

Belinda Yuen
Asfaw Kumssa
Editors

Climate Change and Sustainable Urban Development in Africa and Asia

 Springer

Climate Change and Sustainable Urban Development in Africa and Asia

Belinda Yuen • Asfaw Kumssa
Editors

Climate Change and Sustainable Urban Development in Africa and Asia



Editors

Belinda Yuen
Singapore Institute of Planners
Singapore
belyuen8@gmail.com

Asfaw Kumssa
UNCRD Africa Office
Nairobi, Kenya
asfaw.kumssa.uncrd@undp.org

ISBN 978-90-481-9866-5 e-ISBN 978-90-481-9867-2
DOI 10.1007/978-90-481-9867-2
Springer Dordrecht Heidelberg London New York

© Springer Science+Business Media B.V. 2011

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work.

Cover Illustration: Photograph taken by Belinda Yuen in China

Printed on acid-free paper

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

Foreword

Climate change is a grim reality that poses a major threat to humanity and sustainable development. It will result in short and long-term problems, including drought, flooding, storms, increases in sea level temperature and rise, the melting of glaciers, etc. These developments will have repercussions on food security, water availability, epidemic vectors such as malaria, rural–urban migration and other socioeconomic problems. In this regard, climate change has become a major national, regional and international problem, cutting across developed and developing countries.

In developing African and Asian countries, climate change has impacted adversely the livelihoods of people by producing more erratic weather patterns, eroding coastlines, spreading pests and waterborne diseases. With erratic rainfalls and frequent droughts, rural dwellers find it very difficult to work on their farms and are forced to abandon their rural settlements and migrate to urban areas in search of green pastures. The growth in urban dwellers has put further pressure on urban service delivery systems. Since most of these migrants are simple farmers with limited skills and education, oftentimes they end up in the informal sector of the urban economy and settle in slums and shanty towns in the peripheries of cities where poverty, overcrowding, unemployment, crime and environmental degradation are common. Cities are generally the centre of innovation and have the capacity as well as the technical know-how to deal with climate change. At the same time, cities are also the major contributors to greenhouse gases which are responsible for climate change.

To better understand the impacts of climate change on sustainable urban development, the United Nations Centre for Regional Development (UNCRD) and the Singapore Institute of Planners (SIP) organized a senior policy seminar on Climate Change, Housing and Liveable Cities in Africa and Asia from 25 to 27 June 2009 in Singapore. The overall objective of the seminar was to discuss, exchange information and experiences; and draw lessons from best practices of combating climate change; and come up with effective policies and strategies to address climate change and create Liveable cities. In this regard, a number of senior policymakers and scholars from Asia and Africa were invited to present papers.

This book represents the proceedings of this seminar. Most of the papers selected for publication in this book have gone through peer review and were revised for publication. I hope the various chapters that deal with various themes of climate change and urban development will make a contribution to the current debate on climate change and sustainable urban development in both Africa and Asia.

Kazunobu Onogawa
Director, UNCRD

Preface

Climate change is a subject that has an impact on humanity and human settlements. It is an imperative topic that requires strong understanding and knowledge for better planning and preparation by cities, organisations as well as individuals.

The anthology of papers and case studies in this book were first presented at UNCRD-SIP Senior Policy Seminar on *Climate Change, Housing And Liveable Cities In Asia And Africa*, which was jointly organized by the United Nations Centre for Regional Development (UNCRD) and Singapore Institute of Planners (SIP). The seminar was held at Holiday Inn Atrium in Singapore during 25–27 June 2009. The papers and workshop were well received by the participants, which included key policy decision-makers, scholars from Asia (China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, Thailand and Vietnam), Africa (Botswana, Ethiopia, Ghana, Kenya, Namibia, Tanzania and Uganda), key representatives from the World Bank and United Nations.

Mr. Andrew Tan, the Director of Centre of Liveable Cities and CEO of National Environment Agency Singapore was our Guest-of-Honour. He mentioned that crises are inter-related. During the seminar, various questions were raised, such as “how can we design systems that take into account the complex inter-relationships between humans and their living environment” and “how to manage issues such as water, energy and food as inter-related rather than standalone challenges?” Climate Change and Eco-Planning topics were of particular interest to the fraternity of town planners and allied professionals in Singapore. The theme of the seminar and the follow-up publication of the selection of papers in this volume are very timely.

As the Immediate Past President of SIP, with versatility in the planning of various eco-cities and sustainable communities in Singapore and overseas, I observe that these papers offer a comprehensive coverage of the theme and depth of understanding the issue. This publication will increase the society’s awareness of the emerging effect of climate change which influences our lives, economy and cities. With experiences illustrated from African and Asian case studies, this book offers a preview into collaborative and design resilient strategies in the areas of housing, urban forms and quality of life.

I wish to take this opportunity to thank all those who have helped to make this publication and the seminar a success. Special thanks to Dr. Asfaw Kumssa and Dr. Belinda Yuen for sharing the same vision and commitment to publish these selected proceedings of the UNCRD-SIP Senior Policy Seminar.

Mrs. Seetoh Kum Chun
Immediate Past President
Singapore Institute of Planners

Contents

Part I Introduction

- 1 Africa and Asia: Two of the World's Fastest Growing Regions** 3
Belinda Yuen and Asfaw Kumssa

Part II Climate Change and Urban Development

- 2 Climate Change and Living Cities: Global Problems with Local Solutions**..... 21
Priyanka Anand and Kallidaikurichi Seetharam
- 3 Climate Change in the Context of Urban Development in Africa**..... 37
Kempe Ronald Hope, Sr.
- 4 A Region of Contrasts: Urban Development, Housing and Poverty in Asia** 57
Kioe Sheng Yap
- 5 The Effects of Climate Change on Urban Human Settlements in Africa**..... 69
Aloysius Clemence Mosha

Part III Climate Change and Housing: Case Studies from Africa and Asia

- 6 Climate Change and the Housing Environment in Ghana**..... 103
Kwasi Kwafu Adarkwa and Michael Poku-Boansi
- 7 Creating a Sustainable Living Environment for Public Housing in Singapore**..... 117
Johnny Liang Heng Wong

8	Climatic Change and Housing Issues in South Africa.....	129
	Bornwell C. Chikulo	
9	Climate Change and Sustainable Housing in Uganda.....	153
	Stephen A.K. Magezi	
10	Housing and Climate Change: Adaptation Strategies in Vietnam.....	167
	Vinh Hung Hoang	
Part IV Climate Change and Its Effect on Cities: Case Studies from Africa and Asia		
11	Climate Change and Cities' Actions in China.....	195
	Xiaodong Pan and Zhenshan Li	
12	Climate Change and Its Effect on Cities of Eastern African Countries.....	211
	Samuel Kerunyu Gichere, George Michael Sikoyo, and Ally Matano Saidi	
13	Climate Change and Liveable Cities in Malaysia	221
	Kamalruddin Shamsudin and Suan Siow Neo	
14	Climate Change and Its Effect on Urban Housing and Liveable Cities: The Case of Harare, Zimbabwe.....	243
	Rodreck Mupedziswa	
	Index.....	263

About the Contributors

Kwasi Kwafu ADARKWA is Vice-Chancellor of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. He holds a B.Sc. from Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, M.Sc. from University of British Columbia, Vancouver, Canada and Ph.D. from Michigan State University, East Lansing, Michigan, USA. His research interests include rural transport planning, urban and regional development policy as well as local economic development. His publications include a book co-edited with J. Post, *The Fate of the Tree – Planning and Managing the Development of Kumasi, Ghana* (2001). Adarkwa has also published widely in international journals, including *Journal of Property Management*, *Journal of Science and Technology*, *Journal of Ghana Institute of Engineers*, *Regional Development Dialogue*, *Journal of Advanced Transportation*, *Mountain Research and Development*, *World Health*, *African Urban Studies*, *Rural Africana*, *Canadian Journal of African Studies* and *Journal of Social Development in Africa*. Email: kwasiadarkwa@yahoo.com

Priyanka ANAND is a Research Associate with the Institute of Water Policy at the Lee Kuan Yew School of Public Policy and holds a joint appointment at the Global Asia Institute, National University of Singapore, Singapore. Anand’s research work is focused on urban development and she is currently conducting research on the concept of Living Cities – cities that have the potential of being sustainable centres of growth, excellence and high standard of living. She is also interested in studying provision of water infrastructure and services in cities across Asia. Her publications include “Achieving Sustainable Cities” co-authored with K.E. Seetharam and D. Tay in *Developing Living Cities: from Analysis to Action* (ed.) K.E. Seetharam and B. Yuen. Anand graduated from National University of Singapore in 2009 with a Masters degree in Applied Economics and holds a Bachelors degree in Economics (Honours) from Lady Shri Ram College, University of Delhi, India. Email: priyanka.anand@nus.edu.sg

Bornwell C. CHIKULO is Professor of Development Studies at the University of North West, South Africa. He has a M.A. (Econ) and Ph.D. from the School of Government, Victoria University of Manchester, UK. His research interests focus on decentralization and local governance, development and governance issues, development issues in countries emerging from conflict, development studies with an

emphasis on Africa, climate change and development and capacity building issues. Chikulo has published extensively in major international journals and contributed chapters to several books. He is also the co-editor of *Democracy in Zambia: Challenges for the Third Republic* (1996), and *Corruption and Development in Africa: Lessons from Country Case-Studies* (2000). Email: bornwell.chikulo@nwu.ac.za

Samuel Kerunyu GICHERE is Deputy Executive Secretary (Programmes and Projects) at the Lake Victoria Basin Commission, Kisumu – Kenya. He joined the Commission in 2008. He holds an M.Sc. Degree in Operations Research from the Polytechnic University of New York, USA and a Bachelor of Arts (Economics) degree from University of Nairobi, Kenya. Prior to joining the Lake Victoria Basin Commission, Gichere had served in various capacities in the Government of Kenya where he mainly advised on policy analysis in natural resources management. He has a wide experience in institutional capacity analysis. Gichere has also worked for 4 years with UNDP in developing and managing the Capacity 21 Kendelevu Project that supported participatory planning for sustainable development. He has extensive experiences in natural resources management and resources mobilization in support of sustainable development. He has participated in various regional and international conferences and consultancies. In 2005 he co-authored a World Bank Working Paper No. 69 on Climate Variability and Water Resources Degradation in Kenya. Email: gichere@lvbsec.org

Kempe Ronald HOPE, Sr. is Senior Economic Governance Advisor with United Nations Development Programme (UNDP), Kenya. He was previously Senior Economic Adviser and Manager of the Governance and Economic Management Assistance Program (GEMAP), United States Agency for International Development (USAID), Liberia. He was also Director of the Development Policy and Management Division, United Nations Economic Commission for Africa (UNECA) and was Founding Director of the Center of Specialization in Public Administration and Management (CESPAM) and Professor of Development Studies at the University of Botswana. Hope is the author of more than 100 refereed journal articles on development issues and author/principal editor of numerous books including *Poverty, Livelihoods, and Governance in Africa: Fulfilling the Development Promise* (2008); *From Crisis to Renewal: Development Policy and Management in Africa* (2002); *Corruption and Development in Africa: Lessons from Country Case-Studies* – with Bornwell C. Chikulo (2000); *AIDS and Development in Africa: A Social Science Perspective* (1999); *African Political Economy: Contemporary Issues in Development* (1997); *Development in the Third World: From Policy Failure to Policy Reform* (1996). Email: hopekr@excite.com

Vinh Hung HOANG is a lecturer in Faculty of Urban and Regional Planning, Hanoi University of Architecture. He received Ph.D. from Graduate School of Global Environmental Studies, Kyoto University, Japan in urban planning and disaster risk management. He has been a visiting scholar in Institute of Urban and Regional Development, University of California, Berkeley, USA. His scholarly research focuses on housing policy, urbanization, urban risk management and

climate change adaptation. His applied research comprises work with Ministry of Construction of Vietnam, NDM-P, UNDP, DFID and the World Bank on urban development policy, climate change – poverty nexus and the integration of disaster risk reduction into socio-economic development planning. His publications include a book chapter: Urban Flood Risk Management in Hanoi in *Urban Risk Reduction: An Asian Perspective* (ed.) Shaw, R. et al. (2009) and papers in international journal, *Disaster Prevention and Management*. Email: hvhung.hau@gmail.com

Asfaw KUMSSA is the Coordinator of the United Nations Centre for Regional Development (UNCRD) Africa Office, Nairobi, Kenya. He has a M.A. and Ph.D. from Graduate School of International Studies, University of Denver, USA, where he was subsequently an adjunct professor of economics and political economy. He has also a M.Sc. in national economic planning from Odessa National Economic Planning Institute, Ukraine. His research interests focus on regional and urban development; decentralization and local governance; globalization; human security and conflict resolution; social development issues; transitional economies; development studies with an emphasis on Africa; climate change; and capacity building issues. His publications include a book co-edited with T.G. McGee (2001) *Globalization and the New Regional Development* and another with J.F. Jones (2000) *The Cost of Reform: The Social Aspect of Transitional Economies*. Kumssa has also widely published in international journals, including in *International Journal of Sustainable Development and World Ecology*, *International Journal of Social Economics*, *International Review of Administrative Sciences*, *the Journal of African Studies*, and *Journal of Social Development in Africa*, *Social Development Issues*, *Regional Development Studies* and *Regional Development Dialogue*. Email: asfaw.kumssa.uncrd@undp.org

Zhenshan LI is Associate Professor of environmental engineering and Head of Department of Environmental Engineering, Peking University, China. Li has a Ph.D in physical geography, Cold and Arid Regions Environmental and Engineering Research Institute, Academy of Chinese Sciences, China. He has nearly 20 years experience in geography and environmental science, and supervises over 20 graduate students. Li's research interests include environmental management, especially solid waste management; wastewater treatment, especially heavy-metal wastewater treatment; aeolian desertification and aeolian sand transport. He has authored more than 20 publications in refereed international journals and obtained funding of about 8M RMB from China government and enterprises. Li is a member of the executive commission of the working group for arid regions, International Association of Geomorphologists and member of Chinese Society for Sustainable Development. Email: lizhenshan@pku.edu.cn.

Stephen A.K. MAGEZI is Head of Uganda National Meteorological Services and is also Uganda's Permanent Representative with World Meteorological Organization (WMO). Magezi is a Certified Environmental Practitioner and Auditor specializing in atmospheric pollution assessment and monitoring. He has also been the UNFCCC National Focal Point for Uganda until January 2009 when

he was given other responsibilities. He has a B.Sc. (Hons) in Physics of Makerere University, Uganda, Postgraduate Diploma in Meteorology from University of Nairobi, Kenya, M.Sc. from University of Reading, UK and Postgraduate Diploma in Environmental Management from University College Galilee, Israel. His research interests focus on climate change studies, implications of applying UNFCC to the transport sector and atmospheric pollution potential assessment in the tropics. Email: sak_magezi@yahoo.com

Aloysius Clemence MOSHA is Associate Professor of Town Planning at the Department of Architecture and Planning, University of Botswana. He has a B.Sc. (Hons) from University of Newcastle upon Tyne, UK and Ph.D. from University of Nottingham, UK. He previously practiced and taught urban planning in Tanzania and Zimbabwe. His research interests focus on urban land use issues, urban agriculture, urban poverty, informal settlements, climate change and urban management and governance. His publications include *A Handbook for Physical Planners in Botswana*, *A Reappraisal of the Urban Planning Process* and *A Physical Planning Manual for Physical Planners in Botswana*. Mosha has also published conference papers and journal articles in *Regional Development Dialogue*, *African Urban Quarterly*, *AMBIO: A Journal of the Human Environment*, *Urban Agriculture Magazine*, *SPATIUM* (Urban and Spatial Planning, Architecture, Building, Geodesia and Environment), among others. Email: moshaac@mopipi.ub.bw

Rodreck MUPEDZISWA holds a Ph.D. in social development, London School of Economics, University of London, UK and M.Sc. (Social Planning), University of Zimbabwe, Zimbabwe. Mupedziswa is Head of Department of Social Work at University of Botswana, Botswana and since 2005 is Editor-in-Chief of *Journal of Social Development in Africa*. Previous positions include Director of the Forced Migration Studies Programme, at University of Witwatersrand, Johannesburg, and Deputy Director at the School of Social Work, University of Zimbabwe. Mupedziswa has been visiting professor with a number of universities, including University of Lesotho, and Institute of Health and Social Care, Anglia Ruskin University in Cambridge, UK. He has served as a consultant for several international agencies including the United Nations Centre for Regional Development (UNCRD), United Nations Development Programme (UNDP), and World Health Organisation (WHO). He is author or co-author of seven books, including one on Impact of Structural Adjustment on Children in Zimbabwe, and numerous book chapters, articles in refereed journals, research reports, monographs, occasional papers, etc. His area of particular interest is social development issues. Email: mupedziswa@mopipi.ub.bw

Suan Siow NEO has 31 years of experience as a Town Planner in the Department of Town and Country Planning, Ministry of Housing and Local Government, Malaysia. Neo has been Project Manager and key person in the preparation of the National Physical Plan 2005, which is the first blueprint on spatial planning for Peninsular Malaysia, establishing key policies and strategies towards achieving an integrated and sustainable land use planning in Malaysia. Neo is currently heading a Special

Task Force Unit for Safe City in Malaysia, working together with Ministry of Home Affairs in the implementation of safe city program in all local authorities. Safe city program is one of the 55 initiatives recommended in national development and as key priority area in crime reduction. Neo has a Bachelor of Urban and Regional Planning from Universiti Teknologi Malaysia. Email: snsiew@yahoo.com

Xiaodong PAN is Coordinator of Social and Regional Development in the Administrative Center for China's Agenda21 (ACCA21). He has a Master Degree of International Environmental and Natural Resource Law from Wuhan University, China and is a Ph.D. Candidate in Physical Geography in Beijing Normal University, China. He has been team leader/project manager in several national and international cooperation projects including the Local Municipal Development Project of EU-China Funded Environmental Management Cooperation Programme (EMCP/LMD), 2002–2005; China National 10th 5-year Science and Technology (S&T) Programme Evaluation of China National Sustainable Communities and S&T Demonstration Project; UN-HABITAT Second Round China Sustainable Cities Project, 2005–2007; Sino-US Cooperation Project Sustainable Planning for Middle and Small Cities, 2008–2009. He is also a senior researcher in urban sustainable development, Local Agenda21, energy efficiency and emissions reduction policy, green technologies transfer mechanism, regional and local sustainable development evaluation indicators and relevant cases studies and has published extensively on China's sustainable development, energy and low carbon. Email: panxd@acca21.org.cn

Michael POKU-BOANSI is a lecturer in the Department of Planning of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. He has a B.Sc. and Ph.D. in Planning from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. His research interests include transportation planning and economics; urban planning; urban development; human security, urbanization; land use planning, decentralization, urban infrastructure planning; housing; climate change and regional planning. His publications include a paper co-authored with K.K. Adarkwa, *Transport as an Interface for Poverty Reduction and Wealth Creation* (2006) and another with D.K.B. Inkoom, *State of the Cities in Africa Reports: Preparatory Literature Review for Ghana* (2009). Poku-Boansi has also published in international journals, including *Journal of Social Development in Africa*. Email: pokuboansi@yahoo.com

Ally Matano SAIDI is Principal Programmes Officer with the East African Community based at the Lake Victoria Basin Commission in Kisumu, Kenya. He has a M.Sc. in Resource Management from Edinburgh University in UK and is currently undertaking his Ph.D. in Environmental Sciences at Maseno University in Kenya. His research interests focus on transboundary natural resources management; climate change adaptation; land/water resources management; rural development with emphasis on community participation in natural resources management and micro-enterprises; integrated water resources management; and institutional and public policy research and analysis. Matano has wide experience spanning over 15

years in formulation and implementation of transboundary natural resources management programmes. His publication includes Vulnerability Assessment of Climate Change Risks in the Lake Victoria Basin; The Share Vision and Strategy Framework for Management and Development of Lake Victoria Basin (popular version, 2007); The Succession Dynamics of Water Hyacinth in the Winam Gulf of Lake Victoria Basin (2008); Biodiversity of Lake Victoria Basin (2008); Challenges and Opportunities for Farm Forestry (2002). Email: matano@lvbcsec.org

Kallidaikurichi SEETHARAM is an internationally recognized expert with over 20 years of professional experience in development cooperation, infrastructure, integrated planning for economic growth, participatory social development, diplomacy and human values. His current research interests focus on sustainable urban development and urban water management and governance issues. His publications include a co-edited book with B. Yuen, *Developing Living Cities: from Analysis to Action* (2010) and another with B. Rao *Index of Drinking Water Adequacy: International and Intra-national Explorations* (2009). He is currently Visiting Professor and founding Director of Institute of Water Policy at Lee Kuan Yew School of Public Policy, and founding Director of the Global Asia Institute, at National University of Singapore, Singapore. He is on secondment from the Asian Development Bank (ADB) where he was Principal Water Supply and Sanitation specialist, and a focal point guiding ADB's operations in water supply, sanitation and wastewater management in line with ADB's Water Policy. Seetharam is also a board director of the Asia Infrastructure Project Development Company, an innovative joint-venture between ADB and Singapore water companies, to expeditiously prepare public-private-partnership water projects in China. Seetharam obtained his Doctor of Engineering in Regional Planning and Transportation, (Monbusho Scholar) University of Tokyo, Japan; Master in Industrial Engineering and Management, Asian Institute of Technology, Bangkok, Thailand; and Bachelor of Technology in Mechanical Engineering, Indian Institute of Technology, Madras, India. Email: kseetharam@nus.edu.sg

Kamalruddin SHAMSUDIN is Deputy Director-General I of the Federal Town and Country Planning Department (JPBD), Malaysia. He has served JPBD for more than 32 years holding various planning posts including as Director of Research and Development JPBD Headquarter, JPBD Negeri Sembilan, JPBD Terengganu. His interests focus on assessing urban planning, planning theories, history of planning, application of decision science and spatial analysis, and social impact assessment. He has written extensively on town planning history, in particular, the contribution of Charles Reade, the first government town planner in British Malaya and GIS development. He has an Advance Diploma in Town and Regional Planning from Institut Teknologi MARA, Malaysia; M.Phil. from University of Newcastle-upon-Tyne, UK, and a Postgraduate Diploma in Urban Renewal from Institute of Housing Studies (IHS) Netherlands. He has successfully completed a number of GIS projects in the Klang Valley including creation of the GSARD programme (geotechnical spatial analysis research and development, 2001) and TRANSIMPACT (social impact of transportation development in the Klang Valley, 1998) and currently

responsible for the development of the Safe City Monitoring System (a GIS mapping and monitoring system under the Safe City Programme). He is currently Vice President of Malaysian Association of Social Impact Assessment (MSIA), and a member of Malaysia Institute of Planners. Email: kldinkldin@yahoo.com

George Michael SIKOYO holds a MSc. in Ecological Economics from University of Edinburgh, UK (1994–1995), B.Sc. Forestry, Upper Second Degree, Makerere University Kampala (1989–1993), and Diploma in Education, National Teachers College, Kaliro (1985–1987). He has wide experience ranging from academic, research, policy analysis and development, natural resources and environmental management, trade and environment, intellectual property rights, standards for sustainable trade and market access, wildlife enterprises for local development and impact assessment. Currently, Sikoyo is Regional Programme Coordinator of Mount Elgon Regional Ecosystem Conservation (MERECP) at the Lake Victoria Basin Commission. Previously, Sikoyo has worked in IUCN as Chief Technical Advisor for MERECP (June 2006–February 2009) and Institutional Development Advisor (January 2006–June 2006). Sikoyo has also worked as a Research Fellow at African Centre for Technology Studies (ACTS) where he coordinated the “Plan of Action for the Development of Guidelines for Regional Environmental Impact Assessment (EIA) of Shared Ecosystems in East Africa and as a Programme Officer at the African Wildlife Foundation (AWF), Nairobi. He has conducted pioneering research on economic effects on livelihoods, and conservation impact of major community-based wildlife enterprises in East Africa including Rwanda. Email: sikoyo@lvbcsec.org

Johnny Liang Heng WONG is currently Acting Director, Building Quality Department, Housing and Development Board (HDB), Singapore. He has a honours degree in civil and structural engineering and Ph.D. from University of Sheffield, UK. Wong has been involved in many research studies on areas relating to new housing materials, prefabrication technology, urban solutions and systems, green construction technology, environmental sustainability, product development and information technology, and in promoting sustainable development initiatives in HDB buildings and estates. Some of the key projects on environmental sustainability that he has spearheaded include the development of the Prefabricated Extensive Green (PEG) tray system for green roof implementation, solar energy systems and applications in public housing, spiral connector development for pre-cast application and hybrid green roof systems. Wong is a Professional Engineer. He has been conferred several awards including the Henry-Boot Award, Laverick-Webster-Hewitt Award, the Institute of Civil Engineer’s Award and National Day Awards 2008 – Public Administration Medal (Bronze). He and his team have been conferred the TEC Public Service Innovation Award 2006 and Prestigious Engineering Achievement Award 2007 by the Institution of Engineers, Singapore for the development of the PEG Tray system. Email: jw4@hdb.gov.sg

Kioe Sheng YAP, a national of the Netherlands with a Ph.D. in cultural anthropology, worked for the United Nations during two periods: at the United Nations

Centre for Human Settlements (HABITAT) in Nairobi from 1982 to 1987, and at the Economic and Social Commission for Asia and the Pacific (ESCAP) from 2000 to 2009. From 1987 to 2000, he was Professor of Housing and Urban Development at Asian Institute of Technology in Bangkok, Thailand. Yap worked extensively in Tunisia, Pakistan, Sri Lanka, Laos, Cambodia and Indonesia. He worked as an advisor for the Governors of Phnom Penh and Battambang in Cambodia. In the middle of 2009, he retired from the United Nations and now works as a free-lance consultant for various organizations. He was recently appointed Visiting Professor at the School of City and Regional Planning, Cardiff University, UK. Yap has published on low-income housing, community participation and urbanization. Email: yapksh@gmail.com

Belinda YUEN is council member, Singapore Institute of Planners. She has been President, Singapore Institute of Planners (2005–2008), Vice-President, Commonwealth Association of Planners (S E Asia) (2006–2008; 2010–2012), member of United Nations Commission on Legal Empowerment of the Poor Working Group and advisory board member of several UN-HABITAT flagship urban publications and research network.

