share is lower than that for other developing countries – less than half. The reason for this is the high level of consumption of low-priced roots and tubers. The share held by this group – more than 16% – far exceeds that of any other world region. As a result, production of grains plays an important role in the food security.

Since 1990, SSA had the highest growth in grain production of 1.65% per year, but this growth was outstripped by the region's high population growth. In fact, all regions except Asia experienced negative per capita growth in grain production. In Asia, grain production and population growth rates were virtually identical. In SSA, nearly 90% of the growth in production came from area expansion. The region's yields are the lowest in the world, measuring about one-third of the world average. In the other regions, yields were the driving force behind the growth. In fact, yield growth in Asia accounted for 97% of production growth. In the other regions, area devoted to grains actually declined through the 1990s. The yield growth was realized as a result of increased fertilizer use, adoption of higher yielding varieties, or increased irrigation. Many developing countries are close to their maximum technical potential for growing crops. Therefore, maintaining recent growth rates will be unlikely in these areas with current technologies and practices. However, in many countries, particularly those in SSA, potential exist for improved productivity. Domestic food production is less critical to food security if countries can import required foods. For low-income, food-insecure countries, however, financial constraints severely limit their ability to do this.

Despite wars in Sierra Leone, Guinea and Liberia, as well as continuing instability in Ivory Cost, the West African sub-region has experienced the continent's highest rates of growth over the past 6 years with both GDP and agricultural growth averaging around 3%. Although per capita agricultural incomes decreased by 35% between 2001 and 2002, from US$315 to US$204, the sub-region still has higher per capita agricultural incomes than the other two sub-regions. Similarly, per capita food and agricultural production has not skyrocketed but West Africa has at least maintained its 1989–1990 level of production while the other two sub-regions have experienced a decrease. Regardless of this growth, the region could benefit from increased use of agricultural inputs. Most of the countries only use one-third of their potentially arable land, and irrigate about 1% or less of arable cropland. Even though fertilizer application rates are slightly higher than those found in East Africa, they are more than twice as low than those in Southern Africa. While HIV/AIDS prevalence is not as high as in Southern Africa, it still averages around 5% of the adult population according to a recent FAO report; HIV/AIDS will cause Ivory Cost and Burkina Faso to lose between 24% and 20% of their work forces by 2020. Other diseases, including measles and malaria, also pose significant risks to the Region's labor productivity (FAO 2002).

## *3.1 Climatic Change*

In SSA progress towards the achievement of the MDGs will be a function of how well households are protected against impacts of extreme weather events as they are mostly dependent on rural agriculture. Hard earned developmental gains can be wiped out by emergencies if not properly protected against major risks.

Climate change and climate variability refers to the variation in the Earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere or average weather over time scales ranging from decades to millions of years. These changes may come from processes internal to the Earth, be driven by external forces (e.g. variations in sunlight intensity) or, most recently, be caused by human activities.

Climate change affects developing countries' agriculture, while agricultural practices also contribute to climate change. According to various studies, cited in a paper by IFPRI's Director General, Joachim (2008), many poorer developing countries are in tropical and sub-tropical regions that are vulnerable to global warming and in semi-desert areas threatened by water scarcity. By 2080, agriculture output in developing countries may decline by 20% due to climate change, and yields could decrease by 15% on average. The number of under-nourished people in SSA may rise from 138 million in 1990 to 359 million in 2050. Responses to climate related threats in agriculture underestimate the problem, and there is little work on how the negative effects can be mitigated, according to IFPRI.

According to the recent report of the IAASTD (Independent Assessment of Agricultural knowledge, Science and Technology for Development), climate change can irreversibly damage the natural resource base on which agriculture depends. Some negative impacts are already visible in many parts of the world. Water scarcity and the timing of water availability will increasingly constrain production. Climate change will require a new look at water storage to cope with the impacts of more and extreme precipitation, higher seasonal variations and increased rates of evapotranspiration in all types of ecosystems. Extreme climate events (floods and drought) are increasing and are likely to adversely affect food and forestry production and food security (IAASTD 2008).

### 3.2 Weather Patterns and Drought Occurrence in Africa

The African continent enjoys a wide variety of climate regimes ranging from humid climate in the tropics to arid and semi-arid climate in the sub-tropics. Africa's location, size and shape play a major role in determining its climate. The rainfall pattern of SSA is modulated by large-scale intra-seasonal and inter-annual climate variability. The El Niño-Southern Oscillation (ENSO) is the most important phenomenon responsible for inter-annual climate variability over Eastern and Southern Africa. More specifically, periods of strong warm and cold ENSO phases have been associated with large-scale rainfall anomalies over many parts of Africa including the Sahel region, Eastern Africa and Southern Africa (Folland et al. 1986; Nicholson and Etekhabi 1986; Ogallo et al. 1988). However, the magnitude of ENSO influence on the local climate variability varies significantly from one location to another, as well as from season to season and year to year, and hence further research is required to better understand ENSO impacts at local level.

### 3.3 Government Responses

The effectiveness of government responses to drought-related food crises depends on many factors including the political set-up of the government; emergency preparedness and response capacity of the government; and availability of reliable food security information. The immediate response is to mobilize the necessary resources and meet the immediate food requirements of those affected. This may include: using contingency funds, reallocating funds from development projects and requesting humanitarian aid through international emergency appeals. While addressing the immediate food crises, governments recognize the need for developing comprehensive national response mechanisms that would ensure timely intervention that would protect the livelihoods of their populations.

Following the severe droughts of 1974/1975 and 1983/1984 that caused major food crises in SSA, many countries, supported by the international community, have initiated national and regional humanitarian response systems. For example, in Ethiopia the disaster prevention and preparedness commission, and in the Sudan the humanitarian aid commissions have been established to address food emergency. Similar government institutions exist in other countries. A drought emergency response framework may include various components such as: food security monitoring systems to provide early warning information; strategic food reserve systems to enable timely delivery of food assistance; and contingency funds to enable the emergency operation.

In a recent New Partnership for Africa's Development (NEPAD) study aimed at enhancing the effectiveness of existing and future national food-reserve systems in supporting food security policies in SSA, eight countries have been reviewed.

They include: in the Sahel, Burkina Faso, Mali and Niger; in Southern Africa, Malawi, Tanzania and Zambia; and in the Horn of Africa, Ethiopia and the Sudan. Lessons from this study indicate that the effectiveness of drought emergency response systems vary from one country to another. The main constraints that the systems share appear to be lack of resources, lack of appropriate strategy and political will, and lack of reliable and timely food security information. A common observation of most national humanitarian response systems is that they are heavily dependent on donor funding and lack government commitment to allocate adequate resources from its national budget. To coordinate and harmonize their efforts, governments have also created regional groupings such as Intergovernmental Authority for Development (IGAD), Southern African Development Community (SIDC) and Comité Permanent Inter États de Lutte Contre la Sécheresse dans le Sahel (CILSS). The purpose of these regional institutions is to promote regional cooperation and facilitate sustainable development, as well as humanitarian intervention through improved regional food security information systems. In addition, regional centres to provide climate services to member states have been created through international agreement. They include: African Centre of Meteorological Applications for Development (ACMAD), Research Center for Agriculture, Hydrology and Meteorology (AGRHYMET) based in Niamey, the SADC Drought Monitoring Centre in Harare and the IGAD Climate Prediction and Applications Centre in Nairobi.

On the other hand, agriculture is a major contributor to climate change as it is the main emitter of nitrous oxides and methane. The total global contribution of agriculture (direct and indirect emissions) is between 8.5 and 16.5 billion tonnes of carbon dioxide equivalent, representing 17–32% of all global human-induced greenhouse gas (GHGs) emissions, including land use changes (Greenpeace 2008). According to current projections, total GHGs from agriculture will reach 8.3 billion tonnes of carbon dioxide equivalent in 2030, compared to the current level of about 6 billion tonnes (ITC 2007).

## *3.4 Mitigation Potential of the Region*

Human activities, such as fossil fuel burning and deforestation, have significantly increased the atmospheric concentration of GHG leading to global climate change. Climate change and its associated weather extremes pose considerable challenges worldwide, and mitigating the adverse impacts of climate change is a high priority for the global community.

To reduce global emissions and curb the threat of climate change, many countries are participating in carbon trading. This includes allowance-based agreements that impose national caps on emissions, and allow participating countries to engage in emission trading as well as project-based transactions (for example, through the Clean Development Mechanism-CDM). The CDM allows industrialized countries with greenhouse gas reduction commitments to invest in emission-reducing projects in developing countries as an alternative to generally more costly emission reductions in their own countries. Funds made available by the CDM for carbon offsets provide an opportunity for cash-strapped developing countries to fund much needed adaptation measures.

The potential annual value stream for SSA from mitigating GHG emissions is estimated to be US$4.8 billion at carbon prices of US$0–20/tCO2e. Moreover, agricultural mitigation measures, including soil and water conservation and agroforestry practices, also enhance ecosystem functioning, providing resilience against droughts, pests and climate-related shocks.

Yet the potential for Africa to contribute to global reductions in GHG emissions is quite substantial. Estimates suggest Africa could potentially contribute to GHG reductions of 265 MtCO2e (million tons of carbon dioxide or equivalent) per year at carbon prices of up to US$20 through agricultural measures, and 1,925 MtCO2e/year at carbon prices of up to US$100/tCO2e by 2030 through changes in the forestry sector. These amounts constitute 17% and 14%, respectively, of the global total potential for mitigation in these sectors. However, countries in SSA are marginalized in global carbon markets. SSA's share of the CDM market is nine times smaller than its global share of GHG emissions, including emissions from land use and land-use change.

### *3.5 Sub-Saharan Africa's Market Share and Potential*

As of October 2008, SSA accounted for only 1.4% of all registered CDM projects. Only 17 out of 1,186 projects, and most of these projects (14 out of 17) were located in just one country, South Africa. Thus, African projects still represent a small fraction of the entire CDM market. China dominates the CDM market with about 73% of volumes transacted (in 2007). While SSA's contribution to global emissions is relatively small (5% of the global total), there is significant potential for the region to contribute to climate change mitigation, particularly in the forestry and agriculture sectors, which together accounted for 73% of emissions from the region (and 13% of the global total emissions from these sectors). Table 20.2 shows Africa's emissions from agriculture and land-use change and deforestation.

**Table 20.2** Estimated economic mitigation potential by management practice and region (Source: Smith et al. 2008)

| Economic mitigation potential by 2030 at US$0–20tCo2 e (Mt Co2 e/year) | | | | | | |
|---|---|---|---|---|---|---|
| Region | Cropland management | Grazing land management | Restoration of organic soils | Restoration of degraded land | Other practces | Total |
| East Africa | 28 | 27 | 25 | 13 | 15 | 109 |
| Central Africa | 13 | 12 | 11 | 6 | 7 | 49 |
| North Africa | 6 | 6 | 6 | 3 | 3 | 25 |
| South Africa | 6 | 5 | 5 | 3 | 3 | 22 |
| West Africa | 16 | 15 | 14 | 7 | 8 | 60 |
| Total | 69 (26%) | 65 (25%) | 61 (23%) | 33 (12%) | 37 (14%) | 265 (100%) |

Greenpeace (2008) has suggested many mitigation actions. The large mitigation potential can change agriculture from the second largest emitter to a much smaller emitter or even a net sink. Because there is low carbon concentration in croplands, there is great potential to increase carbon content through beneficial management practices. On agricultural lands, restoration of the carbon content in cultivated organic soils has a high per-area potential and is the area of greatest mitigation potential in agriculture (Greenpeace 2008).

### *3.6 Greenpeace Suggestions on Mitigation*

– Cropland management (avoiding leaving land bare; using an appropriate amount of nitrogen fertilizer; no burning of crop residues in the field; reducing tillage).
– Grazing land management.
– Restoration of organic soils that are drained for crop production, and restoration of degraded lands to increase carbon sinks.
– Improved water and rice management.
– Set-asides, land use change and agro-forestry.
– Increasing efficiency in manufacturing of fertilizer.
– Consumer behaviour change towards eating less meat.

## 4 Conclusions and Policy Recommendations

Most significantly, genuine and sustained political commitment to agriculture is paramount, particularly since lack of political will is often identified as the major constraint in achieving food and nutrition security in Africa (FAO (2004b); International Food Policy Research Institute 2004). In fact, a recent survey of experts on African agricultural successes revealed that government policy makers, agricultural ministries and extension services are most frequently seen as the initiators of positive change. This reflects that many of the necessary ingredients for agricultural growth, such as research and infrastructure, are public goods that require government involvement and support (Gabre-Madhin and Haggblade 2003).

Given the many advantages of organic farming and sustainable agriculture, in terms of climate change as well as social equity and farmers' livelihoods, there should be a much more significant share of research, personnel, investment, financing and overall support from governments and international agencies that should be channeled towards sustainable agriculture. Promotion of sustainable agriculture can lead to a superior model of agriculture from an environmental and climate change perspective, as high-chemical and water-intensive agriculture is phased out, while more natural farming methods are phased in, with research and training programmes also promoting better production performances in sustainable agriculture.

There is a general consensus that rural areas and rural livelihood systems will bear the brunt of climate change across the globe. More frequent extreme weather events, such as heat waves and intense precipitation, are likely to place the livelihoods of many rural people at risk. Africa is expected to be the most vulnerable continent to climate change, and will face a decline in both food security and agricultural activity, particularly in relation to subsistence farming. The impact of climate change on agriculture is expected to be devastating in many parts of the developing world. Especially in the least developed countries, declining crop productivity and livestock deaths, associated with further global warming, pose a serious threat to food security and national economies.

Efforts to achieve sustainable development pathways and economic growth rates will be affected by changes in ecosystems, natural resources and rural infrastructure. A key challenge will be to continue promoting win-win development options, such as pro-poor approaches to climate change without compromising the timely achievement of the MDGs. Declining economic growth in the wake of global warming will result in reduced income opportunities for the rural poor, and will directly affect achievement of the MDGs.

The adverse impact of climate change will exacerbate poverty, hampering the achievement of the first goal (MDG1), which aims to eradicate extreme poverty and hunger.

The seventh goal, on environmental sustainability (MDG7), is at highest risk due to the direct impact of climate change on agricultural land, hydrology and water resources, coastal and low-lying areas, ecosystems, biodiversity and human health. Changes in temperature, precipitation and climatic extremes will place added stress on agricultural resources while eroding the quality of agricultural land. The impact will be particularly serious in areas where droughts and land degradation, including desertification, are already severe.

By decreasing agricultural productivity, depleting the natural resource base and further exacerbating current gender inequities, climate change will place additional burdens on rural women. It will increase their vulnerability, affecting achievement of the third goal (MDG3) on gender equality in particular. Unequal access to resources needed to adapt to and mitigate climate change could widen existing gaps and differential impacts in terms of achieving the MDGs as a whole. The following policy measures are recommended for sustained agriculture and mitigation against food crisis in the SSA region:

- The countries in the region must be allowed to provide adequate support to their agriculture sector, and to have a realistic tariff policy to advance their agriculture, especially since developed countries' subsidies are continuing at a high level.
- The agriculture policy paradigm in developing countries must be allowed to change, and countries should have the policy space to expand public expenditure on agriculture.
- Developing countries should place high priority on expanding local food production, and should be accompanied by measures and a policy which is expected to bring about the needed positive change. The countries should be allowed to

calibrate their agricultural tariffs in such a way as to ensure that the local products can be competitive, the farmers' livelihoods and incomes are sustained and the national food security is assured.

- The policies of the World Bank, IMF and regional development banks should be reviewed and revised as soon as possible, so that they do not continue to be barriers to food security and agricultural development in developing countries.
- The problems of climatic change should be urgently addressed through more research and action on adaptation in the region in order to assist farmers to reduce the adverse effects of climatic change in agriculture.
- Arrangements should be made for the sharing of experiences and the transfer of good practices in agriculture that can constitute mitigation and adaptation. Also, financing of adaptation and mitigation measures in the agriculture sector in the region should be prioritized.

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# Chapter 21
# Soaring Food Prices and Africa's Vulnerability and Responses*

**Abdul B. Kamara, Albert Mafusire, and Vincent Castel**

**Abstract** While the food price spike in 2007 and the beginning of 2008 has abated, food price pressures have remained. Many African countries are yet to recover from the severe economic and social strain caused by the sudden escalation of prices. This situation, however, triggered a renewed attention that led to increased spending in the agriculture sector in Africa, and created an opportunity for agriculture to find its way back on the development agenda in several countries. Indeed, numerous opportunities exist for exploiting Africa's unused food production potential, but this requires appropriate policy responses, accompanied by adequate investments to enhance Africa's agricultural revitalization. This chapter seeks to review the recent global food crisis with specific attention on Africa, and present a country level vulnerability analysis methodology that could be useful in guiding policy responses in addressing food price shocks.

**Keywords** Africa • Crisis • Food • Responses • Vulnerability

## 1 Introduction

The 2007–2008 episode of high food prices was more severe than previous ones, and its impact, as expected, has persisted with the global food market characterized by higher levels of prices compared to the period before the crisis. The sharp increases in food prices from the last quarter of 2007 to early 2008 triggered various reactions around the world, including Africa, and raised grave concern about the

*This paper benefitted from substantial inputs from Desire Vencatachellum and Marianne Kurzweil. Assistance from Laureline Pla and Nirina Letsera is also acknowledged.

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_21,

food security situation of the Regional Member Countries (RMCs). While food prices receded from their peak during the first half of 2008 to early 2009, upward price pressures remain. From June 2008 to June 2009, international market prices for most cereals, whose prices had risen the most (maize, barley, wheat and rice), fell. This fall was uneven and more pronounced for barley (traded at December 2006 price in January 2009) than for rice (still two times more expensive in January 2009 than in December 2006) (IMF 2008). Furthermore, the actual picture in African countries remains mixed, as the fall in cereal prices observed on international markets does not seem to be reflected in a uniform fall in prices of cereals in all African countries.

These developments are of particular concern as cereals and tuber crops (notably cassava) constitute about 55% of the households' food basket (African Development 2008a). Over the years, growth in cereals consumption in Africa outpaced production due to several reasons, including inadequate policy environment and poor incentives in the agriculture sector, weak capacity and inadequate investment flows, and climate change. As a result, the continent is a net importer of cereals. The FAO estimated Africa's cereal import bill at about US$ 21.7 billion in 2008 and about US$ 9.8 billion in Sub-Saharan Africa in the same year, translating into increases of 30% and 35% over the 2007 level, respectively. Generally, the high food prices hit developing countries harder; they recorded 42% increase over 2007, compared to 19% for developed countries (IMF 2008; FAO 2008c). Low-Income Food-Deficit Countries (LIFDCs) are particularly under stress as most of them are also importers of petroleum products whose price hike preceded food price increases. In its November 2008 issue of *Food Outlook,* the FAO estimated the total food import bill of the LIFDCs rose by 32% in 2008 relative to 2007 (from US$89 million to 117 billion).

In the absence of appropriate measures, increases in food prices have the potential to roll back progress toward poverty reduction and the attainment of MDGs, as low-income households spend a significantly larger proportion of their income on food. These figures are as high as 57% in Tanzania and 62.5% in Comoros (African Development Bank Statistics, ICP database).

The 2008 food related riots/demonstrations in Africa and elsewhere in the developing world underscored the gravity of the burden of high food prices on households. Some African countries responded through measures meant to either reduce prices and/or increase access to food (African Development 2008a). However, these responses led to a deterioration in fiscal balances and balance of payment positions. It is against this background that the criteria for determining relative country vulnerability were developed, to guide the Bank's responses to the crisis. On the basis of this index, the Bank identified 27 RMCs as critically in need of food assistance, with another 12 requiring assistance (African Development 2008). Even though the situation has evolved quite considerably from what it was in mid-2008, the issues of food prices and food security in particular remain critical challenges for the continent.

The purpose of this chapter is to provide a review of recent food price movements, describe the methodology that was used to assess the relative country vulnerability that helped the African Development Bank operations and RMCs to design appropriate responses to the food crisis.

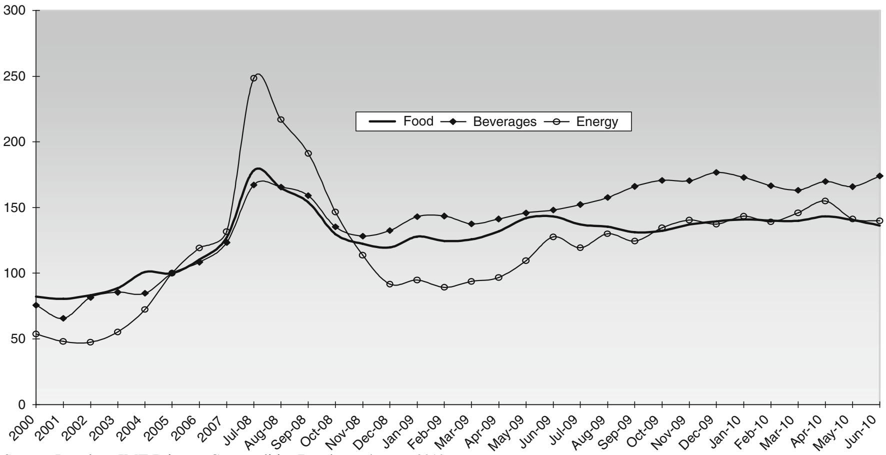
The study constructs a vulnerability index using indicators that measure a country's ability to pay for food imports, the degree of urbanization and import dependency. It is a static approach that allows one to assess the vulnerability of a country over a 1 year period, which forms the basis for assessing the severity of the likely impact and recommend appropriate policy responses.

In the next section, a historical perspective of food price movements is presented. This is followed by an analysis of recent price increases and the factors driving price movements. Section 2 takes a special look at the trends and drivers of food prices at global level and in Africa. The description of the vulnerability index is given in Section 3, followed by an assessment of the relative vulnerability of African countries. Section 4 discusses the implications of food price increases and vulnerability. The response by the African Development Bank to the crisis and conclusions are given in Sections 5 and 6, respectively.

## 2 Trends in Global Food Prices

### 2.1 *Historical Perspective*

Contrary to the general belief that the food prices spike of late 2007 and early 2008 was a surprise, real food price increases actually started as far back as 2003. Food prices receded from an earlier upward movement in 1995 to reach their lowest level in two decades in July 1999. The prices, however, rose slowly in the following years until 2004 when a sudden spike was noticed before leveling off in 2005. It was only after the acceleration in food prices in 2006 and 2007 that the world recognized the negative impacts on the majority of the world's poor and the threat to global macroeconomic stability. Compounding the situation is the coincidence of



Source: Based on IMF Primary Commodities Database, August 2010

**Fig. 21.1** Monthly food, beverages and energy prices (Indices, 2005 = 100) the recent increase in food price and high energy prices (Fig. 21.1). While food prices decreased during the second half of 2008 and the early part of 2009, they remained at levels above their 2006 level, with the World Bank (2010) warning that food price pressures would remain in the short to medium term.

Whereas Africa has suffered severe food crises in the past, most of these were related to weather shocks[1] or conflicts. The 2007–2008 food crisis was different: it was the first time in history that the continent was threatened with food crisis as a result of higher food prices rather than physical lack of food. Another new dimension is that the recent high food prices disproportionately affected the politically more sensitive urban areas – '*urban hunger*' – compared to the traditional countryside as in the past.

## 2.2 Recent Trends in Food Prices

Globally, the prices of maize, wheat and rice rose the most in 2008 (Fig. 21.2). Over this period, the price of rice, a major staple crop on the continent doubled to reach a record high of more than US$1000 per tonne in April 2008 (up from US$373 per tonne in early January); the average wheat price in March 2008 stood at US$439 per tonne (over a 100% increase over the 2007). The average price of maize increased again by about 42%, rising from US$171 per tonne in November 2007 to US$288 per tonne in June 2008. This escalation of food prices was largely a reflection of the growing energy cost, a vital input in crop production and processing, as well as market speculation due to lower yields, and a reallocation of crop land to

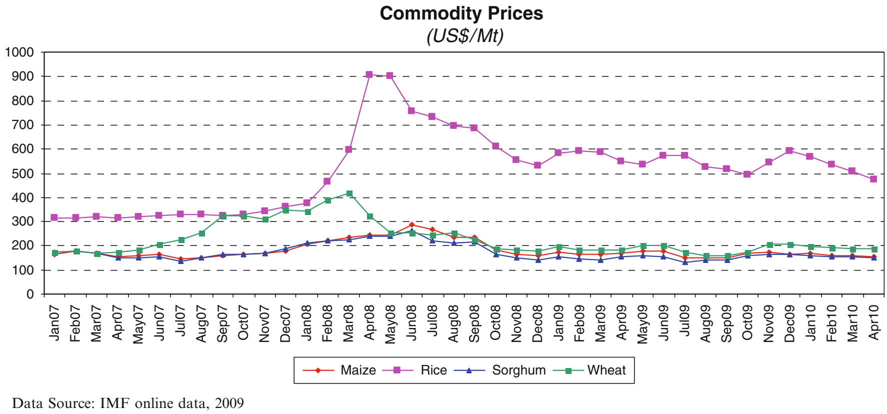



**Fig. 21.2** Food price trends (US$ per metric tonne)

[1]For example, the 1984 drought in Ethiopia killed more than one million people.

biofuel production. A general comparison of food prices in 2005 and 2007 further depicts the trends, with 2007 clearly emerging as the year of continuous price escalation. These trends hold true not only for cereals, but also for sugar, dairy, meat and oils.