Belinda has served on various local planning committees of Singapore including as Planning Appeals Inspector, subject group of Singapore Master Plan 2003, Concept Plan 2011, Action programme Working Committee of Singapore Green Plan 2012. Belinda holds a MA (Town and Regional Planning), University of Sheffield, UK and PhD (Environmental Planning), University of Melbourne, Australia, and is a certified practising planner (Member, Planning Institute of Australia), Member, Royal Town Planning Institute, Fellow, Singapore Institute of Planners. Email: belyuen8@gmail.com.

Part I
Introduction

Chapter 1

Africa and Asia: Two of the World's Fastest Growing Regions

Belinda Yuen and Asfaw Kumssa

1.1 Introduction

This book is about two of the world's fastest growing regions: Africa and Asia. They are the world's two largest and most populous continents. Many of the world's poorest people – those living on less than US \$1 a day live in these regions. Their urban areas are fast expanding, most with inadequate solid waste management, sanitation, clean water, housing and living space and are at risk from increased frequency and intensity of extreme weather events and sea level rise. To illustrate; more than 70% of the urban population in sub-Sahara Africa lives in slums. More than half of the population of Mumbai, India's richest city, lives in slums (Mehta and Dastur 2008). By 2020, some 75–80% of the world's total urban population is projected to live in developing countries, with the largest increases anticipated in Africa and Asia. This development trajectory and the increased incidence of natural disasters and diseases caused by climate change will challenge cities already burdened with urban growth. How can these cities prepare for the urban future?

The effects of climate change are expected to be most keenly felt in cities, which in turn have the greatest impact on climate change. For most cities in Africa and Asia, the pressure to address climate change is mounting. More than half of the world's low elevation coastal cities are in Asia and 15% in Africa. Their heavily populated river deltas and low elevation coastal zones, including capital cities such as Bangkok, Jakarta and Tokyo, may become inundated (UN-HABITAT 2008a; Asian Development Bank 2009). Just like many other cities around the world, the goal is to reduce GHG emissions and prepare for the future. Climate change has become a major national, regional and international problem cutting across developed and developing countries.

B. Yuen (✉)
National University of Singapore, Singapore
e-mail: belyuen8@gmail.com

A. Kumssa (✉)
UNCRD Africa Office, Nairobi, Kenya
e-mail: asfaw.kumssa.uncrd@undp.org

It affects all important sectors of the economy, including agriculture and forestry, hydrology and water resources, natural ecosystems and biodiversity, coastal areas, settlements and health. Research has indicated that climate change and poverty are inextricably interconnected; climate change disproportionately affects the poor (The World Bank 2010).

In June 2009, the United Nations Centre for Regional Development (UNCRD), and Singapore Institute of Planners (SIP) jointly convened a senior policy seminar in Singapore to discuss the issues of urban development and climate change in Africa and Asia with a special focus on housing and liveability. The aim was to promote policy dialogue and enable policymakers from the two regions to exchange experiences and design strategies to address the consequences of climate change and advance urban resilience. Housing and liveability are two fundamental aspects of urban living. This volume brings together a selection of the papers submitted to the seminar and subsequently revised for this collection.

1.2 Understanding Africa

Africa remains the world's poorest and most underdeveloped region. Many of the low HDI countries in the UN Human Development Report 2009 are in Africa. A large proportion of its people suffer malnutrition, inadequate water supply and sanitation, poverty, crime and violence. As much as 76% of its urban population, with more than 100,000 inhabitants, are victims of crime, the highest in the world (UN International Crime and Justice Research Institute 1995). To compound matters, African countries are experiencing some of the world's highest urbanization rates, ranging from an average annual urbanization rate (2005–2010) of 2.4% in North Africa, 2.56% in Southern Africa, to 4.02% in West and Central Africa and 4.05% in East Africa (UN-HABITAT 2008b).

Africa is in a historic period of demographic change; more and more of its population are becoming urban. Even though Africa is the least urbanized region in the world (with 38.7% of its population living in cities in 2007), half of its total population is expected to live in cities by 2030, half of its total population is expected to live in cities. By 2050, more than 1.2 billion Africans will live in cities; this figure is more than the combined urban and rural population of the western hemisphere (UN-HABITAT 2008b). The number of cities with one million or more inhabitants has increased from 2 (Alexandria and Cairo) in 1950 to 43 in 2005, and is expected to grow to 53 in 2015 with an average size of 3.1 million people. The number of mega cities (cities with more than ten million people) will increase from one (Cairo: 11.9 million) in 2007 to three in 2015 – Cairo (13.4 million), Lagos (12.4 million) and Kinshasa (11.3 million).

Many of Africa's evolving cities are unplanned and have been associated with uncontrolled growth of informal settlements, inadequate housing and basic services, and increasing urban poverty. Despite the impressive economic growth, 40% of all Africans are living on less than US\$1 a day, and their number is growing. Among the major challenges facing African cities is the provision of jobs, housing and

infrastructure, compounded by the impact of weak political economies and global environmental change.

In the face of rapid urbanization, knowledge and measures are needed to integrate the processes of urbanization and industrialization so as to reduce poverty and arrest and manage anthropogenic activities that cause climate change. Urban service delivery strategies, including the housing aspects of development have to be integrated into urban planning and management policies. African countries have neither the economic power nor the human capacity to cope with the impacts of extreme climate changes. At the same time, Africa lacks the technology to mitigate and regulate effectively air pollution caused by industrialization as well as the ever-increasing motor vehicles, which is a key factor in road traffic congestion. Vulnerabilities are often heightened by the poor quality of buildings and infrastructure.

Climate change has produced more erratic weather patterns, eroded coastlines, spread pests and waterborne diseases. It is estimated that African farmers are losing \$28 per hectare per year for each 1°C rise in global temperature (*The Economist* September 13, 2008). As documented elsewhere, cities are major contributors of greenhouse gases. In the recent past, emission of exceptionally large amounts of gaseous carbon dioxide has raised environmental concerns in African countries. The sources include increased industrial emissions and large periodic fires aimed at clearing bush, grassland and forests to pave room for subsistence farming systems.

Another major impact of climate change on African countries is desertification. Desert conditions are induced by gradual and prolonged loss of vegetation cover over extensive land areas in a country, and/or across two or more countries. Permanent loss of vegetation cover leads to reduction in soil moisture that curtails biodiversity productivity. Poor land utilization practices, especially in subsistence farming and nomadic pastoral economies in the majority of the African countries have accelerated the loss of natural vegetation and exacerbated the problem of climate change. With time, desertification has transformed extensive land areas in and across countries into arid- and semi-arid conditions. In this regard, the capacity of the original vegetation land cover to regenerate is severely impaired because of near-total absence of rainfall.

Ambient temperatures are typically very high, a factor that sustains continuous huge losses of soil moisture and the few available water bodies through direct evaporation. Unusually high wind speeds, low and high atmospheric pressure spots, etc. sustain these adverse climatic conditions. Desertification in African countries has therefore created a vast land area that has no sufficient quality life-supporting natural resource base and physical weather conditions. In the desert environment, human life is only possible at sites where water is accessible. However, these are few and widely distributed. Settlements around these sites have very limited scope to sustain large human populations.

African countries, therefore, are facing daunting challenges from both desertification and greenhouse gas emissions. To overcome these, major and costly technology is required to curb desertification and reclaim arid and semi-arid lands for normal human life. Worsening climatic conditions, political and ethnic conflicts, erosion of

traditional safety nets, deteriorating physical infrastructure and absence of general security in rural areas have forced an increasing number of people to migrate to urban areas and satellite cities around major urban areas, thereby adding more pressure to the socioeconomic problems encountered by African cities. Cities are generally the centre of innovation and have the capacity as well as the technical know-how to deal with climate change. Yet, in Africa, cities lack the capacity to fulfil this potential. The challenge is to learn from other cities, reform and reinvest so as to deliver quality urban living options to their inhabitants, especially the poor. The answer lies within the cities themselves.

1.3 Understanding Asia

Asia has witnessed strong population, urban and economic growth in recent decades. Although located worlds apart, besides being very different in their demographic and economic composition, Asia and Africa share several commonalities. Asia, like Africa, is made up of different sub-regions, covering a range of diverse and varied country settings in terms of size, history, culture, geography, development and environment. It also contains several post-conflict states (for example, Cambodia and Timor-Leste) and some of the world's poorest countries (for example, Myanmar and Lao PDR). A unifying theme is the irreversible and pervasive trend of urbanization, with some, often the low-income countries, registering higher annual urban population growth rates, for example, Timor-Leste (6%), Cambodia (5%) and Indonesia (4%). China, one of the largest countries in the region, and indeed in the world, is expected to double its urban population from about 40% during 2006–2030 to more than 70% by 2050 (Yusuf and Saich 2008). It will add 270 million people to its urban areas by 2030. Similarly, India's urban population will grow from 30% to 40% by 2030. Asia's urban population, which has increased from 836 million to 1.56 billion over the past 2 decades, is expected to double between 2000 and 2030.

As with the rest of the world, economic growth in Asia is largely concentrated in urban areas. Cities are becoming larger. The number of large cities (mega-cities) is growing. By 2015, ten of the world's 22 mega-cities will be in Asia. The uneven pattern of urbanization is most apparent in situations where urban growth is concentrated around a country's major cities, sometimes including their surrounding areas. Commonly referred to as primate cities (some are growing into megacities), these cities attract a disproportionate amount of national provision of services, resulting in the concentration of investment and resources in a few major cities. They are also places of the most important impacts of globalization, making cities the places of change and expectations for the future.

Many countries in the Southeast Asia sub-region are distinguished by the primacy of their capital cities; Indonesia (Jakarta), Philippines (Manila), Thailand (Bangkok), Malaysia (Kuala Lumpur), Myanmar (Rangoon) and Vietnam (Hanoi and Ho Chi Minh). These urban areas account for a large proportion of the national

urban population, from 20% in the Jakarta Metropolitan Region, to 50% in Bangkok Metropolitan Region. The easy availability of land and land tenure arrangements that restrict the redevelopment of older inner city areas has encouraged urban growth on the urban fringe. In the process, it has transformed rural villages into urban settlements without displacing most of the residents.

Estimates indicate that 77% of urban growth in Jakarta's extended urban region and, 53% in Bangkok's in 2025 will be in peri-urban areas (Webster and Muller 2004). Bangkok, Thailand, has grown from 67 km² during the 1950s to 426 km² by the mid-1990s. The Bangkok Metropolitan Area covers an area of 7,761 km² and has a registered population of ten million, which is projected to grow to 30 million by 2020. By 2020, the Jakarta Metropolitan Region is projected to have a population of 100 million. Up to 40% (200 million) of China's urban growth in 2025 is expected to occur in peri-urban areas. The peri-urban zone can be extensive, extending as far as 150 km, or in some Chinese cities, 300 km from the core city. Shanghai Metropolitan Urban Region, for example, covers an area of over 6,300 km² while the Beijing Metropolitan Urban Region is more than 16,800 km². These mega-cities are introducing an urban context of a size and geographic scale never before experienced.

Urbanization both reflects and contributes to economic growth. Economically, the region includes the first generation of newly industrializing economies of the Republic of Korea, Hong Kong SAR and Singapore; the second generation of newly industrializing ASEAN-4 countries (Malaysia, Thailand, Indonesia, and the Philippines); the transitional economies of China and Vietnam; and the yet to emerge economies of Mekong area, some of which, for example, Lao PDR, are among the poorest in the world (The World Bank 2002; UNESCAP/UNDP Joint Poverty Centre 2003). Hong Kong (a special administrative region of China) is perhaps the most *laissez-faire* economy in the world, while North Korea (DPRK) is one of the few remaining socialist economies.

Over the past few decades, many countries in the region, especially those in East Asia (except for North Korea) and South-East Asia sub-regions are rapidly emerging as engines of global growth. Out of the world's ten fastest growing countries, three (China, Macau SAR and Timor-Leste) are in Asia. Increases in foreign direct investment (FDI) in urban-based manufacturing and value-added economies have been a major factor in the region's rapid and sustained economic growth (The World Bank 1993; Lo and Marcotullio 2000). In this regard, African countries received very little of this global investment for a variety of reasons, including lower political instability, inadequate infrastructure, undeveloped workforce and higher costs of doing business, among others.

The inter-relationship between economic growth and urbanization and the resultant pace and scale of change of cities has generated considerable challenges. Even though there is a growing middle class, poverty remains a big issue in Asia. While Asia has a lower poverty level than the world average, countries in the region vary widely in terms of poverty level. Cambodia, Lao PDR and Mongolia, for example, are among the poorest countries that have significant portions (more than 70%) of their population still living under the international

poverty line. As with Africa, the rising number of people in urban areas on a scale never before experienced, has led to pervasive slums and squatter areas, and sprawling peri-urban development, especially when there is no matching capacity to govern the city and ensure that the growing population and economy can get the land, infrastructure and services they need.

With a few exceptions, the number of slum dwellers has grown, and continues to rise in Asia. In some large cities such as Mumbai, Phnom Penh, Jakarta and Manila, it is not uncommon to find a quarter or more of the population living in informal settlements. In metro Manila, for instance, 61% of its people are squatters. These informal settlements are often located in unsafe areas, which generate further risks to life, health and property, leaving them vulnerable to climate change. The region faces a range of urban environmental challenges, from rapidly-expanding but poorly planned cities, to forest fires, polluted air and water, inadequate water supply, sanitation and energy, deficient drains and flooding fears. Weak finances of urban local authorities have left many without the capacity to renew and expand urban infrastructure to meet the growing need. The United Nations Environment Programme has ranked Jakarta, Indonesia and Bangkok, Thailand, as among the world's most polluted mega-cities.

Cities often have to address all of the above urban challenges at the same time. The pressure is magnified in megacities. Without effective management, rapid urban growth is expected to exacerbate existing problems of poverty, slums, pollution, water, sanitation, etc. Urbanization is adding more people to the region's cities every year, requiring not just more new housing, but also roads and additional infrastructure to supply schools, clinics, sanitation and water. Mainstreaming of sustainable development remains a critical and a must-act urban challenge. The impacts of major drought and flooding in recent years are refocusing attention on the environment and the need to recognize and respect the symbiotic relationship between environment, economic and urban growth. The challenge of climate change is real and urgent. Scientists are predicting that climate change may trigger more frequent and violent seismic activities. The Philippines, Vietnam, Cambodia, Lao PDR, Thailand and Indonesia are among the countries identified as climate change 'hotspots' (Yusuf and Francisco 2009). They are particularly vulnerable to some of the worst manifestations of climate change expected in the coming decades.

Against these urban challenges, some Asian cities, for example, Hong Kong, Singapore and Japanese cities such as Tokyo and Yokohama seem to have developed positive ways to manage housing, urban development and environment management (Yeung and Wong 2003; Castells et al. 1990). Many of these best practices are documented in the World Bank *eco2cities* book launched during the UNCRD-SIP senior policy seminar in Singapore, June 2009 (Suzuki et al. 2009). Singapore's expertise in urban planning and development has been increasingly recognized by urban scholars and policymakers (Ooi and Yuen 2010; Wong et al. 2008). In 2009, the World Bank and Singapore jointly set up an Urban Hub in Singapore to leverage Singapore's expertise in urban solutions for developing country cities, especially in the area of urban management.

1.4 The Chapters

The book consists of 14 separate but interlinked essays on climate change and urban development issues in Africa and Asia organised under four main themes. Part I is an Introduction, while Part II deals with climate change and urban development in general, and Africa and Asia in particular. Part III deals with climate change and housing problems in Africa and Asia and examines the impact of climate change on housing and the policy options available to planners and policymakers to deal with the adverse effects of climate change on housing. Part IV is on climate change and its effects on cities of Africa and Asia and how to create resilient cities. Within these broader themes, the authors of the various chapters focus on different issues related to the respective themes and examine the impact of climate change on Africa and Asia.

Chapter 1, by Belinda Yuen and Asfaw Kumssa, *Introduction: Africa and Asia, Two of the World's Fastest Growing Regions* examines urban development trends in Africa and Asia in comparative perspective and highlights the general impact of climate change on urban development in Africa and Asia. Chapter 1 also provides a summary of the topics covered in the volume, highlighting the different issues discussed in each chapter.

Chapter 2 on *Climate Change and Living Cities: Global Problems with Local Solutions* by Priyanka Anand and Kallidaikurichi Seetharam examines how climate change and growth of cities affect each other. Anand and Kallidaikurichi argue that rapid urbanization and the growth of cities will be accompanied by a change in people's lifestyle and patterns of human settlement and hence it will increase the demand for energy, transportation, infrastructure, etc. This in turn will impact on climate change due to an increase in GHG emissions, waste disposal and unsustainable land use, etc.

Their further hypothesis is that although cities could be the engines of growth and solution to climate change, they are also severely affected and could be vulnerable to climate change. Climate induced problems such as flood, droughts, rising sea levels, etc. will adversely affect the health of the city dwellers, reduce food production, threaten coastal cities, create water stress and destroy the infrastructure of urban areas. The authors argue that the solution to climate change problems should come from cities themselves because they have a complex system of mitigation and adaptation capacities and abilities. Therefore, urban planners and policymakers should think locally and design long-term and integrated plans that incorporate both mitigation and adaptation strategies.

Chapter 3 by Kempe Ronald Hope, Sr., *Climate Change and Urban Development in Africa*, examines the relationship between climate change and urban development in Africa and assesses the impact of climate change on urban development patterns in sub-Saharan Africa. The chapter also highlights the policy options available to policymakers in terms of adaptation and mitigation strategies.

Hope tells a compelling story that although Africa contributes the least to global climate change, it is the most impacted by the adverse effects of climate change due

to the continent's low capacity to deal with the problem, and to the high level of poverty in Africa. Hope further stresses that with 11% of the world's population, Africa contributes only 3% of the total global emissions while the rich countries with 15% of the global population contribute 45% of CO₂ emissions.

Although Africa has the highest urbanization rate in the world, it is the least urbanized continent. Urbanization in Africa is due both to the natural population growth and rural – urban migration that is triggered by the “push” and “pull” factors. The author identifies two major common characteristics of urban development in Africa: high level of poverty and the mushrooming of slums and informal settlements.

Hope states that climate change will further exacerbate these problems and undermine the progress so far made in improving the well-being of the urban population in Africa. In this regard, climate change will adversely impact agriculture and food security, the availability of clean water and increase water stress in Africa. It will also increase the frequency and impact of drought and floods and cause havoc on urban settlements in Africa. Climate change will also have significant effects on human health in Africa.

Hope concludes by arguing that since Africa's contribution to climate variation is marginal, policymakers in Africa should focus on adaptation policies rather mitigation. In this regard, both local and national governments should design effective strategies and “be vigilant in their policy approaches for controlling the impacts of climate in their cities as well as nationally.”

Chapter 4 by Kioe Sheng Yap, *A Region of Contrasts: Urban Development, Housing and Poverty in Asia*, examines urban development, the problems of housing and poverty in Asia. According to Yap, although Asia has achieved the fastest economic growth and is oftentimes considered the model for other developing countries, Asia is a vast region with “an enormous diversity, deep contrasts and wide disparities.” This disparity and contrast is vivid and visible in urban development in general, and in housing and poverty in particular. The region includes the most populous and fastest-growing economies (China and India) as well as small and poor countries such as Nepal and Lao PDR.

The region is also home to some of the richest countries in the world such as Japan and Singapore. For example, the per capita GDP of Singapore was US\$47,950 in 2007 while Nepal's GDP for same period was US\$1,060. Yap also argues that there is income and social disparity within the same country as in the case of China where the coastal provinces are richer than the inland regions.

According to Yap, although Asia's urbanization rate is not as fast as that of Africa, the region will be predominantly urban by 2030. Therefore, Asian policymakers and planners should design effective urban policies that will cater for urban poverty, settlement, urban governance, housing and slum upgrading programmes.

Chapter 5, *Climate Change and its Effect on Urban Human Settlement in Africa* by Aloysius Clemence Moshia looks at the impact of climate change on urban human settlement patterns in Africa. The chapter begins by presenting the physical and geographical conditions as well as the socioeconomic facts of Africa. Following these, the author examines the impact of climate change on urban

human settlement. Mosha argues that climate change affects human settlements in three areas: economic sectors, physical infrastructure and population, and discusses the major effects. Climate change affects the economy by adversely affecting the productive capacity (e.g. in agriculture and fisheries). Climate change also adversely affects the infrastructure when transportation or other service delivery systems are destroyed by floods. Extreme weather changes can also directly affect the health of the population and lead to death, injuries or illness.

According to Mosha, climate change will also increase the frequency and intensity of hazards such as floods and drought that in turn adversely affect availability of water, agricultural yields, and the availability of pasture for livestock. Climate induced sea-level rise will also impact on the coastal urban settlements. Mosha argues that climate change disproportionately impacts the poor communities since they live in hazardous and unhealthy urban environments. To tackle the problem of climate change in urban areas, Mosha recommends the following measures:

- Planners and policymakers should take into account the potential and actual impacts of climate change on human settlements both at the national and local levels, and ensure the effective implementation of urban development plans and enforcement of rules and regulations. Capacity building and raising awareness among relevant stakeholders about the impact of climate change is also essential.
- Local and municipal governments in Africa should adopt plans that are sensitive to energy saving and design, and implement appropriate land use policies, as well as promote public transport (buses, bicycles, etc.).
- Local and municipal governments should create conducive environment for the urban population and industry to have access to clean and affordable energy. Strategies should therefore emphasise local and appropriate technologies, renewable energy, cost-effectiveness, and energy efficiency.
- They should seek to promote technologies and policies that facilitate harvesting rain water from residential houses and from other surfaces.
- Local and national governments should promote and encourage investments in climate-resilient infrastructure in urban areas, especially with respect to erosion and flood control, drainage, water treatment, housing and transport systems.
- African countries should also promote slum upgrading programmes and encourage public-private partnership in providing affordable housing to the poor communities.
- In general, African countries should prepare and come up with effective urban development plans as well as disaster preparedness and risk management policies in urban areas.

Chapter 6, *Climate Change and Housing in Ghana* by Kwasi Kwafo Adarkwa and Michael Poku-Boansi examines the impact of climate change on housing in Ghana. The authors review the recent change in temperature, humidity and rainfall patterns in Ghana in a bid to link these changes to climate variability. According to Adarkwa and Poku-Boansi, Ghana, like any other country, has recently experienced the effect of climate change that has led to a rise in sea level and an increase in the frequency

and intensity of extreme weather conditions such as drought or heavy rainfall. Quoting the *Ghanaian Times*, the authors argue that by the year 2080, rainfall in Ghana will reduce by 20–40%, making life very difficult for farmers who depend on rain-fed agriculture.

As a result of the decline in water inflows to reservoirs, the country is also experiencing an electricity crisis. At the same time, due to climate change, Ghana is experiencing increasing air temperatures, heat waves, a rise in sea level, drought and storms. Adarkwa and Poku-Boansi argue that as a result of sea-level rise, two coastal towns (Ada and Keta) are slowly submerging under the sea.

On the impact of climate change on housing, the authors argue that climate induced rising temperatures and humidity levels, etc. have greatly contributed to the increasing warmth in buildings and the housing environment. Moreover, haphazard development of housing and the growing slums and informal settlements, combined with high heat absorbing materials such as glass used in construction have contributed to effects of global warming on housing in Ghana.

Chapter 7, *Creating a Sustainable Living Environment for Public Housing in Singapore*, by Johnny Lian Heng Wong discusses the role and experiences of the Housing and Development Board (HDB) in creating sustainable public housing schemes in Singapore. According to Wong, since independence, Singapore has made significant progress in economic and urban development. It has consciously implemented a process of urban development that has managed to extract a semblance of order and a more functional use of land out of the urban congestion. Singapore is often held up as a model of success of a formerly underdeveloped, economically backward and squatter city redeveloped into a modern, clean and green city with efficient infrastructure and an effective urban environmental management policy.

Over 80% of its population lives in self-owned public housing flats built by HDB. HDB was established in 1960 to provide low-cost housing for Singaporeans. Singapore is probably the only country in Asia where the authorities have managed to provide affordable quality housing to low-income families while avoiding debilitating settlements and low-class social housing that characterizes public housing in other countries. As a result, Singapore was awarded “the prestigious United Nations Public Service Award in 2008 for her Home Ownership Programme.”

According to the author, due to scarcity of land in Singapore, HDB has built high-rise and high-density housing. Besides meeting the housing needs of the population, urban and housing designs in Singapore give due consideration to the environment and effective energy utilization, water and waste management. More specifically, Wong states that as part of its overall strategy of achieving environmental sustainability, HDB has been taking the following initiatives:

- Promoting energy efficiency
- Reducing urban heat island effect
- Promoting sustainable construction

In 2007, HDB also launched its eco-precinct at Punggol town. According to Wong, this is a residential housing project where green technologies and solutions will be

available to “show the industry that innovation and sustainable development can be both practical and cost-effective.”

Chapter 8, *Climate Change and Housing in South Africa*, by B. C. Chikulo discusses climate change and housing issues in South Africa, with special emphasis on housing for the poor. The chapter also addresses the dilemma the government is faced with in terms of meeting the objectives of the energy-intensive economy of the country, which is mainly based on coal, a product that has high emission rates.

South Africa is a middle-income developing economy with a sophisticated financial and physical infrastructure, good telecommunication and energy supply networks. The country has also one of the best stock exchanges in the world. South Africa's economy accounts for 40% of all industrial output and 25% of the GDP of the African continent. Yet, the country has one of the highest income disparities in the world. South Africa is also the largest emitter of greenhouse gases on the African continent and the world's biggest single emitter of CO₂ due to its economy's high dependency on coal.

According to Chikulo, climate variability is already affecting housing and human settlements, particularly the informal settlements and low-cost housing where the majority of the poor live. Chikulo argues that 19% of dwellings in South Africa are considered as informal and squatter settlements – about 3.6 million people live in these informal settlements and have no access to proper sanitation, infrastructure and electricity. Most use coal, kerosene, wood or liquid petroleum to cook and heat their homes. As a result, they are exposed to indoor air pollution that impact adversely on their health. Also, in these settlements, people have no access to clean water and proper sanitation systems. Consequently, when there is heavy rain, they are exposed to floods and infectious diseases.

Chikulo further argues that the government should come up with a more positive, pro-active and integrated housing policy and legislation to improve the quality of housing as “the poor quality of the dwellings increases the vulnerability of most poor households to adverse weather conditions and makes them susceptible to storm damage, with several hundred homes being swept away every year.” The government should also provide the informal dwellers with proper services and facilities such as clean water, good infrastructure, electricity and health facilities to improve the social and economic conditions of the poor.

To the assertion that South Africa's dependency on coal-fired power stations has resulted in high emission of carbon dioxide, Chikulo suggests that the country should therefore look into its source of energy and implement clean and sustainable policies, which are already identified in various policies such as the 2004 *National Climate Change Response Strategy for South Africa*.

Chapter 9, *Climate Change and Sustainable Housing in Uganda* by Stephen A. K. Magezi looks at the challenges of housing infrastructure in Uganda and the additional problems and threats brought by climate change to housing development in Uganda. According to Magezi, climate change has increased temperatures and the frequency and intensity of floods in Uganda. The warming of temperatures has been felt in the highland areas of western and south-western Uganda where temperatures have increased by 0.3° per decade. As a result of climate change, there

will be an increase of 10–20% in water run-off at the current climate change scenarios. Between 1991 and 2000, Uganda experienced prolonged and frequent droughts.

Climate-induced droughts have affected food security and availability of water, while the floods have led to an outbreak of water-borne diseases, and have destroyed the country's infrastructures. Floods not only lead to the outbreak of diseases such as cholera and malaria, but they also destroy houses, infrastructure and water sources. Floods also often wash away pit latrines and thereby contaminate drinking waters, causing water-borne diseases. Magezi also argues that due to the increase in temperatures, "the ice cap on the Rwenzori Mountain is fast retreating" and thereby negatively affecting the water catchments downstream, eco-tourism and agriculture.

As Magezi demonstrates in his chapter, the poor and the rural people are the most affected by climate-induced floods and droughts. Since houses in most rural areas are built with grass and wood, they are vulnerable to bush fires caused by prolonged droughts. Also, the increased intensity and frequency of heat waves have adversely affected the health and life of both the urban and rural populations.

Magezi further argues that, currently, Uganda does not have a climate change or a comprehensive housing policy, although there is a National Shelter Strategy. He recommends a comprehensive and an integrated development policy that caters for and incorporates climate change challenges in Uganda.

Chapter 10, *Housing and Climate Change in Vietnam* by Vinh Hung Hoang examines the impact of climate change on the socio-economic development and housing of Vietnam. It also highlights the institutional arrangements and strategies that the country has put in place to tackle the adverse impacts of climate change.

Vietnam embarked on an economic reform policy, *Doi Moi*, in 1986 and introduced a market-oriented economic policy by abandoning the centrally planned economy. The reform policy stimulated economic growth and increased per capita GDP from US\$200 to US\$400 in the 1990s, to US\$835 in 2007. The incidence of poverty also declined from 58% in 1993 to 12.4% in 2008.

Although Vietnam has made tremendous progress in socio-economic development in the past 2 decades, the country is prone to disasters such as typhoons, tropical storms and landslides. Since most of the industrial and urban development belts are located along the coastal areas, they are susceptible to climate induced disasters such as frequent typhoons, tropical storms, sea surges and salt intrusion. According to Hoang, in the next 100 years, it is expected that the sea level will rise by between 30 cm and 1 m, and thereby increase the frequency and intensity of floods and threaten low-lying coastal areas. A 1-m rise in the sea level will adversely affect six million Vietnamese, or 7.3% of the population.

Hoang argues that due to the recent climate variability, Vietnam has experienced a change in the intensity and frequency of storms and rainfall. Between the years 1990 and 2000, general floods killed about 3,173 people while about 804 people lost their lives to storm surges and coastal floods.

To address the challenges of climate change in Vietnam, Hoang suggests that the government should design both short-term and long-term policies that will increase the adaptation capacity of the local community. He also suggests that the poor

communities should get special attention and support from the government so as to enable them to manage climate-induced disasters. Although the government has taken several steps towards this goal, further efforts are needed to effectively manage climate change induced disasters and to enable local communities to develop a sustainable and resilient capacity.

Chapter 11, *Climate Change and Sustainable Development in Chinese Cities*, by Xiaodong Pan and Zhenshan Li provides a detailed analysis of the impact of climate change on China with special emphasis on its urban environments. According to Pan, due to climate change, the average temperature of China has risen by 1.1°C between 1908 and 2007. Consequently, drought and high temperatures have become frequent and prolonged, adversely affecting agricultural and livestock production. The intensity and frequency of climate induced problems such as high temperatures, severe droughts and floods have increased. Pan observes that in the past 30 years, sea level has also risen by 90 mm, thereby threatening coastal towns. He further contends that China's main source of energy comes mainly from coal, which provides 68.9% of the total energy consumption of the country, compared to 27.8% for rest of the world. In this regard, the author believes that China will face difficulties in decreasing its carbon intensity per unit of energy consumption.

According to Pan, the government has taken certain initiatives to mitigate the problems of climate change, including accelerating the development of service industries, promoting low-carbon and high-tech industries and gradually eliminating industries that discharge a large quantity of CO₂. The government is also encouraging afforestation programmes besides promoting R&D to tackle the challenges of climate change. In 1998, the government also established the National Coordination Committee on Climate Change to deal with climate related issues in China. China has also strengthened its early warning and disaster monitoring systems.

Pan's thesis is that climate change is a global challenge that requires global solutions. In this regard, the international community should come together and design and agree upon effective and viable adaptation and mitigation strategies. China will also do its part and contribute to the international community's efforts to mitigate the adverse effects of climate change.

Chapter 12, *Climate Change and Its Effects on Cities of Eastern African Countries* by Samuel K Gichere, George M Sikoyo and Ally M Saidi examines the impact of climate change on the cities of East African Community (EAC) partner states that comprise Burundi, Kenya, Rwanda, United Republic of Tanzania and Uganda. According to the authors, the effect of climate change is already being felt in the cities of EAC partner countries in the form of floods, deteriorating infrastructure, increased energy costs, increased outbreak of diseases and food insecurity.

Gichere et al. posit that the temperature in East Africa is expected to warm up by 2–4°C by 2100, and the rainfall patterns will also change. Rainfall is expected to decrease by 0–20% and dry seasons will be longer in the inner parts of East Africa, while rainfall is expected to increase by 30–50% in the coastal regions. At the same time, the region has experienced periodic droughts and flooding.

The authors argue that to mitigate the adverse effects of climate change in the region, the cities of East Africa have already undertaken several initiatives,

including rehabilitation of infrastructure, strengthening the capacity of the community to manage climate induced disasters, formulation of laws and relocation of communities and families who are at risk of climate change induced disasters. Adaption measures have also been put in place, which include managing climate risks, mainstreaming adaptation strategies into local, regional and national plans and policies, strengthening and establishing early warning systems and disaster preparedness.

Chapter 13, *Climate Change and Liveable Cities in Malaysia* by Kamalruddin Shamsudin and Suan Siow Neo presents the current policy initiative of the government of Malaysia in addressing the effect of climate change, and examines how physical planning policies should incorporate climate change issues. The authors argue that climate change is expected to increase the surface temperature of Malaysia on average by 1.5°C by the year 2050. This will have ramification for the general sustainable development of the country because climate change will lead to extreme weather conditions, including heavy rainfall and droughts. As a result of climate change, the annual rainfall is expected to increase by 10% in some regions such as Kelanta, Terengganu and Pahang, while in other regions such as Selangor and Johor, the amount of rainfall is expected to decline by 5%, while the river flows will be reduced by 31–93%. Climate change induced 1-m rise in sea-level rise will also lead to the submersion of 745 km of land area in the country. The impacts of sea-level rise also include tidal inundation, shoreline erosion, increased wave action and saline intrusion.

According to the authors, as a result of climate change, Malaysia experienced mild climate induced disasters such as floods, droughts, storms/wave surges, wildfires, wind storm and landslides. For instance, between 1965 and 2007, about 49 cases of natural disasters were reported, and resulted in the death of about 1,062 people besides affecting 1.24 million others.

The authors suggest that climate change will adversely affect the agricultural sector, forestry, availability of clean water and human settlements. In this regard, they argue that climate change is a cross-sector problem and therefore should be mainstreamed into the national and local plans of the country. Cognizant of this, the government has encouraged and initiated planning policies that place sustainable development and environmental concerns at the centre of all projects and plans. Planners are also requested to take up climate change issues seriously and design strategies in their statutory development plans.

The authors argue that the government has come up with an integrated planning and resource management framework that promotes holistic and systematic integration of resource management through integration of sectoral plans into federal level and national plans. This type of plan aims at ensuring viable and environmental friendly public transport systems and arresting encroachment of urban development into environmentally sensitive areas, and designated agricultural and food production areas.

Chapter 14, *Climate Change and Its Effect on Urban Housing and Liveable Cities: The Case of Harare, Zimbabwe* by Rodreck Mupedziswa addresses the

impact of climate change on the urban population in Zimbabwe with a special emphasis on Harare city, and highlights how climate change has become a major threat to human security in this city. The chapter also examines how climate change has exacerbated poverty.

According to Mupedziswa, Zimbabwe once called the “bread basket of Southern Africa” has now become the “basket case of Southern Africa.” The economy of the country has crumbled due to the political turmoil in the country. Poverty has risen while the unemployment rate tottering at about 94%.

These problems are exacerbated by the effects of climate change, which have increased the intensity and frequency of drought. Since the 1990s, crop yields have been adversely affected by the prolonged and frequent droughts. According to the author, climate change-induced erratic weather has eroded river banks, spread pests and water-borne diseases. At the same time, the chaotic land reform programme which began in 2000 resulted in the destruction of vegetation, especially cutting down of trees and incessant fires. Further the author argues that as the poor struggle to survive, they have destroyed trees and grass that resulted in the reduction of soil moisture, and have curtailed biodiversity in the country in general; and Harare in particular.

Mupedziswa also argues that climate-induced floods have destroyed the infrastructure of the city, including sewer lines and water pipes. Floods often lead to an outbreak of water-borne diseases such as cholera. In 2008, about 4,200 people died of a cholera outbreak. At the same time, the rise in temperatures has reduced availability of water and led to power black-outs in the city. The author asserts that urban agriculture is an important activity in Harare, which has been adversely affected by climate-induced drought and floods.

As a way forward, Mupedziswa suggests that, more than anything, the country needs political stability. The government should also explore survival alternatives for the poor so that they do not destroy the environment, by exploring alternative sources of energy such as solar energy. At the same time, reforestation and other mitigation measures must be put in place, otherwise some parts of the country such as the Matabeleland region may gradually turn into desert. The author also strongly suggests mainstreaming climate change issues into the municipal, local and national plans of the country.

The various authors in this volume have outlined some of the key challenges facing Asian and African cities. Better practices and areas of improvements are also discussed. A central thread in this work is the need to formulate action plans and design resilient strategies to deal with the cities' challenges. This was also emphasized in the final session of the June 2009 senior policy seminar where the participants came together to develop an action plan, underscoring capacity building, institutional coordination, need for full political commitment and improved governance, knowledge management systems, advocacy and awareness, increased international collaboration and partnership, local coping strategies and the formulation of an environmental policy and strategy. In the face of expanding urban challenges, the time for cities to act is now.

References

- Asian Development Bank (2009) Addressing climate change in the Asia and Pacific Region. Asian Development Bank, Manila
- Castells M, Goh L, Kwok RYW (1990) *The Shek Kip Mei Syndrome: economic development and public housing in Hong Kong and Singapore*. Pion, London
- Lo FC, Marcotullio PJ (2000) Globalization and urban transformations in the Asia Pacific region: a review. *Urban Studies* 37(1):77–111
- Mehta B, Dastur A (2008) *Approaches to urban slums – a multimedia sourcebook on adaptive and proactive strategies*. The World Bank, Washington, DC
- Ooi GL, Yuen B (eds) (2010) *World cities: achieving liveability and vibrancy*. World Scientific, Singapore
- Suzuki H, Dastur A, Moffatt A, Yabuki N (2009) *Eco2Cities*, conference copy. The World Bank, Washington, DC
- The Economist (September 13, 2008). *Adapt or die: climate change and the poor*
- The World Bank (2010) *World development report*. The World Bank, Washington, DC
- The World Bank (1993) *The East Asian miracle: economic growth and public policy*. World Bank and Oxford University Press, New York
- The World Bank (2002) *World development indicators*. World Bank and Oxford University Press, Washington, DC
- UNESCAP/UNDP Joint Poverty Centre (2003) *Promoting the millennium development goals in Asia and the Pacific: meeting the challenges of poverty reduction*. UNESCAP, Bangkok
- UN-HABITAT (2008a) *The state of the world's cities report 2008/2009: harmonious cities*. UN-HABITAT, Nairobi
- UN-HABITAT (2008b) *The state of African cities 2008*. UN-HABITAT, Nairobi
- UN Interregional and the acronym to (UNICJRI) Crime and Justice Research Institute (1995) *Criminal victimisation of the developing world*. UNICJRI, Rome
- Webster D, Muller L (2004) *The challenge of peri-urban growth in East Asia: the case of China Hangzhou-Ningbo Corridor*. In: Freire M, Yuen B (eds) *Enhancing urban management in East Asia*. Ashgate, Aldershot
- Wong TC, Yuen B, Goldblum C (eds) (2008) *Spatial planning for a sustainable Singapore*. Springer, Dordrecht, The Netherlands
- Yeung YM, Wong TKY (eds) (2003) *Public housing in Hong Kong*. Chinese University Press, Hong Kong
- Yusuf AA, Francisco H (2009) *Climate change vulnerability mapping for Southeast Asia*. IDRC, Canada
- Yusuf S, Saich T (2008) *China urbanizes: consequences, strategies, and policies*. World Bank, Washington, DC

Part II
Climate Change and Urban Development

Chapter 2

Climate Change and Living Cities: Global Problems with Local Solutions

Priyanka Anand and Kallidaikurichi Seetharam

2.1 Introduction

In a report published in 2007, IPCC concluded that “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level” (IPCC 2007:2). Climate change has been one of the causes of increased incidences and/or intensity of extreme weather events such as floods and heat waves. These weather-related occurrences have had a major impact on cities, particularly those in developing countries and coastal regions.

Accompanying this change in climate patterns is the rapid urbanisation and growth of cities in the twentieth century. As centres of economic growth, urban centres play an important role in the economic development of a nation. Urbanisation is accompanied by change in lifestyles, increased energy demand, transportation, infrastructure, etc. It therefore exerts considerable pressure on the existing city resources. Rampant growth of cities has thus resulted in a number of governance, infrastructural and environmental issues. Further, changes in lifestyle have come at a considerable cost to the environment and human activities are often seen as major contributors to climate change. Given the increase in the number of people residing in cities, the effect that cities and human activities have on the climate, and the impact that climate change has on cities, the relationship between cities and climate change should be studied in depth. This chapter delves into this relationship.

P. Anand (✉)

Institute of Water Policy, Lee Kuan Yew School of Public Policy and Global Asia Institute,
National University of Singapore, University Hall, Lee Kong Chian Wing,
#UHL-03-01, 21 Lower Kent Ridge Road, Singapore 119077
e-mail: priyanka.anand@nus.edu.sg

K. Seetharam (✉)

Institute of Water Policy, Lee Kuan Yew School of Public Policy and Global Asia Institute,
National University of Singapore, 469C Bukit Timah Road, Wing A, Level 2,
OTH Building, Singapore 259772
e-mail: keseetharam@nus.edu.sg

The chapter is divided into four main sections following the introduction. In [Sect. 2.1](#), the trends of global climate change and urbanisation are discussed. Emphasis here is on understanding the implications of these trends on health, resource availability, infrastructure and governance. [Section 2.2](#) discusses the inter-relationship between cities and climate change. The rapid growth of cities and accompanied changes in lifestyles and energy use has resulted in increased emissions of greenhouse gases and has ultimately altered the climate. Climate change has also had an impact on city life, competitiveness and growth. [Section 2.3](#) focuses on the ability of cities and urban centres to mitigate and adapt to climate change. It discusses the important role played by cities in fighting climate change.

This chapter proposes that the solution to the global climate change challenge should be implemented at the local level. While cities may be the source of a considerable amount of GHG emissions, waste disposal and adverse land use changes, they also possess the potential to provide solutions to climate change and global warming through adoption of good policies and governance. Although global coordinated action is required, the important role that cities can play needs to be recognized and exploited. In keeping with the idea of centrality of cities in the fight against climate change, the concept of “Living Cities” has been introduced in [Sect. 2.4](#). This concept serves to help cities address the problems of climate change while enabling them to retain or even strengthen their image as vibrant centres of economic prosperity.

2.2 Climate Change – Current Trends

The latest report by the IPCC (2007) concluded that climate change is a global phenomenon. In coming years, global temperatures, precipitation, droughts and floods are likely to be more extreme and intense. The earth’s mean temperature has been rising steadily over the past 100 years by approximately 0.6°C (Walther et al. 2002). Sea levels are likely to continue to rise, causing major problems for coastal low lying areas. [Figure 2.1](#) shows the increase in global mean temperatures over the past 150 years.

The human influence on this change in climate and temperature is substantial. It is a major contributor to the increasing emissions of greenhouse gases (GHGs) such as carbon dioxide (CO₂). CO₂ is the most important GHG. Between 1970 and 2004, its emissions have grown by 80% due to an increase in the use of fossil fuels, industrial activity, transportation and other human activities. The concentration of CO₂ in 2005 was approximately 379 ppm, which exceeds the natural range of 180–300 ppm over the past 650,000 years (IPCC 2007). The rate of human-induced climate change is much higher than that attributable to natural processes.

It is highly unlikely that climate change can be reversed or stopped in the near future. The effect of an increase or decrease in GHGs emission is not felt immediately. This implies that climate has not yet fully reacted to the current levels of emissions and this “unrealized” effect could be close to a warming of 0.5°C (Karl and Trenberth 2003). As a result, even if emissions are held constant at the year 2000 level, it is highly likely that the warming trend will continue into the near future.

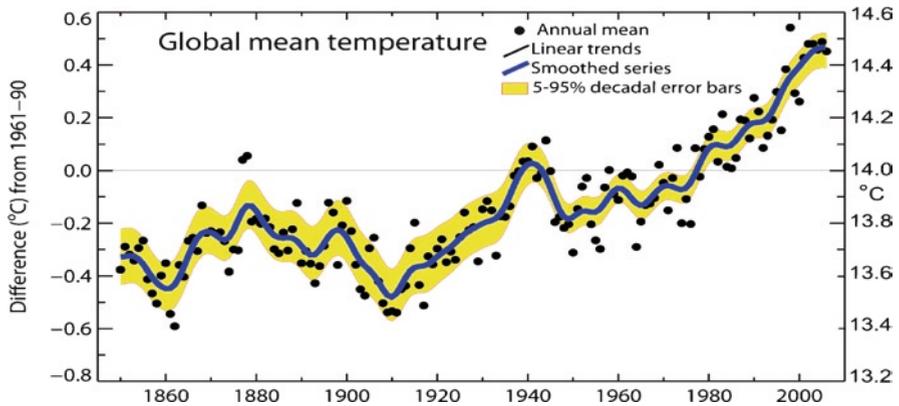


Fig. 2.1 Changes in global average surface temperature (IPCC 2007)

Since climate change trends will largely depend on population growth, changes in lifestyles, technology and innovation, future studies on climate change need to interrogate these attributes.

Rising global temperatures and heat waves, extreme precipitation and flooding in some parts of the world, and frequent droughts in others, rising sea levels precipitated by melting glaciers, are all telltales of climate change (IPCC 2007). Although floods, heat waves, and storms are all naturally-occurring phenomena, and mostly cannot be prevented, climate change results in the amplification of these phenomena and an increase in the frequency at which these extreme weather events occur. These changes have far-reaching impacts on human health, food and water resources.

2.2.1 Urbanisation and Growing Cities

In the last century, urbanisation, which is the process of migration of people from rural areas to urban areas, has been on the rise, with approximately 48% (three billion) of the world's population living in urban areas today (UN Department of Economic and Social Affairs, Population Division 2004). A further two billion people are expected to be added to this number by 2030, most of whom will be in developing countries (at approximately 2.3% per annum since 2000) (Cohen 2006). The growth rate of urban population in the period 2000–2030 is expected to be 1.8%. When this is compared to the expected total population growth rate of less than 1%, the high rate of urbanisation and subsequent growth of cities is put into perspective. As can be seen from Fig. 2.2, urban population growth is expected to be greater than rural population growth in the next few decades.

Due to urbanisation, there has been a rapid increase in the size of existing cities, in addition to the emergence of new ones. From only 80 cities with a population of one million or more people each in 1950, today there are more than 300 cities with a population of 1 million and above. Further, the average size of the largest 100 cities

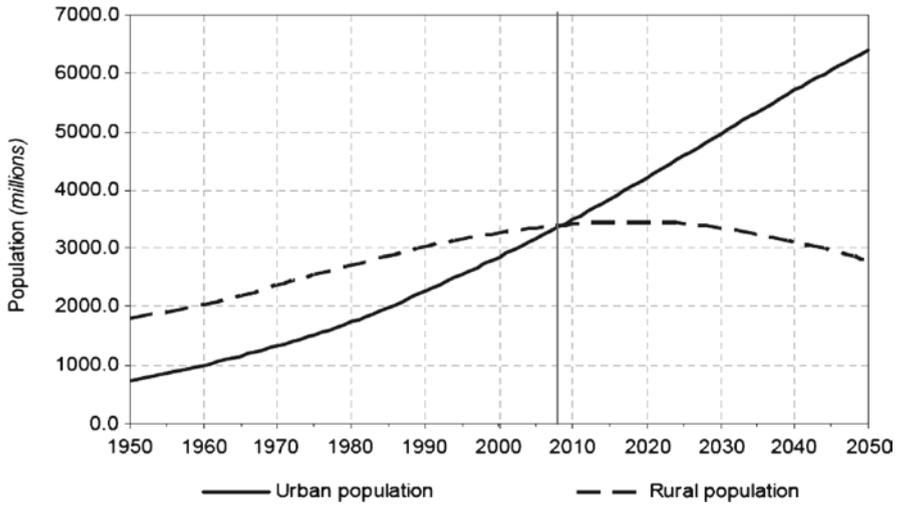


Fig. 2.2 Urban and rural populations of the world, 1950–2050 (United Nations 2004). World Urbanization Prospects, NY: United Nations

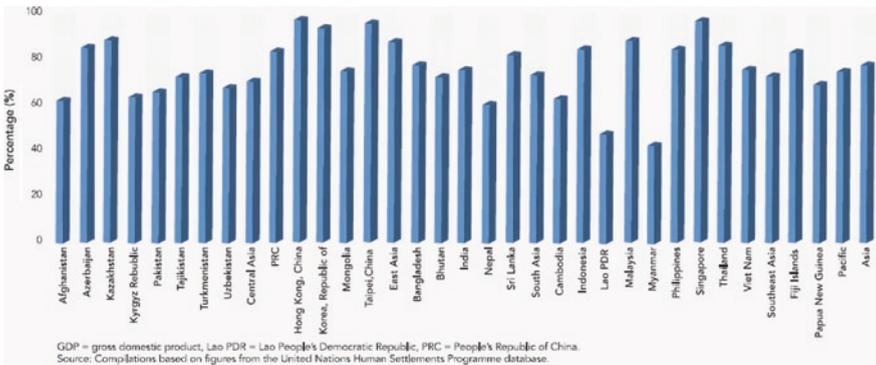


Fig. 2.3 Urban share of GDP, 2004 (Asian Development Bank 2008). *Managing Asian Cities*. Manila: ADB

around the world has also grown from 200,000 to nearly five million (Satterthwaite 2000). The increasing concentration of people in a city is both a cause of, and a result of, increasing economic opportunities and growth. Urban areas are typically more productive than rural areas since they are centres of innovation, development and growth. The growth of cities is therefore not an adverse trend since some of the largest economies in the world are from countries with the largest cities (Cohen 2006). Since cities tend to be the hub of economic growth, they often carry the burden of improving the economic performance of the entire country. The high degree of dependence of Asian countries on their cities for economic growth is reflected in Fig. 2.3. For Asia, the contribution of cities towards the continent’s GDP is close to 80%.

While cities are engines of growth, they are also the most vulnerable. Due to the rapid and unplanned increase in urban populations, cities face increasing pressure on their resources, infrastructure and the environment. In terms of population, cities such as Lagos and Dhaka are nearly 40 times the size they were in 1950 (Davis 2006). One of the largest and most populous mega cities in the world, Mumbai, provides a perfect example of the challenges that face major cities. “Mumbai is bursting at the seams due to an influx of migrants from other parts of the country to this financial magnet. The result is an overpopulated city with an unbearable load on a crumbling infrastructure and pressure on every available open space. Awkward and incremental planning has compounded the problems” (Remaking of Mumbai Federation 2008).