All prices fell during the second half of 2008. In January 2009, commodity prices stood at US$173 for maize, US$615 for rice, US$122 for barley and US$239 for wheat. Since their respective peaks, this trend represents a 51% decrease for barley, 39% decrease for rice, 40% decrease for maize and 44% decrease for wheat.[2] Yet once again we observe an increase in prices in the latter part of 2009 followed by a surprise spike in wheat prices in August 2010 due to reduced supplies arising from a heat wave in Russia, dry weather in Kazakhstan and the European Union and floods in Canada. Wheat prices have since increased by about 71% from US$4.72 to US$8.08 per bushel on the USA market between June and August 2010. The impact of this increase in wheat prices is likely to have significant effects on food prices in countries where bread is the main food component as is the case in Egypt.

Current developments on the global food market threaten a return of the 2008 experiences in vulnerable countries, especially as Russia imposed a temporary export bans on grains until the end of 2010. Given that grains are an important input into meet and milk production, the spillover effect of the rise in wheat prices, if sustained, is likely to affect other food items as well.

While global commodity demand remains relatively weak and unpredictable, as a result of the financial crisis, the fall in food prices is now in question. Specifically, trade controls by Russia and some recovery in energy prices is likely to lead to higher food prices. The correlation between food and energy prices is particularly noticeable. For instance, the general fall in the food price index started just about a month earlier than the fall in the price of crude oil. In January 2009, the New York price index for crude oil dropped to less than US$33.20 per barrel, representing a 78% fall since its peak (US$147.27) in July 2008. Similarly, since its peak in June 2008 the prices of natural gas had fallen by about 59% in January 2009. In January 2009, there were already some signs that food prices might stabilize, but at a higher level than that for 2006 and upward pressures remain for 2010 and 2011.

In spite of these general trends, country experiences remain mixed:

In *West Africa* a mixed picture has been observed for cereal prices (Fig. 21.3). Senegal in particular experienced a huge jump in rice prices, from just above CFA 30,000 per 100 kg, to more than CFA 45,000 per 100 kg between June and July 2008. In September 2008, rice prices were still 81% higher than a year before. In Burkina Faso on the other hand, imported rice prices fell from their peak of about CFA 45,000 in June 2008 to below CFA 40,000 per 100 kg, but remained flat at CFA 39,000 in July and August 2008. In Mali, no fall was reported as prices stabilized at above CFA

[2]The recorded monthly price peaks are as follows: Barley: US$248.3 in July 2008; Maize: US$287.1 in June 2008; Wheat : US$348.6 in June 2008; Rice : US$1015.2 in April 2008.

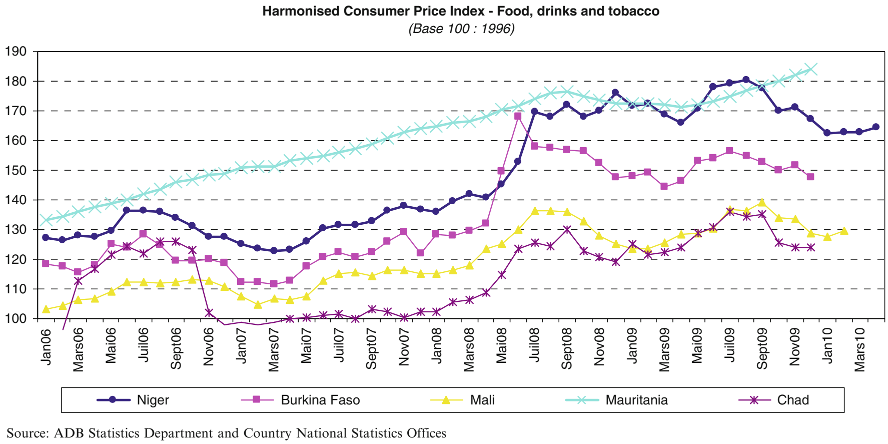



**Fig. 21.3** Food consumer price index, 2006–2010

35,000 per 100 kg. Over all, in January 2009, in Niger, Burkina Faso and Mali, rice prices have somehow stabilized but are still 50%, 60% and 29% higher than a year earlier, respectively. FAO attributes this increase to the sharp depreciation of the CFA against the US dollar between July and November 2008 (from US$0.24/100CFA to US$0.19/100CFA), and the relative low initial tariff levels. While the FAO acknowledges a series of measures that have been implemented by the governments in the region, including the waiver on import tariffs, food price pressures have remained in many countries in the region. An assessment of the food situation in the Sahel region has also shown that food price pressures have continued (Mafusire et al. 2010).

On the other hand, in Nigeria the appreciation of the Naira against the US dollar, and the reduction of tariff levels on rice led to a price decline on some local food markets (16% between May and September 2008). Nevertheless, the sharp depreciation of the Naira against the dollar (20% during the last quarter of 2008) due to falling oil prices in November and December 2008 may have a negative impact on rice prices contributing to another general food price increase in the country (FAO 2008b, 2009b).

In *Southern Africa*, food prices declined since July 2008. In food importing countries, such as Zimbabwe, prices are still increasing while in other countries, such as Malawi and Mozambique, they have stabilized. Nevertheless, in November 2008 prices for maize were still 107% and 73% higher in these two countries than in November 2007 (FAO 2008b), respectively.

In *East Africa*, maize prices almost tripled in 2008 over the previous year, and were above US$ 600 per tonne in September 2008. In Kenya, prices of maize were close to their peak (US$379 – May 2008) and above US$331 per tonne in January 2009, which represents a 49% increase over the previous year. Tanzania experienced a continuous fall in maize prices, from about US$330 per tonne in January 2008, to about US$240 in July 2008 following the good harvest. In January 2009, maize prices in Tanzania were 5% lower compared to a year earlier. In Ethiopia, a sharp decline in prices was noticed since October 2008, but the price of maize in

January 2009 was still 13% higher than a year before. In Sudan, Eritrea and Ethiopia, wheat prices increased contrary to developments on the international market, even though the prices varied considerably between these countries (Ethiopia US$700 per tonne; Eritrea US$1,800 – end of July 2008). By September 2008, the prices for wheat in Eritrea had more than doubled on a year-to-year basis (114% increase). In December 2008, maize prices in Sudan and Ethiopia had increased by 18% and 52%, respectively compared to a year earlier. Similarly in Khartoum (Sudan), sorghum was quoted to trade at above US$406 per tonne in October 2008, which is twice the 2007 price (FAO 2008b, 2009a, b).

In *Central Africa*, food prices were volatile in Central African Republic, Chad and the Democratic Republic of the Congo, due to civil unrest. In Cameroon, the recovery of the poultry industry after the Avian Influenza in 2006 negatively affected cereal prices. The situation in the country is worsened due to the high country dependency for imported rice. The government took action in signing an agreement with staple food traders in January 2009 to stabilize the price of imported food products. The agreement will run until June 2009 (FAO 2009b).

In *Northern Africa*, the good crop prospects in Morocco and Egypt (for June 2009) were expected to lessen pressure on food prices in the coming month. In Egypt, this may have a positive effect on inflation which was mainly driven by raising food prices. The yearly inflation rate already dropped from 30.9% in August 2008 to 16.3 in January 2009 (FAO 2009b).

Similarly, the World Bank (2010) observes that the price differentials in Africa could be attributable to climatic shocks, conflict and macro-policy factors. Table 21.1 shows the wide differences in price changes in some of the continent's countries.

The large differences in prices of cereals between African countries could also be a reflection of market fragmentation, arising mainly from government controls, structural deficits and poor transport infrastructure. With the exception of South Africa, these trends also illustrate weaknesses in the functioning of the African food market, which does not reflect movements in international markets, in particular during periods of price decline (FAO 2008b). The prices on African markets remain

**Table 21.1** Countries with the largest increase in the price of the main food staple (Source: Adapted from World Bank (2010))

| Price increase, annual average up to year ending February 2010 | | | Price increase, October 2009–February 2010 | | |
|---|---|---|---|---|---|
| Location | Commodity | % Increase | Location | Commodity | % Increase |
| Sudan (Khartoum) | Sorghum | 39.8 | Burundi (Bujumbura) | Beans | 58.0 |
| Tanzania (Dar es Salaam) | Maize | 21.2 | Zimbabwe (Harare) | Maize | 36.0 |
| Mali (Bamako) | Millet | 17.0 | Sudan (Khartoum) | Sorghum | 28.2 |
| Kenya (Nairobi) | Maize | 16.8 | Chad (Abeche) | Sorghum | 23.5 |
| | | | Somalia (Lasanod) | Sorghum | 20.6 |

All price increases reported correspond to current LCU prices extremely high, increasing the pressure on household budgets, especially in food deficit countries. Even though prices have started to decline in some countries, there is no real evidence of a long-term general downward trend, and it seems that prices are now stabilizing at very high levels. Nevertheless, crop yields in several countries seem to be more favorable for 2009. This may ease the pressure on some national markets, at least in the short-term (FAO 2009b).

## *2.3 Drivers of Short-Term Trends*

The causes of high cereal prices are both of a temporal and structural nature. Adverse weather conditions, stock build-ups, the crisis in the financial markets, depreciation of the United States dollar, high fuel prices, price controls and export bans are among the temporal factors pushing up food prices (IMF 2008; World Bank 2008a, 2010; FAO 2008a; IFAD 2008). Apart from declining production in major world producing countries, for example, drought in Australia, deep frost in China, flooding in parts of South Asia, cold weather in Vietnam, several African countries' production was negatively affected by bad weather conditions in 2006. Chad and Tanzania were hit by drought, while Mozambique suffered from floods in 2006. Ghana experienced several weather shocks, including prolonged droughts followed by floods in August 2007, followed by yet again another drought spell in 2008. Similar conditions were also experienced in the cereal producing regions of Angola. In response to low yields, food producing countries fill demand gaps by depleting their own stocks.

Coupled with the crisis in the financial markets, low stock levels triggered speculative demand on the commodity futures markets contributing to the spike in food prices. For instance, wheat and soybeans futures prices on the US market more than doubled in a year to March 2008. Corn futures prices, on the other hand, have risen from about US\$3.50 to US\$7.60 per bushel in a year from June 2007. Similar observations have been made following Russia's ban on grain exports in August 2010. Moreover, the rising fuel prices affected food prices in importing countries as they were faced with higher transport costs, and rising food production costs. The poor state of African infrastructure increases the transport costs even further.

Inappropriate policy responses in the form of export bans and price controls on cereals, especially rice, in China, Pakistan, India, Viet Nam and most recently Russia resulted in lower prices to producers who responded by holding on to supplies to the world market, fuelling price increases at the global level. Some African countries (Nigeria, Egypt, Ethiopia) adopted similar policies on staple food products but that did not help; instead it worsened the situation. Nevertheless in most of these countries, policy measures related to export restrictions were relaxed during the second half of 2008 (Vietnam-July 2008, Pakistan and India-October 2008). In December 2008, China reduced export taxes for wheat and wheat flour from 20% and 25% to 3% and 8% respectively. Furthermore China cancelled a 5% export tax on maize and soybeans and a 10% tax on maize flour (FAO 2008b).

Even if the effects seem to be acute, the changing structure in agricultural commodity use and evolving production technologies at the global level will have long-term implications on food prices (African Development 2008a). Increased consumption of meat, dairy and fish products has led to growing use of cereals for feed production (Steinfeld et al. 2006). On a calorie for calorie basis, more cereals are needed to produce meat than bread. In addition, cereal requirements for bio-fuel production increased by 22% over the 2007–2008 period, and account for 5% of the world cereal production (UN 2009).

As African agriculture is mainly small-scale and subsistence-based, the adoption of techniques associated with economies of scale remains difficult. In addition, the move towards high-yielding varieties that require intensive fertilizer use and irrigation also contributes to rising production costs, especially as expenditures on energy use increase (Steinfeld et al. 2006). All these factors point to increasing production costs that essentially are being passed on to the consumer in the form of higher prices and affect the continent's competitiveness.

The strong yield increase for cereal production in 2008 (6.6% higher than in 2007) has reduced speculative pressure on food prices, as the global cereal supply and demand balance is getting stabilized. According to the FAO, the global stock of cereal will increase to 496 million tonnes (highest level since 2002) by the end of the next cropping season. At the same time, the reduced demand for crops by the agro-industry and the livestock sectors (used as feed) due to the current economic crisis may contribute to the global downward trends in crop prices, especially during the first half of 2009. As a result of these trends, the prices of wheat and maize on the international markets were 33% and 17% lower in January 2009 than a year before, and 50% and 40% lower than their recent peak values in February 2008 (for wheat) and in June 2008 (for rice). Rice prices, however, have not followed these trends. In January 2009, the international market prices were 59% higher than a year before. Nevertheless, the situation may worsen during the course of the year, as a result of forecasted lower cereal production in 2009 due to a reduced planted area (especially in the USA and Europe), and drought or low precipitation in China, India and Latin America (FAO 2009b).

## 3 Cereal Vulnerability of African Countries

### *3.1 Africa's Cereal Situation*

Africa is currently a net importer of cereals, yet cereals constitute a large share of the continent's food basket. Cereals, for example, constitute 69% of total calorie intake in Niger, 64% in Egypt, 58% in Malawi, 54% in Sierra Leone, 57% in Algeria, 53% in Madagascar, and 36% in Liberia (Annex A). Despite the growing importance of cereals in the food basket, growth in cereal production in Africa continues to lag behind consumption especially for key cereals like rice and wheat.

This situation is partly due to declining cereal yields, especially those for rice (a major staple), with rice yields in most African countries only a third of global averages. However, the gap between demand and production of cereals has also been growing, not only because of population growth but also due to changing tastes, largely in favor of imported varieties, creating further pressure on foreign exchange to foot the import bills.

Before the late 1970s, the continent was self-sufficient in all food crops except for wheat. This position changed as the population grew, tastes and lifestyles changed and production declined. The urbanization level also increased coupled with the substitution of local varieties with cheap non-traditional cereals that became prevalent on the markets. For example, communities in semi-arid regions which used to grow local grains varieties of sorghum and millet switched to growing short-season maize varieties. These crops, however, continue to fail due to inadaptability to droughts, high input requirements, which are not always met and seasonal shifts. In predominantly rice consuming countries like Sierra Leone, a similar effect was felt as tastes shifted gradually towards cheap imported Asian rice eventually dominated the market. These shifts in consumption and the 1980s reductions in strategic stocks, as governments embraced structural adjustment policies, exposed Africa to the vagaries of market and weather conditions. The effect of all these factors has been to increase Africa's vulnerability as its dependency on cereal imports increased. As of 2008, over 23 countries in Africa had a cereal import dependency in excess of 50% of total requirements (Annex B).

## *3.2 Construction of a Vulnerability Index*

The continent's increasing dependence on cereal may be assessed by developing an index of vulnerability. The vulnerability index forms a basis for developing targeted policies and generating responses that are specific to country groups. Rising food prices have different impacts at the country level depending on the food market and other structural conditions, notably the supply and demand conditions as well as the structure of the economy in general. In this context, a multi-variable vulnerability index is constructed to measure the differential impact of the crisis.

A country's vulnerability to high food prices is assessed in terms of the country's:

- Cereal balance;
- Ability to pay for food imports;
- Degree of urbanization; and
- Import dependency.

Important variables used in the construction of the vulnerability index include the following:

(a) Cereal balance is the difference between the sum of production and imports minus export minus consumption requirement. It translates into the following equation: Cereal Balance (CB) = Availability of cereals, in value terms *less* requirements.

- *Availability* is defined as total cereal production *plus* total cereal imports (contracted or delivered) *less* cereal exports.
- *Requirements* are given by the total cereal food *plus* non food consumption.

(b) Cereal import dependency is the ratio of cereal imports to total cereal consumption:

- Cereal Import Dependency (CID) = Total Cereal Imports/Total Cereal Consumption.

(c) A country's ability to pay is measured by its GDP per capita, current account and fiscal position in 2007 in relation to the size of its import requirements.

- Fiscal Balance (FB) (+ = surplus; − = deficit)
- Current Account Balance (CAB) (+ = surplus; − = deficit)
- Gross Domestic Product (GDP)
- GDP per Capita

(d) Degree of urbanization is defined as the urban population divided by total population.

$$\text{Urbanization} = \text{Urban Population} / \text{Total Population}$$

Net cereal importers have negative CBs, hence countries with large cereal deficits are considered vulnerable. A country's ability to pay for imports is determined by its GDP level, CAB and FB position. At the first stage, the CB, FB, and CAB are all normalized by GDP to construct three *vulnerability indices* (*Vi*).

$$V_{1i} = \frac{CB_i}{GDP_i}; \quad V_{2i} = \frac{FB_i}{GDP_i}; \quad V_{3i} = \frac{CAB_i}{GDP_i} \tag{1}$$

Where *i* is a country subscript. *Vi* lies between 1 and −1. In the case of the CB/GDP ratio, countries with positive values need virtually no imports of cereals (although they may have to imports cereals not produced locally such as wheat), and those with negative values require cereal imports. Higher cereal deficits imply a greater sacrifice on the part of the country to meet its cereal requirements. With respect to CAB and FB to GDP ratio, countries with surplus positions face no difficult in paying for cereal import requirements, yet those with higher current account and fiscal deficits face relatively challenging conditions.

The next input variable to be considered is urbanization. This is because urban populations are generally net food buyers, implying that rising food prices disproportionately affect the position of the urban poor. Thus, the burden faced by governments as a result of rising food prices increases with higher levels of urbanization. Consequently, an urban-weighted measure of vulnerability capturing the interaction between cereal balances and urbanization is constructed.

$$UWV_{1i} = V_{1i} * (1 + \delta_i); \quad UWV_{2i} = V_{2i} * (1 + \delta_i); \quad UWV_{3i} = V_{3i} * (1 + \delta_i) \quad (2)$$

Given an initial vulnerability index *Vi, this normalization adjusts* the country relative vulnerability by a parameter delta ($\delta$) defined as the ratio of urban population to total population. Therefore countries with higher levels of urbanization become more vulnerable when compared to those with lower urbanization levels.

Similarly, an *urban-dependency weighted index* (*UDWVi*) is constructed to take into account differences in import dependency.

$$\begin{aligned} &UDWV_{1i} = UWV_{1i} * (1 + \alpha_i); \quad UDWV_{2i} = UWV_{2i} * (1 + \alpha_i); \\ &UDWV_{3i} = UWV_{3i} * (1 + \alpha_i) \\ &where \quad \alpha = 0,....,1 \end{aligned} \quad (3)$$

As with $\delta$, countries with lower levels of import dependency will have relative vulnerability indices adjusted by a smaller ratio alpha ($\alpha$) as opposed to those with higher import dependency levels. In the current analysis, the higher a country's cereal import dependency, the higher is its vulnerability to rising cereal prices.

Finally, *country relative well-being*, as measured by the GDP per capita, is also taken into account. This last step involves normalization of the *UDWVi* by GDP per capita.

$$PAV_i^1 = \frac{\left[\frac{CB_i}{GDP_i}(1+\delta)(1+\alpha)\right]}{\frac{GDP_i}{POP_i}} = \frac{CB_i * POP_i}{(GDP_i)^2}(1+\delta)(1+\alpha) \quad (4)$$

The result from this normalization is that vulnerability increases at lower levels of per capita income and falls as per capita income increases, everything else constant. While it is noted that poverty rates could have been a better measure compared to GDP per capita, poverty data are not available for all countries for the relevant period. In addition, a longer period could have been used to take into account long-term food vulnerability.[3]

## 3.3 Results of the Vulnerability Assessment

Based on the index constructed using data for 2008, countries were classified into four quartiles of relative vulnerability as follows: very high vulnerability, high vulnerability, moderate and low vulnerability. On the basis of this categorization,

[3]In particular, some countries experience recurrent famines and may react by increasing food imports. This is captured by our index only if the famine occurred in recent times and is still affecting food trade.

**Table 21.2** Country classification of vulnerability (Source: African Development (2008a))

| Vulnerability group | | | |
|---|---|---|---|
| 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
| (1) Liberia | (1) Ghana | (1) Benin | (1) Chad |
| (2) Zimbabwe | (2) Comoros | (2) Central African | (2) Gabon |
| (3) Guinea-Bissau | (3) Senegal | (3) Republic | (3) Ethiopia[a] |
| (4) Eritrea | (4) Mozambique | (4) Lesotho | (4) Seychelles |
| (5) The Gambia | (5) Cape Verde | (5) Uganda | (5) Angola |
| (6) Congo (DRC) | (6) Morocco | (6) Sudan | (6) South Africa |
| (7) Djibouti | (7) Burkina Faso | (7) Egypt | (7) Botswana |
| (8) Sao Tome and Principe | (8) Cameroon | (8) Tunisia | (8) Equatorial Guinea |
| (9) Burundi | (9) Côte d'Ivoire | (9) Algeria | (9) Namibia |
| (10) Togo | (10) Rwanda | (10) Mauritius | (10) Tanzania |
| (11) Niger | (11) Congo, Republic | (11) Mali | (11) Guinea |
| (12) Mauritania | (12) Kenya | (12) Zambia | (12) Malawi |
| (13) Sierra Leone | (13) Nigeria | (13) Swaziland | (13) Madagascar |
| | | (14) Libya | |

Note: Somalia is not included because of lack of data

[a]Although Ethiopia receives substantial amounts of food aid, its national food balance was positive. The unbalanced geographical distribution of food, which is not captured by the index

the five most vulnerable countries in the First Quartile are Liberia, Zimbabwe, Guinea-Bissau, Eritrea and The Gambia (Annex C and Table 21.2). In all these cases, the factors that categorize them into the high vulnerability group are related to the constrained ability to pay for the required imports. For each of these four countries, the share of GDP required to fill the cereal shortage, via imports, ranges between 5% and 8%, reflecting an import bill of 43–69 million US dollars. For The Gambia, Liberia and Djibouti, the situation is further exacerbated by an above average degree of urbanization of 56%, 59% and 87%, respectively. Furthermore, these countries have high import dependency. Eight other countries belong to this category of very highly vulnerable countries: The Congo (DRC), Djibouti, Sao Tome and Principe, Burundi, Togo, Niger, Mauritania and Sierra Leone.

The Second Quartile comprises countries considered as highly vulnerable with regards to the rising cereal prices, but not at such a level as the countries in the first quartile (Annex C). While Ghana, for instance, only has localized food shortages, the high cost of transport and its relatively weak fiscal position makes it highly vulnerable. Its low urbanization level means a larger part of its population lives in the countryside, and thus compounding the problem as transport costs increase. Côte d'Ivoire, Rwanda, Congo Republic, Kenya and Nigeria are ranked 9th and lower in this quartile. These countries have large proportions of their populations being poor, hence lower per capita incomes. Consequently, they have lower abilities to pay especially at the household level.

The countries shown in the Third Quartile are considered as moderately vulnerable. Benin, Central African Republic, Lesotho and Uganda are the top four in this group. Except for Lesotho, with a positive current account position, the other three countries need to allocate more than 3% of their GDP to import cereals while they already have negative current account positions. Algeria, Libya and Tunisia are in this category because of their relatively high degrees of urbanization. Of these three, only Tunisia has a negative current account balance.

The Fourth Quartile represents the group of countries with a low level of vulnerability. Chad, Gabon, Angola and Equatorial Guinea are all oil producers and have healthy foreign currency reserves. The appearance of Ethiopia in this group is somewhat unexpected. Although the country has a very low import dependency ratio of only 1%, localized high food shortages exist though requirements could be met from internal supplies given the good harvests. Redistribution of food is largely in the hands of donor agencies. Despite its weak current account balance (–10% of the GDP), the country has a low urbanization rate of only 17%. On the other hand, Malawi, Madagascar and South Africa are net exporters of some cereals. As such they are classified as countries with low vulnerability.

Given their relatively weaker position, fragile states received special consideration in the analysis. This is because they have weak production capacity, and a number of them are emerging from conflicts which severely damaged their economies and weakened their institutions. Fragile states are thus less able to cushion their populations from rising food prices, as they lack adequate safety nets. Hence fragile states appear in the high vulnerability category. As reported in Table 21.2, eight out of the nine African Regional Member Countries of the Bank classified as fragile (Burundi, Central African Republic, Côte d'Ivoire, Comoros, Guinea Bissau, Liberia, Sierra Leone and Togo) fall in the first and second quartiles. Given the need to better target scarce resources with the aim of achieving the best outcomes, it appears that fragile states need special treatment in tackling high food prices. For these reasons, Table 21.3 is amended to isolate fragile states.

## 4 Implications of the Food Price Trends

### *4.1 Social Implications*

The socio-economic impacts of the rising food prices vary according to the level of income. It is estimated that if food prices rise by one-third, they will reduce living standards by about 3% in rich countries compared to over 20% in poor countries. Poverty is still highest in Africa compared to other regions. Therefore, rising food prices have serious implications for the poor and food-insecure people in Africa. This is especially true for urban consumers who are net food consumers. As a consequence of rising food prices, households across Africa have had to reduce their food intakes. Food price-related riots were observed in countries such as Burkina Faso, Cameroon and Niger (IFAD 2009).

In addition, as the poor allocate more income to food, other expenditures on education and health are reduced. Moreover, the ability of the population to save is reduced. These reduced expenditures may further be manifested later in the form of

**Table 21.3** Adjusted classification of vulnerability (Source: African Development (2008a))

| Vulnerability group | | | | |
|---|---|---|---|---|
| Very highly vulnerable | Highly vulnerable | Moderately vulnerable | Lowly vulnerable | Fragile states |
| (1) Zimbabwe | (1) Ghana | (1) Benin | (1) Chad | (1) Liberia |
| (2) Eritrea | (2) Senegal | (2) Lesotho | (2) Gabon | (2) Congo (DRC) |
| (3) The Gambia | (3) Mozambique | (3) Uganda | (3) Ethiopia | (3) Guinea-Bissau |
| (4) Djibouti | (4) Cape Verde | (4) Sudan | (4) Seychelles | (4) Burundi |
| (5) Sao Tome and | (5) Morocco | (5) Egypt | (5) Angola | (5) Togo |
| (6) Principe | (6) Burkina Faso | (6) Tunisia | (6) South Africa | (6) Sierra Leone |
| (7) Niger | (7) Cameroon | (7) Algeria | (7) Botswana | (7) Comoros |
| (8) Mauritania | (8) Rwanda | (8) Mauritius | (8) Equatorial Guinea | (8) Côte d'Ivoire |
| | (9) Congo, Republic | (9) Mali | (9) Namibia | (9) Central African Republic |
| | (10) Kenya | (10) Zambia | (10) Tanzania | [a]Somalia |
| | (11) Nigeria | (11) Swaziland | (11) Guinea | |
| | | (12) Libya | (12) Malawi | |
| | | | (13) Madagascar | |

[a]Somalia is not listed as a fragile state in ADF/BD/WP/2008/2010 but included as a non-ranked country

increased disease incidences and lower education levels, reinforcing the poverty cycle. Further, during hardships, girls have a higher probability of being taken out of school, compared to boys, which undermines the progress towards gender equality.

In contrast, in rural areas, farmers that are net food producers can benefit from rising food prices (IFAD 2009). At the local level, two kinds of responses to high food prices were observed in production systems recently. On the one hand, a growing number of poor farmers in some countries increased their food crops production for home consumption and storage, shifting away from market-oriented production. Under this shift, the production systems apply lower levels of purchased inputs resulting in lower output levels. This situation was notably observed in Senegal, Congo, Mozambique and Nigeria. On the other hand, an increasing number of better-off farmers were able to take advantage of the opportunities generated by high food prices to move from subsistence production towards high value crops production (maize, wheat, rice). This situation emerged in countries where opportunities are favorable, such as Kenya and Uganda, characterized by small-holding sizes and market reliability (von Braun 2008).

These trends create an opportunity for agriculture to find its way back on the development agenda in several countries. High food prices have generated positive incentives for policy makers, farmers and investors to increase agricultural productivity. On the other hand, price volatility constitutes an obstacle for long term planning in food importing countries. The recent downward trend prices in food may severely impact farmers who intensified their production resulting in income losses and even financial distress. In addition, with the current global credit crunch, farmers might also have to scale down their planned investment as lines of credit dry up (von Braun 2008).

### 4.2 Implications for Regional Trade and Foreign Investments

The current food price crisis offers an opportunity to promote regional integration and trade liberalization. It has already been noted that food price increases vary across countries due to a number of reasons. The different levels of food prices between neighbouring countries have in some instances presented a challenge for governments. For example, large differences in food prices are observed between Nigeria and Niger, between Zimbabwe and Botswana, Zambia and Angola, Ethiopia and Somalia, and indeed among many other African countries. Government responses to these emerging challenges have varied considerably among countries. Food shortages forced some governments to ban exports of staples and other food products. This response worsened the disparity in prices among neighbouring countries. These bans are ineffective, and always result in the smuggling of food products between neighbouring countries, and often leads to higher consumer prices.

Despite this reality, regional food security has always played second fiddle to national food security. Responses, at the national level alone, may not be effective as they result in higher prices. In this context, regional food security is a mean for not only reducing consumer prices, but is also helps to promote social harmony among communities in border locations. For example, clashes are reported between bordering communities and informal sugar, rice and dried fish traders at the border between Zimbabwe and Mozambique. Moreover, price differences across borders encourage corruption in customs services.

## *4.3 Implications for Policies*

In response to the global food crisis, African governments have moved to dampen price increases and improving food supply. Actions from major world cereal exporters that include export bans and import restrictions (e.g. Senegal's refusal to accept food aid arguing that food aid is negatively affecting domestic agriculture) have not helped the situation. Such actions have led to speculation and major disruptions of international markets. Whereas some of these countries eventually lifted export bans, the damage had already been done, as it caused panic on the markets resulting in speculation.

African countries have generally followed three major policy responses: (a) demand-side; (b) supply-side; and (c) trade-oriented policies. Given the large share of food in household expenditures, food price increases also have a higher impact on inflation, to which policy makers have responded through higher monetary policy, mainly interest rate adjustments. These measures, most of which reduce the revenue flows into RMCs, have serious fiscal implications and may lead to macroeconomic problems. A summary of these measures is presented in Annex D. Malawi's approach to food shortages is highlighted in Box 21.1. For instance, reducing taxes and increasing subsidies have negative impact on fiscal balances, which may imply future costs to the countries, to be financed either through increases in taxes or external and internal borrowing. High inflation may undermine the gains made in many of these countries in reducing poverty over the past decade. In particular, countries run the risk of policy reversal, thereby eroding the reform gains acquired so far.

Attempts to face the food crisis through subsidies have been fiscally costly. Food subsidies in Egypt, which are criticized for not being properly targeted, cost the government US$2.3 billion for fiscal year 2007/2008 (American Chamber of Commerce in Egypt 2008). Malawi's input supply scheme cost the government an estimated US$186 million tripling the previous year's figure of US$62 million for 2005/2006. The program was commended for revitalizing agriculture and improving the food security situation in the country (AfricaFocus Bulletin 2009).

While it is important that countries seek to minimize the short-run impact of high food prices, it is critical to ensure that the impact of such intervention on the fiscal balance is limited and only short-lived. Measures should be put in place to ensure that government revenues increase while allowing some exchange rate adjustments to foster expenditure switching. Any measures that cause distortions should

**Box 21.1** Malawi's Approach to Food Shortages

Malawi has a land area of 9.43 m ha of which only 32% is suitable for rain-fed agriculture but most of the soils need fertilizers for agricultural production. Given its per capita income of only USD 170 per year, most smallholder farmers are unable to purchase agricultural inputs. The agricultural sector accounts for approximately 40% of national income and employs more than 80% of the total labor force. The share of recurrent government expenditure in agriculture fell from 6–7% in early 1990s to 3–5% during the late 1990s. The Government of Malawi is committed to poverty reduction through the empowerment of the poor and this is being implemented within the context of the Vision 2020

Malawi is still listed among the net importers of petroleum and major grains, with high levels of chronic hunger, by the Food and Agriculture Organization of the United Nations. Acute maize shortages in 2005 (45% deficit), were described by the United Nations as a humanitarian crisis in August of that year. The shortages were considered to be a result of poor weather, sale of the strategic grain reserve, long-term deterioration in rural incomes, price fixing and smuggling. Following this, the government introduced a subsidized input-supply program at a cost of USD 60 million that benefited one million smallholder farmers. Each farmer got seeds and fertilizer enabling then to plant one acre of maize, the primary target, and similar inputs to cash crops like tobacco. The program was described by some as "misguided" as the markets were better placed to deal with the situation. To others, the program was saddled with implementation problems (poor planning, distribution system and fraud and corruption).

Despite the early criticisms, Malawi has managed to produce maize surpluses for two consecutive years (0.5 million in 2005/2006 and 1.3 million metric tonnes in 2006/2007). Donor support towards the program is increasing and its implementation is being refined to make it more targeted and effective

To fight against the soaring food crisis the government took a series of policy measures. First in April 2008, maize exports were banned (except for the residual contract amounts for Zimbabwe). Second in August 2008, maize private trading was banned and put under the control of Agriculture Development and Marketing Corporation. Through this agency, the government fixed buying and selling prices. Third, to stimulate production, the government agreed in November 2008 to continue the subsidization of agricultural inputs for the coming agricultural season.

Source: Adapted from Fao; Undp 2008

be discouraged. Instead efforts should be deployed to stimulate a positive agriculture sector supply response to rising food prices. In addition, well targeted safety-nets are required to cushion the vulnerable groups. Cash transfers, food-for-work programs and targeted food packs/subsidies are some such measures that can alleviate the burden of rising food prices.

The growing scarcity of natural resources, combined with the loss of confidence on markets created by high food prices, have also renewed attention on foreign direct investment in agriculture. To secure their food supply, capital rich countries facing natural resource constraints are investing in African countries to secure reliable sources of food. For instance, Egypt invested in the agriculture sector in Libya, Madagascar and Sudan in 2008, while China invested in numerous African countries. These investment flows will directly contribute to improve agriculture and the agro-industry in the targeted countries, and indirectly contribute to value-addition activities. However, recipient countries need to ensure that appropriate clauses are included in the contracts ruling these investments, paying particular attention to the respect of customary property rights and trade policy rules, supporting the participation of local producers and ensuring that food security is preserved in the recipient country (von Braun 2008).

## 5 The African Development Bank's Response

While acknowledging the short-term impact of rising food prices in Africa, the African Development Bank is of the view that there are opportunities associated with the current trends. By increasing the value of agricultural assets, high food prices have the potential of stimulating investment into the sector. An enabling policy environment, however, is required. The Bank, has capitalized on its internal capacity and past experience in the sector, to address critical constraints and accelerate support to agriculture. Within the context of the African Food Crisis Response (AFCR) framework, the African Development Bank adopted short-term and medium-to-long term responses. In this regard, the vulnerability index described above was instrumental for the prioritization of the Bank's response to the crisis. These responses sought to enhance the Bank's contribution in areas where it has some comparative advantage. Some of these responses are summarized below.

### *5.1 Short-Term Responses*

In the short term, the African Development Bank pursued specific and targeted responses aimed at cushioning the effects on the poor, minimizing macroeconomic instability and enhancing supply responses in RMCs. The Bank's role in providing sound policy advice was also emphasized. In its quest to stabilize food prices, the African Development Bank granted budget and balance of payments support to eligible RMCs, as expressed in the Bank's response to the Food Crisis paper. The Bank utilized resources from its surplus account to support targeted projects and accelerate disbursements and realignment of existing agriculture and non-agricultural portfolios to address food crisis issues. Accelerated disbursement of resources to approved projects and realignment of existing agriculture portfolios, however, did not imply additional resource requirements. Such realignments mainly targeted improving input supply, and increasing access to and utilization of improved seeds such as the NERICA rice seeds. Through policy advice, the Bank engaged RMCs in dialogue to explore viable policy options for macroeconomic stability, while protecting vulnerable groups. In these efforts, the Bank is cognizant of the need for a differentiated approach in its response depending on the vulnerability of the RMCs, and the need to ensure future food security of the continent.

As reported by the Bank's Agriculture and Agro-Industry Department, the Bank initially identified 75 projects (including 42 agricultural projects) in 23 countries[4] as candidates for budget realignment to address the crisis. By January 2009, 26 agricultural and 22 non-agricultural projects had been realigned. This resulted in a budget re-allocation amounting to UA86.43 million to address productivity issues. Furthermore, 12 operations had been identified for budget support operations to alleviate some of the pressure on countries' macro-economic frameworks, and help free up resources for immediate responses to the food crisis. In addition, the Bank allocated UA20 million from the Bank's Surplus Account to assist 11 countries[5] affected by the increased food prices. Finally, the Bank has made a commitment to enable an expansion of the total area under NERICA cultivation over the next 2 years, based on its on-going multinational NERICA dissemination project in seven West African countries.[6]

The Bank has also promptly responded by offering indirect support through other instruments. In particular, affected countries will benefit from budget support earmarked for the purchase of inputs to increase production levels since access to inputs is widely recognized as one of the key constraints to productivity in Africa. The use of the inputs is affected by other constraints including low development of irrigation capacity, low mechanization, inadequate infrastructure and missing or imperfect markets. Most of these issues will be addressed during the implementation of the Medium-to-Long Term Responses.

## *5.2 Medium-to-Long Term Responses*

The African Development Bank Medium-to-Long Term Responses were formulated within the context of the Bank's Medium-Term Strategy. This strategy recognizes the importance of incentives to transform and revitalize the agriculture sector.

[4] Angola, Benin, Burkina Faso, Chad, Djibouti, Ethiopia, Gambia, Ghana, Guinea Bissau, Guinea, Kenya, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, RDC, Rwanda, Senegal, Sierra Leone and Zambia.

[5] Burundi, Central African Republic, Comoros, Djibouti, Eritrea, Gambia, Libera, Mauritania, Niger, Sao Tome and Togo.

[6] Benin, Gambia, Ghana, Guinea, Mali, Nigeria and Sierra Leone.

Support to the small-holder sector, as in Malawi, and women's empowerment, may play a key role in poverty reduction. Moreover, access and utilization of new innovations in agriculture require increased flows of investment into the sector to enhance the continent's capacity to respond to trade opportunities and enhance its ability to adapt to climate change. Furthermore, the Bank strategy also acknowledges the importance of a cross-sectoral approach that addresses some of the constraints to supply response. Finally, the Bank is aware of the critical role of building partnerships and harmonization of actions to improve the effectiveness of interventions.

In the *medium-term*, the Bank will strengthen internal capacity to respond more successfully to crises in Africa. A Crisis Response Facility (CRF) is being discussed so that the Bank can provide timely responses to emergency situations like global price shocks and regional trade disruptions due to a conflict. Such a facility would allow the Bank to provide quick disbursing compensatory financial assistance to affected RMCs on concessionary terms using existing Bank instruments. Moreover, following the endorsement of the African Fertilizer Financing Mechanism (AFFM) by the Board of Governors in March 2008, the Bank moved to utilize the resources available to catalyze private sector investment in the manufacturing, procurement and distribution of fertilizer in RMCs. Access to fertilizers by the small-holder farmers, especially women, will be supported. The Bank is actively involved in the coordination of the processes under this facility.

In the *long-term*, measures that ensure food security and increased participation by the poor in income generating activities are key. In this context, it is important to intensify the development of new seed varieties of staple foods and their dissemination, improve quality control and access to financing, especially by small-holder farmers. Furthermore, the Bank will scale up efforts in rural infrastructure development and management of water resources. This will include measures to increase storage facilities, improve modalities of access and efficiency in water usage. In addition, post-harvest losses will need to be reduced through the support to improve and increase the capacity of storage facilities, as well as human capacity building in post-harvest management. Central in these processes is the importance of enhancing the knowledge and management abilities of farmers and institutions involved in agriculture. Agriculture research, science and technology will, therefore, be critical in promoting a commercial approach to agriculture on the continent. Also important is the creation of an enabling environment that encourages the private sector to play an increasing role in agriculture, thereby stimulating resource flows into agriculture.

## 6 Conclusion

The recent global food price pressures created pressure on poor people in Africa and elsewhere. Millions of Africans were affected, with a risk of dragging many more people into poverty and offsetting the modest gains made towards achieving the MDGs. Further, in some African countries, high food and fuel prices have threatened a return to the high levels of inflation that the continent had painfully managed to control in recent years.

Many factors behind the price spike, and appropriate policy responses are urgently needed to ensure that the continent is adequately equipped to copes with the negative effects of high food prices on the long term, while taking advantage of opportunities associated with observed price trends. Most African countries remain agriculture-based and thus have a potential to benefit from high food prices, given the substantial unexploited agricultural potential. Real food prices are expected to remain high in the short- to medium-term, and this could stimulate increased flows of investment in agriculture. Carefully targeted programs aimed at increasing the productivity of the small-holder agriculture sector would help millions of Africans to overcome extreme poverty, through increased production, value addition and market orientation. The Bank, in collaboration with other development partners, is committed to playing a leading role in helping African countries design and implement strategies for hedging against food price shocks, and reaping the benefits of higher producer prices. In this respect, the Vulnerability Index described in this chapter will help development partners to better target the populations that need assistance the most to deal with food supply shocks.

## Annex A. Food Consumption Shares (% of Total Expenditure)

| Country | Cereals share in total calorie intake | Household food expenditure shares | | Household cereal expenditure shares | | |
|---|---|---|---|---|---|---|
| | | Food | Cereals | Wheat | Rice | Coarse grains |
| | (I) | (II) | (III) | (IV) | (V) | (VI) |
| Algeria[a] | 57 | _ | _ | 78.2 | 1.1 | 20.7 |
| Angola | 32 | 43.9 | 12.6 | 38.5 | 19.8 | 41.7 |
| Benin | 36 | 46.9 | 18.5 | 5.2 | 18.3 | 76.5 |
| Botswana | 51 | 25.3 | 7.3 | 34.8 | 16.0 | 49.2 |
| Burkina Faso | 75 | 43.7 | 15.7 | 2.2 | 13.8 | 83.9 |
| Burundi | 16 | 46.6 | 13.9 | 15.1 | 23.4 | 61.5 |
| Cameroon | 43 | 44.2 | 8 | 15.0 | 26.5 | 58.5 |
| Cape Verde | 50 | 30.4 | 7.2 | 29.6 | 44.4 | 26.0 |
| Central African Republic | 22 | 62.4 | 12.8 | 22.9 | 15.0 | 62.1 |
| Chad | 54 | 56.2 | 8.0 | 7.0 | 11.6 | 81.5 |
| Comoros | 44 | 69.2 | 29.8 | 13.2 | 83.3 | 3.5 |
| Congo, Dem. Rep. | 18 | 62.5 | 7 | 27.3 | 25.5 | 47.2 |
| Congo, Republic of | 30 | 41.2 | 8.1 | 69.9 | 28.2 | 1.9 |
| Côte d'Ivoire | 41 | 44.4 | 6.5 | 12.7 | 71.0 | 16.3 |
| Djibouti | 53 | 37.1 | 9.3 | 56.9 | 40.4 | 2.7 |
| Egypt | 64 | 44.7 | 7.3 | 58.5 | 14.9 | 26.6 |
| Equatorial Guinea | 15 | 39.9 | 7.8 | 61.4 | 38.6 | 0.0 |

(continued)

**Annex A** (continued)

| Country | Cereals share in total calorie intake | Household food expenditure shares | | Household cereal expenditure shares | | |
|---|---|---|---|---|---|---|
| | | Food | Cereals | Wheat | Rice | Coarse grains |
| | (I) | (II) | (III) | (IV) | (V) | (VI) |
| Eritrea[a] | 79 | _ | _ | 67.3 | 2.8 | 29.9 |
| Ethiopia | 79 | 55.9 | 26 | 34.5 | 0.2 | 65.4 |
| Gabon | 26 | 38.1 | 6.9 | 43.1 | 47.4 | 9.5 |
| Gambia | 55 | 41.8 | 10.6 | 11.9 | 45.0 | 43.2 |
| Ghana | 28 | 50.6 | 7.8 | 20.4 | 27.9 | 51.7 |
| Guinea | 44 | 44.6 | 25.5 | 8.8 | 65.7 | 25.5 |
| Guinea-Bissau | 58 | 52.9 | 13.6 | 6.5 | 67.0 | 26.5 |
| Kenya | 50 | 38.6 | 9.9 | 30.0 | 10.6 | 59.4 |
| Lesotho | 78 | 38.7 | 16.9 | 51.2 | 6.5 | 42.2 |
| Liberia | 36 | 26.8 | 7.5 | 16.8 | 81.2 | 2.1 |
| Libya[a] | 47 | _ | _ | 88.1 | 7.5 | 4.4 |
| Madagascar | 53 | 61.5 | 35.5 | 4.1 | 89.3 | 6.6 |
| Malawi | 58 | 23.3 | 10.4 | 4.9 | 4.6 | 90.4 |
| Mali | 73 | 48.6 | 21.5 | 5.9 | 37.9 | 56.3 |
| Mauritania | 54 | 65.8 | 17 | 65.8 | 20.1 | 14.1 |
| Mauritius | 45 | 26.3 | 5.3 | 49.7 | 30.4 | 19.9 |
| Morocco | 62 | 38.9 | 7.5 | 74.7 | 0.3 | 25.0 |
| Mozambique | 43 | 62.7 | 23.8 | 21.8 | 25.7 | 52.6 |
| Namibia | 64 | 32.4 | 7.7 | 40.0 | 0.0 | 60.0 |
| Niger | 69 | 47.9 | 21.8 | 1.8 | 9.5 | 88.7 |
| Nigeria | 46 | 58.1 | 19.1 | 15.0 | 22.0 | 63.0 |
| Rwanda | 17 | 45 | 6.7 | 9.8 | 25.5 | 64.7 |
| Sao Tome and Principe | 33 | 54.6 | 15.8 | 46.1 | 36.2 | 17.7 |
| Senegal | 61 | 53.1 | 14.4 | 22.0 | 48.0 | 30.1 |
| Seychelles[a] | 34 | – | – | 18.6 | 51.3 | 30.0 |
| Sierra Leone | 54 | 44.6 | 15 | 11.0 | 80.2 | 8.8 |
| Somalia[a] | 34 | – | – | 39.5 | 21.4 | 39.2 |
| South Africa | 54 | 20.2 | 3.3 | 32.6 | 9.0 | 58.4 |
| Sudan | 56 | 55.5 | 10.4 | 41.0 | 1.6 | 57.4 |
| Swaziland | 44 | 44.5 | 11.6 | 34.9 | 11.6 | 53.5 |
| Tanzania | 51 | 69.6 | 25.7 | 12.1 | 27.8 | 60.1 |
| Togo | 47 | 50.7 | 13.7 | 10.7 | 16.8 | 72.5 |
| Tunisia | 51 | 29.1 | 4.8 | 73.3 | 0.6 | 26.1 |
| Uganda | 21 | 37.2 | 6.9 | 7.0 | 13.1 | 79.9 |
| Zambia | 65 | 12.3 | 3.5 | 19.8 | 4.2 | 76.0 |
| Zimbabwe | 58 | 46.3 | 21.6 | 24.9 | 1.8 | 73.2 |
| Africa | – | 39.9 | 9.9 | 35.9 | 20.7 | 43.4 |

Source: AfDB Statistics Department, ICP Data (2005) and FAO (2008)
[a]Countries did not participate in the ICP