An excellent example of the vulnerability of cities is the emergence of slums and the problems associated with them. Urbanisation and the growth of cities has been accompanied by the growth of slums, with nearly a third of the entire world population residing in slums (Sclar et al. 2005), and in some cities like Mumbai, nearly half of the population reside in slums (Stecko and Barber 2007). Slums are usually built on land that is dangerous and unsuitable for settlement. For example, shanty towns near Buenos Aires and slums in India (like the ‘bustee’ in Vijayawada) are built on flood prone land. The residents have to choose between safety and health, and their need for shelter (Davis 2006). The conditions faced by slum residents include poor housing, poor access to clean water and unsanitary conditions, overcrowding and insecure land tenure. Living in these conditions has a serious impact on the welfare of the city population (Sclar et al. 2005).

In summary, cities face a number of infrastructural and resource constraints. Ageing and insufficient infrastructure cannot cater for the demands of a growing population. Water stress, sanitation, growth of slums and shanty towns due to poor housing policies, inadequate health support, and environmental degradation are only a few of the growing concerns and problems that cities are plagued with.

As discussed earlier, climate change and the growth of cities affect each other. While cities contribute towards the changing climate, climate change and global warming seriously affect city life, health and the infrastructure.

2.3 How Cities Contribute Towards Climate Change

Urbanisation is often accompanied by a change in lifestyle, increased consumption, fossil fuel usage and inefficient energy uses, which contribute heavily towards global warming and climate change.

The use of fossil fuels to generate energy has been a major cause of GHG emissions. About 80% of the total global energy is supplied from fossil fuels. Dhakal (2008) has established that incomes and energy usage are positively correlated. Since cities are usually characterised by higher average incomes compared to rural areas, it would be logical to assume that cities’ contribution to GHG emissions is higher than that of other areas. According to a UN-Habitat report (2006), cities

contribute up to 80% of the total CO₂ emissions globally, mainly through generation of energy, vehicular emissions, etc. Rapid urbanisation and increasing per capita incomes will continue to increase energy demand, and will therefore continue to contribute towards increasing CO₂ emissions. These GHG emissions may be directly generated within the cities, or indirectly in cases where energy is generated outside a city, but consumed within the city. However, regardless of the form of emission, the city is responsible and accountable for the same.

The impact of cities on the local environment is determined and affected by a number of characteristics such as urban structure, economic activities and development pattern, population growth and size, average household size, society, traditions and culture. Depending on these factors, either separately or as a combination, the level of emissions and the impact of the city on climate vary. Other factors that impact the level of emissions include a city's institutional and policy framework and the ability to implement and enforce policies, and a city's land use pattern among other natural factors.

2.3.1 Impact of Climate Change on Cities

Although cities contribute significantly towards climate change, they are also severely affected by it. The various hazards of climate change such as rapid population growth, housing and infrastructural constraints, poor water and sanitation have exacerbated the problems faced by cities. Although floods, heat waves, and droughts are not a recent phenomenon, the frequency and/or severity of these extreme weather events is likely to increase with the changing climate.

2.3.1.1 Impact on Health

Climate change is likely to have a serious (adverse) impact on human health in urban areas. Health risks vary from thermal stress to spread of infectious diseases, to injury and deaths. Intense summers, heat waves and drought can cause heat strokes, allergies, and in extreme cases, death. The experience of Chicago in July 1995 is a perfect example of the effect that heat waves can have on human health and mortality. During that incident, a severe heat wave hit the Midwestern United States, severely affecting Chicago, with temperatures hovering between the 90°F and 100°F for an entire week (The University of Chicago Press 2002). During this month, approximately 514 heat-related deaths were reported, which at that time was amongst the highest heat-related death toll in the history of the United States (Whitman et al. 1997). A rise in the incidence of heat waves and associated events, which is highly probable with climate change, is therefore likely to have a serious effect on people residing in heat-wave prone areas. Further, the impact of surface warming is likely to be more serious in city regions and, according to Whitman et al. (1997), urban centres are usually a "prime target for heat mortality". The 'Urban Heat Island'

effect precipitated by the high concentration of concrete structures in urban areas also plays a major role in amplifying the impact of rising temperatures, putting urban agglomerations at a higher risk (Patz and Kovats 2002).

Floods, extreme precipitation, and stagnant water also pose a major health problem since they provide an ideal environment for the spread of vector and water-borne diseases such as diarrhoea, cholera, malaria and dengue, which have been known to cause morbidity and even death. These diseases can reach epidemic proportions during periods of flooding. For example, more than 17,000 cases of cholera were reported in Mozambique during 2000 as floods ravaged the southern part of the country in February 2000 (Naidoo and Patric 2002). Health issues are already a major concern in cities, especially in slum areas where there is overcrowding, poor water and sanitation, poor drainage, poor housing and infrastructure. The spread of communicable diseases is therefore relatively easy in slums and cities (Sclar et al. 2005). These concerns are further compounded by frequent flooding caused by poor drainage.

These extreme weather events also lead to mental and physical stress, injury and even death. On 26 July 2005, Mumbai city centre experienced a heavy downpour (2.89 in.), which was among the heaviest recorded in India. The city's infrastructure and disaster mitigation strategy were unable to respond to the onslaught of the rains, and the resultant floods left approximately 410 people dead in Mumbai, and more than 1,000 dead in the state of Maharashtra. The existence of heavily populated slums in low-lying flood prone areas in the city exacerbated the situation (Stecko and Barber 2007).

Alarmingly, the health impact of climate change is not likely to be evenly distributed across the world. Developing countries and people in populated coastal areas will, in all likelihood, be more severely affected (WHO, n.d.) Cities that are located in developing countries are likely to be the worst affected by the changing climate and its manifestations.

2.3.1.2 Impact on Food Production

According to the FAO (2006), "Climate change will directly affect future food availability and compound the difficulties of feeding the world's rapidly growing population." By 2050, climate change will reduce the agricultural production by anywhere between 9% and 21% in the developing world (FAO 2009). Crop failure, loss of livestock (including marine livestock), reduced forest production, increase in weeds, new variety of pests and diseases are all side-effects of increasing temperatures, droughts and floods. Water stress is also likely to increase, and will therefore play a major role in the reduction of food production.

The effect of climate change is, once again, not likely to be uniform across regions, with crop yields expected to increase up to nearly 20% in East and Southeast Asia, whereas a decrease of 30% is expected in Central and South Asia by 2050 (Cruz et al. 2007). The poor and rural populations, which are already vulnerable, will be most effected by the changing environment and reduced food

production. Most of these people depend on agriculture to earn a living and will therefore be adversely affected. World hunger is expected to rise, and with it malnutrition will rise too.

However, since a large portion of the world's population will reside in cities in the future (Cohen 2006), cities will also likely be affected by food shortage. An increasing urban population implies more mouths to feed, and considering the reduction in food production, this may be a major challenge for city planners and citizens.

2.3.1.3 Impact on Coastal Areas

Between 1961 and 2003, sea levels have been rising at an average of 1.8 mm per year (IPCC 2007). Accompanying this rise in sea level is the risk of flooding, increase in the salinity of freshwater, land erosion, and a possibility of increased storm frequencies (Nicholls 1995). According to an estimate for India, a 1-m rise in sea level could result in the inundation of up to 5,763 km² (Chattopadhyay 2008). A direct result of this flooding and inundation is the loss of lives and homes of people living in coastal regions, which are often very heavily populated. Further, loss of coastal ecosystems affects the aquaculture industry and consequently the livelihoods of the people. As recorded in *The Big Melt: Global Warming*, "In a simple word: even with a small rise in sea level, nations and their civilizations could be destroyed." This statement provides a powerful indictment of the magnitude of the problem we face.

Many coastal cities across the globe are already facing the threat of subsiding and are slowly being "swallowed by the sea". According to Bohannon (2005), Venice, like New Orleans, is slowly being submerged due to the rising sea level, a problem that the city has faced since the Middle Ages. However, he claims that "an accelerating rise in sea levels linked to global warming has turned the sporadic flooding from a nuisance into a looming catastrophe" (Bohannon 2005:1978). Global warming and climate change are therefore likely to hasten and amplify the problems faced by many coastal cities. When we consider that currently 13 out of the largest 20 megacities in the world are coastal cities (Patz and Kovats 2002), the grave situation facing urban populations around the world becomes poignantly apparent.

2.3.1.4 Impact on Water Resources

By 2025, it is estimated that the proportion of the world's population living in countries facing water stress will increase to approximately five billion people; or two-thirds of the world population by then (Arnell 1999).

The hydrological cycle – quality, quantity and accessibility of water – will change with climate change. On the supply side of water, climate change alters precipitation patterns, snowfall, runoff, river flows and water recharge. As global

temperatures rise, the hydrological cycle will be intensified, leading to longer and more extreme periods of dry weather and intense precipitation, implying a higher risk of droughts and floods. By changing the precipitation and runoff, the water resource in some countries will rise, while it will diminish in others (Arnell 1999). In areas where melting snow is a major source of water flow, a change in the snowfall pattern will directly affect the availability of water. On the demand side, warming is likely to affect water resources by increasing the demand for irrigation, domestic and industrial use (Frederick and Major 1997).

2.3.1.5 Impact on Infrastructure, Economic Growth and Development

Floods, storms, heat waves, and other hazards linked to climate change will also have an adverse impact on the infrastructure and the economy of the affected areas. For example, the Mozambique floods in February 2000 resulted in a decline of nearly 7% in real annual growth rate of the country. Besides, 150,000 homes were destroyed along with the livelihoods of many (Department for International Development 2004). Given the high concentration of industry and economic activities in cities, their higher susceptibility towards flooding, proximity to the coast and the ageing infrastructure that characterises many cities around the world, and damage occasioned by extreme weather events is likely to be enormous. The 26 July 2005 floods in Mumbai which brought the city to its knees, grounded the transport network, cut off telecommunication and power, and disrupted financial services, cost the city approximately US\$ 109 million in local businesses alone (Stecko and Barber 2007). The city of New Orleans met with a similar fate in August 2005 when Hurricane Katrina lashed her shores, causing immense damage. According to Comfort (2006:502) "...the destruction in New Orleans left the entire city uninhabitable, with no functional services – communications, water, electrical power, sewerage, transportation, gas distribution – for weeks. Mandatory evacuation was the only possible course of action." An entire city was lost to a single disaster! Given the prediction that climate change could increase the frequency of flooding and other extreme weather events, and the immense damage, including financial loss, accompanying these events, the future prospects are very grim.

Other areas that are likely to be affected include natural ecosystems, biodiversity and natural cycles (such as the water cycle). Many animal species such as polar bears and plants face extinction as their habitats are destroyed due to warming and rising sea levels.

According to O'Brien et al. (2006:68) "Climate change is a multifaceted (from drought to flood) and multidimensional (from local to global) hazard that has short-, medium- and long-term aspects and unknown outcomes." Therefore, it is highly likely that the effects of climate change will threaten long-term development activities. The world must brace for the immense challenges that lie ahead.

How can cities play a major role in controlling global climate change? This section attempts to answer this question by looking at the unique features that make cities ideal weapons for combating climate change. The idea proposed here is that

global changes in climate have been caused, to a large extent, by city-level activities. The argument here is that if they have city level causes, they must have city level solutions. This does not mean that national- and international-level policies and discussions are not important. However, action needs to be localised in order to directly target the sources of GHG emissions and climate change.

2.4 Global Issues, Local Solutions

The importance of cities in the fight against climate change is derived from the fact that cities have certain characteristics that make them unique. They also play a significant role in contributing towards GHG emissions. Cities and urban areas have historically been places of creativity and industry. They have played a major role in the industrial development of the world (Dhakal 2008; Grimm et al. 2008). They have therefore, in some ways, led the way for others to follow. Consequently, they can play a similar role in leading the world in the fight against climate change.

Besides, the disproportionately high emissions of GHGs from cities place on them a disproportionately higher responsibility for mitigating the effects of climate change. In addition, cities operate at sub-optimal levels with respect to emission optimisation and their impact on the climate (Dhakal 2008). Cities therefore possess a great potential for effective management of GHG emissions.

The impact on climate by different cities varies, just like the urban structure, economic make-up, cultural, traditional and social aspects of each city are different. A city's economic growth and development pattern, urban structure and existing infrastructure and technology determine the impact that the city will have on the climate. For example, Dhakal (2008) claims that emission levels deriving from economic growth differ across cities depending on the dominant economic activity in the city. Therefore, a city like Beijing or Ho Chi Minh will have a higher emission level due to their concentration of industries as opposed to a city like Tokyo which is dominated by service sector industries. Further, good urban infrastructure and the use of eco-friendly technology, as is the case in Tokyo, also affect a city's emission levels, and would explain the reason for the much lower per capita CO₂ emission in Tokyo compared to Shanghai and Beijing (Dhakal 2008). The interaction between a city and the local ecosystem is unique for each city, and policies need to be suited to local conditions, based on immense local knowledge and experience. As has been aptly put by Bohannon (2005:1978), "Determining a particular city's risk – and what to do about it – requires an understanding of how climate change plays out locally." Therefore, the case for local urban governance and policy making is crucial in the fight against climate change.

Economic considerations also give cities an upper hand in efforts to control climate change. Cities constitute a concentration of people, industry and commerce. According to McGranahan and Satterthwaite (2003), a result of this concentration

is that waste management is more effective, and environmental management is cheaper. They claim that checking emissions and waste disposal is more difficult in dispersed industries. Cities are therefore uniquely suited to control climate change.

Since cities play a very important role in combating climate change, they need to initiate both adaptation and mitigation policies. In response to the changing climate, cities must adapt, and as an acknowledgement of their role in contributing towards this climate change, they need to mitigate their impact.

2.4.1 Mitigation and Adaptation

Cities have a considerable stake in both controlling emissions and lessening impacts and, therefore, have to play a leading role in mitigation and adaptation activities (Dhakal 2008:188).

2.4.1.1 Adaptation

Adapting to climate change involves adopting policies and practices that offset the adverse (long- and short-term) effects of climate change. Adaptation policies should be anticipatory and flexible, and their benefits must outweigh the costs (Smith and Lenhart 1996). Since most natural hazards cannot be prevented (O'Brien et al. 2006), the best defence against them is to be prepared and to have in place strong disaster management programs and policies. If and when extreme weather events strike a city, the structure or the city should be resilient enough to respond to the threat and adapt to the changes that result.

As a general rule, city planners must include adaptation policies in the overall long-term city plans, and must address the current as well as potential future impacts of climate change. Due to the slow reaction of oceans to agents causing climate change (IPCC 2007), many climate change impacts are yet to be felt. It is therefore prudent to include adaptation policies in the long-term plans so as to mitigate the long-term effects of climate change.

Adaptation policies need to be put through a rigorous cost-benefit analysis so as to ensure their long term viability. Since many of these policies are likely to be anticipatory in nature, they must be based on strong scientific assumptions, which must be tested against various scenarios.

Cities will need to involve everyone in the fight against climate change. To do this, they will have to spread awareness and educate the public on climate change issues. Education must focus on understanding the effects of climate change on water resources, land use, sea levels, health and the overall ecosystems, and must provide the people with the information they require to adapt to these policies. Water conservation, improved agriculture and irrigation techniques, the importance of increasing the green cover and understanding the ecological footprint of different human activities are some of the areas on which education can be focused.

2.4.1.2 Mitigation

While adaptation policies address the adverse effects of climate change, cities also need to reduce their impact on the environment. Policies for mitigation should be focused on emission abatement and increasing the green cover.

As previously discussed, emission of GHGs from cities is one of the major causes of global warming. Therefore, mitigation policies must focus on reducing these emissions, both direct and indirect. To cater for the demands of a growing city population, a lot of products and services are churned out. In the process, GHGs are emitted. For example, the demand for transportation may result in an increase in private car ownership (in the absence of a good public transport system), which would lead to more pollution and higher incidences of GHG emissions. Mitigation policies should therefore either focus on reducing demand for private cars, or on making the technology to make cars more environmental-friendly, or focus on both these aspects. For each source of GHGs and pollution-causing activities, policymakers need to identify the entire supply and demand chain, understand the relationship between them and then decide which one is the most appropriate for intervention. A detailed study of costs and benefits, and understanding the demand and supply linkage needs to be done before any policy decision can be made. However, it would not be wise to simply concentrate on either demand or supply. Instead, policymakers should adopt a layered approach, where initial focus is on demand or supply, and subsequently address the other side. For the transportation sector, Dhakal (2008) suggests that the supply (the side that directly contributes towards generation of GHGs) should be addressed first, followed later by the demand side.

The demand side of GHG emissions can be addressed by a number of policy initiatives that include educating people on the ecological impact of their habits, and formulating policies that encourage people to modify their lifestyles and consumption patterns. The supply side can be addressed by changing technology, improving efficiency and investing in research and development. The possibility of implementing emission abatement policies and taxes and developing carbon trading systems also need to be explored.

Both adaptation and mitigation policies should work towards fighting climate change; while adaptation policies address the impact of climate change, and enable a city to respond to the changing environment, mitigation policies should address the cause of climate change and help to reduce the effect that cities have on global warming.

In order to fully understand the causes of emissions as well as their impact, scientific knowledge is essential (Dhakal 2008). Therefore, for adaptation and mitigation policies to be effective, a considerable amount of scientific knowledge is required, accompanied by economic and technological expertise. Investment in research and development, and increasing the knowledge base plays a vital role in fighting climate change. Sound and realistic local policies that address products or activities that contribute towards GHG emissions should be designed and implemented.

In order for a city to manage climate change concerns and incorporate mitigation and adaptation policies at every stage of its development, it must be based on a

framework that addresses the various concerns in an integrated manner. These should include good governance, good infrastructure and an integrated urban management approach. Although this framework must be unique to the city, while designing plans and policies, urban architects and policymakers must ensure that the concept of “Living Cities” is upheld.

2.5 Living Cities – Better Governance and Better Infrastructure¹

When the effects of climate change are considered alongside the unique challenges already facing cities, it becomes clear that cities need to be managed wisely if they are to continue being the centres of economic success. The concept of “Living Cities” is based on an integrated approach that addresses the main requirements of every city – to be competitive, to ensure good infrastructure, shelter and transportation systems, to ensure steady and timely flow of information and to protect the environment and sustain the growth of the city. In order to achieve a city that epitomises the “Living City” concept, good leaders, good governance and informed policy-making is essential. Policies that address all the main requirements of a city should be developed and must be based on the adaptation and mitigation guidelines already discussed.

On the infrastructure front, addressing water supply and sanitation, solid waste management and urban transport is essential for an environmentally responsible city. These areas provide good opportunities for implementing adaptation and mitigation policies. Since climate change impacts greatly on water resources, every city should prioritise it. Sound water management policies can help a city respond to these changes, while the provision of sanitation helps to check the spread of communicable diseases. Since solid waste and urban transport are major polluting agents, their adverse effects on climate change should be addressed as matter of priority. A marshal plan aimed at providing better housing, or upgrading existing slum dwellings should also be considered so as to serve a city’s growing population better.

The urban environment needs to be managed well; a unique city-ecosystem relationship needs to be fostered in a sustainable manner; and an urban environmental management system, one of the most important pillars of “Living Cities”, should be implemented.

Through such an integrated approach to urban management, a city can embark on a responsible development path that provides a high quality of life for its citizens where the environment is protected and the adverse impacts on the climate are minimised.

¹This concept has been developed further in ‘Developing Living Cities’ (2010) edited by Seetharam Kallidaikurichi and Belinda Yuen.

2.6 Conclusion

This chapter has argued that global climate change has a local, city-level solution. As the climate change phenomenon unfolds, it is manifesting itself in many ways: intense heat waves, floods, droughts and rising sea levels. These hazards can spell disaster to city life, affecting the health of the people, destroying infrastructure and livelihoods. “The quintessential responsibility of government is to protect its citizens from danger” (Comfort 2006:503). This statement highlights the role of good governance and the importance of strong policies in protecting the cities against the manifestations of climate change. City planners need to embrace the climate change challenge by first recognising the important role played by cities. Although greater urbanisation has had a negative impact on the climate, primarily due to greater energy intensity and increased demand for transportation, cities are also immensely affected by climate change. They therefore have a huge stake in the fight against climate change.

The key message that this chapter propounds is that cities possess certain unique characteristics that make them excellent weapons in the fight against climate change. It is the responsibility of the local governments to recognise this and act accordingly; policymakers and urban planners must exploit these characteristics to the fullest. The aim should be to integrate adaptation and mitigation policies with overall urban planning – think locally, think long-term. Since cities are complex systems, climate change adaptation and mitigation policies should be designed in a way that suits the unique form of each city; and urban design should be based on an integrated framework where policies and decisions are aimed at improving the quality of life of a city’s citizenry in an environmentally responsible manner.

References

- Asian Development Bank (2008) *Managing Asian Cities*. Manila: ADB
- Arnell NW (1999) Climate change and global water resources. *Global Environ Change* 9:S31–S49
- Bohannon J (2005) Venice: a sinking city yields some secrets. *Science* 309:1978–1980
- Chattopadhyay DN (2008) Climate change and food security in India. *International Symposium on Climate Change and Food Security in South Asia, Dhaka, Bangladesh*
- Cohen B (2006) Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. *Technol Soc* 28:63–80
- Comfort LK (2006) Cities at risk: Hurricane Katrina and the drowning of New Orleans. *Urban Aff Rev* 41:501–516
- Cruz RV, Harasawa H, Lal M, Wu S, Anokhin Y, Punsalmaa BY, Honda Y, Jafari MC, Li C, Huu NN (2007) Asia: climate change 2007: impacts, adaptation and vulnerability. In: Parry M, Canziani O, Palutikof J, Linden PV, Hanson C (eds) *Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge University Press, Cambridge, UK
- Davis M (2006) Slum ecology, inequity intensifies Earth’s natural forces. <http://www.orionmagazine.org/index.php/articles/article/167>. Accessed Oct 2009

- Department for International Development (2004) Key Sheet 06 – adaptation to climate change: making development disaster-proof. DFID, London
- Dhakal S (2008) Climate change and cities: the making of a climate friendly future. In: Droege P (ed) *Urban energy transition: from fossil fuels to renewable power*. Elsevier, Amsterdam, pp 173–192
- FAO (Food and Agricultural Organization). (2009). 2050: Climate change will worsen the plight of the poor. <http://www.fao.org/news/story/en/item/35831/icode/#>. Accessed Oct 2009
- FAO (Food and Agricultural Organization) (2006). Climate change will affect future food availability. <http://www.fao.org/newsroom/en/news/2006/1000436/index.html>. Accessed Oct 2009
- Frederick KD, Major DC (1997) Climate change and water resources. *Clim Change* 37:7–23
- Grimm NB, Faeth SH, Golubiewski NE, Redman CR, Wu J, Bai X, Briggs JM (2008) Global change and the ecology of cities. *Science* 319:756–760
- IPCC (2007). Climate change 2007: synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team: Pachauri, R.K and Reisinger, A. (eds)]. IPCC, Geneva, Switzerland
- Karl TR, Trenberth KE (2003) Modern global climate change. *Science* 302:1719–1723
- McGranahan G, Satterthwaite D (2003) Urban centres: an assessment of sustainability. *Annu Rev Environ Resour* 28:243–274
- Naidoo A, Patric K (2002) Cholera: a continuous epidemic in Africa. *J R Soc Promot Health* 122:89–94
- Nicholls RJ (1995) Coastal megacities and climate change. *GeoJournal* 37:369–379
- O'Brien G, O'Keefe P, Rose J, Wisner B (2006) Climate change and disaster management. *Disasters* 30:64–80
- Patz JA, Kovats RS (2002) Hotspots in climate change and human health. *BMJ* 325:1094–1098
- Remaking of Mumbai Federation (2008) RoMF. <http://romf.wherrelz.com/?page=Need%20for%20Remaking>. Accessed Oct 2009
- Satterthwaite D (2000) Will most people live in cities? *BMJ* 321:1143–1145
- Sclar ED, Garau P, Carolini G (2005) The 21st century health challenge of slums and cities. *Lancet* 365:901–903
- Kallidaikurichi S, Yuen B (eds) (2010) *Developing living cities: from analysis to action*. World Scientific, Singapore
- Smith JB, Lenhart SS (1996) Climate change adaptation policy options. *Clim Res* 6:193–201
- Stecko S, Barber N (2007) Exposing vulnerabilities: Monsoon floods in Mumbai, India. Case study prepared for Revisiting Urban Planning: Global Report on Human Settlements 2007. <http://www.unhabitat.org/downloads/docs/GRHS.2007.CaseStudy.Mumbai.pdf>. Accessed Oct 2009
- The Big Melt – Global Warming (n.d.). Rising sea level – The Big Melt – Global Warming. <http://www.bigmelt.com/rising-sea-level>. Accessed Oct 2009
- The University of Chicago Press (2002) Dying Alone: An interview with Eric Klinenberg (author of *Heat Wave: A Social Autopsy of Disaster in Chicago*). <http://www.press.uchicago.edu/Misc/Chicago/443213in.html>. Accessed Jan 2010
- UN Department of Economic and Social Affairs, Population Division (2004) *World urbanization prospects* (rev. edition). United Nations, New York
- UN-Habitat (2006) *Climate change: the role of cities*. UN-Habitat, Nairobi
- Walther G-R, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin J-M, Hoegh-Guldberg O, Bairlein F (2002) Ecological responses to recent climate change. *Nature* 416:389–395
- Whitman S, Good G, Donoghue ER, Benbow N, Shou W, Mou S (1997) Mortality in Chicago attributed to the July 1995 heat wave. *Am J Public Health* 87:1515–1518
- WHO (n.d.). Climate change and human health. <http://www.who.int/globalchange/en/>. Accessed Oct 2009

Chapter 3

Climate Change in the Context of Urban Development in Africa

Kempe Ronald Hope, Sr.

3.1 Introduction

Based on a number of studies and scientific reports on the historical evolution of global temperatures, it has been determined that climatic change is inclined toward warming. The Intergovernmental Panel on Climate Change (IPCC) has now declared that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level” (IPCC 2007: 30). This global warming has become a major threat to sustainable development and growth in all regions around the world, and particularly so in Africa as this work demonstrates.

In this chapter, climate change is defined as any long-term significant regional change in measures of climate (such as temperature, precipitation, or wind patterns). It is therefore any major long-term variation in the average weather that a given region experiences. These variations must be statistically significant in measurements of either the mean state or variability of the climate for that region, whether due to natural factors or as a result of human activity. Consequently, climate change can be regarded as a change of climate, which is attributed directly or indirectly to human activity, and which alters the composition of the global or regional atmosphere, in addition to natural climate variability over comparable time periods (CCPAN 2007).

Much of the current literature on the science of climate change attributes the temperature variability primarily to emissions of greenhouse gases (carbon dioxide – CO₂, methane, nitrous oxide, hydro fluorocarbons, and others) produced by human activities. These activities (such as burning of fossil fuels – coal, oil, and natural gas – industrial production, cutting down of rainforests) change the atmosphere’s composition by increasing the amount of greenhouse gases in the atmosphere which, in turn, traps more heat in the atmosphere and thereby facilitating climatic change.

Kempe Ronald Hope, Sr. (✉)
United Nations Development Programme (UNDP), Nairobi, Kenya
e-mail: hopekr@excite.com

Although the earth's atmosphere contains 24 different greenhouse gases, only one of them (CO₂) accounts for the overwhelming majority of the greenhouse effect that leads to climatic change. Anthropogenic emissions of CO₂ account for about 63% of the greenhouse gas warming effect in the long-run, and for 91% in the short-term (over the last 5 years) (May and Caron 2009). However, despite the overwhelming scientific evidence on the causes of climate change, there is still a vigorous debate not only on its causes but also over the amount of change and what that change entails.

This chapter discusses and analyzes the relationship between climate change and urban development in Africa. It investigates the role that climate change has played, and will continue to play, in the pattern of urban development in sub-Saharan Africa, and assesses potential policy recommendations for mitigating the consequences of climatic change on urban development in the region. The record shows that climate change is happening. What is not discussed or researched much is the potential devastating impact of climate change on all levels of development in Africa, and the policy measures available to the continent for adaptation.

3.2 Africa and Climate Change

On a per capita basis, Africa contributes the least to global climatic change. This is primarily so because of the region's overall low levels of industrial development (May and Caron 2009). Less than 3% of the world's total emissions of greenhouse gases emanate from the African continent. The rich countries dominate the overall emissions account. Collectively, for example, they are responsible for approximately 7 out of every 10 tonnes of CO₂ that have been emitted since the start of the industrial era, with the emissions being highly concentrated in a very small group of countries (UNDP 2007). The top ten emitters are responsible for over 60%; the top five emitters (China, India, Japan, the Russian Federation, and the United States) account for more than 50%; the United States being the largest emitter, accounting for about 20% of the total emissions (UNDP 2007).

With just 15% of the world's population, rich countries are responsible for 45% of CO₂ emissions. Sub-Saharan Africa, on the other hand, accounts for 11% of the world's population but represents less than 3% of global emissions. Africa's CO₂ technical emissions are predominantly from the energy sector and transport industries compared to emissions from rich countries which derive primarily from the burning of fossil fuels for industrial and other human activities. The largest share (approximately 95%) of CO₂ technical emissions from Africa emanates from only 15 countries (South Africa, Nigeria, Kenya, Zimbabwe, Sudan, Ethiopia, Angola, Ghana, Côte d'Ivoire, Equatorial Guinea, Senegal, Botswana, Tanzania, Cameroon, and Congo-Brazzaville) (Unmüßig and Cramer 2008). It has been noted that rapid deforestation in Africa has also contributed significant amounts of CO₂ emissions. African forests store a stock of CO₂, approximately equal to 60 billion tonnes, almost equivalent to that of all OECD countries combined (Unmüßig and Cramer 2008). However, the biomass stored in the forests is decreasing rapidly and, consequently, CO₂ emissions from forests are

increasing. The Food and Agriculture Organization (FAO) says that Africa's forests are shrinking at the alarming rate of 1% per annum (FAO 2007).

The growing greenhouse gas emissions have now been proven to be responsible for worldwide climatic changes. Global warming is occurring worldwide, and temperatures are rising both on the African land mass and in the surrounding oceans. Indeed, "there is evidence that Africa is warming faster than the global average and this is likely to continue" (Collier et al. 2008: 338). Globally, the average temperature has increased by around 0.7°C since the industrial era, and this trend appears not to let up, with average global mean temperature rising by 0.2°C every 10 years (UNDP 2007). In Africa, the climates are both varied and varying. "Varied because they [climates] range from humid equatorial regimes, through seasonally-arid tropical regimes, to sub-tropical Mediterranean-type climates; and *varying* because all these climates exhibit differing degrees of temporal variability, particularly with regard to rainfall" (Hulme et al. 2001: 145).

The climate of Africa is influenced by complex maritime and terrestrial interactions that produce these varying and varied climates across the various sub-regions of the continent. Undoubtedly, the continent is warmer than it was 100 years ago. During the twentieth century, the continent has been warming at an average rate of about 0.5°C, with the 6 warmest years occurring from 1987, similar to patterns in the rest of the world (Hulme et al. 2001). The observed temperatures have indicated a greater warming trend since the 1960s, although these changes have not always been uniform. Based on an assessment of a number of studies, it has been observed by Boko et al. (2007), for instance, that there have been decadal warming rates of 0.29°C in the African tropical forests, and 0.10–0.3°C in South Africa. In Ethiopia and South Africa, minimum temperatures have increased slightly faster than maximum or mean temperatures. For instance, between 1961 and 2000, there was an increase in the number of warm spells in Southern and Western Africa, and a decrease in the number of extremely cold days. In Eastern Africa, the trend has been decreasing temperatures. Figure 3.1 shows the annual mean merged land, air, and sea surface temperature anomalies for the continent during the last century. According to the National Climatic Data Centre (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) of the United States, these deviations average 0.05°C per decade (NCDC 2008).

In terms of future trends, based on the few studies available, for the period 2080–2099, annual mean surface air temperature is expected to increase by an average of between 3°C and 4°C, compared to the 1980–1999 period, which witnessed less warming in the equatorial and coastal areas (Boko et al. 2007). Other studies, based on scenarios of average or other emission controls, indicate higher levels of warming (up to 9 °C) for the period 2070–2099 for North Africa (Mediterranean coast) in the June–August months, and up to 7°C for Southern Africa in the September–November months (Ruosteenoja et al. 2003). In the 2080s in Southern Africa, the December–February (summer) mean surface air temperature is forecasted to increase by an average of 3.7°C, topping at an average of 4°C in the winter (June–August) (Hudson and Jones 2002). Nonetheless, as remarked by Unmüßig and Cramer (2008), these averages do not shed light on the probable seasonal and

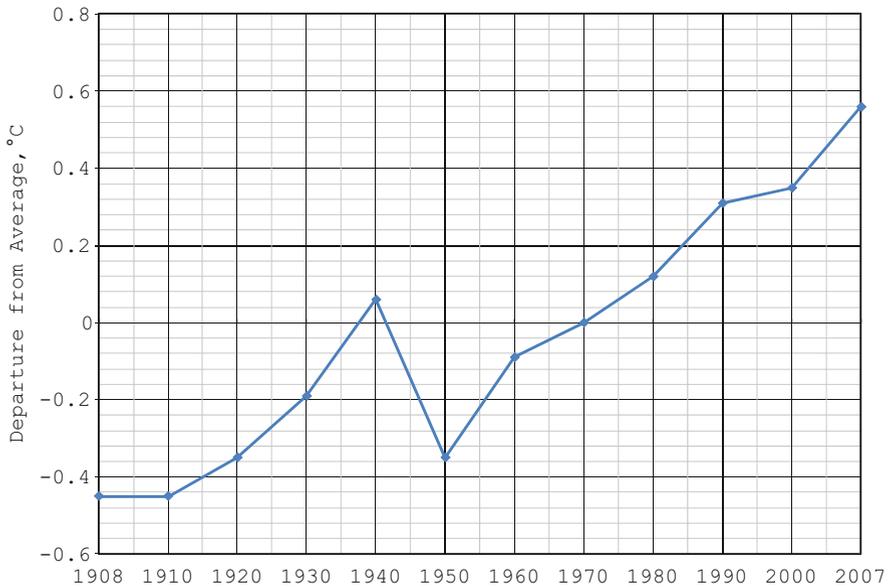


Fig. 3.1 African annual mean merged land, air, and sea surface temperature ($^{\circ}\text{C}$) anomalies, 1908–2007 (NCDC 2008)

sub-regional variations that are likely to occur. For example, while the summer months are expected to be hotter in North Africa, winter temperatures will be lower in contrast. Also, the Sahel zone is forecasted to see potential temperature increases of $2.6\text{--}5.4^{\circ}\text{C}$, with an average of 3.6°C .

According to Nicholson (2001), most of Africa lies in tropical and subtropical latitudes where temperatures are high throughout the year, and generally vary from day-time to night-time than over the course of the year. However, extreme range of climates cuts across the continent, the most significant climatic change being a long-term reduction in rainfall, particularly in the semi-arid areas of West Africa (Nicholson 2001; Desanker and Justice 2001). In general, there has been a decline in rainfall on the African continent since the 1960s (Barrios et al. 2006). Declining rainfall and a rising rate of evaporation due to higher temperatures will have serious consequences for development in Africa.

The precipitation trends in Africa are well documented by Nicholson (2001) and Boko et al. (2007). Mean annual rainfall ranges from less than 1 mm per year in some parts of the Sahara, to over 5,000 mm per year in parts of the tropical rainforest. Most of the continent experiences prolonged seasons of dry weather during the year and, in the driest areas, the rainy season can be as short as 1–2 months. In West Africa, a decline in annual rainfall has been recorded since the end of the 1960s, with a decrease of 20–40% observed between 1931 and 1960, and between 1968 and 1990 (Boko et al. 2007; Chappell and Agnew 2004; Dai et al. 2004). Malhi and Wright (2004) have noted declines in mean annual precipitation in the tropical rainforest area of around 4% in West Africa, 3% in North Congo, and 2% in South

Congo for the period 1960–1998. In recent decades, Eastern Africa has also been experiencing erratic rainfall patterns, with increased rainfall occurring in the northern sector, and declining rainfall being registered in the southern sector (Boko et al. 2007; Schreck and Semazzi 2004). In the Sahel region, very dry conditions were observed from the 1970s to the 1990s, after a wet period in the 1950s and 1960s. The decreasing rainfall and resultant devastating droughts in the Sahel region during the last 3 decades of the twentieth century have been regarded as being “among the largest climate changes anywhere” (Bates et al. 2008: 80).

Looking towards the future, the current projections of rainfall in Africa are less consistent than they are with respect to temperatures. Nonetheless, the technical and scientific analyses being undertaken by the IPCC suggest that, under the average emissions scenario, rainfall along the Mediterranean coast, extending to the north of the Sahara, will likely decrease by 20% during the period 2080–2099 (Boko et al. 2007). Similar projections for the same period indicate an increase in rainfall in tropical and Eastern Africa of more than 7%, while Southern Africa will likely witness a decrease in rainfall during the months of June–August varying from 30% to 40% (Boko et al. 2007; Christensen et al 2007).

The climate of Africa is definitely warmer than it was a century ago. Moreover, as Hulme et al. (2001: 165) points out, “model-based predictions of future greenhouse gas-induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate so that the continent on average could be between 2°C and 6°C warmer in 100 year time”. The projections with regard to rainfall are less confident despite the advances that scientists have made in understanding the complex mechanisms responsible for rainfall variability. Nonetheless, as Nicholson (2001) points out, almost the entire African continent has been affected by increased aridity, especially since the 1980s, but it has been much more severe in the Sahel. Besides, it is now common knowledge that warm conditions over global oceans, particularly the Atlantic and Indian Oceans, tend to create drier conditions over the continent as a whole. Consequently, with a trend towards higher temperatures over the global oceans over the longer-term, it is highly likely that there will be declining rainfall and greater aridity, which in turn means that climatic changes generally have serious implications for development in Africa. According to LaFleur et al. (2009), by the 2080s, Africa’s arid and semi-arid terrain is projected to expand by 5–8%.

3.3 Urbanization and Urban Growth Trends in Africa

Patterns of urbanization and urban growth not only influence the nature of urban development in a given country or region, but also the nature of development policies pursued by central and municipal governments. During the past three decades, the pattern of human settlements in Africa has shifted towards an urban bias. Since cities are the main catalysts of economic growth in Africa, their economic attraction has been the principal driver of urbanization and urban growth on the continent (Hope

Table 3.1 Proportion of African population residing in urban areas by sub-region, 1980–2030 (%) (UN-HABITAT 2008)

Region	1980	1990	2000	2010	2020	2030
Africa	27.9	32.0	35.9	39.9	44.6	50.0
Eastern Africa	14.4	17.7	21.1	24.6	29.0	34.8
Northern Africa	44.4	48.5	51.1	53.5	56.8	61.3
Southern Africa	31.5	36.7	42.1	47.1	52.3	57.9
Western Africa	29.2	33.0	38.4	44.1	50.1	56.1

2008). Over the past several years, there have been many publications by reputable development institutions that project very significant increases in the urban population in Africa for most of the twenty-first century. Although the rate of urbanization in Africa is the highest in the world, the continent is still the least urbanized region in the world. By 2008, the whole of Africa had only 39.1% of its total population living in urban areas, compared to 28% in 1980. In contrast, the urban population proportion in the Arab States, Latin America and the Caribbean, Eastern Asia, and OECD States exceeds 55%, 77%, 43%, and 75%, respectively. By 2030, it is projected that one-half of the African continent-wide population will reside in urban areas (Hope 1998, 2008; UN-HABITAT 2008). Table 3.1 shows the proportion by sub-region of the population residing in urban areas, as well as continent-wide, by decade intervals from 1980 to 2030. Across the continent as a whole, Northern Africa has the largest proportion of total population living in urban areas for each decade, while in sub-Saharan Africa, the Southern Africa sub-region took those honours. Eastern Africa, on the other hand, has the highest rate of urbanization.

The rate of urbanization is the speed at which a population urbanizes. It can be defined as the average annual rate of change of the percentage population living in urban areas. It is also the difference between the growth rate of the urban population and that of the total population (Hope 1998). The factors contributing to Africa's increasing urbanization rates are the direct result of the shift in the balance between the urban and rural sectors. This shift is closely linked to economic activities and to changing patterns of employment; that is, towards the urban bias in development strategies, which has resulted in the development of commerce and industry; and the growth of transportation, communication, education, and other types of infrastructure in the urban areas. Consequently, urban areas (and capital cities in particular) are prevalent in Africa, mainly for purely historical reasons, which date back to colonial times (Hope 1998). Cities in Africa remain the focal point of both public and private sector activities and, as such, they have become the rational settling place for the population.

The two primary variables influencing rapid urbanization in Africa are the natural population increase and rural–urban migration. A natural population increase occurs when birth rates exceed mortality rates. In sub-Saharan Africa, current (2007) birth rates exceed mortality rates by 24 for every 1,000 inhabitants; this despite the fact that some mortality rates have been fuelled by the HIV/Aids epidemic, and the alarming re-emergence of other diseases that were believed to have been eradicated

or brought under control. For example, deaths attributed to malaria and tuberculosis have increased as these diseases re-emerge to pose a real health challenge in a number of African nations. Africa has the lowest life expectancy levels in the world. The region has the highest fertility rates in the world, and child-bearing is influenced by factors such as marriage and reproductive behaviour patterns. For example, child-bearing tends to be encouraged, irrespective of economic circumstances, as a matter of cultural norms. Consequently, women in Africa, both the educated and uneducated, want and have more children than their counterparts in the rest of the world; although educated African women want far fewer children than do uneducated ones. Fertility generally tends to decline monotonically as a mother's education increases above primary schooling. However, in Africa, the effect of education on fertility has been less pronounced than elsewhere in the world.

With respect to rural–urban migration in Africa, where most of the cities are relatively small but growing rapidly, migration from the rural areas is a major influence on urban growth. Rural–urban migration in Africa is primarily influenced by the need for economic empowerment. People migrate to urban areas primarily in response to the better employment and economic opportunities available there (pull factors). However, they also migrate to escape negative conditions such as drought, flooding, famine, internal conflict such as civil strife or war, or inequalities in the spatial distribution of social, cultural, and/or political opportunities, for example – that persuade them to move (push factors) (Hope 1998, 2008). To escape poverty, for instance, large numbers of Africans migrate to cities in search of better opportunities. The World Bank (2009: 1) observes that: “migration to urban areas is unavoidable and even desirable as a way to improve allocation of human resources, especially in land-scarce countries”. It also has significant positive impacts on people's livelihoods. The migrants are predominantly young adult men. Undoubtedly, rural–urban migration in Africa will continue into the foreseeable future given the continent's rapid population growth, the limited developmental capacity of the vast majority of rural areas, and the seemingly permanent economic attraction of cities. Available data indicate, for example, that an estimated 50–80% of African rural households have at least one migrant member in a city (Deshingkar and Grimm 2005). In Botswana, for instance, the 2001 census shows that rural–urban migrants accounted for 14% of the total urban population, and 35% of the total population in urban towns, compared to 11% and 23%, respectively, in the 1991 census.

Two important characteristics of African urbanization that must be brought to the fore are poverty and settlement patterns. Sub-Saharan African countries have the highest levels of urban poverty in the world. Despite African cities generating about 55–60% of the continent's total GDP, a massive 43% of its urban populations live below the poverty line. In some countries, the populations living below the poverty line exceeds 50% (UN-HABITAT 2008; Eriksen et al. 2008). Urban poverty in Africa frequently manifests itself in unequal access to decent housing. For example, the majority of the urban and peri-urban poor tend to live in ecologically fragile zones where they over-exploit the surrounding lands for, among other things, fuel-wood, subsistence and small cash-crop production; further endangering their environment, their health, and the lives of their children. One result of this state of

affairs is that the urban poor are disproportionately threatened by environmental and other climate change related hazards.

These patterns of settlement by the urban poor have resulted in the emergence and growth of slum communities. By 2005, more than 60% of urban residents in sub-Saharan Africa were slum dwellers – nearly double the proportion for the rest of the developing world (UN-HABITAT 2008). “Africa’s urban slum populations continue to grow. In some of the fast-growing African cities, almost all of the current urban spatial growth is the result of slum and informal settlements proliferation” (UN-HABITAT 2008: ix). In these slum settlements, basic urban services and infrastructure are virtually non-existent. Slum households tend to lack, among other things, clean water, improved sanitation, and adequate collection and disposal of sewage and solid waste. These slum communities therefore have to contend with frequent foul smells emanating from the decomposing waste, sewage ponds, informal abattoirs, irregularly emptied pit latrines, and/or industrial wastes (Hope and Lekorwe 1999).

3.3.1 Impacts of Climate Change in the Context of African Urbanization

Although Africa contributes the least to global climatic change, it will be the region most affected by climate change. The continent is a victim of circumstances that are beyond her influence and is, therefore, one of the most climate change vulnerable regions in the world. Climatic change has consequently emerged as a major threat to sustainable growth and development in Africa. Given the rapid urbanization on the continent, climatic change will impact greatly on urban areas. Urbanization and urban population growth influence, and are influenced by, environmental factors, including climatic change. Although cities are the main catalysts of economic growth in Africa, their economic attraction, and the resultant urbanization, has been a major contributor to the significant consequences of urban development that emanate from climate change. Urban centres contain a large proportion of people who are highly vulnerable to the effects of climate change.

Climate change impacts have the potential to undermine, and even undo, the progress made in improving the socio-economic well-being that Africa has been experiencing in the past several years. The negative impacts now associated with climate change are also compounded by factors such as poverty, weak capacity, diseases, and high population density. In addition, while Africans can take some steps to mitigate climate change as argued here, and as pointed out by Collier et al. (2008), the most important aspects of relief for Africa are the implications of the mitigation strategies adopted by the developed countries. Consequently, the rich developed countries have the ability to subvert the viability of the livelihoods of millions of Africans if they do not make serious efforts to tackle climate change. Below is a discussion of the principal impacts of climate change in the context of African urbanization.

3.3.1.1 Agriculture and Food Security

Agriculture and fisheries are very sensitive to climate change, making their production processes highly amenable to climate change (FAO 2008). By the 2080s, climate change is estimated to place an additional 80–120 million people at risk from hunger, and 70–80% of these will be in Africa (Parry et al. 2004). This will, in turn, worsen the state of food insecurity and malnutrition while demonstrating agriculture's position as the most vulnerable sector to climate change (Nyong 2005, 2009). The majority of the African population derive their livelihoods from agriculture, which represents the single largest economic activity on the continent. In sub-Saharan Africa for instance, it contributes at least 40% of exports, 34% of GDP (more than 50% in some countries), up to 30% of foreign exchange earnings, and 64–80% of employment (Hope 2008).

Overall in Africa, both arid and semi-arid areas are expected to expand by between 5% and 8% by 2080. This corresponds to a reduction of approximately 60–90 million hectares of agriculturally productive land (Boko et al. 2007). Climate change is expected to considerably reduce cereal production in countries such as Nigeria, Ethiopia, Zimbabwe, Sudan, and Chad. In East Africa, the declining rainfall during 1996–2003 has resulted in declining production in crops such as maize and sorghum (Case 2006). In South Africa, crop revenues are estimated to fall by as much as 90% by 2100, and wheat production is likely to disappear entirely from the continent by 2080 (Boko et al. 2007). In Cameroon, it is estimated that farm losses could be as high as US\$20.3 billion by 2100 (Molua and Lambi 2007). For sub-Saharan Africa, reduced agricultural productivity due to climate change is projected to reach US\$26 billion (going by 2003 prices) by 2060 – an amount that currently exceeds bilateral aid transfers to the region (UNDP 2007).

Climate change may also impact Africa's fisheries. The region's fish supply is already in a crisis as it is the only continent where fish supply per capita is on the decline. By 2020, the continent will need 61% more fish per year just to maintain current consumption levels (APF 2008). Since significant numbers of Africans depend on fish as a source of protein, employment, and revenue, climate change will have an impact not only on nutrition, but also on livelihoods. Approximately 30–45 million people in Africa depend on fish for their livelihoods, and more than a quarter of Africa's population regularly eat fish (APF 2008). Climate change is projected to exacerbate declining productivity levels, which will result in a shift in the range of fish species as well as fish reproductive patterns. Africa earned US\$2.7 billion from fish exports in 2001 (APF 2008). According to Allison et al. (2009), export income dependency on fisheries was highest in African coastal nations. In Namibia and Senegal, for example, fisheries contribute more than 6% of GDP (Boko et al. 2007). Nutritional reliance on fish as a source of protein is very high in sub-Saharan Africa, with countries such as Sierra Leone, Ghana, and The Gambia deriving 59–67% of their animal protein from fish (Allison et al. 2009).

Based on empirical analysis of (1) exposure (E) to physical effects of climate change; (2) the degree of intrinsic sensitivity (S) of fisheries dependence by the national economy on social and economic returns from the sector; and

(3) the extent to which adaptive capacity enables potential impacts to be offset, it was determined by Allison et al. (2009) that the countries with the lowest adaptive capacity were concentrated almost exclusively in Africa, and that the region most vulnerable to climate-induced changes in fisheries is also Africa. In fact, two-thirds of the most vulnerable countries were found to be in tropical Africa, “where fisheries are important to the poor, and regional assessments indicate that fishery production in both continental and marine waters is closely tied to climatic variation” (Allison et al. 2009: 15).

Food security is a function of food availability, food access, and food utilization. Given that agricultural production is primarily a rural activity that also sends food to urban areas, any decline and shortage of locally produced agricultural products will also impede food availability and access in the urban areas. Urbanization is increasing rapidly in Africa, and a growing proportion of the expanding urban population is poor. Consequently, climate change can result in food access issues that are likely to become more and more significant in urban areas over time. Not only will the availability of certain basic local agricultural foods be affected in the urban areas, but crop failures can further increase the rural–urban migrant flows as more and more rural residents seek alternative opportunities in the cities. Africa’s poor are highly dependent on climate-related activities for their livelihoods. For most of these people, the rational response to the impact of climate change on their livelihoods would be to move to the cities.

3.3.1.2 Water, Sea Level Rise and Coastal Zones

Among the future potentially-devastating impacts of climate change in Africa will be changes in water availability. Changes in precipitation will ultimately affect the availability of water, which, in turn, may lead to decreased agricultural production as discussed earlier. Changes in precipitation and evaporation translate directly into deficits in water supply. Some analyses suggest that the population at risk of increased water stress in Africa is projected to be 75–250 million by 2020, and 350–600 million by 2050 (Boko et al. 2007). Water is critical to the realization of the development potential of Africa. Apart from being an essential input for agriculture and other productive activities, including the provision of hydroelectric power, safe water is also critical to health and well-being (APF 2008).