# Annex B. Cereal Balance (Values in Million) (2007/2008)

| Country | Cereal production | Cereal imports (contracted or delivered) | Possible Stock draw down | Cereal exports | Cereal availability | Consumption (food) | Consumption (non-food) | Require-ments | Cereal balance | GDP (2007) | Anticipated imports[c] | Cereal balance/GDP | Cereal import dependency[a] | Current account balance/GDP[b] | Fiscal balance/GDP[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USD million | | | | | USD million | | | USD million | | | Percentage | | Percentage | |
| Algeria | 1,462 | 924 | 139 | 24 | 2,501 | 2,966 | 869 | 3,835 | −1,334 | 134,517 | 2,499 | −1.0 | 65 | 21.6 | 11.4 |
| Angola | 188 | 194 | 8 | 28 | 361 | 432 | 32 | 464 | −103 | 60,852 | 267 | −0.2 | 58 | 17.7 | 10.0 |
| Benin | 278 | 22 | 5 | 77 | 228 | 212 | 63 | 275 | −47 | 5,538 | 80 | −0.9 | 29 | −5.5 | −2.0 |
| Botswana | 7 | 80 | 1 | 0 | 88 | 97 | 1 | 98 | −11 | 10,706 | 94 | −0.1 | 96 | 21.0 | 7.1 |
| Burkina Faso | 824 | 2 | 5 | 80 | 752 | 710 | 131 | 841 | −89 | 7,135 | 98 | −1.3 | 12 | −13.9 | −6.0 |
| Burundi | 81 | 10 | – | 0 | 90 | 97 | 11 | 108 | −18 | 946 | 24 | −1.9 | 23 | −14.2 | 0.7 |
| Cameroon | 416 | 22 | 28 | 49 | 417 | 545 | 116 | 660 | −244 | 21,509 | 281 | −1.1 | 43 | 0.2 | 4.5 |
| Cape Verde | 1 | 1 | 4 | 0 | 6 | 29 | 0 | 30 | −23 | 1,397 | 21 | −1.7 | 72 | −11.5 | −2.3 |
| Central African Rep. | 51 | 5 | 1 | 0 | 57 | 59 | 5 | 64 | −7 | 1,732 | 14 | −0.4 | 21 | −3.4 | −2.7 |
| Chad | 477 | 2 | 2 | 70 | 411 | 320 | 103 | 423 | −12 | 6,509 | 23 | −0.2 | 5 | −9.9 | 0.8 |
| Comoros | 8 | 11 | 1 | 1 | 19 | 23 | 1 | 24 | −5 | 466 | 18 | −1.2 | 73 | −3.7 | −2.0 |
| Congo, Dem. Rep. | 409 | 1 | 0 | 1 | 409 | 544 | 72 | 617 | −208 | 10,589 | 237 | −2.0 | 38 | −6.9 | 2.2 |
| Congo, Republic of | 2 | 6 | 3 | 0 | 11 | 129 | 5 | 134 | −123 | 8,243 | 126 | −1.5 | 94 | 16.8 | 15.1 |
| Côte d'Ivoire | 665 | 122 | 6 | 46 | 747 | 849 | 88 | 937 | −190 | 19,810 | 513 | −1.0 | 55 | 4.1 | 0.3 |
| Djibouti | 0 | 1 | 2 | 14 | −11 | 31 | 0 | 31 | −43 | 833 | 27 | −5.1 | 85 | −14.5 | −1.6 |
| Egypt | 7,508 | 1,186 | 414 | 481 | 8,628 | 7,819 | 2,626 | 10,444 | −1,817 | 128,512 | 2,956 | −1.4 | 28 | 2.1 | −5.7 |
| Equatorial Guinea | 0 | 3 | 1 | 2 | 2 | 9 | 0 | 9 | −7 | 9,731 | 10 | −0.1 | 109 | −2.4 | 22.8 |
| Eritrea | 53 | 34 | 0 | 0 | 86 | 162 | 9 | 171 | −85 | 1,084 | 98 | −7.9 | 57 | −3.7 | −18.1 |
| Ethiopia | 4,186 | 0 | 81 | 186 | 4,082 | 3,256 | 756 | 4,012 | 69 | 15,069 | 22 | 0.5 | 1 | −10.2 | −3.1 |
| Gabon | 7 | 6 | 2 | 0 | 15 | 61 | 17 | 78 | −63 | 10,652 | 70 | −0.6 | 89 | 19.8 | 9.6 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gambia | 51 | 14 | 4 | 17 | 51 | 80 | 10 | 90 | −39 | 640 | 53 | −6.1 | 58 | −21.8 | 1.8 |
| Ghana | 403 | 32 | 85 | 79 | 441 | 580 | 81 | 661 | −220 | 14,830 | 268 | −1.5 | 41 | −6.9 | −8.2 |
| Guinea | 827 | 13 | 0 | 72 | 768 | 471 | 274 | 745 | 23 | 4,743 | 200 | 0.5 | 27 | −8.7 | 1.0 |
| Guinea-Bissau | 63 | 9 | 5 | 6 | 72 | 77 | 10 | 86 | −14 | 357 | 34 | −4.0 | 40 | −12.7 | −17.3 |
| Kenya | 778 | 95 | 150 | 4 | 1,019 | 1,166 | 111 | 1,277 | −257 | 29,860 | 290 | −0.9 | 23 | −1.7 | −1.7 |
| Lesotho | 17 | 60 | 2 | 0 | 79 | 86 | 1 | 87 | −8 | 1,634 | 63 | −0.5 | 72 | 1.6 | 7.7 |
| Liberia | 68 | 18 | 11 | 1 | 96 | 143 | 11 | 154 | −58 | 716 | 71 | −8.2 | 46 | −20.1 | 1.5 |
| Libya | 52 | 229 | 0 | 0 | 280 | 401 | 325 | 727 | −446 | 64,134 | 675 | −0.7 | 93 | 28.3 | 40.2 |
| Madagascar | 1,660 | 95 | 0 | 3 | 1,753 | 1,176 | 79 | 1,255 | 498 | 7,314 | 106 | 6.8 | 8 | −12.5 | −3.5 |
| Malawi | 806 | 35 | 2 | 122 | 721 | 483 | 159 | 642 | 79 | 2,580 | 35 | 3.0 | 6 | −4.0 | −1.5 |
| Mali | 965 | 4 | 27 | 34 | 961 | 796 | 154 | 950 | 11 | 7,113 | 120 | 0.2 | 13 | −5.5 | −1.0 |
| Mauritania | 49 | 26 | 18 | 11 | 81 | 131 | 40 | 171 | −90 | 2,798 | 117 | −3.2 | 68 | −6.8 | −2.8 |
| Mauritius | 0 | 19 | 0 | 16 | 3 | 73 | 20 | 93 | −91 | 7,400 | 109 | −1.2 | 117 | −5.4 | −4.3 |
| Morocco | 834 | 518 | 735 | 20 | 2,067 | 2,641 | 832 | 3,473 | −1,406 | 73,374 | 1,380 | −1.9 | 40 | 3.1 | −3.4 |
| Mozambique | 507 | 217 | 16 | 32 | 708 | 671 | 97 | 768 | −61 | 7,663 | 281 | −0.8 | 37 | −10.2 | −5.1 |
| Namibia | 27 | 49 | 5 | 0 | 80 | 71 | 3 | 74 | 7 | 7,312 | 50 | 0.1 | 68 | 15.5 | 1.9 |
| Niger | 823 | 4 | 35 | 11 | 851 | 761 | 164 | 924 | −73 | 4,280 | 78 | −1.7 | 8 | −7.1 | −0.8 |
| Nigeria | 6,651 | 84 | 290 | 151 | 6,874 | 6,323 | 1,798 | 8,121 | −1,247 | 124,000 | 1,996 | −1.0 | 25 | 4.0 | 5.6 |
| Rwanda | 101 | 20 | 0 | 0 | 121 | 122 | 21 | 142 | −21 | 2,822 | 45 | −0.8 | 32 | −5.8 | −0.4 |
| Sao Tome and Principe | 1 | 1 | 0 | 0 | 2 | 6 | 0 | 6 | −4 | 90 | 4 | −4.1 | 69 | −64.9 | −11.9 |
| Senegal | 288 | 98 | 11 | 1 | 395 | 532 | 55 | 587 | −192 | 10,946 | 350 | −1.8 | 60 | −8.3 | −5.5 |
| Seychelles | 0 | 1 | 0 | 0 | 1 | 3 | 1 | 4 | −3 | 706 | 4 | −0.4 | 100 | −30.4 | −5.8 |
| Sierra Leone | 264 | 6 | 0 | 0 | 270 | 249 | 40 | 289 | −20 | 1,668 | 108 | −1.2 | 37 | −6.7 | −3.4 |
| Somalia | 38 | 1 | 7 | 2 | 45 | 174 | 33 | 206 | −161 | Not available | 130 | NA | 63 | Not available | |
| South Africa | 2,394 | 880 | 251 | 152 | 3,373 | 2,450 | 1,140 | 3,589 | −216 | 272,726 | 1,125 | −0.1 | 31 | −6.8 | 0.8 |
| Sudan | 1,337 | 165 | 60 | 43 | 1,519 | 1,568 | 303 | 1,872 | −352 | 45,725 | 459 | −0.8 | 25 | 0.0 | −3.8 |
| Swaziland | 6 | 30 | 3 | 4 | 35 | 45 | 4 | 49 | −14 | 2,725 | 37 | −0.5 | 76 | 0.2 | −2.0 |
| Tanzania | 1,404 | 167 | 72 | 106 | 1,537 | 1,243 | 185 | 1,428 | 110 | 14,504 | 223 | 0.8 | 16 | −11.8 | −4.5 |
| Togo | 215 | 9 | 2 | 52 | 174 | 181 | 38 | 219 | −44 | 2,537 | 222 | −1.8 | 101 | −6.4 | −2.5 |

(continued)

**Annex B** (continued)

| Country | Cereal production | Cereal imports (contracted or delivered) | Possible Stock draw down | Cereal exports | Cereal availability | Consumption (food) | Consumption (non-food) | Require-ments | Cereal balance | GDP (2007) | Anticipated imports[c] | Cereal balance/ GDP | Cereal import dependency[a] | Current account balance/ GDP[b] | Fiscal balance/ GDP[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USD million | | | | | USD million | | | USD million | | | Percentage | | Percentage | |
| Tunisia | 688 | 183 | 32 | 50 | 853 | 870 | 562 | 1,432 | –579 | 34,458 | 543 | –1.7 | 38 | –0.5 | –3.1 |
| Uganda | 594 | 0 | 48 | 75 | 566 | 540 | 60 | 599 | –33 | 10,968 | 32 | –0.3 | 5 | –3.8 | –2.8 |
| Zambia | 353 | 12 | 21 | 64 | 322 | 295 | 37 | 332 | –11 | 11,417 | 22 | –0.1 | 7 | –4.1 | –1.8 |
| Zimbabwe | 277 | 147 | 7 | 4 | 428 | 478 | 67 | 545 | –117 | 4,732 | 169 | –2.5 | 31 | –0.9 | –24.6 |
| Total Africa | 39,164 | 5,872 | 2,602 | 2,193 | 42,843 | 43,238 | 11,618 | 54,856 | –12,013 | 1,232,603 | 16,877 | –1.0 | 31 | 2.2 | 2.8 |

Source: AfDB Statistics Department, FAO (2008)

Note: Countries differ with respect to the marketing year, 2007/08 or 2008, depending on data availability. 2006 production data used for: Wheat: Botswana, Cameroon, Mauritania, Mozambique, Somalia, Swaziland; Rice: Ethiopia, Gabon, Swaziland; Maize: Djibouti, Mauritius. Products included in the food category are wheat, rice, and coarse grain. It is assumed that coarse grains are mainly composed of maize. Thus, the world price for maize is used to compute the value of coarse grains. Cereal Balance is defined as domestic production plus food imports(contracted or received) minus domestic food and non-food consumption, and exports. Accordingly, a negative value represents a deficit, while a positive value represents a sirplus.

[a] A value exceeding 100 is due to stock build up, exports and/or re-exports from further processing sectors.

[b] 2007, Excluding debt relief

[c] Anticipated imports are the sum of the cereal balance plus cereal stock shortfalls

# Annex C. Indicators of Vulnerability and Country Ranking

| | | | | | | Vulnerability indices | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | Cereal balance/ GDP | Cereal dependency | Share of urban population | 2007 GDP per capita | Urban weighted | Dependency weighted | Urban and dependency weighted | Urban and dependency weighted deflated by GDP per capita | Current Account balance/GDP | Quartile |
| 1 | Liberia | −9.69 | 0.46 | 0.59 | 357 | −15.42 | −14.16 | −22.54 | −6.31 | −20.1 | 1st |
| 2 | Zimbabwe | −2.62 | 0.31 | 0.37 | 188 | −3.59 | −3.44 | −4.70 | −2.49 | −0.9 | 1st |
| 3 | Guinea-Bissau | −5.50 | 0.40 | 0.30 | 484 | −7.13 | −7.70 | −9.98 | −2.06 | −12.7 | 1st |
| 4 | Eritrea | −7.87 | 0.57 | 0.20 | 774 | −9.48 | −12.35 | −14.88 | −1.92 | −3.7 | 1st |
| 5 | Gambia | −6.75 | 0.58 | 0.56 | 1,326 | −10.52 | −10.69 | −16.65 | −1.26 | −21.8 | 1st |
| 6 | Congo, Dem. Rep. | −1.97 | 0.38 | 0.33 | 309 | −2.62 | −2.72 | −3.63 | −1.18 | −6.9 | 1st |
| 7 | Djibouti | −5.38 | 0.85 | 0.87 | 2,271 | −10.06 | −9.94 | −18.57 | −0.82 | −14.5 | 1st |
| 8 | Sao Tome and Principe | −4.53 | 0.69 | 0.60 | 1,565 | −7.25 | −7.66 | −12.25 | −0.78 | −64.9 | 1st |
| 9 | Burundi | −1.89 | 0.23 | 0.10 | 372 | −2.08 | −2.32 | −2.55 | −0.69 | −14.2 | 1st |
| 10 | Togo | −1.83 | 1.01 | 0.41 | 806 | −2.59 | −3.69 | −5.21 | −0.65 | −6.4 | 1st |
| 11 | Niger | −2.53 | 0.08 | 0.16 | 667 | −2.94 | −2.75 | −3.19 | −0.48 | −7.1 | 1st |
| 12 | Mauritania | −3.86 | 0.68 | 0.41 | 2,008 | −5.44 | −6.49 | −9.15 | −0.46 | −6.8 | 1st |
| 13 | Sierra Leone | −1.18 | 0.37 | 0.38 | 692 | −1.63 | −1.62 | −2.24 | −0.32 | −6.7 | 1st |
| 14 | Ghana | −2.06 | 0.41 | 0.49 | 1,426 | −3.07 | −2.89 | −4.31 | −0.30 | −6.9 | 2nd |
| 15 | Comoros | −1.35 | 0.73 | 0.28 | 1,125 | −1.72 | −2.33 | −2.98 | −0.27 | −3.7 | 2nd |
| 16 | Senegal | −1.85 | 0.60 | 0.42 | 1,685 | −2.63 | −2.95 | −4.20 | −0.25 | −8.3 | 2nd |
| 17 | Mozambique | −1.00 | 0.37 | 0.36 | 830 | −1.36 | −1.36 | −1.86 | −0.22 | −10.2 | 2nd |
| 18 | Cape Verde | −1.97 | 0.72 | 0.59 | 3,244 | −3.13 | −3.39 | −5.39 | −0.17 | −11.5 | 2nd |
| 19 | Morocco | −2.92 | 0.40 | 0.56 | 4,076 | −4.54 | −4.08 | −6.35 | −0.16 | 3.1 | 2nd |
| 20 | Burkina Faso | −1.33 | 0.12 | 0.19 | 1,253 | −1.58 | −1.48 | −1.77 | −0.14 | −13.9 | 2nd |

(continued)

**Annex C** (continued)

| | | | | | | Vulnerability indices | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | Cereal balance/GDP | Cereal dependency | Share of urban population | 2007 GDP per capita | Urban weighted | Dependency weighted | Urban and dependency weighted | Urban and dependency weighted deflated by GDP per capita | Current Account balance/GDP | Quartile |
| 21 | Cameroon | –1.26 | 0.43 | 0.56 | 2,088 | –1.97 | –1.80 | –2.81 | –0.13 | 0.2 | 2nd |
| 22 | Côte d'Ivoire | –0.99 | 0.55 | 0.48 | 1,716 | –1.47 | –1.53 | –2.27 | –0.13 | 4.1 | 2nd |
| 23 | Rwanda | –0.75 | 0.32 | 0.18 | 899 | –0.88 | –0.99 | –1.16 | –0.13 | –5.8 | 2nd |
| 24 | Congo, Republic of | –1.53 | 0.94 | 0.61 | 3,730 | –2.46 | –2.97 | –4.78 | –0.13 | 16.8 | 2nd |
| 25 | Kenya | –1.36 | 0.23 | 0.21 | 1,699 | –1.65 | –1.67 | –2.03 | –0.12 | –1.7 | 2nd |
| 26 | Nigeria | –1.24 | 0.25 | 0.48 | 2,035 | –1.83 | –1.54 | –2.28 | –0.11 | 4.0 | 2nd |
| 27 | Benin | –0.95 | 0.29 | 0.41 | 1,541 | –1.33 | –1.22 | –1.72 | –0.11 | –5.5 | 3rd |
| 28 | Central African Republic | –0.48 | 0.21 | 0.38 | 726 | –0.66 | –0.58 | –0.80 | –0.11 | –3.4 | 3rd |
| 29 | Lesotho | –0.59 | 0.72 | 0.25 | 1,285 | –0.73 | –1.01 | –1.26 | –0.10 | 1.6 | 3rd |
| 30 | Uganda | –0.73 | 0.05 | 0.13 | 939 | –0.83 | –0.77 | –0.87 | –0.09 | –3.8 | 3rd |
| 31 | Sudan | –0.90 | 0.25 | 0.43 | 2,172 | –1.28 | –1.12 | –1.60 | –0.07 | 0.0 | 3rd |
| 32 | Egypt | –1.74 | 0.28 | 0.43 | 5,491 | –2.48 | –2.23 | –3.18 | –0.06 | 2.1 | 3rd |
| 33 | Tunisia | –1.77 | 0.38 | 0.66 | 7,473 | –2.95 | –2.45 | –4.06 | –0.05 | –0.5 | 3rd |
| 34 | Algeria | –1.10 | 0.65 | 0.65 | 6,533 | –1.80 | –1.81 | –2.98 | –0.05 | 21.6 | 3rd |
| 35 | Mauritius | –1.23 | 1.17 | 0.42 | 11,152 | –1.75 | –2.66 | –3.79 | –0.03 | –5.4 | 3rd |
| 36 | Mali | –0.21 | 0.13 | 0.32 | 1,031 | –0.28 | –0.24 | –0.31 | –0.03 | –5.5 | 3rd |
| 37 | Zambia | –0.28 | 0.07 | 0.35 | 1,309 | –0.37 | –0.29 | –0.40 | –0.03 | –4.1 | 3rd |
| 38 | Swaziland | –0.63 | 0.76 | 0.25 | 4,836 | –0.79 | –1.11 | –1.39 | –0.03 | 0.2 | 3rd |
| 39 | Libya | –0.70 | 0.93 | 0.77 | 12,277 | –1.23 | –1.34 | –2.38 | –0.02 | 28.3 | 3rd |
| 40 | Chad | –0.21 | 0.05 | 0.26 | 1,675 | –0.27 | –0.22 | –0.28 | –0.02 | –9.93 | 4th |
| 41 | Gabon | –0.61 | 0.89 | 0.85 | 14,083 | –1.13 | –1.16 | –2.15 | –0.02 | 19.8 | 4th |
| 42 | Ethiopia | –0.08 | 0.01 | 0.17 | 806 | –0.09 | –0.08 | –0.09 | –0.01 | –10.2 | 4th |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | Seychelles | −0.43 | 1.00 | 0.54 | 16,642 | −0.67 | −0.86 | −1.33 | −0.01 | −30.4 | 4th |
| 44 | Angola | −0.18 | 0.58 | 0.56 | 5,590 | −0.28 | −0.29 | −0.45 | −0.01 | 17.7 | 4th |
| 45 | South Africa | −0.17 | 0.31 | 0.60 | 9,761 | −0.27 | −0.22 | −0.36 | 0.00 | −6.8 | 4th |
| 46 | Botswana | −0.11 | 0.96 | 0.59 | 16,450 | −0.17 | −0.21 | −0.33 | 0.00 | 21.0 | 4th |
| 47 | Equatorial Guinea | −0.08 | 1.09 | 0.39 | 12,895 | −0.11 | −0.16 | −0.23 | 0.00 | −2.4 | 4th |
| 48 | Namibia | 0.03 | 0.68 | 0.36 | 5,189 | 0.03 | 0.04 | 0.06 | 0.00 | 15.5 | 4th |
| 49 | Tanzania | 0.26 | 0.16 | 0.25 | 1,256 | 0.32 | 0.30 | 0.37 | 0.03 | −11.8 | 4th |
| 50 | Guinea | 0.48 | 0.27 | 0.34 | 1,074 | 0.64 | 0.61 | 0.81 | 0.08 | −8.7 | 4th |
| 51 | Malawi | 2.97 | 0.06 | 0.18 | 785 | 3.51 | 3.13 | 3.71 | 0.47 | −4.0 | 4th |
| 52 | Madagascar | 6.81 | 0.08 | 0.29 | 1,068 | 8.80 | 7.39 | 9.54 | 0.89 | −12.5 | 4th |
| 53 | Somalia | NA | 0.63 | 0.36 | NA | NA | NA | NA | NA | NA | |
| | African Average | −0.97 | 0.31 | 0.39 | | −1.35 | −1.27 | −1.77 | | - | |

Source: African Development Bank 2008b

# Annex D. Policy Measures Taken by Governments

| | Consumer oriented | | | | | | | Producer oriented | | Trade oriented | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tax | Social | | | Market | | | Production support | Market management | Import | Export |
| | Taxes (direct and indirect) | Food assistance | Food subsidies | Safety net and other | Price controls | Release stocks | Food procurement and other | Producer credit and other | Minimum producer prices and other | Import tariffs and other | Quantitative export controls |
| Algeria | | | X | | | | X | X | X | X | |
| Angola | | | | | | | | X | | | |
| Benin | | | | | X | | X | X | | X | |
| Burkina Faso | X | X | | | X | | | X | | X | |
| Cameroon | X | | | | X | X | X | | | X | X |
| Cape Verde | X | X | | | X | | | | | X | |
| Central African Republic | | | | | | | | | X | | |
| Congo | X | | | | | | | | | | |
| D.R Congo | | | | | X | | | | | X | |
| Djibouti | X | | | | X | | | X | | | |
| Egypt | | X | X | X | X | | | | | | X |
| Eritrea | | | X | | | X | | | | | |
| Ethipia | X | | X | | X | | | X | | | X |
| Gambia | X | | | | | | | | | X | |
| Ghana | | | | | | | | X | | X | |
| Guinea | X | | | | | | | X | | X | X |
| Kenya | X | | | | | | | X | | X | X |
| Liberia | | X | | | | | | X | | X | |
| Libyan Arab Jamahiriya | | | | X | X | | X | X | | X | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Madagascar | X | X | | | X | X | | X | | X | |
| Malawi | | | | | | | | X | X | | X |
| Mauritania | | | | | | | X | X | | X | |
| Morocco | | X | X | | X | | | | | X | |
| Mozambique | | | | | | | | | | X | |
| Namibia | X | X | | | | | | | | | |
| Niger | X | | | | | | X | X | | X | |
| Nigeria | | X | | | | X | X | X | X | X | |
| Rwanda | | | | | X | | X | | | X | |
| Senegal | X | X | X | | X | | X | X | X | X | |
| Seychelles | X | | | | | | | X | | | |
| Sierra Leone | X | | | | X | X | | X | | X | |
| South Africa | | X | | | | | | X | | | |
| Sudan | X | | | | X | | | | | | |
| Togo | | | | | X | | | X | | | |
| Tunisia | | | | | | | | X | X | | |
| Uganda | X | | | | | | | | | | |
| United Republic of Tanzania | X | | X | | | | | X | | X | X |
| Zambia | | | X | | X | | | X | X | | X |
| Zimbabwe | | X | | | | | | | | X | |
| Total | 11 | 10 | 8 | 2 | 9 | 0 | 9 | 18 | 7 | 23 | 8 |

*Source:* FAO, 2008b; IMF and AfDB Databases

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# Chapter 22
# Significance of Vegetable Farming as a Strategy to Enhance Household Food Security in Communal Areas of Zimbabwe

**Thomas Marambanyika**

**Abstract** Food grain crops are the focal point of household food production in communal areas of Zimbabwe. These have remained the prime target of national agricultural policies. Prioritization of cereals has been done at the expense of horticultural products' potential to stablise communal food systems. This chapter reflected on how local communities in Uzumba Maramba Pfungwe district of Zimbabwe transformed their livelihoods through locally initiated small-scale vegetable farming projects. Information was collected through questionnaires, informal interviews and on-site observations as the basis for rapid rural appraisal. Local communities significantly improved on quantities of vegetable output and subsequently food access, availability and consumption patterns. Hecterage of land under cultivation has been extended from small gardens to communal or dryland fields. Farming is thriving viably without assistance from local authorities, central government and NGOs. The chapter concluded that sustainable reduction of hunger in rural societies of developing countries could be achieved if development and donor funding is centered on local initiatives. However, strategies to co-opt traditional vegetables and seasonally grown need to be devised in order to improve and maintain nutrition, especially for HIV/AIDS related illness.

**Keywords** Vegetables • Farming • Household • Food security • Communal areas

## 1 Introduction

Concern with food security can be traced back to the Universal Declaration of Human Rights in 1948 and world food crisis of 1972–1974. In the 1970s, the focus was on national and international food supplies, but later shifted to access to food at

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_22,

household and individual levels after 1980 (Maxwell and Smith 1992). A number of coping strategies were implemented to enhance food access in different countries at both local and national levels. In Zimbabwe, rural communities remained vulnerable to hunger and poverty due to underdevelopment and their location in relatively dry areas as defined by the Land Apportionment Act of 1930. The semi-arid conditions of the regions, where about 70% of Zimbabwe's rural population lives, left large proportions of communal households continuously threatened by food insecurity.

The hub in communal areas of Zimbabwe on household food production has been on maize, sorghum, pearl millet, finger millet and wheat that make up the traditional food grain crops at the expense of horticultural products which are essentially for direct consumption (Mudimu 2008). Food security in the country is mainly defined in the context of availability or access to cereals, particularly maize as a staple food crop (Mudimu 2008). This conception has overshadowed the ability of small-scale vegetable production to stabilize communal food systems.

In Chikwira and Manyika wards of Uzumba Maramba Pfungwe district, households have opted for and intensified annual vegetable farming for food and income generation at household level. This is despite the fact that the horticultural production sector was dominated by large-scale commercial farmers who had both the liquidity and knowledge to viably carry out the activity. In order to ascertain how small-holder communal farmers have managed to transform themselves into competitive horticulturalists, this analysis also considered the motivating factors behind this transition.

This chapter focuses on whether vegetable production has had a positive bearing on rural livelihoods in terms of households' income, access to food, food availability and food consumption patterns since it started in earnest in the early 1990s. This research was done in order to ascertain whether communal vegetable production can be adopted as a sustainable tool in fulfilling the Millennium Development Goal number one of eradicating extreme poverty and hunger. It is clear that the notions of poverty, under-nutrition and vulnerability are closely intertwined in definitions of food security (Maxwell and Smith 1992).

## 2 Location and Description of Study Area

Chikwira and Manyika wards are located in Uzumba-Maramba-Pfungwe district of Mashonaland East province in Zimbabwe (Fig. 22.1). The area is in Zimbabwe's agro-ecological region three which experiences annual rainfall amounts ranging from 700 to 1,000 mm, and is associated with short mid-rainy season dry spells (Govereh et al. 1989). Mean annual temperature is 18°C, with maximum temperature recorded in October–November and lowest in June–July.

Soils in the area are of the medium grained sandy type belonging to the paraferrallitic group (Nyamapfene 1991). The soils have generally low potential hydrogen, and are deficient in both nitrogen and phosphorous (Govereh et al. 1989). There are isolated patches of both red and black clayey soils across the plain. In Zimbabwe, these soils are of high agricultural potential. Vleis are dominantly found along main streams but those located away from major streams are usually desiccated during the dry season.

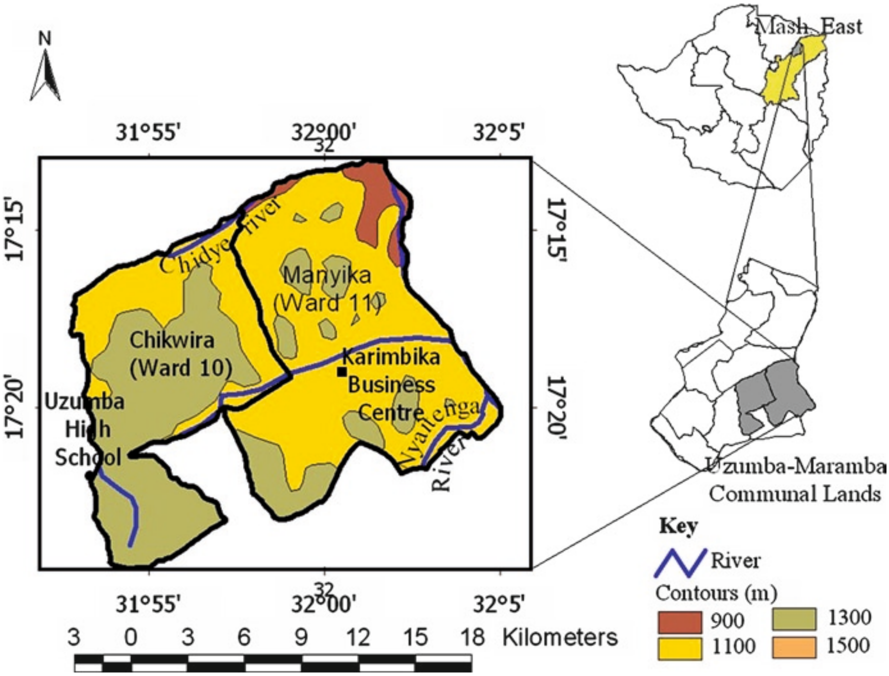


**Fig. 22.1** Map of the study area

Altitude in the area is between 900 and 1,300 m above sea level (Fig. 22.1). The area has a rugged terrain characterized by existence of uplands with relatively steep valleys sandwiching ephemeral and intermittent stream channels. Communication services in the area are generally poor with only one all weather road from the capital Harare to Mutawatawa district service center in Uzumba Maramba Pfungwe (UMP). All the other road networks that traverse the area through most of the wards are of very poor conditions, particularly during the rainy season. Maize is the staple food crop in the area. Uzumba, which is part of UMP district and where Chikwira and Manyika wards are located, is suited for horticultural production because of the availability of ground water and a frost-free environment (Govereh et al. 1989). Other livelihood activities in the area include crop farming, sugar cane farming, poultry and livestock rearing.

## 3 Data Collection and Analysis

In order to have an in-depth understanding and analysis of vegetable production in relation to food security of Chikwira and Manyika wards' households, the research used rapid rural appraisal (RRA) as a method for data acquisition. RRA helped the researchers to make contact with the rural population in a learning process (Crawford 1997). This method of data acquisition allowed for triangulation; hence informal interviews, questionnaires and on-site observations were concomitantly conducted during fieldwork. Respondents for questionnaires and interviews were selected through purposive sampling. A multi-disciplinary team comprising of four researchers met with 36 local farmers, and shared ideas through probing for information over a period of 3 weeks. The research instruments collected information on type of vegetable varieties grown, volumes of produce, proportions of output consumed and sold, marketing strategies, impact of output on food access, availability and consumption patterns.

Since farmers were mainly producing for the market, the researchers examined the contribution of horticultural activities to rural well-being in terms of income levels for households. Hoddinott (1999) and Bickel et al. (2000) explained that income was one of the best indicators of household food security as it determines family entitlements. The researchers converted vegetable output prices from Zimbabwe dollars into stable United States dollars in order to evade the effects of national economic hyperinflation rates surging at 231 million percent in October 2008 (Distressed Volatility 2008).

October 10, 2008 rates were used because that was the day and month in which fieldwork was concluded. Conversions from Zimbabwe dollars were done using OANDA foreign currency converter and prevailing parallel market rates or *"black market"* rates. OANDA rates were used as they depict prevailing official exchange rates (OANDA Corporation 2008).Use of both parallel and official market rates was meant to cater for discrepancies between the two monetary systems. Government as well as foreign agencies and individuals rely on official rates, but local market prices were mostly pegged at black market rates. Conversions were done in order to determine the viability of vegetable production as a strategy to enhance household income.

# 4 Results and Discussion

## *4.1 Motivating Factors*

Individual households started small-scale intensive vegetable farming as from mid-1990s due to retrenchment of bread winners from formal employment in urban areas as a result of the Economic Structural Adjustment Programme (ESAP) of early 1990s. Unemployment was further exacerbated by the economic meltdown since the turn of the twenty-first century that left most youths with limited opportunities of finding off-farm jobs and other livelihoods enhancement options. Given the background that 76% of the respondents fell within the economically active category, and at least 77% have reached ordinary level education, increasing rates of lack of formal employment left most people with limited or no means of generating household income.

Subsequent to considering favorable environmental resources within their locality, such as perennially flowing rivers, wetlands, small dams and good soils, households found that horticultural farming was one of the few viable options to enhance their livelihoods portfolio and food security. The existence of a conveniently large market in the capital city Harare to profitably sell vegetable products throughout the year was another strong motivating factor. The deteriorating economic situation in the country, with inflation at 231 million percent (Distressed Volatility 2008), further boosted the urban vegetable market as all types of meat and related products became either unavailable or too expensive for the majority of the residents. With the concomitant fall in the value of the Zimbabwe currency also rendered workers' earnings almost useless necessitating the need to supplement formal employment wages and salaries, hence even the households with formally employed breadwinners sought other sources of additional income to survive. Vegetable farming mushroomed as a result of moral, technical and economic support shared amongst friends and community at large. Prior to this commercial endeavour, households were growing vegetables in small gardens for subsistence purposes.

## *4.2 Farm Size and Location*

Vegetable farming is done in both wetlands and some dryland fields close to reliable water supply sources, such as rivers and small dams. Each household has an average plot size of approximately 0.5 ha in the dryland fields, and 0.1 ha in wetlands. Plot sizes were mainly determined by variability in availability of both family and hired labour, capital status of farmers, source of water, soil quality, land shortage and the need to strike balance between horticultural crops and other important crops. Dryland fields are generally small averaging 2–3 ha in Zimbabwe (Zinyama 1989). Distance covered by farmers to their fields is variable, as on average 1,120 m are travelled to wetlands compared to 685 m to dryland fields. By communal area standards, the dryland fields are relatively close to the homesteads, and therefore little time is lost to get to the plots and the security of the vegetables from animals and thieves is guaranteed since the fields can be observed from the homesteads. However, most of the wetland located sites are significantly detached from homesteads, and this presents two main challenges to the farmers. Firstly, a significant amount of time is lost through travelling because at least an average of 1 km has to be covered to get to and from the fields. Considering the fact that horticultural crops require close monitoring, and therefore frequent field visits to water and guard them against animals and thieves, much time and effort are invested in travelling to and from the fields.

Plots for vegetable farming in both dryland fields and wetlands were apportioned to farmers under customary law through the headsmen. However, some households got farming plots through fragmentation of existing pieces of land inherited from parents. Crop farming is still practiced in dryland fields although under reduced portions of land. Farmers devote most of their time towards vegetable farming even during the summer season when crop farming was dominantly practiced, and this has implications on the productivity of other crops like maize that constitute the country's food crop. This area has therefore witnessed reduced production of cereals over the years due to ensuing competition between horticultural crops and cereals in the context of very limited land availability.

### 4.3 Vegetables Grown and Output Levels

Tomato is the most grown vegetable crop as each of the sampled farmer harvest an annual average of 4,546,94 kg per acre (Fig. 22.2). Average onions output per acre was 1,347,78 kg, and the crop was ranked second in terms of productivity. Leafy vegetables and beans were ranked third and fourth respectively (Fig. 22.2). Carrot is the least grown crop due to high cost for seed and low market demand. Unlike other vegetables whereby farmers use seeds from previous harvests, seed for carrots had to be purchased from seed manufacturing companies and retailers. However, production levels for each vegetable type vary from farmer to farmer. For example, higher producer of tomatoes yield an annual average of 5,542 kg per acre compared to 3,580 kg per acre from low producing household. Least producer for beans produces 250 kg per each farming season. These variations are a result of differences among households on acreage under production for each crop, availability of chemicals, organic manure, labour, water, soil type and household's vision.

### 4.4 Strategies Used to Enhance Vegetable Productivity

Wetland farming is mainly performed during winter season in order to utilize available water. Dryland farming is mainly done in summer as farmers take advantage of rain-fed watering. Irrigation is required in dryland fields despite the availability of rainfall during this period as the area normally experience mid-season dry spells. However, some

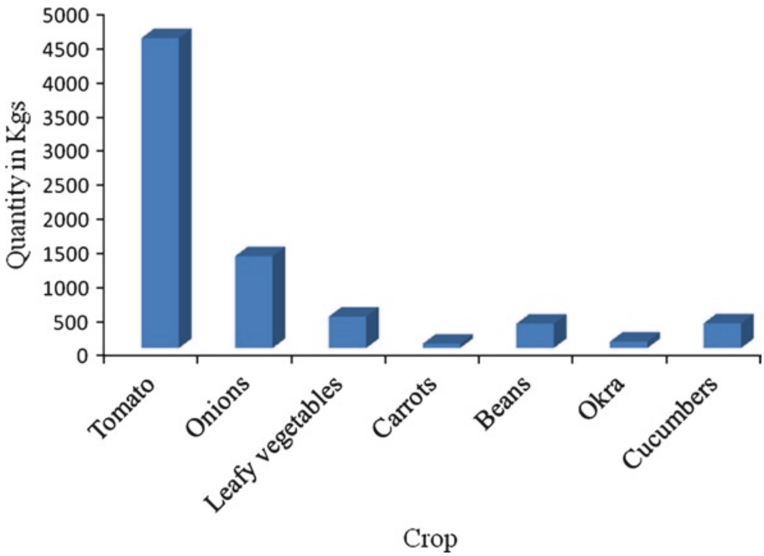


**Fig. 22.2** Average annual vegetable output per household per acre

sections of dryland fields are put under irrigation production during the winter period. This is achieved by constructing small dams upslope of river channels and siphon water into their fields using gradient induced pressure hosepipes. In order to reduce costs, farmers with adjacent fields formed teams, pooled together their resources and bought irrigating pipes extending up to 4 km. Constructed irrigating pipes pass through farms of farmers who have contributed in investment towards the project.

Farmers introduced the principle of water sharing, whereby watering is done during designated time for each farmer. Water sharing prompted watering of vegetables during the evening in order for farmers to replenish and maintain moisture in their fields. This again means that farmers managed to put large hectares of land under vegetable farming throughout the year. However, some farmers use garden cans and buckets to water vegetables from small dams in their gardens. Mulching is done using crop residue, grass and leaves from pastures to reduce excessive loss of moisture in summer due to high temperatures experienced in the area.

As a result of shortage and high costs incurred in acquiring farming inputs, farmers now generate seeds for selected crops such as tomatoes, beans, cucumbers and leafy vegetables from previous yields. Eighty-five percent of the farmers primarily use organic manure from composts, cow dung and tree leaves to improve vegetable output levels. Despite their lack of formal knowledge on environmental issues, farmers are practicing environmentally sound techniques. On average, each farmer uses 3,000 kg of organic manure for all vegetables grown per season. However, inorganic fertilizers are used to supplement organic manure despite their high costs and shortage on the market. Generated organic manure especially from composts is sometimes not adequate to cover large portions of land under vegetable cropping. Fifteen percent of the farmers resorted to use inorganic fertilizers, and these were mainly high producers, therefore had the liquidity to procure adequate chemicals. There are wide variations in applications of inorganic fertilizer amongst farmers as this depends on the soil type being treated, even when different soil types coexist in the same field.

Pesticides are intensively used to control problem horticultural pests to enhance quality, and therefore a fair price on the market. Competition on the urban market is quite stiff since the farmers involved have suddenly increased due to the economic hardships currently obtaining, and therefore poor quality products are easily outcompeted and therefore fetch very low prices or fail to sale at all. Thirty-seven percent of the farmers indicated that crop diseases are more rampant in summer due to humid and hot conditions. However, they use agro-chemicals to control outbreaks of pests and diseases. All farmers agreed that vegetable farming is less costly during winter as crops are less vulnerable to diseases as a result of cool and dry conditions.

## *4.5 Contribution of Vegetable Outputs to Dietary Diversity*

Horticultural outputs can be categorized into direct and indirect consumption. Vegetable outputs remain the main source of food nutrients for the majority of households in the study area. All vegetables produced by farmers are primarily used

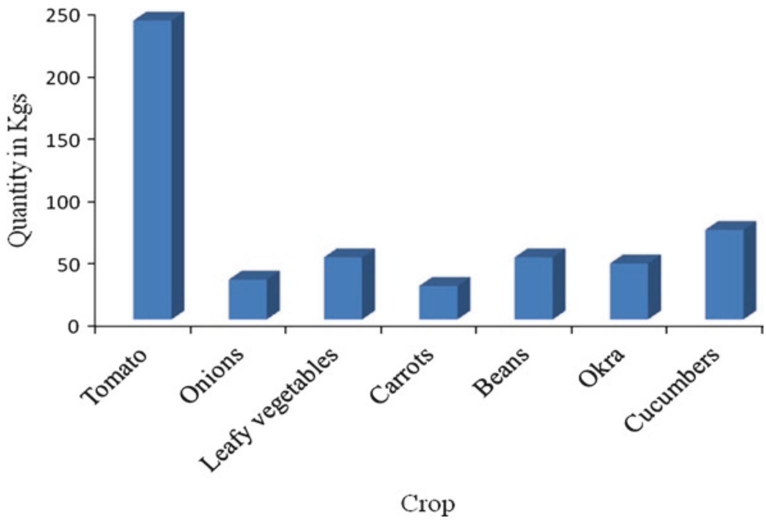


**Fig. 22.3** Household vegetable consumption per season

for family consumption. However, the bulk of vegetable produce is channeled into local and urban markets. Average amount of vegetables directly consumed by each household per season were quantified (Fig. 22.3). Tomato is the most consumed crop as it is an important ingredient in almost all the basic daily meals. Other vegetables like beans, onions, okra and leafy vegetables are less frequently consumed since they alternate with other foodstuffs.

Vegetable farming transformed the communities' food consumption patterns since inception of small-scale intensive farming in mid-1990s. However, the impact on households' food availability, access and consumption became more pronounced at the turn of the twenty-first century as more people became involved. Ninety-six percent of households now afford at least three basic decent daily meals with nutritious components such as meat, bread, butternuts among others that a lot of other rural households cannot afford. However, the main challenge associated with some horticultural crops grown in this area is their seasonality. Crops such as sweet potatoes and yams are summer crops that become mainly available after harvesting in winter, whilst butternuts become available for consumption in summer. This brings about fluctuation in the availability and composition of food whilst at the same time guarantees the availability of food throughout the year though of varying types and nutritional composition.

Ninety-six percent of households' food for lunch is more identical to what they consume at breakfast. Two major explanations were given for the duplication in meals at breakfast and lunch. The new food culture emerged as farmers now spend most of their daytime in the fields. Tea preparation has been considered as less time consuming and less laborious as it mainly involves boiling of water. This is contrary to the conventional food consumption pattern whereby thick porridge traditionally known as *"sadza"* was consumed at lunch. Scarcity of mealie-meal in the country in year 2008 also compelled farmers to adopt this consumption pattern.

Sadza meals were mainly limited to supper due to scarcity of mealie-meal in the country in year 2008. Relish for sadza meals is composed of beans, leafy vegetables and meat from family's domesticated animals and local butcheries. Since the inception of the current practice of vegetable farming, 96 % of the families now afford at least three decent meals per day in the order of breakfast, lunch and supper. This is different from the previous food culture whereby non vegetable growing families were assured of at most two meals supplemented by seasonal wild fruits.

## *4.6 Contribution of Vegetable Sales to Household Income*

The research revealed that the average annual income from sales for each household is equivalent to US$10,089.04 and US$1,831.77 at official and parallel market rates respectively. This translates into US$27.64 for official rate conversions and US$5.02 for parallel market rates as daily expenditure for each household. Since the average number of persons in each household is 4.51 (Central Statistical Office 2002), an individual's daily income is US$6.13 and US$1.11 basing on official and black market rates respectively. These figures do not embrace monetary value for output directly consumed from fields by households (Table 22.1).

Total value for produce from direct consumption is US$3,578.46 (parallel market rates) and US$19,468.04 (official market rates) (Table 22.1). Therefore, combined monetary value of vegetable produce from both direct consumption and sales is US$5,410.23 and US$29,557.08 for parallel and official market rates respectively. These translate into US$14.84 for parallel market rates and US$81.09 for official market rates as daily household income. Therefore individual daily expenditure is US$3.29 and US$17.98 for parallel and official market rates respectively in a country where more than 80% of population is living on less than US$2 a day (Distressed Volatility 2008). This showed that vegetable farming has transformed both household and individual income for farming families.

Tomatoes, onions and beans distinguished themselves as major income crops for the families in Chikwira and Manyika wards (Fig. 22.4). The pattern emerged

**Table 22.1** Monetary value for vegetable produce directly consumed from farms

| Crop | Annual household consumption (kg) | Parallel market price in (US$) per kg | Total parallel market price (US$) | Official market rate price in (US$) per kg | Total official market price (US$) |
|---|---|---|---|---|---|
| Tomatoes | 960 | 2.67 | 2563.20 | 14.70 | 14,112.00 |
| Onions | 128 | 0.50 | 64.00 | 2.76 | 353.28 |
| Beans | 200 | 0.23 | 44.00 | 1.24 | 248.00 |
| Leafy vegetables | 192 | 2.88 | 552.96 | 15.88 | 3,048.96 |
| Carrots | 108 | 0.37 | 39.96 | 2.03 | 219.24 |
| Okra | 180 | 0.55 | 99.00 | 7.60 | 1,368.00 |
| Cucumbers | 288 | 0.75 | 215.34 | 4.12 | 118.56 |
| Total | 2,048 | | 3,578.46 | | 19,468.04 |

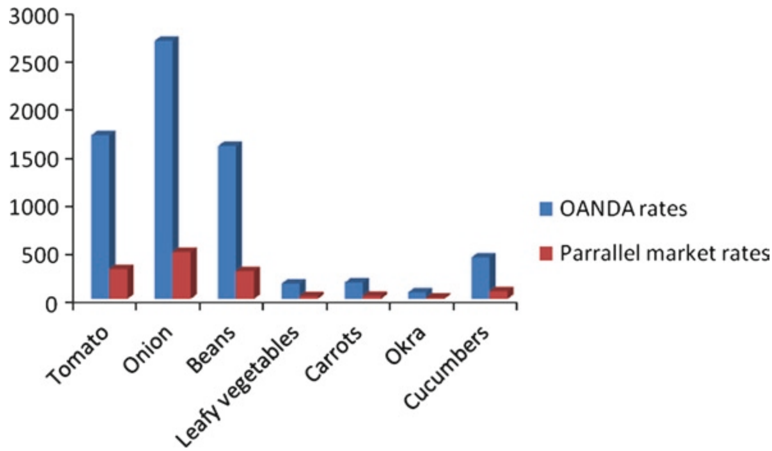


**Fig. 22.4** Average annual income per crop per household from sales

because tomatoes are grown annually and have got multiple harvests. Onions and beans have high market value irrespective of their low yield quantities compared to tomatoes. Income from leafy vegetables and okra is low, as these are mainly sold locally where prices are relatively low compared to urban market where the bulk of other crops are marketed.

## 4.7 Use of Income from Vegetables by Households

Questionnaire survey results indicated that 73% of the families acknowledged that vegetable farming significantly improved their income status. The communities' income is used for purchasing and supplementing basic non-vegetable household requirements in order to boost their nutritional status. Ability to purchase non-vegetable products has improved the families' food quality and nutritional diversity. In these days of HIV/AIDS prevalence, growing of vegetables is contributing significantly to balanced diet required by AIDS patients.

Moreover, in the event that families have acquired enough food for consumption, income is used to buy assets such as farming implements, livestock, furniture, housing construction and to meet other social requirements such as paying for school fees and medical expenses. Accumulated assets act as security to buy food in times of food shortage, especially due to climatic constraints as in 2007–2008 farming season when the country experienced an early and abrupt end of rains midway through the rain season. Some income is used to meet social obligations such as paying for outstanding lobola or investing in their children's education and entertainment. However, 13% of the farmers could not ascertain their positions regarding contribution of vegetable farming to their income as continuous hyperinflation in the country was triggering market price fluctuations rendering their profits negligible.

### 4.8 Challenges Encountered by Households in Vegetable Farming and Marketing

Notwithstanding the fact that vegetable faming has transformed local communities' livelihoods, their activities have not been spared by national economic meltdown experienced in Zimbabwe. Farmers rely on hired transport to ferry their products to the market. Therefore, fuel shortages and high costs for transport maintenance resulted in transport shortage and high expenses for hiring. Some of the unpaved roads become inaccessible during the rain season, further affecting the timeous transportation of the perishable horticultural products from the area. This has resulted in vegetable output losses due to rotting as a number of days elapse before their produce is transported. In some cases, high inflation rates erodes all income, as fluctuating market prices makes profit insignificant as it would be used to meet production and transport costs only.

Since the area has predominantly poor soils, high costs and shortage of inorganic fertilizers signals that farmers retain low yields than expected due to limited soil nutrients. High costs for chemicals to spray pests and diseases meant increased output losses as a result of their absence. Uncontrolled domestic animals during winter also account for substantial destruction in vegetable crops. Loss in output is compounded by rampant thefts by people who do not reside in these communities' vicinity.

## 5 Conclusion

Commercialized small-scale vegetable farming system has had a positive impact on rural food security and livelihoods in the study area. This is clearly evidenced by improved socio-economic status of households involved in market gardening. Farming families improved on food availability and consumption patterns as a result of increased income and assets accumulation. The significance of vegetable farming as a survival strategy in Chikwira and Manyika wards shows that sustainable reduction in hunger can be achieved in the context of supporting local initiatives. However, financial, mechanical and technical support needs to be given to families in order to boost farming production from current levels and reduce gross vegetable output losses incurred. Lastly, local communities must integrate indigenous crops due to increased experienced changes in weather conditions and need to improve nutritional security for HIV/AIDS related illness.

## 6 Policy Considerations or Recommendations

- Training farmers on proper storage, use and application of chemicals to reduce negative environmental impacts and on personal safety.
- Training farmers on budgeting, grading, packaging and marketing for them to expand supply to big retail shops which sale fresh products.

– Formation of social organizations or clubs to draw sponsorship for projects improvement (e.g. buying of own transport for members to ferry produce to market).
– Improvement in mechanization in order for farmers to enhance productivity and increase competitiveness on market (e.g. they must buy engines to efficiently pump water to irrigate dryland fields upslope).

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# Chapter 23
# Changes in Agricultural Landscape: Some Ecological Implications for Sustainable Agriculture in Indian Punjab

**Davinder Kumar Grover**

**Abstract** During the post green revolution period (mid-1960s), owing to major technological breakthrough along with the availability of adequate marketing infrastructure and price support policy led to a rapid shift in the agriculture landscape and food production patterns. The present paper broadly aimed to study the trend towards specialized and resource exhaustive food crops in Punjab and its several adverse effects on environment, ecological/hydrological balance and human health, etc. and possibilities of resource conserving technologies for sustainable agriculture in the state. To accomplish the objectives, both primary and secondary data have been used. Published and unpublished research reports, various journals, magazines, newspapers and research bulletins were also used to study the gravity of the problem. The data pertaining to area under different crops in the state was obtained from various issues of Statistical Abstract of Punjab from 1960–1961 to 2007–2008. Shifts in cropping pattern were analyzed by comparing the percentage of net cultivated area under different crops for different periods of time. Two measures of crop specialization/diversification were used viz., Herfindahl Index and Entropy Index. The measures were compared overtime to study the trend of specialization/diversification in the state. The study has witnessed the emergence of rice–wheat monoculture in the state leading to fast decline of ground water as 85% of area of the state has been facing the problem of falling water table. The fertility of Punjab soils has diminished over the years with deficiency of all the micro and macronutrients. Resource conserving technologies and organic matter management practices that enhance resource/input use efficiency for better utilization of natural resources and hence the sustainability are now being considered more seriously than ever before. The adoption of select resource conserving technologies such as zero tillage, bed planting and laser leveling in the state has already been initiated, though at slower pace. There is a need to identify the constraints inhibiting

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_23,

such technologies and solutions thereof. To accomplish such goals, it is essential to develop multidisciplinary approach in production agriculture by involving the fields of sociology, anthropology, environmental sciences, and economics for the development of a sustainable agriculture and food system.