In addition, some African countries are also prone to vagaries of climate change such as droughts and floods. About one-third of people in Africa live in drought-prone areas and are vulnerable to the consequences of droughts, which have contributed to, among other things, migration to urban areas (Bates et al. 2008). Droughts have occurred in the Sahel, Southern Africa, and the Horn of Africa since the end of the 1960s. These droughts have visited untold destruction on productive assets and have had severe impacts on the size of livestock populations. For instance, between 1975 and 1997, cattle owners in Southern Ethiopia lost 46% of their cattle and 41% of their sheep and goats (FAO 2008). This state of affairs leads to meat scarcity and higher meat prices in urban areas.

In Mali's Bamako city, the availability of water is declining as groundwater levels fall; while in Nouakchott, Mauritania, large areas are buried in sand due to prolonged droughts; and in Diourbel, Senegal, the River Sine has dried up completely since the 1970s, while groundwater salinity has been increasing with the over-exploitation of underground water (Dodman 2008).

Flooding also tends to have a direct impact on urban populations and urban areas. Indeed, many of the urban poor in Africa are at risk of severe flooding due to increased storm frequency and intensity. Rapid urbanization and urban population increases have forced large numbers of people, especially the poor, to settle in flood-prone areas such as floodplains usually found in and around urban areas (Douglas et al. 2008). This pattern of settlement, which has resulted in the emergence and concentration of slum communities, has rendered the region more vulnerable to flooding. "In August 2006, in Addis Ababa [capital city of Ethiopia], floods killed more than 100 people and destroyed homes in eastern Ethiopia after heavy rains caused a river to overflow"; while in "Tanzanian urban communities, hundreds of families were left homeless by floods in 2002"; and Mozambique experienced heavy rains and cyclones in 2000 that resulted in the "worst flooding in 50 years and brought widespread devastation to the capital city, Maputo, as well as the city of Matola. Upwards of one million people were directly affected. Water and sanitation services were disrupted, causing outbreaks of dysentery and cholera" (Douglas et al. 2008: 190). In West Africa, the floods of 2002 left 4,000 houses in Bamako, Mali in ruins (Dodman 2008).

Climate change induced sea-level rise along coastal zones where there are high human populations is likely to disrupt economic activities such as tourism, fisheries, and mining. Rising sea levels and the resulting coastal erosion and destruction of coral reefs will also threaten human settlements and mangrove forests. More than a quarter of Africa's population live within 100 km of the coast, 12% of the urban population live within the low elevation coastal zones. It is projected that the number of people facing the risk of coastal flooding will increase from one million in 1990 to 70 million in 2080 (APF 2008; McGranahan et al. 2007). In West Africa, for example, 40% of the population live in coastal cities. In Eritrea, a 1 m rise in sea level was estimated to cause an estimated damage of over US\$250 million due to the submergence of infrastructure and other economic installations in the port city of Massawa (Boko et al. 2007). In Cotonou, Benin, the rise in sea level due to climate change has led to the disappearance of roads, drains, pavements, and coconut plantations, which have been swallowed up by the sea as the shoreline retreats; with some shorelines having retreated by 400 m (Dossou and Gléhouenou-Dossou 2007). In other residential districts in Cotonou, part of the hotel infrastructure has been destroyed or severely damaged as some villas, or parts thereof, have been swept away (Dossou and Gléhouenou-Dossou 2007). In the City of Cape Town in South Africa, the combination of sea-level rise, a degraded coastal zone, extreme high tides, and altered frequency and intensity of storm events are feared to threaten tourism revenue, public infrastructure, and real estate by as much as between US\$500 million and US\$6 billion in any given year over the next 25 years (City of Cape Town 2008).

3.3.2 *Human Health*

The effects of climate change on human health in Africa and elsewhere continue to be a matter of scientific debate, primarily due to the mixed results of research on climate suitability for malaria transmission. Nonetheless, there is a sufficient body of research that suggests that climate change will have significant negative effects on human health in Africa. The continent is already vulnerable to several climate-sensitive diseases and altered temperatures and rainfall patterns, factors which are expected to increase incidences of vector-borne diseases such as malaria, for example. A number of studies have demonstrated a correlation between climatic change and malaria incidence, as well the incidence of dengue fever, for instance; and projections of the regional health effects signal a massive impact on the poor countries such as those in Africa. The impact on malaria is noteworthy since weather disturbances influence vector breeding sites, and hence the transmission potential of the disease.

The nature of the rapid urbanization and the increasing pattern of slum settlements in Africa mean that the continent's cities and the urban poor will be most vulnerable to health hazards arising from climate change. Africa's urban poor generally live in slum-like conditions, which tend to be opportunistic breeding grounds for disease carriers such as mosquitoes. These slums are also characterized by high population densities, supplying a large pool of susceptible individuals (Campbell-Lendrum and Corvalán 2007). Currently, it is estimated that the majority of the almost one million people who die of malaria each year are poor African children; and by 2100, it is projected that malaria cases among this vulnerable group will increase by 5–7% (Boko et al. 2007; WHO 2008).

The social and economic costs of the additional burden of malaria will also be significant. This will have serious implications on growth and development on the continent. One study by Gallup and Sachs (2001) has estimated the economic burden of malaria as resulting in an average annual reduction in economic growth of 1.3% among severely affected African nations. They further noted that a 10% reduction in malaria was associated with a 0.3% higher growth per year. Estimates for a group of 31 African countries show that the impact of malaria on national incomes between 1980 and 1995 exceeded US\$73 billion, equivalent to 10% of 1995 income (Sachs and Malaney 2002). In addition, young children in Africa bear a considerable burden in terms of malaria morbidity and mortality, while school-age children report increased incidences of school absenteeism. In Kenya, for example, primary school children miss 11% of school days every year due to malaria; and secondary school students miss 4.3% of school days per year. Other analyses suggest that 13–50% of medically-related school absences are due to the disease (Sachs and Malaney 2002). The socio-economic effects of climatic change on malaria alone in Africa demonstrate very clearly that climatic changes will have serious consequences on human health, growth and development on the continent.

3.3.3 *Rural–Urban Migration*

Environmental stress has been known to contribute to rural–urban migration and urbanization processes in Africa (Hope and Lekorwe 1999). Climate change impacts have and will continue to contribute to the higher levels of migration on the continent. Researchers (Barrios et al. 2006: 359) have provided evidence that “climatic change has been an important determinant of rural–urban migration in sub-Saharan Africa”. They demonstrate that “rainfall has indeed been an important determinant of urbanization growth in sub-Saharan Africa”. They further posit that climatic conditions (rainfall) push people out of rural/agricultural areas to urban areas. African agriculture relies heavily on rainfall for watering crops. The declining rainfall means that the capacity of most African soils to retain moisture is very poor, rendering agricultural lands unproductive. This in turn affects the livelihoods of rural residents, forcing them to migrate to the urban areas. In Burkina Faso, droughts in the 1970s and 1980s were linked to a steady increase in labour migration to nearby urban areas (Henry et al. 2004).

The influence of future climatic changes on rural–urban migration in Africa can, disturbingly, have potential compound effects. For instance, a decrease in the viability of farming in rural areas may encourage people to migrate to urban areas, yet the economies of African cities may also be affected by climate change impacts and thereby diminish the prospect of rural migrants finding gainful employment in urban areas. Also, droughts and floods in rural areas have forced many rural people to migrate to towns and cities, adding large new populations to existing slums. These new migrants, in turn, add to the urban activities that increase the flow of rainwater to rivers, and consequently exacerbate the intensity of urban flooding (ActionAid International 2006). Moreover, when climate stresses coincide with economic or social stresses, the potential for migration from rural areas increases significantly. However, it must also be noted here that both the distance travelled and the amount of time spent in urban areas may vary depending on the severity of the impact of the climatic changes. For example, it was found that in the West African Sahel, when harvests are fair, younger family members may stay much closer to home, travelling to nearby cities for paid work so as to reduce the strain on the food reserves of their households, and to top-up household incomes (Brown 2008). However, based on the scientific predictions regarding future climate change and its ability to severely disrupt water supplies and damage agricultural productivity, it is likely that all resulting rural–urban migration will be permanent.

This negative economic impact of climate change as a push factor in rural–urban migration in Africa has also been further quantified as demonstrated in a few studies. For example, in a recent study of the Ferlo Region in Northern Senegal by Hein et al. (2009), the authors illustrate how the people there are highly dependent on their natural resource base. These resources are highly vulnerable to climate change, in particular changes in rainfall. It was found that changes in annual rainfall together with changes in rainfall variability affect the optimal livestock density and

profits that can be derived from livestock ownership and rearing. These reductions in both livestock numbers and profits lead to reduced employment opportunities in the Ferlo Region and puts further pressure on local people to move to urban areas in search of work. Similar findings were reported by UN-Habitat (2008) and Girardet (2008) on Mauritania where the urban population, primarily in the capital city, Nouakchott, has swollen exponentially since the mid-1950s due to massive rural–urban migration, mainly from the cattle- and camel-herding nomadic tribes who lost their grazing land as a result of persistent desertification and droughts.

3.4 Climate Change, Urban Development, and Adaptation: Policy Implications for Africa

Significant numbers of African urban dwellers face life-threatening risks from the increased intensity of weather variations that climate change heralds. These and other impacts will also bring the threat of damage to their livelihoods, property, environmental quality, and future prosperity. However, the African continent is a victim of circumstances (the negative externality of greenhouse gas emissions from rich nations). Climate change is therefore not a problem of Africa's making, yet most urban areas in Africa stand to be particularly impacted due to geography, patterns of settlements, and low adaptation capacity. Given this state of affairs, the policy implications are clear. African national and municipal governments must intensify efforts toward formulating and implementing strategies for adapting to the impacts of climate change, and must incorporate those strategies into their urban development policies and public investment decisions. These efforts must also be accompanied by parallel attempts to improve adaptation capacity.

Adaptation strategies must aim at the eventual ability of African cities to cope with the impacts of climate change as an outcome of harmonious urban development. Policies for urban development therefore need to address the multiple challenges of supporting sustainable, climate-resilient growth, along with good local governance, better jobs, better urban infrastructure, and better basic urban public services. In addition, national governments would need to put much greater emphasis on rural development so as to allow for the emergence of multiple economic opportunities in these rural areas. This will reduce the attraction of cities for rural residents (Hope 1999). Adapting to climate change affords governments the ability to implement and/or scale-up appropriate plans for urban development by drawing from available international assistance. All African nations have ratified the United Nations Framework Convention on Climate Change (UNFCCC), which was adopted by UN member states in 1992; and the Kyoto Protocol to the UNFCCC adopted in 1997. In addition, Africa fully supports the Bali Roadmap, including the Action Plan agreed to in 2007, which, among other things, established an Adaptation Fund. This Fund benefits developing countries that are party to the Kyoto Protocol, and which are particularly vulnerable to the adverse effects of climate change. Funding from the Fund assists them in meeting the costs of adaptation.

A broad definition of adaptation, as employed in this work, is the modification in human and other activities in adjustment to actual or expected changes in climate through current or future measures, which are designed to reduce the negative impacts. Adaptation is therefore more about responding to climate change as opposed to preventing climate change. It entails actions by individuals, organizations, and governments. “Because climate change will affect every aspect of society, environment and economy, adaptation includes activities that are both directly and indirectly related to the impacts of climate change” (Schipper 2009: 19). Given its current and future elements, various types of adaptation have been identified. These include: (1) anticipatory adaptation; (2) autonomous adaptation; and (3) planned adaptation (Aaheim et al. 2008). Anticipatory adaptation refers to adaptation that takes place before impacts of climate change are observed. It is also referred to as proactive adaptation. Autonomous adaptation – also known as spontaneous adaptation – does not involve a conscious response to climate change; it is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Planned adaptation is the outcome of deliberate policy decisions, based on the awareness that conditions have changed or will change, and that action is needed to moderate the situation and achieve a desired result (Aaheim et al. 2008).

The UNFCCC commits countries to prepare for and facilitate adequate adaptation to climate change, with adjustments and changes required at the community, national, and international levels. Among other things, appropriate adaptation strategies must involve a relationship between (1) the accurate assessments of current vulnerabilities to climate change impacts; (2) use of appropriate technologies; and (3) information on traditional coping practices, diversified livelihoods, and current government and local interventions. In the Bali Action Plan, adaptation is identified as one of five key building blocks for a strengthened future response to climate change that goes beyond 2012 (UNFCCC Secretariat, n.d.a). It is generally agreed among stakeholders that adaptation strategies are best implemented through, and within, National Adaptation Programmes of Action (NAPAs). A NAPA provides an important platform for a country to prioritize urgent adaptation needs. It draws on existing information and data as well as community-level input to both identify and determine the priority adaptation approaches and projects that are required to enable a country to cope with the impacts of climate change.

As of May 2009, some 41 countries had submitted a NAPA to the UNFCCC Secretariat. This group included 29 African nations classified as least developed countries (UNFCCC Secretariat n.d.b). A NAPA is one of the requirements for accessing funding from the various funding sources available under the UNFCCC and the Kyoto Protocol. While most of the NAPAs are national in scope, as they ought to be, there is still need to disaggregate their strategies in terms of the urban–rural divide, given what we know now about the differential impacts of climate change on these two distinct geographic areas in each country. In fact, what is being advocated here is the need to think nationally but to act locally in a more community-oriented manner. In some countries such as South Africa, for example, the approach to adaptation to climate change obliges municipalities to respond to and implement the objectives of the National Climate Change Response Strategy.

South African municipalities have taken up the challenge, representing a good model for other African countries to follow.

Adaptation strategies for moderating the impacts of climate change in urban areas must include a number of elements and projects that deal specifically with urban public services (including health, water, and sanitation), settlements, coasts, and good local governance. The latter is often overlooked. However, the success of urban adaptation depends on good local governance combined with appropriate funding flows (Swalheim and Dodman 2008). Moreover, as convincingly argued by Moser and Satterthwaite (2008), the quality of local government influences the levels of risk from climate change, especially for those with limited incomes and assets. In addition, good local governance is absolutely necessary to drive and sustain effective pro-urban-poor actions and projects to reduce their vulnerability to climate change (Satterthwaite et al. 2007).

To date, adaptation planning in most African countries has been focused primarily at the national level, and has not adequately addressed urban adaptation. However, it is at the urban level that many people are directly affected by climate-induced impacts, and it is at that level that appropriate institutional approaches that target large numbers of people should be introduced. The South African approach for urban adaptation to climate change provides a good framework for other African countries to emulate. In Cape Town, for example, a municipal adaptation plan (MAP) for climate change has been developed. It covers a number of adaptation initiatives that include water supplies (restrictions, tariffs, reducing leaks, pressure management, regulations, awareness campaigns, etc.); storm water; bushfires; and coastal zones. The MAP is to be integrated into on-going strategic plans for all municipal departments (Mukheibir and Ziervogel 2007). Similarly, in Durban (eThekweni Municipality), another coastal South African city, a locally rooted climate change adaptation strategy has been developed. Durban's MAP is being rooted in initiatives that include, for example, human health, water and sanitation, coastal zone, food security and agriculture, infrastructure, and cross-sectoral activities (Roberts 2008; eThekweni Municipality 2007).

African central governments need to move with speed to empower and encourage their municipal governments to develop urban adaptation plans to moderate the impacts of climate change in urban areas. These plans must also of necessity include elements for building local adaptive capacity (Phalatse 2008), and be facilitated with the cooperation and support of the central government so as to seek out all potential opportunities available for funding of adaptation projects under the UNFCCC and the Kyoto Protocol, as well as from other international and bilateral donors. South Africa has led the way in this regard and, in this author's view, represents an excellent model for other African countries to pursue.

3.5 Conclusion

African urban centres contain a large proportion of the people most at risk from the effects of climate change. The growing urban population and urbanization in Africa have led to increased vulnerability of urban areas to climatic changes. However,

urbanization has not been met with a sufficient expansion of infrastructure and services, and many urban settlements are located in highly fragile areas. In addition, many of the cities are also located in coastal areas that are vulnerable to sea-level rise, storm surges, and flooding. In particular, the urban poor are most vulnerable to multiple dimensions of climate change such as heat-waves, sea-level rise, the destruction of coastal zones, and water shortages due to drought, for example.

Undoubtedly, climate change poses a serious threat to urban development in Africa. It will add to the burdens of those urban residents who are already poor and vulnerable, as well as burden the capacity of governments to cope with and adapt to the severe impacts that this work has outlined. In Africa, many of the adverse consequences of climate change are already apparent. However, given that Africa's contribution to climatic variation is marginal at best, the concern for the continent is not the reduction of carbon emissions (*mitigation*) but *adaptation*, which is an impact-oriented action for adapting to climatic changes so as to minimize adverse impacts. Strategies for facilitating adaptation need to be continuously developed, and African governments (both national and municipal) need to be vigilant in their policy approaches for controlling the impacts of climate in their cities as well as nationally.

References

- Aaheim A, Berkhout F, McEvoy D, Mechler R, Neufeldt H, Patt A, Watkiss P, Wreford A, Kundzewicz Z, Lavalle C, Egenhofer C (2008) Adaptation to climate change: why is it needed and how can it be implemented? CEPS Policy Brief No. 161. Centre for European Policy Studies, Brussels
- ActionAid International (2006) Climate change, urban flooding and the rights of the urban poor in Africa: key findings from six African cities. Action Aid International, London
- Allison EH et al. (2009) Vulnerability of national economies to the impacts of climate change on fisheries. *Fish Fisheries* 10(2):173–96
- APF (Africa Partnership Forum) (2008). Climate challenges to Africa: a call for action. <http://www.africapartnershipforum.org>. Accessed 15 March 2009
- Barrios S et al. (2006) Climatic change and rural-urban migration: the case of Sub-Saharan Africa. *J Urban Econ* 60(3):357–71
- Bates BC et al. (2008) Climate change and water: IPCC technical paper VI. IPCC Secretariat, Geneva
- Boko M et al. (2007) Africa. In: Parry M et al. (eds) *Climate change 2007: impacts, adaptation and vulnerability: working group II contribution to the fourth assessment report of the inter-governmental panel on climate change*. Cambridge University Press, Cambridge, UK, pp 433–67
- Brown O (2008) Migration and climate change. International Organization for Migration, Geneva
- Campbell-Lendrum D, Corvalán C (2007) Climate change and developing-country cities: implications for environmental health and equity. *J Urban Health* 84(1):i109–i117
- Case M (2006) Climate change impacts on East Africa: a review of the scientific literature. World Wide Fund for Nature, Gland, Switzerland
- CCPAN (2007) Climate Change Glossary. <http://www.climatephilanthropists.org/basics> Accessed 20 May 2009
- Chappell A, Agnew CT (2004) Modelling climate change in West African Sahel Rainfall (1931–90) as an artifact of changing station locations. *Int J Climatol* 24(5):547–54

- Christensen JH et al. (2007) Regional Climate Projections. In: Solomon S et al. (eds.). *Climate change 2007: the physical science basis: contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge University Press, Cambridge, UK, pp 847–940
- City of Cape Town (2008) Final report: sea-level rise adaptation and risk mitigation measures for the City of Cape Town. <http://www.capetown.gov.za>. Accessed 20 March 2009
- Collier P, Conway G, Venables T (2008) Climate change and Africa. *Oxf Rev Econ Policy* 24(2):337–53
- Dai A et al. (2004) The recent Sahel drought is real. *Int J Climatol* 24(11):1323–31
- Desanker PV, Justice CO (2001) Africa and global climate change: critical issues and suggestions for further research and integrated assessment modeling. *Climate Res* 17(2):93–103
- Deshingkar P, Grimm S (2005) Internal migration and development: a global perspective. International Organization for Migration, Geneva
- Dodman D (2008) Against the tide: climate change and high-risk cities. IIED Briefing. International Institute for Environment and Development, London
- Dossou KMR, Gléhouenou-Dossou B (2007) The vulnerability to climate change of cotonou (Benin): the rise in sea level. *Environ Urban* 19(1):65–79
- Douglas I et al. (2008) Unjust waters: climate change, flooding and the urban poor in Africa. *Environ Urban* 20(1):187–205
- Eriksen S, O'Brien K, Rosentrater L (2008) Climate change in Eastern and Southern Africa: impacts, vulnerability and adaptation. Global Environmental Change and Human Security (GECHS) International Project Office, University of Oslo, Oslo
- eThekwini Municipality (2007) Climate change: what does it mean for eThekwini Municipality? eThekwini Municipality, Durban
- FAO (2007) Africa. State of the world's forests 2007. FAO, Rome
- FAO (2008) Climate change and food security: a framework document. FAO, Rome
- Gallup JL, Sachs JD (2001) The economic burden of malaria. *Am J Trop Med Hyg* 64(1,2):85–96
- Girardet H (2008) Cities people planet: urban development and climate change. Wiley, Chichester, UK
- Hein L, Metzger MJ, Leemans R (2009) The local impacts of climate change in the Ferlo, Western Sahel. *Clim Change* 93(3–4):465–83
- Henry S, Schoumaker B, Beuchemin C (2004) The impact of rainfall on the first out-migration: a multi-level event-history analysis in Burkina Faso. *Popul Environ* 25(5):423–60
- Hope KR (1998) Urbanization and urban growth in Africa. *J Asian Afr Stud* 33(4):345–57
- Hope KR (1999) Managing rapid urbanization in Africa: some aspects of policy. *J Third World Stud* 16(2):47–59
- Hope KR (2008) Poverty, livelihoods, and governance in Africa: fulfilling the development promise. Palgrave Macmillan, New York
- Hope KR, Lekorwe M (1999) Urbanization and the environment in Southern Africa: towards a managed framework for the sustainability of cities. *J Environ Plann Manage* 42(6):837–59
- Hudson D, Jones R (2002) Regional climate model simulations of present day and future climates of Southern Africa. Technical Note 39. Hadley Center, Bracknell, UK
- Hulme M et al. (2001) African climate change: 1900–2100. *Climate Res* 17(2):145–68
- IPCC (2007) Climate change 2007: synthesis report. <http://www.ipcc.ch>. Accessed 15 March 2009
- LaFleur V, Purvis N, Jones A (2009) Double jeopardy: what the climate crisis means for the poor. Brookings Institution, Washington, DC
- Malhi Y, Wright J (2004) Spatial patterns and recent trends in the climate of tropical rainforest regions. *Philos Trans Royal Soc B* 359(1443):311–29
- May E, Caron Z (2009) Global warming for dummies. Wiley, Mississauga, Ontario
- McGranahan G, Balk D, Anderson B (2007) The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environ Urban* 19(1):17–37
- Molua EL, Lambi CM (2007) The economic impact of climate change on agriculture in Cameroon. Policy Research Working Paper 4364. World Bank, Washington, DC

- Moser C, Satterthwaite D (2008) Towards pro-poor adaptation to climate change in the urban centres of low- and middle-income countries. International Institute for Environment and Development, London
- Mukheibir P, Ziervogel G (2007) Developing a municipal adaptation plan (MAP) for climate change: the City of Cape Town. *Environ Urban* 19(1):143–58
- NCDC (National Climatic Data Center) (2008) Global climate at a glance: mean temperature anomalies. <http://www.ncdc.noaa.gov/gcag/index.jsp>. Accessed 20 March 2009
- Nicholson SE (2001) Climatic and environmental change in Africa during the last two centuries. *Climate Res* 17(2):123–44
- Nyong A (2005) The economic, developmental and livelihood implications of climate induced depletion of ecosystems and biodiversity in Africa. Presented at the Scientific Symposium on Stabilization of Greenhouse Gases, Exeter, UK, 1–3 Feb 2005
- Nyong A (2009) Climate Change Impacts in the Developing World: Implications for Sustainable Development. In: Brainard L, Jones A, Purvis N (eds) *Climate change and global poverty: a billion lives in the balance?* Brookings Institution Press, Washington, DC, pp 43–64
- Parry ML et al. (2004) Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environ Change* 14(1):53–67
- Phalatsé L (2008) Capacity building needs and opportunities from the perspective of municipal government. Prepared for the Workshop to Assess Needs and Opportunities, African Climate Change Fellowship Programme, Dar es Salaam, Tanzania, 11–13 March 2008
- Roberts D (2008) Thinking globally, acting locally – institutionalizing climate change at the local government level in Durban, South Africa. *Environ Urban* 20(2):521–37
- Ruosteenoja K et al. (2003) Future climate in world regions: an inter-comparison of model-based projections for the new IPCC emission scenarios. Finnish Environment Institute, Helsinki
- Sachs J, Malaney P (2002) The economic and social burden of malaria. *Nature* 415(6872):680–5
- Satterthwaite D et al. (2007) Adapting to climate change in urban areas: the possibilities and constraints in low- and middle-income nations. International Institute for Environment and Development, London
- Schipper ELF (2009) Meeting at the crossroads?: exploring the linkages between climate change adaptation and disaster risk reduction. *Climate Dev* 1(1):16–30
- Schreck CJ, Semazzi FHM (2004) Variability of the recent climate of Eastern Africa. *Int J Climatol* 24(6):681–701
- Swalheim S, Dodman D (2008) Building resilience: how the urban poor can drive climate adaptation. Sustainable development opinion. <http://www.iied.org>. Accessed 20 March 2009
- UNDP (2007) Human development report 2007/2008: fighting climate change: human solidarity in a divided world. Palgrave Macmillan, New York
- UNFCCC Secretariat (n.d.a.) Adaptation. <http://www.unfccc.int>. Accessed 15 March 2009
- UNFCCC Secretariat (n.d.b.). Submitted NAPAs <http://www.unfccc.int>. Accessed 15 March 2009
- UN-HABITAT (2008) The state of African cities 2008: a framework for addressing urban challenges in Africa. UN-HABITAT, Nairobi
- Unmüßig B, Cramer S (2008) Climate change in Africa. Hamburg: German Institute of Global and Area Studies (GIGA) Focus Africa, No.2
- World Bank (2009) Africa development indicators 2008/09: youth and employment in Africa. World Bank, Washington, DC
- WHO (2008) Protecting health from climate change: World Health Day 2008. WHO, Geneva

Chapter 4

A Region of Contrasts: Urban Development, Housing and Poverty in Asia

Kioe Sheng Yap

4.1 Introduction

Over the past few decades, Asia has made headlines around the world as the region with the fastest economic growth, the economic powerhouse of the world, the saviour of the global economy in times of financial crises, etc. However, Asia is a vast region with an enormous diversity, deep contrasts and wide disparities: rapid economic growth, extreme poverty, both affecting large numbers of people. The dimensions of these contrasts and disparities become particularly visible within the context of urban development, housing and poverty.