**Keywords** Ecological problems • Agricultural sustainability • Zero tillage • Soil fertility • Environment • Resource conservation technology

## 1 Introduction

Punjab is a state in northwest India. Punjab (India) borders Punjab (Pakistan) to the west, Jammu and Kashmir to the north, Himachal Pradesh to the northeast, Haryana to the south and southeast, Chandigarh to the southeast and Rajasthan to the southwest. The total area of the state is 50,362 km$^2$ (19,445 square miles). The population is 24,289,296 (2000). Punjab is one of the smallest states of India occupying only 1.53% of the geographical area of the country. The cultivated area forms about 84% of the total reporting area of the state and possibilities of its further expansion are almost negligible. The cropping intensity increased from 126% in 1960–1961 to 189% in 2007–2008, particularly due to adjustment timings of paddy and wheat production periods. The state has been contributing around 40–50% of rice and 60–70% wheat to the country's food kitty and thus is popularly known as the food basket of India.

In view of serious food problem which the country faced after independence (1947), production of cereals was accorded a top priority. The state made significant contribution by changing the agricultural landscape and food production pattern and productivity improvement of cereal crops specifically wheat and rice. During the post green revolution period (mid-1960s), owing to major technological breakthrough along with the availability of adequate marketing infrastructure and price support policy led to a rapid shift in the agriculture landscape and food production patterns that favoured rice and wheat crops. The rice cultivation did not confine only to the traditional rice belt rather spread over to other districts with adequate infrastructure and irrigation facilities.

## 2 Objectives

The study has been conducted keeping in view the following specific objectives:

- To study the trend towards specialized and resource exhaustive food crops in Punjab;
- To examine several adverse effects of specialized farming on environment, ecological/hydrological balance and human health;
- To explore the possibilities of resource conserving technologies for sustainable agriculture in the state.

# 3 Methodology

For the purpose of this investigation, both primary and secondary data have been used. Published and unpublished research reports, various journals, magazines, newspapers and research bulletins were also used to study the gravity of the problem. The data pertaining to area under different crops in the state was obtained from various issues of Statistical Abstract of Punjab from 1960–1961 to 2007–2008. Then the percentage of area under different crops to the net cultivated area was calculated. Shifts in cropping pattern were analyzed by comparing the percentage of net cultivated area under different crops for different periods of time. Two measures of crop specialization/diversification were used viz., Herfindahl Index and Entropy Index. The measures were compared overtime to study the trend of specialization/diversification in the state.

Herfindahl Index (H.I.)

$$\text{H.I.} = \sum P_i 2 \quad (\text{i} = 1 \text{ to N})$$

Where N is the total number of crops and $P_i$ represents the acreage proportion of ith crop in the gross cropped area. The Herfindahl Index is bound by zero and one. Actually, it is a measure of concentration. It becomes one with perfect specialization and its value decreases as diversification increases.

Entropy Index (E.I.)

$$\text{E.I.} = \Sigma P_i \log(I / P_i) \quad (\text{i} = 1 \text{ to N})$$

This is an inverse measure of concentration. The index increases with increase in diversification and approaches zero when there is a perfect concentration. In order to accomplish the third objective of the study, informal survey through participatory appraisal (PA) was conducted in Patiala district of Punjab during 2006 to identify key issues at community level in relation to conservation agriculture issues with emphasis on institutions, drivers and modifiers.

# 4 Results and Discussion

Results have been mainly discussed under the following sub heads:

- Trends towards specialized farming
- Manifestation of several adverse effects
- Resource conserving technologies for sustainable agriculture
- Policy options for rapid adoption of resource conservation technologies:

## *4.1 Trends Towards Specialized Farming*

Owing to major technological breakthrough along with the availability of adequate marketing infrastructure and price support policy, a rapid shift has been

**Table 23.1** Temporal shifts in the cropping pattern in Indian Punjab, 1960–1961 to 2007–2008 (% cropped area)

| ↓ Crop Year → | 1960–1961 | 1970–1971 | 1980–1981 | 1990–1991 | 1997–1998 | 2007–2008 |
|---|---|---|---|---|---|---|
| Paddy | 6.06 | 9.62 | 28.22 | 47.77 | 54.20 | 62.64 |
| Maize | 8.72 | 13.69 | 7.25 | 4.34 | 3.99 | 3.68 |
| Bajra and jowar | 3.43 | 5.23 | 1.66 | 0.28 | 0.11 | 0.14 |
| Groundnut | 1.78 | 4.29 | 1.98 | 0.27 | 0.21 | 0.11 |
| Cotton | 11.92 | 9.79 | 15.49 | 16.61 | 17.30 | 14.51 |
| Sesamum | 0.21 | 0.36 | 0.40 | 0.43 | 0.34 | 0.23 |
| Sugarcane | 3.55 | 3.17 | 1.69 | 2.38 | 3.07 | 2.37 |
| Kharif pulses | 0.67 | 0.81 | 1.39 | 1.74 | 1.55 | 0.60 |
| Wheat | 37.33 | 56.72 | 67.10 | 77.60 | 78.52 | 82.86 |
| Barley | 1.77 | 1.41 | 1.55 | 0.87 | 0.94 | 0.45 |
| Gram | 22.35 | 8.84 | 6.16 | 1.42 | 0.32 | 0.09 |
| Rapeseed and mustard | 2.85 | 2.54 | 3.24 | 1.64 | 1.67 | 0.98 |
| Linseed | 0.08 | 0.07 | 0.05 | 0.02 | – | 0.005 |
| Lentil | 0.81 | 0.32 | 0.48 | 0.23 | 0.11 | 0.10 |
| Sunflower | – | – | – | 0.12 | 1.33 | 0.37 |
| Tobacco | – | – | 1.66 | – | – | – |
| Potato | 0.24 | 3.03 | 0.95 | 0.55 | 1.24 | 1.82 |
| Chillies | – | 0.42 | 0.31 | 0.05 | 0.09 | 0.03 |
| Other vegetables | 0.01 | 0.57 | 0.56 | 0.73 | 2.02 | 0.81 |
| Fruits | 1.12 | 1.23 | 0.69 | 1.64 | 2.15 | 1.36 |
| Fodders and other crops | 23.29 | 17.97 | 20.51 | 19.16 | 18.07 | 17.89 |
| Net cultivated area (000 ha) | 3,750 | 4,053 | 4,191 | 4,218 | 4,204 | 4,184 |

Source: Based on the data collected from various issues of Statistical Abstract of Punjab

observed in the agriculture landscape and food production patterns that favoured rice and wheat crops. Consequently, the area under rice which was only 6.04% of cultivated area in kharif (summer) season during 1960–1961 increased to about 66% in 2007–2008 at the cost of the area under the crops like maize, millets, groundnut and recently cotton. Similarly, in rabi (winter) season, cultivated area under wheat increased from only 37.26% in 1960–1961 to 86.34% in 2007–2008 at the expense of the area under oilseeds, gram and other pulses (Table 23.1). This shift in crop pattern in favour of wheat and rice was mainly because of being these crops, more stable and remunerative. Production of wheat increased from 1.74 million tonnes in 1960–1961 to 14.42 million tonnes in 2007–2008. Similarly the production of rice increased from 0.23 million tonnes to 9.66 million tonnes during the same period. Hence production pattern in Punjab State has become predominantly a monoculture of rice – wheat rotation – highly water and nutrients exhaustive crops.

## 4.2 Indices of Crop Specialization/Diversification

The trend of values of the Herfindahl and Entropy indices calculated from 1960–1961 to 2007–2008 were studied (Table 23.2). It emerged that more or less there was an increasing trend in the values of Herfindahl index and continuous decline in the value of Entropy index from 1960–1961 to 2007–2008. Analysis has brought out that Punjab agriculture has become highly specialized in wheat and rice cultivation. It is largely due to the reason that green revolution came mainly in terms of rice and wheat. The introduction of high yielding varieties of these crops during the green revolution period resulted in significant increase in their yields. At the same time, the government also adopted a proactive price policy towards these two crops as economy was not self sufficient in cereals. Thus farmers started shifting towards rice – wheat rotation due to stability in terms of prices as well as yields of such crops. On the contrary, area under other crops like maize, bajra, jowar, groundnut, gram, barley and lentil had fallen rapidly.

## 4.3 Manifestation of Several Adverse Effects

Since the sixties, the agricultural policy of the country has remained focused on increasing agricultural production especially of food grains. Adoption of production augmenting technologies in Punjab agriculture has led to growth related economic, health and environmental problems. The high growth rate of production and productivity of various crops was at the cost of degradation of scarce resources. The technology encompassing intensive cultivation, high use of agro-chemicals, greater requirements of water and rapid growth of mechanization has resulted in manifestation of several adverse effects on environment and ecological balance. The present section examines such critical issues.

### 4.3.1 Depletion of Ground Water Resources

The spectacular increase in agricultural production in Punjab has been made possible due to expansion of irrigation net work covering about 98% area in 2007–2008 as compared to only 54% in 1960–1961. Water is a single largest threat to the human health, environment and global food security. In modern agriculture, water is an

**Table 23.2** Trend of specialization/diversification indices in Indian Punjab, 1960–1961 to 2007–2008

| Index | 1960–1961 | 1970–1971 | 1980–1981 | 1990–1991 | 1997–1998 | 2007–2008 |
|---|---|---|---|---|---|---|
| Herfindahl index | 0.1715 | 0.2074 | 0.2335 | 0.2840 | 0.2771 | 0.3123 |
| Entropy index | 0.8975 | 0.8959 | 0.8262 | 0.7006 | 0.7110 | 0.6945 |

**Table 23.3** Area under different water table depth in Indian central Punjab: 1973 and 2004

| | Percent area | |
|---|---|---|
| Water table depth (m) | 1973 | 2004 |
| 0–5 | 39 | 0 |
| 5–10 | 58 | 10 |
| >10 | 3 | 90 |

Source: Department of Soils, PAU, Ludhiana (2004)

essential ingredient. In Punjab, the use pattern and management strategies owing to its wasteful over exploitation leading to dire consequences. The over exploitation of water is due to increase in the number of tubewells from 1.92 lakh in 1970–1971 to about 12 lakh in 2007–2008. With rapidly depleting groundwater levels and an erratic rainfall pattern, water is rapidly becoming scarce resource at national level. Hence the conservation and management of water is essential for the sustenance of living population on the earth. The rice-wheat rotation has disturbed the general water balance of the state and raised the question of sustainability of rice-wheat cropping system. At present, the major concern is the decline of ground water as 85% of area of the state is facing the problem of falling water table. Most of this area lies in central part comprising Ludhiana, Patiala, Sangrur, Jalandhar, Amritsar, Kapurthala, Moga and Fatehgarh Sahib districts of Punjab. In the central Punjab, the area having water table below 10-m depth has increased from 3% in 1973–90% in 2004 (Table 23.3).

### 4.3.2 Deteriorating Soil Fertility

The high nutritional requirements of rice and wheat, the major crop rotation in the state has exhausted the soil of nutrients. Resultantly, Punjab state which has just around 3% of cultivated area accounts for about 10% of total chemical fertilizer consumption in the country. The state is adding 1,299 thousand tonnes of nitrogen, 354 thousand tonnes of phosphorus and 39 thousand tonnes of potassic fertilizers to the soil annually. The use of chemical fertilizers in the state has gone up many times from 213 thousand tonnes in 1970–1971 to 1,692 thousand tonnes in 2006–2007 (Table 23.4). More of the basic elements of the soil have been extracted than what has been added. The fertility of Punjab soils has diminished over the years with deficiency in nitrogen and phosphorus (Table 23.5). This was soon followed by deficiency of zinc during 1970s and other nutrients like potash, manganese and sulphur during 1980s. Above all, the deficiency of copper was also visualized since 1990s. Thus, it is clear that the present farming system is not sustainable as the soil is deficient of all the micro and macronutrients.

### 4.3.3 High Use of Insecticides and Pesticides

The use of various production protection chemical inputs has increased manifold in Punjab agriculture since the inception of green revolution due to the emergence of variety of insects, pests and new generation of weeds. The consumption of insecticides

**Table 23.4** Consumption of chemical fertilizers in Indian Punjab: 1960–2007 (‘000 metric tonnes)

| Year | N | P | K | Total NPK | Per hectare cropped area Punjab | India |
|---|---|---|---|---|---|---|
| 1960–1961 | 5 | 0 | 0 | 5 | 1.1 | |
| 1970–1971 | 175 | 31 | 7 | 213 | 38.2 | |
| 1980–1981 | 526 | 207 | 29 | 762 | 112.7 | |
| 1990–1991 | 877 | 328 | 15 | 1,220 | 162.7 | |
| 2000–2001 | 1,008 | 282 | 24 | 1,314 | 165.3 | 88.0 |
| 2001–2002 | 1,070 | 308 | 29 | 1,407 | 177.2 | 91.5 |
| 2002–2003 | 1,111 | 299 | 31 | 1,441 | 184.1 | 84.8 |
| 2003–2004 | 1,170 | 335 | 38 | 1,543 | 195.2 | 89.8 |
| 2006–2007 | 1,299 | 354 | 39 | 1,692 | 215.2 | 90.4 |

Source: Statistical Abstracts of Punjab: Various issues

**Table 23.5** Soil deficiency in Punjab during various decades

| Decade | Deficiency |
|---|---|
| During 1960 | Nitrogen |
| During 1970 | Nitrogen + potash + zinc + phosphrous |
| During 1980 | Nitrogen + potash + zinc + phosphorous + manganese + sulphur |
| During 1990 | All the above + copper |
| During 2000 | All the above |

**Table 23.6** Consumption of insecticides/pesticides in Indian Punjab: 1960–2007

| Year | Insecticides/pesticides consumption (tonnes) | Technical grade (kg/ha) |
|---|---|---|
| 1960–1961 | 624 | 0.132 |
| 1970–1971 | 2,215 | 0.390 |
| 1980–1981 | 3,200 | 0.473 |
| 1990–1991 | 6,500 | 0.867 |
| 2000–2001 | 7,005 | 0.883 |
| 2002–2003 | 6,400 | 0.818 |
| 2006–2007 | 6,500 | 0.866 |

and pesticides has increased from 624 tonnes during 1960–1961 to 6,400 tonnes in 2002–2003 (Table 23.6). This increase is more than ten times during the five decades. Further, per hectare use of chemicals in technical grade has increased from 0.132 to 0.818 kg during the above-mentioned period. As the cropping intensity has been increasing over a period of time, the over utilization of land created the problem of weeds in wheat and rice crops. Some new weeds have also emerged in some pockets of the state. Swank, a less prevalent weed of rice in 1970 has become predominant now. Similarly, Phalaris minor has assumed epidemic proportions in wheat crop. The use of weedicides has increased considerably in case of these two crops. Punjab accounts for 60% of the total weedicides consumption in India. More than 90% of rice and wheat growers use weedicides. The insect-pests have become resistant to

**Table 23.7** Pesticide residue commonly detected in different food commodities in Indian Punjab, 2003

| Sr. | Food | Pesticide(s) detected |
|---|---|---|
| 1. | Milk | DDT and HCH |
| 2. | Cereals | DDT and HCH |
| 3. | Animal feed and fodder | DDT, HCH, malathion, endosulfan, dicofol |

agro chemicals. Therefore, the farmers are using various insecticide mixtures, which pose a serious threat for farming in the state as farmers also re-use pesticide containers as utensils for food and drinking purposes.

#### 4.3.4 Poisoning Food Commodities

Overuse of harmful insecticides/pesticides/weedicides in such crops leads to intake of harmful pesticides by unaware consumers (Dhaliwal et al. 2003). Pesticide residue commonly detected in different food commodities in Punjab are shown in Table 23.7.

#### 4.3.5 Environmental Pollution

This high growth of area under rice replaced the areas under pulses, cotton and fodder crops. This replacement creates soil degradation at a large scale as legume crops made the soil fertile, which were replaced by the rice crop. Further, the post management of loose straw left after combine harvesting of paddy pollutes environment and is detrimental to health. Burning of 14 million tonnes of paddy straw creates a lot of air pollutions that is very harmful for the health of human beings. Thus, the paddy crop itself and the burning of its straw is harmful for the environment and human health.

### *4.4 Resource Conserving Technologies for Sustainable Agriculture*

Lately, the rice-wheat cropping system is experiencing stagnant or declining grain yields, falling water tables and soil degradation (Kumar et al. 1999; Pingali and Shah 1999). These threats are being addressed by the Rice-Wheat Consortium (RWC, www.rwc.cgiar.org) through research on resource-conserving technologies (RCTs, including zero-tillage, permanent beds and mulching) within the context of conservation agriculture. Although the adoption of zero/minimum tillage in wheat is spreading fast, adopters often do so without retaining significant amounts of crop residues as mulch. In part, this seems to relate to practical difficulties with crop residue management, particularly in view of changes in harvesting practices (use of combiners) and the current zero-till drills in use. However, even without zero-tillage, the practice of burning crop residues is common in certain locations (Gupta et al. 2004; Sidhu et al. 1998). The crop residues are also removed for use in agro-based industries and as household fuel and building material. However, the most important factor appears to be that crop residues are an important source of fodder for both landed and landless livestock keepers. Applying conservation agriculture practices typically implies the need to retain crop residues on the soil surface, which reduces the availability of crop residue for livestock production. Thus, to adopt conservation agriculture practices, farmers face trade-offs between crop and livestock production. Retention of crop residue in the field improves the soil organic matter content and hence the soil fertility.

*Use of resource conserving technologies (RCTs)*: RCT usage by household group in the surveyed area has been depicted in Table 23.8. Zero tillage and reduced tillage were the only RCTs used in the study area and that too only for wheat crop. These RCTs were found to be more prevalent on the large farms. In case of large farms, 15.50% households were practicing zero tillage for wheat fully or partially on 21.35% of total wheat area, while only 9.60% small farmers were using this technology on 8.65% wheat area. Reduced tillage practice was found to be more common among the large farmers. About 43% of them were adopting this practice on 44% area, while only 4.68% of small farmers used reduced tillage on only 5.5% wheat acreage in the surveyed area.

*RCT usage by villages type*: RCT usage by village type has highlighted that in RCT villages, 15.3% and 24.83% households adopted zero tillage and reduced tillage respectively for wheat cultivation. Contrary to it, only 1.91% and 0.63% households adopted zero tillage and reduced tillage in Non- RCT villages. Similarly, with regard to the area under RCTs it was found that 15.52% area was under zero tillage, 13.4% under reduced tillage in RCT villages as compared to only 1.2 and 0.28% in the Non-RCT villages (Table 23.9).

*RCT usage by remoteness*: RCT usage by remoteness has been shown in Table 23.10. It has been observed that RCT practices were being adopted in far villages with much more vigor. In far villages 17.5% households were adopting

**Table 23.8** RCT usages by household group, sample villages Patiala, Indian Punjab, 2006

| | | Share of hh adopting [%][a] | | Share of area used [%][b] | |
|---|---|---|---|---|---|
| RCT | Crop | Large farmer (n=6) | Small farmer (n=6) | Large farmer (n=6) | Small farmer (n=6) |
| Zero-tillage | Wheat | 15.50 | 9.60 | 21.35 | 8.65 |
| Direct dry seeded | Rice | – | – | – | – |
| Direct wet seeded | Rice | – | – | – | – |
| Reduced tillage | Wheat | 43.10 | 4.68 | 44 | 5.5 |
| | Rice | 14.35 | 0.24 | 3.9 | 0.06 |
| Bed-planting | Wheat | 0.48 | – | 0.12 | – |
| | Rice | 0.24 | – | 0.01 | – |

[a]Calculated as (No. of large/small hh adopting)/(Total no. total large/small farm hh)
[b]Calculated as (Area used)/[(Total village area) × (Wheat or rice area share)]

**Table 23.9** RCT usages by village type, sample village, Patiala, Indian Punjab, 2006

| | | Share of hh adopting [%][a] | | Share of area used [%][b] | |
|---|---|---|---|---|---|
| RCT | Crop | RCT | Non RCT | RCT | Non RCT |
| Zero-tillage | Wheat | 15.3 | 1.91 | 15.52 | 1.2 |
| Direct dry seeded | Rice | – | – | – | – |
| Direct wet seeded | Rice | – | – | – | – |
| Reduced tillage | Wheat | 24.83 | – | 34 | – |
| | Rice | – | 0.63 | – | 0.28 |

[a]Calculated as (No. of large/small hh adopting)/(Total large/small farm hh) * 100
[b]Calculated as (Area used)/[(Total village area) × (Wheat or rice area share)]

**Table 23.10** RCT usages by village remoteness, sample villages, Patiala, Indian Punjab, 2006

| | | Share of hh adopting [%][a] | | Share of area used [%][b] | |
|---|---|---|---|---|---|
| RCT | Crop | Near villages | Far villages | Near villages | Far villages |
| Zero-tillage | Wheat | 4.21 | 17.5 | 7.8 | 16.1 |
| Direct dry seeded | Rice | – | – | – | – |
| Direct wet seeded | Rice | – | – | – | – |
| Reduced tillage | Wheat | 11.22 | 34.1 | 11.9 | 33.7 |
| | Rice | 0.28 | – | 0.28 | – |
| Bed-planting | Wheat | 0.56 | – | 0.46 | – |
| | Rice | 0.28 | – | 0.05 | – |

[a]Calculated as (No. of large/small hh adopting)/(Total no. total large/small farm hh)
[b]Calculated as (Area used)/[(Total village area) × (Wheat or rice area share)]

zero tillage and 34.1% reduced tillage. On the other hand, 4.21% and 11.22% households adopted zero tillage and reduced tillage practices for wheat cultivation in near villages. About 50% area under wheat in far villages was subject to RCT in the form of zero or reduced tillage, whereas, only 20% wheat area was found under the RCTs in near villages. It is interesting to note that the practice of bed planting was introduced both on wheat and rice, though marginally in the near villages. Such practice was found totally absent in far villages.

*Reasons/Constraints of adoption of RCT*: Reasons/constraints regarding adoption of RCT as reported by various holding size groups in sample villages have been appended (Table 23.11). Cost reduction, better return, input saving, less pollution and diseases-resistance were the reasons, reported by large farmers. Small farmers were of the view that the resource conservation was the basic reason behind the RCT adoption. Landless group apprehended that the farmers adopted RCT, being environment friendly due to less consumption of diesel. Despite the multi benefits of RCT, it couldn't be rapidly adopted in the sample villages owing to various hindrance/obstacles such as poor germination/poor yield after some year, non-availability of required machinery, lack of awareness among the farmers and risk averting attitude of new experiment/technologies of the farmers. It was also reported that zero tillage was not suitable on heavy/hard soils due to compactness. Water management becomes more critical with such practices. The landless group has felt that squeezing land operations would cause unemployment in the study area.

**Table 23.11** Reasons/Constraints regarding adoption of RCT, as reported by various holding size groups in sampled villages, Patiala, Indian Punjab, 2006

| Group type | Reasons for adoption | Constraints for adoption |
|---|---|---|
| Large | Cost reduction, more returns, inputs saving, less pollution and disease resistance | Soil quality is not good, water management become more critical, no faith in RCT, poor germination/poor yield after some years and non availability of machinery |
| Small | Resources conservation | Risk averter of new experiment/technologies |
| Landless | Less diesel required and improved environment | RCT can save money but lack of awareness and availability of machines are not sufficient which reduced its adoption. Also caused unemployment |

**Table 23.12** Reasons for disadoption of RCT, as reported by various holding size groups in sampled villages, Patiala, Punjab, 2006

| Group type | Percent farmers | Reasons for disadoption |
|---|---|---|
| Large | 33.3 | Poor germination, reduction in yield after 2–3 years in case of zero tillage |
| Small | – | No disadoption because it is started by them for the first year |

**Table 23.13** General observations on RCT, as reported by various holding size groups in sampled villages, Patiala, Indian Punjab, 2006

| Group type | General observations |
|---|---|
| Large | Reduction in cost/time saving, low yield, no much exposure, and non availability of required machinery |
| Small | In coming year more area will be under RCT |
| Landless | Zero tillage could cause unemployment |

*Disadoption of RCT*: No case was found of disadoption of RCT among small farmers in the sample villages, as most of them started RCT for the first year only. Because of poor germination and reduction in yield after 2–3 years, 33.3% large farmers disadopted zero tillage in the region (Table 23.12).

*General Observations about RCT*: Large farmers observed that due to inadequate exposure, non-availability of required machines and lower yield after 2–3 years had been the major hindrances in the fast adoption of zero tillage. Small farmers felt that because of reduction in cost/time saving, more area will be under RCT in coming years. Landless group though apprehended the adverse effect of RCTs on employment opportunities in the sample areas (Table 23.13).

## *4.5 Potential and Constraints for Increased Adoption of RCTS*

Excessive tillage is energy, time and cost consuming and is considered harmful to the soil health. During the past few years, scientists have suggested that physical properties favourable for plant growth are destroyed by too much tillage. The cost of hydrocarbon fuels is rising day by day and is a well-known fact that they are bound to be exhausted sooner or later. Keeping these factors in view and with a motive of timely sowing and reducing cost of production, researchers world over have studied tillage operations more closely. In general, zero tillage/minimum tillage is defined as reducing field trips by machinery for seedbed preparation to a minimum numbers. By adopting the minimum/zero tillage concept, the farmers are not only able to reduce the cost of cultivation/enhance their profit margins save a significant quantity of much needed fuel, energy and time but also it enables the farmers to sow the crop at right time. At present, a great deal of emphasis is being laid on the modernization of agriculture, with a view to raise the production per unit area, the income of the farmers under sustainable environment. The goal can be achieved only, if the scientific agricultural technology is efficiently adopted at proper time and stage by large number of farmers at their farm. Though, the farmers in Punjab have started picking up zero till technology yet its adoption level /rate has been very slow. Despite various extension campaigns during the last 5 years, the technology could be adopted only on about 5% of the area under wheat cultivation. It is important to diagnose various constraints associated with its adoption and suggest policy measures for rapid adoption of zero tillage technology in Punjab.

No doubt zero till technology is a resource conservative technology and farmers in Punjab are picking up this technology slowly and slowly. To make the adoption of this technology faster, there is a need to identify the constraints inhibiting the adoption of this technology and solutions thereof. The various constraints of this technology faced by the adopters have been identified in earlier study. About 53% of the farmers didn't report any constraint or problem worth mentioning, in adoption of the technology, and only about 47% farmers reported the problem of non-availability of the drill. About 30% farmers reported that they were not fully aware of the technology, resulting in slow technology adoption process. About 27% farmers reported that there was a problem of sowing with the zero till drill in the standing stubbles. The standing stubbles lead to the wear and tear and also the breakage of the drill, thus, they were burning the stubbles before sowing. Only 8.33% farmers reported that the depth of sowing was a constraint in their way. The zero till drill sows the seed to a depth of about 4 inch which according to them leads to non-emergence of the seed. About 30% farmers were afraid of the low grain yield. They were of the opinion that the tillage practice was necessary in the process of cultivation as their ancestors have been doing it for last so many years. Moreover, The sowing operation consumed more time on zero till farms as against the conventional farms, the reason being the formation of hardpan on the farm, thus, causing a problem while sowing operation.

### 4.6 Policy Options for Rapid Adoption of Resource Conservation Technologies

Keeping the present irrigation status in view, the prevalent production pattern does not seem to be sustainable and agricultural experts have suggested that at least 20% area under paddy must be diverted to other crops. A three – pronged strategy may be suggested in this regard. Firstly, by evolving equally/more remunerative alternatives to existing rice – wheat rotation with emphasis on biotechnology research of improved varieties of alternative crops and development of high value products. This is a long run solution. Secondly, by favourable policy measures, making alternative crops more remunerative through various economic incentives. Thirdly, by reducing water requirement of rice by avoiding early sowing, replacing rice with less water demanding crops in selected areas, judicious use of insecticides/weedicides, expanding the integrated pest management practices and promoting balanced use of fertilizers. The areas suitable for each crop should be marked properly and plant material/seed should be tested and provided by reliable government agencies. The State must initiate steps to harvesting rain water and recharge underground water aquifers.

The Agriculture Department and State Agricultural University should come forward to educate the farming community to achieve the much needed objective of sustainable and safe agriculture by encouraging the rapid adoption of resource conservation technologies. The following suggestions in this direction can help to a great extent: (1) Keeping in view the multifaceted merits of zero tillage technology, the farmers may be encouraged through providing zero till drill at subsidized rates in the beginning or making the drill available at cheap rates through the help of agricultural department or the co-operative societies. (2) Zero tillage technology represents a major departure from the past way of doing things. This implies that the whole range of management practice will need to be evolved, evaluated and matched in the context of new systems. The guidelines for the different farm operations may be published and provided to the farmers for proper crop management, the field trials may be conducted by the agricultural scientists on the farm conditions to demonstrate the various practices needed to be evolved in the technology adoption. (3) Managing zero tillage will be highly demanding in terms of knowledge base and thus, there will be a great need of extension services.

To accomplish such goals, it is essential to develop multidisciplinary approach in production agriculture by involving the fields of sociology, anthropology, environmental sciences, and economics for the development of a sustainable agriculture and food system.

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# Chapter 24
# Emerging Issues for the Formulation of Policy on Agri-Input Delivery System in Nigeria

**Gbolagade Babalola Ayoola and Josephine Bosede Ayoola**

**Abstract** In Nigeria, the perennial inefficient distribution system of farm inputs, namely fertilizer, seed and crop protection products, represents a major constraint to achieving food security. This chapter aims to determine the key issues involved in the formulation of agri-input policy for the country, and to interrogate these issues with a view to facilitating policy implementation. The analysis of agri-input delivery system was conducted within the context of a development communication framework, which had as its main elements the specific package of inputs as a policy *message*, originating from a *source* and passing through a *channel* to be delivered to a *target*. In this framework, were identified the various policy bottlenecks associated with each segment of input flow from factory gate to farm gate as a *noise,* which obstructed the free flow of the agri-input message in its passage from the source through the channel to the target. The negative consequences of these noise elements on the performance of agriculture has manifested in the status of the country as a net importer of food items combined with input import dependence on other countries of the world. The main issues under focus belonged in the political economy and governance, as well as structural and systemic categories. The conclusion reached was that a rule-based, evidence-led and internally consistent policy articulation and strategy formulation was required for enhancing the performance of the agri-input delivery system of the country.

**Keywords** Agri-input • Policy articulation • Strategy formulation • Development communication • Food security

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M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7_24,

# 1 Introduction

The production system is expressed in one economic jargon called production function, mathematically written as: $P = f(x)$. In ordinary language, this means that quantity of output is determined by quantity of input. This is how economists appreciate the role of inputs in the production process, implying that without inputs there is no output. Therefore, the efficiency of the agricultural production system depends on the efficiency of the input delivery system. And, unless the problem with the input delivery system is effectively addressed, there is no basis to expect that volume of output will grow as desired.

The problem with the agri-input delivery system of Nigeria pertains to inadequate quantity of supply, delays in supply relative to the needs of farmers and widespread nature of market sharp practices, among others. These problems form the original basis to justify policy intervention in the system. However the situation is compounded by second-generation problems of implementing the policies in terms of perennial abuse of these policies coupled with the lack of sufficient implementation commitments.

In this chapter, it is argued that poor policy formulation begets poor policy implementation. That is, good formulation is a necessary, albeit not a sufficient, condition for good implementation of agri-input policies. Thus, the goal of this chapter is to determine the key issues involved in the formulation of agri-input policy for Nigeria, and to interrogate these issues somewhat, with a view to proposing their optimal resolutions. First, after the introductory overtures (1), we survey the background of such policy issues (2), followed initially by a highlight of the policy formulation process as regards agri-inputs (3), and finally by the discussion of the issues as they emerge from previous expositions (4).

# 2 Primer of Agri-Input Policies

The need for policy intervention in the agri-input market predicates on four important arguments, namely: the market failure theory, which holds that market for agri-inputs fails in certain respects that the market on its own is unable to correct them on its own; equilibrium adjustment, which pertains to the long time of adjustment of the market from one equilibrium position to the next equilibrium position; externalities, whereby there is visible divergence of private course from social course; and the theory of second best, which states that once the conditions of *pareto optimality* in attaining the first best equilibrium of the market is violated as is generally the case, there is no basis to pursue the remaining conditions in attaining the second best option (Lipsey and Lancaster 1956).

The agri-input delivery system is conceived in the development communication context, which has as its main elements the specific package of inputs as a *message*, originating from a *source,* and passing through a *channel* to be delivered to a *target*. Within this context, we identify the various policy bottlenecks associated with each element as a *noise,* which obstructs the free flow of the agri-input message as it passes from the source through the channel to the target. Elsewhere, the forms and functions of the noise elements in the policy pathway have been described in detail (Ayoola 2001). The manifest consequences of these noise elements on the performance of agriculture is reflected in the status of the country in terms of food import dependence notwithstanding its status in terms of input import dependence (Tables 24.1 and 24.2).

Now, the African green revolution is underway, having gathered substantial momentum in recent past. We recall the Africa Fertilizer Summit held in Abuja in June 2006, which has generated a 12-point agenda for action among the countries (IFDC 2006). We also observe the follow-up action under the Alliance for Africa Green Revolution in Africa (AGRA). Both developments will definitely focus on judicious use of agri-inputs in turning the situation around on the continent, with a view to attaining food security of the people in the shortest possible time. Thus, now is the time to get the policy environment right for agri-inputs delivery in Nigeria with a view to maximizing the advantage of the new programmes.

## 3 Background to Policy Interventions in Agri-Input Market

### *3.1 Policy Intervention Modes*

The principal focus here is on the so-called green revolution inputs – seed, fertilizer and CPPs (crop protection products), in that order.

#### 3.1.1 Seed

Public intervention in the seed industry dates back to the colonial era, when the "travelling teachers of agriculture" used to carry planting materials from place to place, introducing "new improved" crop varieties similar to the "New Improved Blue OMO" in the present time. This translated into organized extension work for the delivery of seed and other planting materials to rural dwellers.

At the moment, the National Seed Service (NSS) – now the National Agricultural Seed Council (NASC) – is the superintending agency for policy interventions in the seed industry. The National Crop Varieties and Livestock Breeds Registration and Release Committee was established by law (Decree 33 of 1987), for the purpose of regulating the activities of stakeholders in the seed industry. Specifically, the Committee was charged with receiving and processing applications for the registration, naming and release of old and new crop varieties, and officially releasing the list of varieties recommended by the Technical Sub-Committee (TSC) established for that purpose. Subsequently, the National Agricultural Seed Committee was established (National Agricultural Seed Act No. 72 of 1992), leading to the publication

**Table 24.1** Imports of food into Nigeria, 1991–2003 (tonnes)

| Commodity/ year 1991 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Sugar refined | 449,780 | 477,133 | 529,708 | 406,000 | 719,355 | 468,000 | 635,768 | 896,000 | 771,782 | 615,930 | 893,500 | 1,099,200 | 716,500 | 456,577 | 461,060 | 288,972 | 288,972 |
| 2 Rice milled | 296,000 | 350,000 | 350,000 | 350,000 | 300,000 | 345,500 | 699,054 | 594,057 | 812,452 | 740,000 | 1,765,500 | 1,232,411 | 1,600,000 | 1,350,000 | 1,040,322 | 963,140 | 963,140 |
| 3 Wheat | 230,000 | 292,506 | 1,125,196 | 675,282 | 608,609 | 799,520 | 1,068,802 | 1,424,009 | 1,473,940 | 2,219,708 | 2,190,200 | 2,397,839 | 2,217,000 | 2,608,947 | 3,714,683 | 3,243,998 | 3,243,998 |

Source: FAOSTAT (FAO Website); *NA*: Not available

**Table 24.2** Imports of farm inputs and machinery into Nigeria (1991–2002)

| Farm input | Quantity/ unit | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pesticide | Value (1,000 $) | 24,373 | 8,495 | 11,000 | 13,000 | 16,065 | 19,000 | 32,187 | 37,149 | 16,000 | 14,361 | 12,721 | 108,313 | 28,029 | 49,688 | 36,095 | 60,906 | 169,082 | 82,338 |
| Fungicide | Value (1,000 $) | NA | 626 | 667 | NA | 5,523 | NA | 8,467 | 15,660 | 1,955 | NA | 1,085 | 10,325 | 6,537 | – | – | 7,586 | 6,170 | 6,170 |
| Herbicides | Value (1,000 $) | NA | 534 | 725 | NA | 1,960 | NA | 3,195 | 2,543 | 3,793 | NA | 7,757 | 50,602 | 7,575 | – | – | 48,622 | 90,525 | 47,063 |
| Mineral fertilizer | Value (1,000 $) | 5,000 | 4,500 | 4,000 | 4,000 | 3,603 | 15,797 | 5,547 | 24,207 | 1,913 | 29,133 | 12,418 | 49,169 | 29,056 | 100,000 | 150,000 | 213,050 | 281,918 | 159,452 |
| Organic fertilizer | Value (1,000 $) | NA | NA | NA | NA | NA | 200 | 76 | 3,619 | 54 | 181 | 189 | 49,169 | 29,056 | 100,000 | 150,000 | 213,050 | 281,918 | 159,452 |
| Agric. tractors total | No. (Numerical) | NA | NA | NA | NA | 405 | 520 | 360 | 400 | 235 | 589 | 2,309 | | | | | | | |

Source: FAOSTAT (FAO website); *NA* Not available of a comprehensive list of all crop variety released and registered in Nigeria (PASS 2007), and giving mandate to NSS (NASC) as sole source of Foundation Seed production in Nigeria, in collaboration with the National Agricultural Research Institutes (NARI).

In practical terms, the key modes of policy intervention in the seed industry at the moment consist in the following:

– The NARIs and Universities as public institutions act as the original source of *breeder seed* of new varieties produced by them; the breeder seed of such public bred varieties should be released to NSS (NASC).
– The NASC is responsible for the production of *foundation seed* from breeder seed in collaboration with NARIs, Universities and Private Seed Companies; the NASC would release the first stage foundation seed to private seed companies, while the second stage foundation seed would be released to ADPs.
– The private seed companies and ADPs are responsible for the production of *certified seed* from the foundation seed provided by NASC, through companies' farms or contracted out to out growers/contract farmers; both the private seed companies and ADPs are also responsible for selling certified seed to farmers to produce commercial grain.

### 3.1.2 Fertilizer

Policy intervention for replenishing the soil dates back to the era of regional control through to the first half of the second post-independence decade, when the Regions/States engaged in separate importation of mineral fertilizer for distribution to farmers. At the federal level, the Fertilizer Procurement and Distribution Division (FPDD) was established as the sole agency for supplying mineral fertilizers to the Nigerian market. A loan was obtained from the World Bank in two stages for the purpose of massive importation and distribution at subsidized prices, which lasted till 1990s. Also domestic supply capacity was enhanced by the establishment of two granulation plants, namely National Fertilizer Company (NAFCON) and Federal Superphosphate Fertilizer Company (FSFC), followed by a series of blending plants. The sector has since undergone substantial reforms leading to the re-designation of the FPDD as FFD (Federal Fertilizer Department), and systematic withdrawal of the government from importation and distribution activities and the reduction of subsidy on fertilizers.

At the moment, the main elements of policy intervention in the fertilizer sector consist in a market stabilization programme (FGN 2006), as follows:

– The Federal government undertakes limited purchase of mineral fertilizer, typically 250,000 MT through tendering in the local market, on a seasonal basis and at a uniform price; the consignments would be distributed to the States as indented.

- The State governments should sell the allocations of fertilizer to farmers at 25% subsidy and uniform price throughout the country; the proceeds should be remitted to the Federal government.
- The States and Local Governments are also at liberty to support the farmers with additional subsidies on federal fertilizers, or to procure additional fertilizer for distribution to farmers at subsidized prices.

#### 3.1.3 CPP

Public intervention in the market for crop protection products also has its roots in the defunct regional control era. The old Western Region launched the popular Cocoa Pesticides Scheme in the 1960s. Subsequently, the supply of CPPs has been mainstreamed through several projects of agricultural development, to facilitate access and judicious use. At the present time, the market for CPPs is considerably liberalized.

### *3.2 Lessons of Implementation Experience*

The collective lessons of experience from the implementation of the policies are better perceived within the development communication context, which helps in examining the agri-input delivery system by treating: (a) the package of agri-inputs as a policy *message* to the farm population; (b) the policy authorities as the *source* of the message for its packaging and mobilization; (c) the market cum public extension system as the joint *medium* or *channel* for the smooth passage of the message; and (d) the farmers as the *target* of the message for decoding and eventual use. This framework helps in determining the nature of issues associated with the delivery system as a means of communicating the policy message about agri-inputs, thereby facilitating the determination of issues emanating there from. Thus, the following lessons of implementation experience can be discerned:

- *Lessons about the Message* – The well-packaged policy message has the property that the **availability** of agri-inputs in desired quantity and quality holds the key to the efficiency of the agri-input delivery system. The fertilizer policy intervention accounts for large-scale awareness and adoption of fertilizers among the farmers. Nevertheless, the degree of availability falls short of the demand generated, which leads to frequent crisis in the past; even at the present time, substantial pent-up demand for fertilizers exist that is not met. The situation is similar with seed whereby limited availability of improved seed provides the basis for the vast majority of farmers to continue with the traditional practice of using own seed saved from precious harvests season after season. Moreover, the nature of agricultural input demand is also important; as inputs they are not demanded for their own sake unlike final products. Thus, the demand for agri-inputs is a derived type, in the sense that they are demanded for the production of other items than themselves. This implies that for their use to expand, the demands for the products that they are used to produce must first expand. That is, much of the sluggish uptake of such inputs would be explained by the low production of the food items in the domestic market possibly emanating from policy-induced competition with food imports (Ayoola 2001).

– *Lessons about the Source* – The role of government as the source of the policy message initially involves the proper packaging of the agri-inputs in terms of proper articulation of the policy statement and proper formulation of strategies for implementing them (FMAWRRD 1987; FMARD 2003), followed by sustained commitment of resources during implementation. This is not the usual experience with past implementation of agri-input policies. Budget provisions could no longer keep pace with growing demand for fertilizers (Nagy and Edun 2002) through public distribution while farmers have also become mentally dependent on subsidy. Similarly, the public system for distributing improved seed failed to meet the need of farmers based on insufficient funding.
– *Lessons about Channel* – The channel or medium of message flow in delivering agri-inputs to farmers represents the most crucial aspect, wherein most of the policy issues of the communication model emerge from. For agri-inputs, the channel comprises the market and the public extension system; indeed the economist's viewpoint is that the extension system is just a parallel market for agri-input. In any event, the most important issue about the channel is the magnitude of noise present, which is any factor impeding the flow of the policy message, distorts it, or at least impairs its reception on reaching its destination. Thus, in the market for agri-inputs the several noise elements affecting the policy message include: (a) the unorganized nature of the market that makes it difficult to reach the agri-input dealers for policy participation, and from enjoying economy of scale in their operations; (b) sharp practices in the market such as short bag weights, adulteration and general lack of truth in labelling practices; etc. On the other hand, the noise elements in the public agricultural extension system include: (a) poorly-trained and immobile extension workers; (b) poor basic infrastructure in rural areas, such as rural road networks, rural water supply, rural electricity, etc.
– *Lesson about Target* – The disposition of the farmers as targets in receiving the policy message depends on their socio-economic circumstances and possession of voice in the policy process, among other factors. All too easy the farmers are too vulnerable to cheats and interest groups who corner the part of the policy benefits meant for the farmers. The fertilizer policy is a case in point whereby the inputs arrive too late and too little for the need of farmers.

## 4 Policy Formulation for Agri-Input Delivery

Getting the policy environment right for agri-input delivery system starts with proper formulation of the policy in the first instance, which is a serious rather than casual analytical exercise to be followed by disciplined adherence to its implementation.

The latter is often blamed for policy failures, which is not necessarily so in all cases. In this section, we first make the case for the adoption of a process approach to policy analysis before proceeding to highlight the requirements for policy formulation with reference to the agri-input delivery system.

## *4.1 Process Approach*

In carrying out any type of policy analysis such as policy formulation, the choice of analytical framework is crucial, which is between treating policy as a set of discrete events or as a sequence of events in process (Idachaba 2006). The process approach to policy analysis is superior because it brings out the real explanatory factors of policy behaviour much more clearly, including the roles of different stakeholders and helps in subjecting such roles to efficiency tests while proffering more feasible solutions. The key stages in the policy process analysis are as follows: articulation (of the policy problem); formulation (of the implementation strategy); appraisal (of the strategy document); implementation (of the strategy as appraised); and evaluation and feedback.

We are presently concerned with the first two stages that comprise policy formulation, i.e. proper articulation of the policy problem and proper formulation of the implementation strategy.

## *4.2 Articulation of Policy on Agri-Inputs Delivery*

Formal *articulation* of government policies represents the first stage of any aspect of the agricultural *policy process*, which involves the formal recognition and proper definition of the policy problem in all its ramifications, and the deliberate specification of the policy directions to follow in addressing the problem. In the practical sense, a policy is formally articulated when it is written down and explicitly and publicly declared in advance, following the due process. Otherwise, we have disparate policy statements about different elements of the policy tucked away in active and closed files or inside some grey literature within the Ministry or the agencies at federal and state levels, constituting the "implicit policies". It is obligatory for government to articulate its policies in a formal way, and such formally articulated policies become laws, more or less, that are binding on its agencies operating in the sector, while also guiding the behaviour of stakeholders in the sector. Suffice it to say that at the moment a formally articulated policy on agri-input integrating all the inputs together is not in existence in this country. And now is the time for one bearing in mind the looming commencement of the African green revolution.

Policy articulation in this sense is an attempt to answer the question of *what* the government position is on agri-input delivery; the critical elements being: background of the agri-input policy environment; the challenges and objectives of agri-input delivery policy; guiding principles; policy directions and instruments to be employed. These elements should be fully specified and succinctly presented, and then published as small, handy quick reference materials for use by government officials and stakeholders in public and private sector, as recently done for the newly articulated National Fertilizer Policy for Nigeria (FMARD 2006).

Thus, consistent with the development communication paradigm discussed earlier in articulating the policy on agri-input delivery system for Nigeria the *what* question borders on: what the position of government is on the issues relating to the different aspects of the agri-input delivery as a communication system – the adequacy and completeness of the package of agri-inputs as a message; the role of government as the source of packaging the agri-inputs message; the noise level in the agri-input message delivery channel; and the disposition of farmers as the target of agri-input message.

### *4.3 Formulation of Implementation Strategy for Agri-Inputs Delivery*

While policy articulation attempts to answer the "*what*" question, strategy formulation attempts to answer the "*how*" question; that is, going by the policy statement articulated, *how* the government will deploy the *policy instruments* at its disposal, and follow the *policy directions* predetermined in addressing the *policy challenges* identified, and in meeting the *policy objectives* stated. The main elements of strategy design and formulation include: elaboration of each instrument and how they will be utilized in various combinations; suitable institutional arrangements for implementation; logical framework; action plans and time phasing; phasing of activities and work programmes; financial plans and fund raising; among others. Thus, strategy formulation results in an elaborate document that contains the full specification of parameters for implementing policy as previously articulated. Again, such a formulation is presently non-existent for agri-input delivery system in the country at the moment, and one is urgently required preparatory to implementing the 12-point agenda of the Africa Fertilizer Summit.

## 5 Emerging Policy Issues and Optimal Resolution of Issues

The foregoing expositions serve as veritable sources of the several issues to consider in formulating the policy on agri-input delivery system in Nigeria. We shall highlight such issues or pose relevant questions for discussion at this stage only, without attempting to resolve them ahead of the consensus around them to be built by the policy stakeholders themselves and not the analyst. Some selected issues have emerged to be grouped in two categories as follows:

## *5.1 Political Economy and Governance Issues*

– *Role of government in the agri-input delivery system* – There are several options in supporting agricultural production, comprising direct and indirect roles of the government. Should government continue to provide direct subsidy in the agri-input delivery system in the presence of widespread abuse by its officials, and the perennial leakages of the subsidy policy benefits to non-targeted individuals in the society? That being a noise!
– *Federal-state relationship in agri-input delivery system* – The division of labour in agricultural development is clearly established in the constitution of the Federal Republic. Is federal government permitted under the relevant section of the constitution (FGN 1999), to embark on market stabilization programme in the agri-input delivery system, like the one in operation for fertilizer? That being a noise!
– *Policy due process and policy best practices in agri-input delivery system* - The buzz words of good policy making include: inclusiveness; consistency; stability; transparency; openness; programme accountability; participation; professionalism; and documentation; to mention a few. What are the elements of these in formulating the policy on agri-input policy delivery system for Nigeria? The absence of these being a noise!

## *5.2 Structural and Systemic Issues*

– *Regulatory and legal frameworks* – The nature of agri-inputs is very scientific and technical implying that unsuspecting farmers can be easily deceived and exploited unless they are effectively protected from the sharp practices of agri-input dealers in the market. Are we satisfied that the existing regulatory agencies, such as NAFDAC and SON, are doing a good job in this area, or should the Agricultural Ministry or should not establish its own regulatory agencies particularly for fertilizer?
– *Public-private partnerships frameworks* – The private sector operates in the agri-input market purely for profit motives while the public sector operates the agricultural extension system as a complementary policy to fill the gaps in service provision to farmers. What frameworks exist to maximize this complementarity within the framework of PPP for the smooth working of the agri-input delivery system?
– *Small versus large-scale farmers* – Both scales are desirable for agricultural development of the country. Is there or is there not a need for discriminatory instruments in the policy on agri-input delivery in respect of each category of farmers?