First of all, what distinguishes Asia from other regions are the absolute numbers of its population. According to recent estimates by the Economic and Social Commission for Asia and the Pacific (UN-ESCAP), the region has a population of over 4.1 billion people (UN-ESCAP 2008). Percentages often hide the absolute number of people affected. It is, for instance, generally said that Asia, like Africa, is not very urbanized. In 2007, Asia's level of urbanization was 40.8% while that of Africa is 38.7%. However, this means that Asia's urban population (1.645 billion) is almost twice as large as Africa's total population of 0.965 billion (United Nations 2008).

The region includes two of the most populous countries, China and India, both of which have rapidly developing economies. Whatever happens in these two countries affects the regional statistics. UN-ESCAP states that the Asia-Pacific region has made dramatic progress in achieving Millennium Development Goal No.1 (reducing income poverty by half), but this has been mainly achieved by two countries: China and India (UN-ESCAP 2005). From this perspective, achievements (or the lack of achievement) of small countries like Nepal or the Lao PDR hardly count.

Asia includes very populous countries like China (1.3 billion) and India (1.2 billion) and countries with very small populations like Bhutan (0.7 million) and the Maldives (0.3 million) (UN-ESCAP 2008). It includes Singapore and Japan, some of the richest countries in the world, and Nepal, one of the poorest. Per capita

K.S. Yap (✉)
45/2, Soi Sailom 2, Phaholyothin Road, Bangkok, Thailand
e-mail: yapksh@gmail.com

GDP was US\$47,950 in Singapore and US\$1,060 in Nepal in 2007 (World Bank 2009). Taking the global poverty line of US\$1.25 a day, some 900 million people or 27% of the total population in Asia live in extreme poverty. If a poverty line of US\$2 a day is used, 1.8 billion people in the region are income poor (Bauer et al. 2008).

The contrasts within the region become very poignant when comparing social indicators such as the Human Development Indicators and the Millennium Development Goals (MDGs). In 2007, life expectancy at birth was 86 years for women in Japan and only 43.5 years for women in Afghanistan (UN-ESCAP 2008). Child mortality (under 5 years of age) was 5 per 1,000 live births in the Republic of Korea, and 55 per 1,000 live births in Nepal in 2006 (UN-ESCAP 2008). In many countries of East Asia, the ratio of girls to boys in primary education is 1.00, but in Pakistan it is only 0.78 (UN-ESCAP 2008). Note that the countries that do not score well on social achievements are often those that have experienced internal strife: for example, Afghanistan, Nepal, and Timor Leste.

While these national averages show the wide disparities within the region, they hide, at the same time, the disparities within a single country. Unfortunately, sub-national data on the MDGs are difficult to find; only a few countries, such as India, publish such data. They show that some states in India would belong to the poorest countries in the world, if they were independent, while others would be among the middle-income countries. China has very publicly recognized that immense disparities exist between coastal provinces and inland provinces.

In almost all countries of Asia, there are wide disparities in economic and social conditions between urban and rural areas, as much of the economic development of the past years was urban based. It is often assumed that socio-economic conditions in urban areas are always better than in rural areas, but that may not be so. There is a serious lack of data on intra-urban socio-economic conditions, but available studies point at wide disparities within cities. Health conditions of the urban poor in under-serviced neighbourhoods such as slums and squatter settlements may be very similar to the health conditions among the rural poor.

Although difficult to quantify, sharp contrasts between the urban rich and the urban poor are very visible for those who are ready to look behind the glass and steel façades of office blocks and shopping malls. However, it may not be appropriate to speak in this respect about divided cities and dual economies. One of the key characteristics of urban development in Asia is the integration of the formal and the informal economy. While the relationship between the two should not be called harmonious, it is a close relationship which benefits both sides.

4.2 An Urbanizing Region

It is generally observed that at 40.8% in 2007, Asia is not highly urbanized. Its level of urbanization is comparable to that of Africa (38.7%) and much lower than that of the other developing region, Latin America and the Caribbean at 78.3% (United Nations 2008). However, the magnitude of the urban population in Asia is already staggering: 1.645 billion people. Although not as high as in Africa's annual urban

growth rate of 3.15%, its urban growth rate of 2.19% implies that the population of Asia will be predominantly urban by 2025 (United Nations 2008). However, it is important to qualify the figures in this paragraph for several reasons.

There is no globally agreed definition of “urban” as each country has its own definition. “Rural” is usually defined as “what is not urban”. In some countries, a settlement is considered urban if it has at least 5,000 inhabitants (United Nations 2004). Moreover, the distinction between “urban” and “rural” is becoming increasingly blurred. Improvements in transport and communication and reduction in their costs have resulted in a constant and massive flow of people, goods, services and ideas between urban and rural areas.

Research in rural areas across Asia has shown that rural households earn an increasing share of their income off-farm, that is, in urban areas, as a result of circular and seasonal migration. Large parts of the urban population (i.e. people with an urban occupation) live in rural areas, on the periphery of metropolitan areas, commuting daily to the city. Peripheral areas are often officially considered “rural”, but may already be completely urbanized in terms of housing, infrastructure and services. The areas may eventually be reclassified as “urban”, but until that happens, the population in these areas is considered rural. At the end of the 1980s, the fourth and the ninth largest urban places in Thailand were yet to be officially defined as urban. These places, in provinces adjacent to Bangkok, were major centres for the location of industries that attracted many rural migrants (United Nations 2001).

Urban population growth is the result of three separate processes: natural population growth, rural – urban migration and reclassification of rural into urban areas. It is difficult to measure the magnitude of these processes separately. Whatever is available indicates that in Asia, migration and reclassification account for about half of the urban population growth (Table 4.1), while natural population growth accounts for the other half. This implies that urban population growth is not caused primarily by rural – urban migration as is often stated. This obviously has policy implications as demonstrated below.

The image of urbanizing Asia is that of mega-cities, i.e. urban agglomerations with ten million inhabitants or more. In 1950, the world had only two mega-cities: New York (12.3 million inhabitants) and Tokyo (11.3 million inhabitants). In 1975, there were three mega-cities, with Tokyo being the largest and still the only one in Asia. By 2007, there were 19 mega-cities in the world. Ten of these were in Asia. Tokyo was the largest with 35.7 million inhabitants; the others being Mumbai, Delhi, Shanghai, Kolkata, Dhaka, Karachi, Osaka-Kobe, Beijing and Manila (United Nations 2008). Many have argued that such mega cities must be dysfunctional, but some of them are very successful economies. According to PricewaterhouseCoopers (2007), Tokyo’s GDP in 2005 ranks top in Asia (Table 4.2).

Table 4.1 Estimate of components of urban growth in Asia during the 1980s (United Nations 2001, p. 35)

Component	Percentage
Migration/reclassification (incl. China)	63.6
Migration/reclassification (excl. China)	48.9

Table 4.2 Estimated GDP in 2005 for top three urban agglomerations in Asia (PricewaterhouseCoopers 2007, p. 18)

	Estimated GDP 2005 (billion)	Population (2005) (million)	GDP per capita
Tokyo	\$1,191	35.2	\$33,800
Osaka/Kobe	\$341	11.3	\$30,200
Seoul	\$218	9.7	\$22,600

Table 4.3 Population distribution by size of urban settlement in Asia (2000, 2015) (United Nations 2004, pp. 90, 92)

Urban settlement size	Population (millions)	Percentage distribution	Average annual growth rate		
	2000	2015	2000	2015	
Ten million plus	142	207	10.4	10.4	2.51
Five to ten million	91	161	6.7	8.1	3.81
One to five million	307	446	22.4	22.4	2.50
0.5–1 million	149	189	10.9	9.5	1.59
<0.5 million	678	986	49.6	49.6	2.50
Total	1,367	1,989	100.0	100.0	2.50

It is often said that half of the world's population now live in cities, but that is not correct, unless the definition of "city" is stretched to include any urban settlement, including those with 2,000 inhabitants. The bulk of the urban population in the world, Asia included, live in small cities and towns. Only 10.4% of the total urban population in Asia lived in mega-cities by the year 2000, while 60.5% lived in cities and towns with less than one million inhabitants (Table 4.3). This distribution is unlikely to change significantly in the foreseeable future. In 2015, 10.4% of the population will still be living in mega-cities; while 59.1% will be living in cities and towns of less than one million inhabitants. On the other hand, the number of people living in cities with five to ten million inhabitants will grow exponentially.

This distribution of the urban population over settlements of different sizes is not just statistically significant. The development of smaller cities and towns is extremely useful in taking off the pressure from mega-cities so as to avoid primate cities and to support the development of the rural areas. While these challenges are enormous, the situation is compounded by lack of human and financial resources among local governments, whose capacity for effective urban management is weak. While metropolitan governments may have the capacity to run their mega-city like a small country, governments of smaller cities and towns are struggling.

If the smaller cities and towns cannot be developed, and cannot attract the requisite investment to develop their urban economy and to retain their population, rural – urban migration as well as foreign direct investments may focus on the major city in the country, resulting in urban primacy (Table 4.4). Thailand and Cambodia, for instance, have a high level of urban primacy, while countries like India and China show a broad distribution of the urban population over a number of cities.

Table 4.4 Urban primacy in Southeast Asia in the 1990s (Dutt and Song 1994, p. 172)

Country	Ratio	Country	Ratio
Thailand	21.4	Malaysia	4.1
Cambodia	17.8	Indonesia	3.9
Philippines	9.2	Vietnam	1.9
Myanmar	4.2	Lao PDR	1.8

Table 4.5 Top ten world port cities in the 2070s by exposed population and exposed assets (Nicholls et al. 2008, pp.13, 29)

City	Population exposed (millions)	Assets exposed (US\$ billions)
1. Kolkata	14.0	1,961
2. Mumbai	11.4	1,598
3. Dhaka	11.1	544
4. Guangzhou	10.3	3,358
5. Ho Chi Minh City	9.2	653
6. Shanghai	5.5	1,771
7. Bangkok	5.1	1,118
8. Yangon	5.0	172
9. Miami	4.8	3,513
10. Haiphong	4.7	334

Scenario: Future city = future socio-economic situation with the 2070s climate change, natural subsidence/uplift and human-induced subsidence

With respect to climate change, it is important to note that many of the large cities are coastal cities that are vulnerable to climate change and violent weather patterns. A recent study estimated that the top ten cities with the highest exposure to the effects of climate change by the 2070s are Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon, Miami and Haiphong (Table 4.5). On the other hand, the top ten cities with the highest number of assets exposed to climate change are Miami, Guangdong, Greater New York, Kolkata, Shanghai, Mumbai, Tianjin, Tokyo, Hong Kong, and Bangkok. Hence, cities in Asia will be significantly affected, courtesy of the rapid urbanization and economic growth expected in these countries (Nicholls et al. 2008). The number of city dwellers at the risk of being affected by flooding in the low elevation coastal zone is estimated at more than 262 million (UN-HABITAT 2008).

Many cities and towns are located in low-lying areas that regularly flood under “normal” climatic conditions. A major factor in this development is that many cities and towns in Asia are growing in an unplanned, haphazard way. The question is often asked: why is there so little, if any, effective urban planning? One category of answers refers to weak governments and lax law enforcement, including corruption. However, another category of answers seem to indicate that urban planning has a low priority, and that urban economic growth is far more important. The Singapore success story shows that urban planning and law enforcement pays

off, but cities like Bangkok and Ho Chi Minh demonstrate that unplanned urban growth is not a hindrance to foreign direct investment, despite the serious social and environmental consequences.

Environmental consequences of unplanned urban growth include traffic congestion, air and water pollution, and problems with solid waste disposal. Social consequences include urban poverty, a proliferation of slums and squatter settlements, poor working conditions and low wages in the urban informal sector. However, conditions within a city or town often differ from one place to another, and where the poorest conditions occur in the informal sector, they are extremely difficult to measure.

4.3 Managing Urban Development

Some policymakers, however, still argue that Asia is an agrarian society and that her key problem is over-urbanization. The proposed solution is to send the urban poor back to the rural areas “where they belong”. This argument is also used to reject any idea of a low-income housing policy to improve the living conditions of the urban poor, and of support to the urban informal sector to improve the urban poor’s working conditions.

The most extreme anti-urbanization policy in Asia was that of the Khmer Rouge, who came to power in Cambodia in 1975 during the final days of the Vietnam War. This regime saw cities as pools of corruption and decadence, and started to evacuate the urban areas immediately after attaining victory. As a result of these disastrous policies, both the Cambodian economy and society quickly broke down, and hundreds of thousands of people died, many of starvation. However, after the defeat of the Khmer Rouge, the cities began to grow again, even faster than hitherto.

The government of the People’s Republic of China also had, for a long time, an anti-urbanization policy. Rural – urban migrants were unable to obtain an urban household registration, and were therefore excluded from access to many basic urban services. China has since changed her views on urbanization after realizing that it needed additional labour in the coastal urban areas, where the export-oriented industry was the engine of economic growth, and also after realizing that returning migrants could also contribute to the development of the urban and rural areas in the interior of the country. The 17th National Congress of the Communist Party held in October 2007, and the 11th National People’s Congress held in March 2008, talked in positive terms about urbanization, explicitly linking it to industrialization and development.

The new thinking was that the proportion of farmers in the population must be reduced, while the urbanization process of the rural population was to be speeded up. Besides, the role of the urban areas in helping and promoting the rural areas to develop was underscored. Planning the urban and rural economic-social development in a unified way has been a major innovation towards a fundamental solution to the problems facing agriculture, rural areas and farmers in the new period (China Development Review 2003).

The example of China demonstrates that economic development and urbanization are closely linked processes that support each other, and that productivity is higher in urban than in rural areas. Moreover, the urban population growth is, as shown before, not only the result of rural – urban migration, but also of natural urban population growth; in other words, many urban residents never lived and worked in the rural areas (United Nations 2001). Also, urbanization does not mean that policymakers should aim for the development of mega and primate cities. The role of secondary cities, small cities and towns, in national development needs to be enhanced.

A more positive view of urbanization does not imply that rural poverty is not important, and that rural development is unnecessary. In Asia for instance, an estimated two-thirds of the poor still live in rural areas, and improving their living and working conditions is of utmost importance. However, the creation of income-generating opportunities in rural areas is limited; and since primary and secondary education is expanding in the rural areas, it will be necessary to increase urban employment for rural schools graduates.

Whether the challenge is over-urbanization or under-urbanization, the issue is the lack of synchronization of the following different processes: (a) economic development and employment generation; (b) urban population growth and distribution; (c) expansion of infrastructure and housing; (d) the adoption of social and environmental policies; and (e) the application of principles of inclusive and participatory governance. In many Asian countries, the first two processes (urbanization with growth) occur at the same time. The other processes are however lagging behind, and this may cause political, social and economic tensions.

The economic growth is of such a high priority that the expansion of basic infrastructure and housing does not have a commensurate priority; infrastructure investment is expected to support economic growth and attract direct foreign investments rather than generate social development. Moreover, there seems to be a trend among many countries to grow and pollute now, and clean up later. Finally, also along the same trend, money and the market determine decisions on public affairs.

Economic growth does not however generate sufficient employment to provide for all the urban residents, most of whom work in the urban informal sector (Table 4.6), which is not just a residual economic sector, but includes a variety of sub-sectors, some of which are well integrated with the formal sector. The informal sector is also not necessarily unrecognized or unorganized; it contributes to the economy as illustrated in Table 4.7. The activities in the informal sector may be unregulated, but so are many economic activities that are clearly part of the formal sector. One might therefore conclude that the term “informal sector” is neither adequate nor very useful.

Many formal-sector enterprises subcontract work, within or outside their premises, to other enterprises, which again subcontract different parts of the work to sub-subcontractors. While the top enterprises may be regulated, listed, organized and registered, the extent to which this happens declines as one goes lower in this hierarchy. Without standards and minimum wages, labour is cheap in Asia.

Table 4.6 Informal employment in non-agricultural employment by sex (1994/2000) (ILO International Labour Office 2002, p. 19)

Region/country	Informal employment as% of non-agricultural employment	Women's informal employment as% of women's non-agricultural employment	Men's informal employment as% of men's non-agricultural employment
Asia	65	65	65
India	83	86	83
Indonesia	78	77	78
Philippines	72	73	71
Thailand	51	54	49

Table 4.7 Contribution of the informal sector to GDP (ILO International Labour Office 2002, p. 24)

Region/country	Year	Informal sector GDP as a percentage of non-agricultural GDP
Asia		31
India	1990–1991	45
Indonesia	1998	31
Philippines	1995	32
Rep. of Korea	1995	17

In Southeast Asia, eating out at informal-sector food stalls is a rule rather than an exception for many urban middle and lower-income families. This makes small wages bearable. This contributes to the competitiveness of the Asian economies in the world. The transport sector has its informal and formal sub-sectors: motorcycle taxis are a critical transport feeder system for formal transport systems such as mass transit systems. In Bangkok, for instance, both the informal food sector and the informal transport sector are at least partly regulated.

4.4 Urban Poverty Reduction

Poverty has to do with more than a lack of money. It can be described as having three related dimensions: (a) lack of income, employment, assets; (b) lack of access to basic services; and (c) lack of power, participation, respect and dignity. Often, the urban poor are considered immigrants who do not belong to the city, and people who do not contribute to its development. As a result, they are not counted and cannot expect to be entitled to a place to live, to have access to adequate water and sanitation, and to be respected by officials. They carry the stigma of informal-sector workers and slum dwellers, often being viewed as good-for-nothing.

Although the informal housing sector houses millions of people, there is an enormous variety of types of informal housing. One can broadly distinguish two

Table 4.8 Slum population in Asia (2005) (UN-HABITAT 2008, p. 90)

Asia	Slum population (millions)	% of urban population
East	216	36.5
South	201	42.9
Southeast	67	27.5
Total	484	37.1

types of informal housing: squatter settlements (i.e. housing that has been developed without the approval of the land owner and the authorities) and slums (i.e. housing whose quality has declined through age and lack of maintenance to a level where it becomes unsuitable for habitation). The United Nations uses the term “slum” for both types, and has set the following distinguishing criteria: insecurity of tenure, lack of access to adequate water supply and sanitation, overcrowding and poor structural quality. The slum population in Asia is summarized in Table 4.8.

Besides urban land being scarce, one of the key problems of informal sector housing is the lack of security of tenure; due to their “irregular” status, the occupants of informal housing can be easily evicted, and the buildings can be demolished without notice. Living under the threat of eviction is not only psychologically heavy, but it also discourages the occupants from maintaining or improving their dwellings. While evictions are extremely common in some cities such as Phnom Penh in Cambodia where the slums are built on valuable land, squatter settlements are largely ignored by the authorities in other cities such as Karachi in Pakistan, largely because an alternative solution does not exist.

Evictions are just one of the many problems facing the urban poor in informal settlements. In order to avoid being in the way of urban development, the urban poor build their informal settlements in the most unattractive places: on rooftops, in swamps, on lakes, and within abandoned buildings. The quality of life under such conditions is obviously extremely poor, and disasters such as flooding, landslides, and buildings collapse and fires can easily happen. Because of their informal status, squatter settlements often lack adequate water supply and sanitation, regular solid waste disposal, electricity supply, street-lights, etc. Many urban poor are, therefore, excluded.

4.5 Conclusion

This chapter has reviewed some of the key challenges facing Asian cities. Many cities and towns lack good urban governance, which simply refers to a very broad normative concept, but which could be operationalized as “the way decision about public affairs are taken and implemented”. Criteria for good governance include adherence to, and the application of, transparency, accountability, equity, the rule of law, subsidiarity, efficiency and effectiveness, participation and inclusiveness. Within an urban context, participation and inclusiveness are particularly important, and closely related.

In a good urban governance setting, inclusiveness relates to the ways decisions on public affairs are taken (involving all concerned) as well as the non-discriminatory nature of the decisions (benefiting all). Participation refers to participation in decision-making on urban affairs, sharing in the benefits of urban development, and recognition of the contributions people make towards urban development. Recognition is important, especially since the work of poor people in the informal sector and their informal settlements are often not recognized as contributors to urban development.

Most governments have done a poor job of ensuring adequate housing for the urban poor. Many policy-makers feel that improving the housing conditions of the urban poor will only encourage rural – urban migration, and that regularizing squatter settlements would mean rewarding people who have occupied other people's land illegally. In the 1980s, governments in Indonesia, the Philippines, Sri Lanka and some other countries introduced programmes that aimed at improving squatter settlements. The land tenure issue was, however, rarely solved as upgraded settlements were often later demolished.

In the past, the most common government response was to build subsidized public housing to resettle the urban poor. This has not worked in most countries (except Singapore and Hong Kong), because there was not enough money and because middle-class households in search of housing would gladly buy out the poor, or simply jump the queue. In the age of privatization and market forces, the general attitude of government is to wait and see whether economic growth will enable the urban poor to become rich enough to buy private sector housing, with the support of the formal housing finance sector. Over the past years, the formal housing finance sector has made a strong showing in many countries, but for many urban poor, formal housing still remains unaffordable.

A few government and various civil society organizations have developed innovative approaches to improve the housing conditions of the urban poor. These approaches include land sharing, community networking, community construction contracts, incremental development schemes, community mortgage programmes, community-based low-cost sanitation systems, community action planning, and women's banking. What characterizes these innovative approaches is that they are community-based, but often bring together civil society organizations and local governments.

In land sharing, a civil society organization or the government mediates between a land owner or developer and a slum community in a bid to reach a compromise agreement. Under this arrangement, the slum community returns a part of the land it occupies to the landowner who then develops it. The land owner allows the slum community to buy or lease the other part of the land, often at a subsidized rate, so that the slum dwellers do not have to leave the place where they have built up their social and economic networks.

Community networking reinforces on slum upgrading, land sharing and resettlement approaches by linking the community-based savings-and-loans groups within a city or town. The networks form a united front when negotiating with land owners, developers, and the local government. This empowers them enough to

negotiate better deals, to develop a common approach, to find vacant land to resettle, and to strengthen the financial basis of the community savings-and-loans schemes (Yap and De Wandeler 2010).

Community construction contracts are signed between a government agency and a community-based organization for the construction of basic infrastructure in the slum settlement. The cost of construction by a community is usually lower than that charged by a private sector contractor, who many communities perceive to be highly inclined to cheating on construction materials. Moreover, construction by the community often results in a sense of responsibility for use, maintenance and repair by the same community. If the community works efficiently, there may even be some profit spill-over for use by the community (UNCHS n.d.)

Incremental development schemes try to emulate squatter settlement development with the dual purpose of making the scheme more affordable for the urban poor and less attractive for other income groups. In conventional housing, development starts with vacant land, where infrastructure is first developed, followed by the construction and subsequent occupation of houses. In contrast, in incremental development, people move on to undeveloped land where they set up dwellings incrementally; while at the same time saving for the construction of basic infrastructure (Aliani and Yap 1990).

References

- Aliani AH, Yap KS (1990) The incremental development scheme in Hyderabad: an innovative approach to low-income housing. *Cities* 7(2):133–148
- Bauer A, Hasan R, Magsombol R, Wan G (2008) The World Bank's new poverty data: implications for the Asian Development Bank, ADB sustainable development. Working papers, vol 2. Asian Development Bank, Manila
- China Development Review (2003) Unified planning of urban and rural economic-social development. *China Dev Rev* 5(2).
- Dutt K, Song N (1994) Urbanization in Southeast Asia. In: Dutt AK, Costa FJ, Aggarwal S, Noble AG (eds) *The Asian city: processes of development, characteristics and planning*. Kluwer, Dordrecht
- UN-ESCAP (United Nations Economic and Social Commission for Asia and the Pacific) (2005) *A future within reach: reshaping institutions in a region of disparities to meet the millennium development goals in Asia and the Pacific*. Economic and Social Commission for Asia and the Pacific, Bangkok
- UN-ESCAP (United Nations Economic and Social Commission for Asia and the Pacific) (2008) *Statistical yearbook for Asia and the Pacific 2008*. Economic and Social Commission for Asia and the Pacific, Bangkok
- ILO (International Labour Office) (2002) *Women and men in the informal sector: a statistical picture*. International Labour Office, Geneva
- Nicholls RJ, Hanson S, Herweijer C, Patmore N, Hallegatte S, Corfee-Morlot J, Chateau J, Muir-Wood R (2008) Ranking port cities with high exposure and vulnerability to climate extremes: exposure estimates, OECD Environment Working Papers 1. Organization for Economic Cooperation and Development, Paris
- PricewaterhouseCoopers (2007) Which are the largest city economies in the world and how might this change by 2010? UK Econ Outlook March:15–26

- UN-HABITAT (2008) State of the world's cities 2008/2009: harmonious cities. Earthscan, London
- (United Nations Centre for Human Settlements) (n.d.) The community construction contract system in Sri Lanka. United Nations Centre for Human Settlements, Nairobi
- United Nations (2001) The components of urban growth in developing countries. United Nations, New York
- United Nations (2004) World urbanization prospects: the 2003 revision. United Nations, New York
- United Nations (2008) World urbanization prospects: the 2007 revision. United Nations, New York
- World Bank (2009) World development indicators database (revised 24 April 2009)
- Yap KS, De Wandeler K (2010) Self-help housing in Bangkok. *Habitat Int* 34(3):332–341

Chapter 5

The Effects of Climate Change on Urban Human Settlements in Africa

Aloysius Clemence Moshā

5.1 Introduction

A common understanding of climate change is any long-term and significant change in the “average weather” that a given region experiences. Average weather may include average temperature, precipitation and wind patterns. It involves changes in the variability or average state of the atmosphere over durations, ranging from decades to millions of years. These changes can be caused by a dynamic process on earth, external forces including variations in sunlight intensity, and more recently by human activities. The main human influence on global climate is emissions of the key greenhouse gases – carbon dioxide (CO₂), methane and nitrous oxide. Human activities, such as fossil fuel burning and deforestation, produce greenhouse gases that trap heat in the earth’s atmosphere. It is predicted that the continuation of these activities will result in a 1.8–4°C average temperature increase over the next century (IPCC 2007a).