– *Organized private agri-input sector* – The effort towards an organized agri-input sector is quite recent, through the IFDC/DAIMINA project. But the observed trend is to the effect that the Agro-Input Dealers Associations (AIDAs) have toed the line of traditional commodity and farmers' associations – political interferences, top-down structure rather than bottom-up, etc. What are the necessary safeguards required in the policy on agri-input delivery to eliminate these negative developments?
– *Technical back-up support services in formulating and implementing policy on agri-input delivery system* – The need for certain supportive services have been recognized as the responsibility of private sector and NGOs; these include professional services such as policy advocacy and brokering services, that are critical to policy best practices and conducting policy (varietal) trials prior to large-scale adoption. How can we promote the private and other non-government sectors to render such services to the benefit of the agri-input delivery system?
– *Role of agricultural universities in agri input delivery system* – The best way for agricultural universities to contribute to the functionality of agri input delivery system as is the case with the American "Land Grant Colleges" which is our role model for the three agricultural universities in Nigeria, is through the "Cooperative Extension System", involving resource collaboration between the federal, state and local governments under a single administrative umbrella of the universities. Are these universities involved in the input delivery system to that extent; if not why not?
– *Regional dimensions* – There is serious effort to harmonize the agri-input delivery policies of countries through the regional bodies such as ECOWAS and NEPAD, particularly within the contexts of Africa Fertilizer Summit and African green revolution. The main issue is the extent of participation of Nigeria, and the degree of commitment of the government to international treaties in regard to policy on agri-input delivery system for the country.

## 6 Concluding Remarks

The formulation of policy on the agri-input delivery system in Nigeria depends on the optimal resolution of the several issues raised. Specifically, the proper articulation of the policy statement on agri-input delivery system and proper formulation of an implementation strategy for the system require that the lessons of experience from past policies are considered in resolving the issues, subject to strict adherence to the tenets of policy due process, and consistent with policy best practices in other parts of the world.

In conclusion, the most important lesson of experience from public intervention in the agri-input delivery system of Nigeria is that there have been certain instances in the past and at present, such as the case of fertilizer, wherein the subsidy policy is good but the implementation strategy has failed to work. Suffice it to say that from this point on, we desire a rule-based, evidence-led and internally consistent policy articulation and strategy formulation for the agri-input delivery system of the country.

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# Postface

Humankind and the ecological systems that embody Earth are facing one of the toughest challenges of the twenty-first century: how to feed 9 billion people in 2050, in the face of climate change, energy shortages, economic and financial crises, and growing competition for the use of natural renewable and non renewable resources. This challenge is even more crucial, given that in the past decade we have not come close to achieving the Millennium Development Goal of halving the number of people living in extreme poverty and hunger by 2015. Scientists and concerned stakeholders are now voicing a clear message: that multiple challenges the world is facing in terms of food insecurity, climate change, degradation of ecosystems, social strife and economic recession require an integrated response and an urgent transition of the world economy towards a sustainable, inclusive and resource efficient path.

This is truly significant as we keep in mind that the recent food crisis, combined with emerging energy and climate-change issues, is threatening the livelihoods of millions of poor people as well as the economic, ecological, social and political situation in many developing countries. Also, this crisis is exposing the vulnerabilities of households, governments and the international system to food and nutrition insecurity. Addressing these challenges will require humankind to develop a more productive and sustainable food and agricultural system. On a long-term basis, these challenges require innovative, multifaceted, science-based, technological, economic and political approaches in theoretical thinking, decision making and action. Food insecurity and agricultural and rural development are now crucial issues of theoretical as well as policy relevance.

With this background central to survival and well-being, the purpose of this volume is to formulate and promote theoretical analysis and policy recommendations for a set of topics central to food security, sustainable agriculture and rural development, climate change and energy. Currently, active interest in these challenges and their driving forces is understandable given that agricultural policies are changing and the importance of rural development policies is growing in many countries in order to confront the challenges of food security and climate change.

The major perspective of this volume is that paradigm and policy shifts at all levels are needed urgently: rural and agricultural development and food security

M. Behnassi et al. (eds.), *Global Food Insecurity: Rethinking Agricultural and Rural Development Paradigm and Policy*, DOI 10.1007/978-94-007-0890-7,

should be at the heart of sustainability and poverty eradication efforts. This is based on the evidence that agriculture in the twenty-first century will be undergoing significant demands, arising largely from the need to increase the global food enterprise, while adjusting and contributing to responses and adaptations to climate change – maximize long-term environmental sustainability. Success in meeting these demands will require a comprehensive approach of technical, regulatory and financial innovations, such that adaptation as well as mitigation strategies are consistent with efforts to safeguard food security, maintain ecosystem services, provide carbon sequestration and reduce emissions. These approaches exist, can be improved, and should be incorporated – and, where possible scaled up – into agricultural policies, development, disaster relief, climate and decision making processes, and management actions at local, national, regional and international levels.

The volume, which contains a spectrum of country experiences with regard to the above key topics, is also rich in theoretical and science-evidence analyses pertained to the above highlighted issues. We are confident the reader will find a wealth of material in the interfaces among agriculture and rural development, policy design and practice, and future challenges. We hope that it will contribute to improving the performance of agricultural and rural development scientific and policy agendas in our countries with the aim of alleviating food insecurity and mitigating climate change.

*The Editors*

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Ms. Nafise, Haghtalab holds a Master in Environmental Management and Planning from Tehran University and a Bachelor's degree in Natural resource engineering from Shahid Chamran University, Ahwaz, Iran. Her Thesis is about "climate change modeling and assess the impacts on protected areas by GIS and RS". She had published three books and presented more than 10 papers in national and international conferences. She is also Environmental Expert in a private company and teaches environmental courses in Payam Noor University, Mashad, Iran.

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Dr. U. Haruna is Associate Professor and Head, Department of Agricultural Economics and Extension, Abubakar Tafawa Balewa University Bauchi, Nigeria. He has been involved in teaching both undergraduate and postgraduate courses in Agricultural Economics since 1997. Born at Hadejia, Jigawa State in 1965; he attended Usman Danfodiyo University, Sokoto, where he obtained a Bachelors degree in Agriculture in 1989. Later in 1995, he obtained a Masters degree in Agricultural Economics from Abubakar Tafawa Balewa University, Bauchi. Also, he obtained his PhD in Agricultural Economics in 2002, from the same University. Dr. Haruna worked as an Agricultural Planning Officer with both Kano and Jigaawa States between 1990 and 1997. He is also involved in several research activities. His major areas of research include: Sustainable Agricultural Production Systems, Farm Management, Agricultural Marketing, Agricultural Policy and Develpoment. As a prolific writer, Dr. Haruna authored and co-authored the following books: (a) Commodity Chain Analysis of Cattle: A Case Study of KRIP Area, Kano State, Nigeria; (b) A Handbook of Home Economics; and (c) Perspectives of Fadama Development in Nigeria. He is also an Associated Editor of the Journal of Researh in Agriculture, Farm Management Association of Nigeria (FAMAN) Journal, Continental Journal of Agricultural Economics and Continental Journal of Agricultural Sciences, as well as the co-editor of the Proceedings of the 9$^{th}$ Annual National Conference of the Nigerian Association of Agricultural Economics. Futhermore, he published more than 40 academic articles in reputable national and international journals. Dr. Haruan also supervised 12 theses of Msc. and Ph.D students; and he is a member of six academic associations, including the Research and Development Network. He was also involved in consultancy activities with the Fadama II Project of the World Bank in Bauchi State and the F.C.T. Abuja ADPs; and a Lead Reseacher (Team Leader) for the Evaluation of the Processes and Impact of the UNICEF Country Programmes in Bauchi State, Nigeria from 2002 to 2007.

**Hayashi,** *Kiyotada*

Dr. K. Hayashi is Leader of the Environmental Assessment and Management Research Team at National Agricultural Research Center, National Agriculture and Food Research Organization in Tsukuba, Japan. He has been a Guest Research Scholar at IIASA and an OECD fellow at ETH Zurich. Recently, he organized an OECD Conference on "Biological resource management for sustainable agricultural systems".

**Kamara,** *Abdul B.*

Dr. A.B. Kamara is a published researcher and Manager of the Research Division of the African Development Bank (ADB). As research manager, he is part of a team that identifies strategic priorities for Bank-led research on African economic and social development. He also takes responsibility for supervising senior research professionals working on the Bank's key flagship publications, such as the Africa Competitiveness Report, the African Development Review, as well as the African Economic Conference. Before becoming research manager in 2007, Kamara served as a Senior Agricultural Economist in the Bank's Agriculture and Agro-Industry Department from 2004 to2006. Since 2007, he has led the Bank's technical teams working on the fuel and food crisis, and recently the financial crisis, and is co-editor of the Bank's recent volume on "Mitigating the impact of the financial and economic crisis in Africa". He currently heads a team that works on the Africa's competitiveness and post-crisis economic recovery among others.

**Karácsony,** *Peter*

Dr. P. Karácsony is Assistant Professor at the Faculty of Agricultural and Food Sciences, University of West-Hungary, Mosonmagyaróvár, Hungary. Since 2005, he works as Lecturer and Researcher in the field of Hungarian agricultural economics at the Institute of Business Economics and Management Sciences. He graduated from University of West-Hungary with M.Sc. in Agricultural Engineer and obtained Ph.D. in 2008 in the field of Agricultural Economics. He has published widely on the competitiveness of Hungarian agriculture.

**Kasza,** *Gyula*

Mr. G. Kasza is head of division at the Ministry of Agriculture and Rural Development, State Secretariat of Food Chain Control, Division of Public Relations, Hungary. He is a PhD candidate at Corvinus University of Budapest, Faculty of Food Science. His professional interest is risk communication of food safety.

**Keszthelyi,** *Krisztián*

K. Keszthelyi is student at the Corvinus University of Budapest. He studies at the Faculty of Food Sciences, and his special field is food industry management.

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Anzelm Kiss has graduated as Agricultural Economist from the University of West-Hungary Faculty of Agricultural and Food Sciences, Mosonmagyaróvár. During his studies, he attended to a rural innovation and development course at CAH University in the Netherlands. Additionally, he was working on Clean Development Mechanism project preparation in Africa at Agroils Srl, an Italian biofuel consultancy.

**Lavallée,** *Sophie*

Dr. S. Lavallée is Professor at the Faculty of Law, Laval University. She is researcher at the Centre interuniversitaire de recherche sur le cycle de vie des produits, procédés et services (CIRAIG) which is specialized in international environmental law.

**Leithold,** *Günter*

Dr. G. Leithold had studied agriculture at the University of Halle (GDR) from 1969-1973 and received his Doctorate in 1976 at the same university with focus on humus and nitrogen reproduction of agricultural soils. Between 1990 and 1994, he continued his professional career as researcher and lecturer at the University of Halle focusing on organic agriculture. He also conducted supplementary studies at Moscow for six months in 1996. From 1994 to 1997, he was Head of the Department of Organic Farming at the Saxon State Institute for Agriculture in Leipzig. Since 1997, he is Head of the Professorship of Organic Agriculture at the University of Giessen (Germany). The research areas of his Institute include: soil fertility under conditions of organic agriculture and different intensities of soil cultivation; establishment of a system for humus balancing in organic agriculture; biogas in organic agriculture; improvement of wheat flour quality by wide row spacing (50 cm between rows), research on the propagation of the Western Corn Rootworm in Europe; nanofibers as new dispensers for pheromones for use as biotechnological control of pest insects.

**Mafusire,** *Albert*

Dr. A. Mafusire is Senior Research Economist in the Development Research Department at the African Development Bank, and holds a PhD in Economics from Queensland University, Australia. Before joining the Bank in November 2007, he was the Programme Coordinator at the Zimbabwe Economic Policy Analysis and Research Unit (ZEPARU) in Zimbabwe after a ten-year academic career at the University of Zimbabwe. During this period, he consulted for Zimbabwean and international organizations. While Albert's research interests are mainly in trade and development issues, his current and previous engagements have exposed him to wider economic policy issues. He has also presented numerous papers in international and local conferences and seminars, mainly in the area of trade.

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Ms. Malbousi S. is Computer science engineer. She has Bachelor in Computer Science from Ferdowsi University, Mashad, Iran and is currently Expert in climate change modeling in climatologic institute, Mashad, Iran. She has presented and published 21 papers in modeling in national conferences.

**Marambanyika,** *Thomas*

T. Marambanyika is Lecturer, Department of Geography and Environmental Studies at Midlands State University. He holds a BA (honours) degree in Geography (2003), and MA in Environmental Policy and Planning (2006) from University of Zimbabwe. He teaches Food Security and the Environment and Natural Resources and Sustainable courses at undergraduate level. He has research publications in fields of environmental management in industry and food security.

**Molla,** *Md. Sirajul Islam*

Mr. S.I. Molla obtained his Master's in Social Science from the University of Dhaka in 1983. He joined the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) (www.icddrb.org) in 1982 and had gathered wide range of experience in fundraising, administration, management, communication and dissemination. He built up a strong rapport with the 55 donors of the Centre that includes UN agencies, embassies representing national government, and other development partners and media as well. Besides, he was the Managing Editor and Translator of Health and Science Bulletin (HSB) disseminated throughout the world. Mr. Molla founded an environmental organization namely Sunder Jiban in early 1999, and has been working as its Executive Director (voluntary). Moreover, he is involved with the Bangladesh Paribesh Andolan as the Member-Secretary to the Air and Noise Pollution Control Programme. In these capacities, he generates funds, liaises with different stakeholders, meets with the government policy-makers, prepares action plans, guide activities related to the development of environment. He likes to dedicate his services for the development of human being and environment. He presented several papers on different environmental issues in local and international conferences, and also published numerous articles and letters on various social and environmental issues in different leading dailies in Bangladesh.

**Nokhandan,** *Majid Habibi*

Dr. M. H. Nokhandan. is Assistant Professor in Climatology and Director of National Climate Center and Climatological Research Institute from 2004 up to now. He has a Bachelor's degree (1993–1997) in physical geography (Climatology) from Azad Islamic University, Torbat e Hydarieh, Iran and a Master degree (1997–1999) in physical geography (Climatology) from Department of Geography Azad Islamic University, Tehran, Iran. He also obtained his PhD degree (1999–2004) in physical geography (Climatology) from Tehran University, Tehran, Iran. He published 3 books and more than 30 papers in scientific journal and presented more than 50 papers in national and international conferences. He also finishes more than 10 national research projects. Dr. Nokhandan teaches climatology and related subject in Ferdowsi University of Mashhad. He was elected as the honored Researcher of Road and Transport Ministry of the year 2005 and honored Researcher of IRIMO of the year 2007.

**Obayelu,** *Abiodun Elijah*

Dr. A.E. Obayelu started his educational career in University of Ilorin, Kwara state Nigeria where he obtained Bachelor Degree in Agriculture (B. Agric.) in 1995. In 2002, he obtained Master degree in Business Administration (M.B.A), and Master in Agricultural Economics from University of Ilorin and Ibadan, Nigeria respectively. By June 2009, Obayelu completed his Ph.D degree program in Agricultural Economics also from University of Ibadan. His field of interest include: Food Policy, Development Economics, Agricultural Innovation and Environmental issues. From 2005 to 2007, he was University of Ibadan Postgraduate School Teaching and Research Assistant. Currently, he is Lecturer in Department of Agricultural Economics and Farm Management, College of Agriculture, Management and Rural Development (COLAMRUD) University of Agriculture, Abeokuta (UNAAB) Ogun State Nigeria. He has published extensively in both international and local journals, and has to his credit over fourteen publications besides conference proceedings and chapter in at least three different books. He is a member of both international and local associations among which are the African Association of Agricultural Economists (AAAE), African Financial and Economics Association (AFEA), Royal Economic Society in UK, Chinese Economics Society (CES), Emerald Literati Network and African Economics Research Consortium Network.

**Orbán,** *József*

J. Orbán was born in 1946, he graduated in Agricultural Engineering at University of Mosonmagyaróvár. Between 2005 and 2009, he was Leader of the Institute of

Social and Management Sciences. He has a Ph.D. from Sciences Of Agricultural Labour Organization. He is Associate Professor at the Faculty of Agricultural and Food Sciences, University of West-Hungary, Mosonmagyaróvár, Hungary.

**Parent,** *Geneviève*

Dr. G. Parent is Professor at the Faculty of Law, Laval University. She is member of the Steering Committee of the Centre d'études en droit économique (CÉDÉ) which is specialized in national and international agri-food law and intenational law.

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Dr. S. Podruzsik is Lecturer at the Corvinus University of Budapest, Department of Food Sciences. His research area is the food sector. Within the sector, his focus is on food consumers' welfare, food logistics and logistics process optimization.

**Ramachandran,** *Nira*

Dr. N. Ramachandran is currently Director, Research and Training, Earth Care Foundation, New Delhi. She holds a Ph.D from the Jawaharlal Nehru University, New Delhi and has lectured extensively and conducted training programmes in the areas of food security, primary education, PRA and project management. She has to her credit several publications including '*Towards a Food Secure India: Issues and Policies*' and '*Coming to Grips with Rural Child Work – A Food Security Approach*'.

**René,** *Jorna*

Dr. J. René is Professor in Knowledge Management and Cognition at the Faculty of Economics and Business of the University of Groningen. He studied Analytic Philosophy and Logic (Master 1981), Experimental Psychology (Master in 1982) and did his PhD in 1989 in Cognitive Science on knowledge representation. His research and publications address cognition, semiotics, knowledge management, sustainable innovation, knowledge technology and decision-support systems, especially related to planning and scheduling. From 2001 until 2004, he was programme manager of the NIDO project on sustainable innovation. In 2006, the books Planning in Intelligent Systems (with van Wezel and Meystel; John Wiley) and Sustainable Innovation (Greenleaf) were published. In 2009, he was appointed Head of the Social Science Department at the Fryske Akademy. He supervises several PhD projects on sustainable innovation, knowledge, cognition and social simulation.

**Schwartz,** *Horst Juergen*

Dr. H.J. Schwartz graduated in Agricultural Sciences at Technical University Berlin, Germany, in 1970, and obtained a Ph.D. in Animal Science at the same institution in 1974. He was then for eight years Lecturer at the University of Nairobi, Kenya; for four years Research Scientist within the UNESCO-Man and the Biosphere Programme; and for three years Professor in Animal Science at Technical University Berlin. From 1990 until his recent retirement, he was Professor of Livestock Ecology at Humboldt University of Berlin, Germany. His research focuses on animal production systems in marginal environments, with an emphasis on livestock environment interactions.

**Shepherd,** *Jane*

Jane Shepherd lectures in Landscape Architecture in the School of Architecture and Design, RMIT University. Her current design research project "Food Lab: Food and Landscape Architecture Bureau" investigates food production and landscape settlement patterns. Her work considers the relationships between policy platforms, land use outcomes and the effects on ecological, community and human health, and is informed by the implications for food justice that emerge from agricultural and food production systems.

**Singh,** *Abhaya Kumar*

Dr. AK. Singh is Associate Professor of Research and Post-Graduate Department of Defence and Strategic Studies at the Dr. R. M. L. Awadh University affiliated College K.S. Saket Post Graduate College, Ayodhya, Faizabad, India. As Environmentalist and Security Analyst, Dr. Singh obtained his early education from Gorakhpur University (S.G.R. Post-Graduate College, Jaunpur, India). He also holds Master degree in Science (M.Sc.) and has completed his research work -D.Phil. degree in Defence and Strategic Studies (International Law) from Allahabad University. Dr. Singh is currently held the post of Liaison Officer, Employment and Information advisory Centre of the college. He has participated in many national as well as international conferences related to national and international security, environmental security, terrorism and international relations. He is the Co-Editor of Suraksha Paridrishya and held various posts in extra curricular activities like District Academic Coordinator of National Children Science Congress. He is a Life member of NCDS, Associate Member of IDSA and South Asia Politics. As a result of a multidisciplinary approach, most of his work strives to break traditional boundaries of disciplines, and includes international relations and development, government policy, environment and climate change and national and international security. His research papers have been published in top-tier journals and edited books in India and abroad. Dr. Singh is a highly reputed name in Indian strategic thought and national security.

**Szigeti,** *Judith*

J. Szigeti is a Ph.D. candidate at the Corvinus University of Budapest, Department of Food Economics. Her thesis is “Analyzing welfare effects in the Hungarian food-consumption by the method of econometrics”.

**Stinner,** *Walter*

W. Stinner had studied agriculture at the University of Bonn from 1991 to 1999, and finished with a MSc thesis about anaerobic digestion tin collaboration with the Fraunhofer Institute (IUSE) at Oberhausen. After that, he was employed at the LOICK Holding and worked on the planning of a biogas plant and a market study on biodegradable plastics in agriculture. In 2000, he joined the Working Group on Biogas in Organic Agriculture as a research associate at the University of Giessen. His PhD thesis on biogas in a stockless organic farming system was recently finished. In 2007, he joined the biogas development department of PROWIND Osnabrück, and since October 2008, he is responsible for different international projects at the German Biomass Research Center (DBFZ) in Leipzig.

**Straquadine,** *Gary S.*

Dr. G.S. Straquadine currently serves as the Dean and Executive Director of the Utah State University Regional Campuses. His responsibilities include academic and fiscal oversight for a university outreach system enrolling 1,700 students across the vast geography of Southern and Western Utah. His previous academic experiences involve leadership as the Associate Dean for the College of Agriculture, as Vice Provost for Faculty and Academic Services, and the Department Head for Agricultural Systems Technology and Education (ASTE), where he holds tenure as a Professor. Dr. Straquadine is a recognized scholar in extension education, teaching undergraduate and graduate courses throughout the ASTE curriculum. He has been awarded Teacher of the Year for the College of Agriculture three times, Distinguished Professor in the College and Advisor of the Year for the entire university. While his administrative responsibilities have reduced his teaching and research activities, he still mentors graduate students at both the MS and Ph.D. level. Dr. Straquadine earned his BS and MA degree in Agricultural Extension Education from New Mexico State University. His Ph.D. was completed at The Ohio State University in Agricultural Education.

**van Haren,** *Rob*

Dr. R. van Haren is Professor of Product Innovation and Knowledge Transfer in Agribusiness at the Faculty of Economics and Business of the University of Groningen. He studied Biology at Wageningen Agricultural University and gained his

PhD in 1995 at the VU University Amsterdam with a thesis on the ‘Application of Dynamic Energy Budgets to xenobiotic kinetics in Mytilus edulis and population dynamics of Globodera pallida’. Until 2001, he worked for Plant Research International in Wageningen as programme leader and senior researcher in Agro-Ecology. Between 2001 and the end of 2007, he worked for AVEBE as Research Coordinator for ‘duurzame keteninnovatie AGROBIOKON’ [sustainable chain innovation AGROBIOKON]. Within the framework of the National Initiative for Sustainable Development (NIDO), Dr. van Haren worked together with the University of Groningen from 2003 to 2006. He is also Project Director of KiemKracht, where he is responsible on behalf of the arable sector for the design of the innovation agenda 2030 for the arable sector in the Netherlands, and the realization of two pioneering innovations. Kiemkracht is an alliance between the InnovatieNetwerk and the Hoofdproductschap Akkerbouw [Main Arable Product Board].

**Yaya,** *Sanni*

Dr. S. Yaya is Associate Professor of Economics and International Health and Assistant Director, Undergraduate Studies at the University of Ottawa’s Interdisciplinary School of Health Sciences. A Socio-Anthropologist (DUEL), Dr. Yaya also holds a degree in Management (M.Sc.) and has received a Ph.D. in Economics and Business from the Joint doctoral program that pools together, the resources of Montreal’s four major universities, Concordia-HEC-McGill-UQAM. Before joining the University of Ottawa, he has taught at Laval University, at the University of Quebec at Montreal (UQAM) and at the Quebec’s School of Public Administration. Dr. Yaya was Postdoctoral Research Fellow at Yale University and Senior Visiting Scholar at New York University (NYU). He is also recognized as a Certified Manager (Adm.A.), and has achieved designation as Chartered Manager (F.CIM.) from the Canadian Institute of Management. He was appointed Fellow of The American Academy of Project Management. To date, Dr. Yaya has received funding from the Canadian Institutes of Health Research (CIHR), Defence Research and Development Canada (DRDC) under the Federal government’s Chemical, Biological, Radiological-Nuclear and Explosives Research and Technology Initiative (CRTI), the International Development Research Centre (IDRC) and from the Fonds québécois de recherche sur la société et la culture (FQRSC). He’s the Editor of La Revue de l’Innovation, Collection Director at Publibook and Director of the Society and Health collection at the University of Ottawa Press. A result of a transdisciplinary approach, most of his work strives to break traditional boundaries of disciplines and includes organizational theories, economics, international development, government policy, public administration and sociology and has been published in top-tier journals.

# Author Index

# Subject Index