Africa contributes the least by any continent to global warming. Emissions of carbon dioxide, the main global warming gas, have risen eightfold since 1950 in Africa to 223 million metric tonnes of carbon. However, these are still less than the emissions of a developed country such as Germany or Japan. South Africa accounts for 42% of these emissions. Egypt, Nigeria and Algeria combined account for 35.5% (IPCC 2006).

According to the U.S. Department of Energy (2002), each year Africa produces an average of just over 1 t of greenhouse gas carbon dioxide per person. The most industrialized African countries, such as South Africa, generate 8.44 t per person, and the least developed countries, such as Mali, generate less than a tenth of a metric ton per person. By comparison, each American generates almost 16 t per year. United States alone generates 5.7 billion metric tons of carbon dioxide per year (about 23% of the world total, making it the leading producer), while Africa as a whole contributes only 918.49 million metric tons (less than 4%). It is thus unfortunate that the continent that has contributed least to climate change is the hardest hit by climate change, which has been caused by the rich Western nations.

A.C. Moshā (✉)

Department of Architecture and Planning, University of Botswana, Botswana
e-mail: moshaac@mopipi.ub.bw

What is obvious, however, is that the continent is particularly vulnerable to the impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution; and overdependence on rain-fed agriculture.

Today, Africa (a continent of more than 800 million people) is already feeling the effects of climate change, whether in urban or rural areas. It has warmed by 0.7°C during the twentieth century. Rainfall in the Sahel region, just below the Sahara, has fallen by 25% in the last 30 years. Africa's tropical rainforests have also witnessed a fall in precipitation of 2.4% each decade since the mid-1970s. Droughts in the Sahel and the Horn of Africa have become more frequent since the 1960s.

According to a UN Report (2000), large African cities will be submerged under rising sea levels and more than 40% of wildlife habitats could disappear. Cereal crop yields that are already desperately low could also fall by a further 5%.

The report gives a stark assessment of what could happen on the continent if developed nations do not rein in their carbon emissions. Up to 30% of Africa's coast could disappear as sea levels rise from between 15 and 95 cm in the next 100 years. Important cities such as Cape Town, Dar es Salaam and Maputo are at risk. If sea levels were to rise by 1 m, part of Lagos, the economic centre of Africa's most populous country, Nigeria, would be submerged. Alexandria, a popular tourist destination in Egypt, could also suffer. The number of people at risk from coastal flooding in Africa will rise from one million in 1990 to 70 million by 2080.

The Gulf of Guinea, Senegal, Egypt, the Gambia, the eastern African coast and the Western Indian Ocean islands are particularly at high risk from rising sea levels. A 1-m rise would flood large areas of the Nile Delta and the Egyptian city of Alexandria would be severely affected. A similar rise would swamp 70% of the Seychelles.

Although adaptation options, including traditional coping strategies are available, in practice many countries cannot implement them since they do not have the enormous financial resources required.

The focus of this chapter, however, is on the effect of climate change on urban human settlements in the continent as more and more people are now residing in cities due to fast urbanisation caused by push-and-pull factors. Section one that follows immediately this introduction presents basic facts about the African continent and how urbanisation has seen its impact on the ecology of cities and lives of the people; section two examines the direct current effects of climate change on urban human settlements in the continent; section three looks at the responses of African governments and local authorities to climate change impacts through mitigation and adaptation. Finally, section four concludes by examining future possible opportunities available to African governments to tackle the scourge of climate change on urban human settlements on the continent.

5.2 Africa – General Overview

The African continent is the largest of all tropical landmasses and is the second largest of the world's seven continents with a land area of 30 million km² – about 20% of the world's total land area. Straddling the Equator with roughly equal

landmasses within both hemispheres, it stretches 8,050 km from the northernmost point in Tunisia to its southernmost tip in South Africa. It is 7,560 km wide, measured from the western tip in Senegal to the eastern tip in Somalia. Mount Kilimanjaro in Tanzania, measuring 5,895 m above sea level, is the highest point while the lowest is Lake Assal (153 m below sea level) in Djibouti.

Many African regions have climates that are among the most variable in the world on intra-seasonal to decadal timescales. The size of the African continent and its amplitude of climate variability makes the region an important component of not only the climate system of surrounding regions, but also of the global climate system itself (CLIVAR 2004). Changes in vegetation, hydrology and dust export from land surface to atmosphere all affect large scale atmospheric properties in the region and have the potential to impact climate variability.

Africa is characterized by a high population growth rate (1.9% between 1992 and 2002). It has a total population of 812 million and a low population density of 249 people per 1,000 ha compared to a world average of 442.

African water resources are not evenly distributed throughout the continent and are often not located where there is the greatest demand. Africa has 17 rivers with catchment areas greater than 100,000 km². It has more than 160 lakes larger than 27 km², most of which are located around the equatorial region and sub-humid East African highlands within the Rift Valley (The Africa Water Vision in the 21st Century 2000). Groundwater represents 15% of Africa's water resource with the major aquifers located in the arid zones of northern Sahara, Nubia, Sahel, Chad Basins, and Kalahari.

Groundwater is a very important source of drinking water supply; it is used by more than 75% of the population. About 52% of Africa's total population has access to safe water, and the average water use per capita is about 226 m³ per annum (World Bank 1996).

About half of Africa's cultivable land is arid- and semi-arid, mostly including desert soils (aridisols and entisols), which have low organic matter content. Pasturelands in Africa are affected by degradation, with consequent decline in crop yields and chronic food insecurity. It is also estimated that 14% of degraded soil result from vegetation removal, 13% from over-exploitation, 49% from overgrazing and 24% from agricultural activities (ECA 2006).

Africa accounts for approximately 27.4% of land degradation of the world, and 500 million hectares of land in Africa are moderately to severely degraded (UNEP 2000). Land degradation in Africa manifests itself mainly in the form of soil degradation, rangeland degradation, declining soil productivity, and desertification.

Agriculture is the economic mainstay of the people and accounts for about 20–30% of GDP in sub-Saharan Africa. It represents up to 55% of the total value of Africa's export (Sokona 2001). Seventy per cent of all Africans – and nearly 90% of the poor – work primarily in agriculture (World Bank 2000).

Urban areas account for 37.9% of the total population and are credited with 60% of Africa's Gross Domestic Product (GDP). As illustrated in Table 5.1, African cities are undergoing rapid population growth (more than 3.5% per year) accompanied by rapid development pressures with high demands for housing and infrastructure. By 2030, the urban population is expected to grow to approximately 54% of

Table 5.1 Sub-Saharan urban population growth to 2025 (millions) (Venard 1995)

Year	1990	2010	2025	% Growth (1990–2025)
Sub-Saharan Africa	527	937	1,362	258%
Urban population	149	387	705	473%
Urban% of total	28%	41%	52%	

Africa's projected population of around 1,405 million (UNCHS 2001a). There are currently 40 cities in Africa with populations of more than a million, and it is expected that by 2015, 70 cities will have population of one million or more.

The reasons for the rapid growth of urban populations include overall high population growth rates, and 'pull factors' such as opportunities for employment, education, and improved access to health care, which attract people to urban areas (UNCHS 2001b).

5.3 The Impact of Climate Change on Urban Human Settlements in Africa

This section looks at the different aspects of climate change, the evidence for current impact, projected future impacts and the zones or groups most affected. The section also highlights the different kinds of impacts that arise from changes in extremes and changes in means.

Urban settlements feature many of the same impacts of climate change as other settlements – such as air and water pollution, flooding, or consequences of increasingly viable disease vectors. These impacts may take unusual or extremely costly forms in urban areas, for example, flooding, which results not from river flooding but from overwhelmed urban storm drains and sewers during extreme rainfall events (which may become more common in the future). Urban settlements also experience the consequences of accommodating migrant populations, the unique aspects of urban heat islands (which affect human health and energy demand), and some of the more severe aspects of air and water pollution. To some extent, the effects of climate change anywhere in the world are integrated through world markets, social and political changes, and migration. Many of these social and economic effects appear in the world's cities, including some of the world's largest (Rosenzweig and Solecki 2000).

Human settlements are affected by climate change in one of the following three major ways:

1. Economic sectors that support the settlement are affected because of changes in productive capacity (e.g. in agriculture or fisheries) or changes in market demand for goods and services produced there (including demand from people living nearby and from tourism). The importance of this impact depends in part on whether the settlement is rural (which generally means that it is dependent on

one or two resource-based industries) or urban, in which case there is usually (but not always) a broader array of alternative resources. It also depends on the adaptive capacity of the settlement.

2. Some aspects of physical infrastructure (including energy transmission and distribution systems), buildings, urban services (including transportation systems), and specific industries (such as agro-industry, tourism, and construction) may be directly affected. For example, buildings and infrastructure in deltaic areas may be affected by coastal and river flooding; urban energy demand may increase or decrease as a result of changed balances in space heating and space cooling; and coastal and mountain tourism may be affected by changed seasonal temperatures and precipitation patterns and sea-level rise.
3. Population may be directly affected through extreme weather, changes in health status, or migration. Extreme weather episodes may lead to changes in deaths, injuries, or illness. For example, health status may improve as a result of reduced cold stress, or deteriorate as a result of increased heat stress and disease. Population movements caused by climate changes may affect the size and characteristics of settlement populations, which in turn change the demand for urban services.

Informal settlements surrounding large and medium size cities in the developing world remain a cause for concern because they exhibit several current health and environmental hazards that could be exacerbated by global warming and have limited command over resources.

Among African urban centres, perhaps the most obvious increased risk comes from the likely increase in the number and intensity of extreme weather events such as heavy rainstorms, cyclones or hurricanes. Of course there are large differentials in the scale of such risks between urban centres in each nation. The urban centres most at risk are generally those where these events are already common and cause serious damage and disruption – although there is some evidence of the geographic range of some extreme weather events expanding. Coastal cities that are at risk from storms will be doubly at risk as sea-level rise increases hazards from coastal flooding and erosion.

For cities, the scale of the risk from these extreme weather events is much influenced by the quality of housing and infrastructure in that city, the extent to which urban planning and land-use management have successfully ensured risk reduction within urban construction and expansion, and the level of preparedness among the city's population and key emergency services. For small and large coastal settlements, the integrity of coastal ecosystems, in particular protective mangrove and salt marsh systems, will also influence risk (Wilbanks et al. 2007).

5.3.1 Impacts of Climate Change on African Urban Settlements

Due to climate change, urban human settlements in Africa have faced daunting challenges. Some coastlines and river deltas of Africa are densely populated low-lying areas, which could be affected by a rise in sea level. Other coastal settlements

will be subjected to increased coastal erosion. Recent flooding in East Africa, Southern Africa and in Angola highlighted the vulnerability of flood plain settlements and the need to develop adaptive strategies for extreme weather events management and mitigation.

In the semi-arid and arid zones, many settlements are associated with inland drainage water sources. Frequent droughts will exacerbate water supply related vulnerabilities. Similarly, water supply and irrigation reservoirs in seasonal river catchments might fail, leading to poor sanitation and food shortages in urban areas.

Hydroelectric power generation could be restricted during dry periods, and where it is a major contributor to the energy budget, reduced power generation could lead to a multiplicity of other problems. In this regard, it is advisable for African states to develop other sources of renewable energy.

Temperature changes will lead to altered distribution of disease vectors such as mosquitoes, making settlements currently free of vector-borne diseases vulnerable. Rapid breeding of the housefly could create a menace associated with enteric disorders, especially in conditions of poor sanitation.

The dry savannas of Africa are projected as possible future food deficit areas. Recurrent crop failures would lead to transmigration into urban areas, creating more problems for municipal governments. Pastoralists are likely to undertake more trans-boundary migration and probably come into conflict with settled communities.

Already, in many African countries, declining agricultural productivity due to climate change related weather patterns, and population pressures, are pushing greater numbers of rural residents towards cities.

5.3.2 Impacts of Climate Change and Natural Disasters on Urban Settlements

Generally, disasters in Sub-Saharan Africa are increasing in frequency, and the urban areas have not been spared. In 2008, 96 recorded disasters – including 9 droughts and 44 flood events – affected 16.3 million people across sub-Saharan Africa and caused nearly US\$1 billion in economic losses (USAID 2009).

On average, about two disasters of significant proportions have been recorded every week in the region since 2000. Few of these ever hit the global headlines, but they silently and persistently erode the capacities of Africans to survive or prosper (Scheuren et al. 2008).

Climatological and hydrological hazards dominate the disaster profile of sub-Saharan Africa, affecting, on average, around 12.5 million people per year. In 2008, droughts had the greatest human and socioeconomic impact, affecting 14.5 million people. In 2007, over five million people were affected by floods and other hydrological hazards, almost double the annual average since 2000 (Scheuren et al. 2008).

Global climate change will significantly affect the frequency and intensity of hazards in sub-Saharan Africa. It will also exacerbate existing vulnerabilities and

create new ones, as decreases in water availability, agricultural yields and suitable land for pasture will threaten the viability of traditional livelihoods. For the inhabitants of coastal cities, climate change poses a real threat. Half of Africa's 37 cities with populations above one million are within low elevation coastal zones and therefore vulnerable to sea-level rise, coastal erosion, storms; and flooding.

Direct impacts of climate change and natural disasters on coastal cities of Africa may include: (a) *sea-level rise, storm surges and coastal erosion*: threatening coastal infrastructure such as port and trade logistics facilities, wastewater and water treatment plants, power plants, and other municipal infrastructure as well as tourism resorts; (b) *earthquake and tsunamis*: threatening the population and the urban infrastructure from destruction or inundation; (c) *flooding and landslides*: due to changes in precipitation patterns, a higher frequency and intensity of flooding and related landslides can occur in urban areas, threatening vulnerable settlements; (d) *heat waves*: extreme weather events caused by climate change include episodes of very high temperatures, which affect cities with the burden of disease; (e) *increased "heat-island" effect*: the temperature differential between the urban areas and the surrounding countryside, due to the concentration of heat-retaining built environment, heat-island effect is exacerbated on account of climate change, increasing the energy demand for air conditioning; (f) *water scarcity and decreasing water quality*: changes in the precipitation patterns will reduce the run-off and the availability of fresh water for urban use, threatening supply. Saline water intrusion to the water-tables due to sea-level rise will also affect water quality; (g) *worsening air quality*: air pollutants from fixed and mobile sources, volatile organic compounds (VOCs) and nitrogen oxides (NO_x) react to increasing temperatures with the formation of ground ozone, and surface inversion increases.

5.3.3 *The Impacts of Flooding*

Today, urban settlements across the continent are being inundated by floods whose intensity and damage is a major concern to municipal and central governments. The frequency, duration and intensity of heavy downpours increases flood risks. Impervious surfaces in urban areas exacerbate the risks by preventing rainwater from percolating into the ground.

Satterthwaite (2007b) argues that urban areas always present some risk of flooding when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil – and so produce more run-offs. Heavy and/or prolonged rainfall produces very large volumes of surface water in any city, which can easily overwhelm drainage systems. One can distinguish four types of flooding in urban areas: localized flooding, due to inadequate drainage; flooding from small streams within the built-up area; flooding from major rivers; and coastal flooding. In well-governed cities, this is rarely a problem, but in poorly-governed cities like those in Africa, this is a major cause for concern. Most residential areas have no drainage system installed and rely on natural drainage channels. It is

common to find buildings or infrastructure that actually obstructs these drainage channels. For instance, in many African countries, buildings often encroach on, or fill in drains; many natural drains have been filled up to provide room for roads construction (Alam and Rabbani 2007). Mombasa in Kenya faces comparable problems (Awuor et al. 2008).

In most urban centres in Africa, a significant proportion of the population is not served by solid-waste collection services. In cities or neighbourhoods with inadequate solid-waste management or drain maintenance, garbage and plant growth can quickly clog drains, leading to localized flooding and even light rainfall.

There is also a growing documentation on the inadequacies in drainage and flood protection for urban centres in Africa, and of the trend towards increased numbers of deaths and injuries from flooding in urban areas. There are also many case studies highlighting the vulnerability of certain cities to floods and/or sea-level rise, such as Alexandria (El-Raey 1997), Cotonou (Dossou and Glehouenou-Dossou 2007), Banjul (Jallow et al. 1999) and Port Harcourt (Abam et al. 2000).

A recent study on six African cities documents the lack of provision for reducing flood risks or for managing floods when they happen (Douglas et al. 2008). Floods are already exerting considerable impacts on cities and smaller urban centres in many African nations – for instance the floods in Mozambique in 2000, which included heavy floods in Maputo; and the floods in Algiers in 2001 (where about 900 people died, and 45,000 others were affected). So too, were the heavy rains in East Africa in 2002 that brought floods and mudslides, forcing tens of thousands to leave their homes in Rwanda, Kenya, Burundi, Tanzania and Uganda; and the very serious floods in Port Harcourt and in Addis Ababa in 2006 (UN-Habitat 2007; Douglas et al. 2008).

Lastly, the 1999/2000 floods in Botswana were the worst in living memory. They affected 23 administrative districts, villages, cities and towns; that is, the entire country (GoB 2004).

5.3.4 Who Are the Worst Affected Urbanites?

Many of the urban poor in Africa face growing problems of severe flooding. Poor communities often live in the most hazardous and unhealthy environments in urban areas. Many build their homes and grow their food on river floodplains in towns and cities. Others construct their shelters on steep, unstable hillsides, or along the foreshore on former mangrove swamps or tidal flats. People who live in these poor conditions may find their difficulties compounded by the consequences of climate change. In the large cities of low latitude countries, it is common for much of the low-income population to live in areas at risk from flooding, and this population is most likely to be affected by factors related to climate change (Satterthwaite 2007a).

Large-scale urbanization and population increases have led to large numbers of people, especially the poor, settling and living in floodplains in and around urban areas. In South Africa, for instance, Soweto-on-Sea near Port Elizabeth, and Alexandra in Johannesburg, illustrate this point.

Separating local changes from global climate changes is not always easy. The populations of towns and cities may be swollen by in-migration from rural areas in times of drought. Although drought might be caused by climate change, the local changes in the city stem from the activities of the migrants as they build homes, compacting the ground and altering the ways in which rainfall collects and flows towards streams and rivers.

As floods begin to occur with greater frequency, local authorities and other agencies may take protective measures to avoid the movement of floodwaters into certain areas of towns and cities, often giving priority to the main business and administrative centres. In many cases, the floodwaters spread into other areas, often those occupied by the poorest communities who scurry away in search of safer land.

5.4 The Rise of Sea Level and Impact on Urban Human Settlements

Climate change can lead to a rise in sea level that may have catastrophic impacts on coastal settlements, towns and cities. The IPCC Working Group II report (2007b) notes the particular vulnerabilities arising from sea-level rise and changes in run-off of large sections of the urban and rural population in heavily populated African sea cities. The same sentiments have been echoed by the UN-Habitat's *State of the World's Cities* report of 2008/09, which details the prospect of sea-level rise and surge-induced flooding. The report warns policymakers, planners and the world at large that few coastal cities will be spared from the effects of global warming.

African coastal cities that could be severely affected by rising sea levels include Abidjan (Cote d'Ivoire), Accra (Ghana), Alexandria (Egypt), Algiers (Algeria), Cape Town (South Africa), Casablanca (Morocco), Dakar (Senegal), Dar es Salaam (Tanzania), Djibouti (Djibouti), Durban (South Africa), Freetown (Sierra Leone), Lagos (Nigeria), Libreville (Gabon), Lome (Togo), Luanda (Angola), Maputo (Mozambique), Mombasa (Kenya), Port Louis (Mauritius), and Tunis (Tunisia).

5.4.1 Constraints on Water Supplies and Other Key Natural Resources

Perhaps one of the major impacts of climate change on human settlements has been on the shortage of water supplies in major African cities, and this has a major impact on cities' economies.

Assuming that current levels of investment in sub-Saharan Africa urban water supply and sanitation continue over the next 20 years, as many as 300 million people will be without sanitation and 225 million without potable supplies of water in African cities by 2020 (Venard 1995, quoted in the *African Water Resources*; World Bank 1996).

During the same period, the percentage of rural Africans with access to potable water is projected to increase from about 38% in 2000 to over 50% in 2020, even if current practices are not improved (World Bank 1996).

A useful definition of slums is urban settlements that lack basic services such as water and sanitation. Using the projections given above, and bearing in mind that conditions differ between countries and cities, almost half of urban Africans – about 300 million people – will be living in slums by 2020 unless current approaches to urban development change radically. This situation has been constantly lamented in various fora by Anna Tibajuka, the current Chief of UN-Habitat who has called for urgent action by all nations.

A heightened emphasis on slum upgrading in the region is clearly justified and will be crucial for future growth.

Today, water shortage is becoming a day-to-day challenge in most African urban centres and cities. Many cities are now reeling under water shortage with taps running dry by the year. For example in Botswana, most perennial rivers are now dry, and the urban centres are struggling to get enough water. The city of Gaborone, Botswana's capital, suffers from frequent water supply shortages due to drought. Late in the 1990s to 2000s, the situation was so acute that city residents were not allowed to water gardens, wash cars, fill swimming pools or practice urban agriculture. Now the city is getting water 420 km away from the capital as the nearby dam cannot suffice.

Again, large cities like Lagos, Nairobi, Kampala, and Dar es Salaam have an almost permanent water crisis, which has not only affected the city residents but has led to a shut-down of some factories on certain days of the week. Women and children have to walk several kilometres in search of running water, both for cooking and sanitation, and they sometimes rely on dirty water from hand dug ponds. The city of Johannesburg has had to search for additional water in the highlands of Lesotho, and now there is talk of getting water from the Zambezi River in the north (Zimbabwe/Zambia).

In Kenya, water rationing and dry taps have characterized most of the major towns, especially Nairobi, the capital city. A Kenya blog writer narrates that "A visit in Kitengela town, 40 km South of Nairobi revealed the glaring water problem as over 200 residents queued up on one tap for domestic water. Many were pulling carts while others rode their bicycles loaded with water cans to buy water at \$0.15 (Ksh.10) per 20 L container. Many jobless youths in the area have seen a business opportunity and are delivering water to homes by bicycles and donkey carts selling it at double price. In addition, the area is semi-arid and hundreds of pastoralists who are mainly from Maasai community are travelling long distances in search of water along the dry river bed of the famous Athi River which cuts across Kitengela town" (*The Guardian* 2008: 7).

Attempts by some countries to tap regional water have almost led to water wars. An example of this is when Namibia tried in the late 1990s to tap water from the Okavango River for the city of Windhoek and thereby impacting on its neighbour Botswana (*World News* 1997).

All in all, at least 14 African nations are already facing water stress or water scarcity, and many more are likely to join this list in the next 10–20 years as IPCC Working Group II noted: “by 2020, between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change” (Adger et al. 2007: 433). Many cities and their water catchments will get less precipitation (and have more constrained fresh water sources) – which is particularly problematic for growing and large cities already facing serious problems obtaining sufficient fresh water supplies (Anton 1993).

Any reduction in the availability of fresh-water resources caused by climate change will be particularly problematic for those who live in areas already suffering from water scarcity or water stress – with poorer groups likely to be most affected (Romero 2006). There is already a failure to manage water resources well in much of this region, independent of climate change – where around half the urban population already lacks adequate provision for water and sanitation, although this is mainly linked to inadequate governance than to water shortages (UN-Habitat 2003).

5.4.1.1 Climate Change and Its Effects on Rural – Urban Migration

Climate change is one of the major factors that have led to rural – urban migration with all its attendant problems of squatting in African cities. As noted by Barrios (2006) climatic change, in terms of decreasing trends in rainfall, has changed urbanization in sub-Saharan Africa. With decreasing rainfall and recurring droughts, many rural dwellers have abandoned life in the rural areas and migrated into urban settlements in search of employment and a better life. These migrants are called “environmental refugees”. With limited skills, these migrants cannot access prime land and can only end up settling in marginal lands like flood-prone river valleys, steep hills, etc. Similar sentiments have been expressed by other researchers and writers. The Tunis-based Sahara and Sahel Observatory argue that even if more research is needed, the link between desertification and migration is clear. According to the researchers, first the soil quality breaks down, then people produce less food and poverty deepens, which leads to social tensions and forces people to move – some to urban areas, some to other countries (Palus 2008).

5.4.2 Impact on Human Health

Climate change has also led to an increase in health problems such as malaria, meningitis, and dengue fever that affects urban as well as rural people. In sub-Saharan Africa, climate change has several features that could influence the

prevalence of malaria in urban settlements. Rising temperatures, for example, can extend the habitats of the mosquitoes that carry the malaria parasite, shifting the boundaries of latitude and altitude for malaria transmission – for example many highland areas in Burundi, Kenya and Uganda that have historically been classified as malaria-free are now experiencing epidemics.

It is projected that climate-related mortality will increase in the large cities of North Africa too (IPCC 1996), from direct effects as well as from indirect impacts of climate change. These impacts will include potential increases in the incidence of VBDs such as malaria, yellow fever, dengue fever, onchocerciasis, and trypanosomiasis arising from elevated temperatures and altered rainfall. High-elevation locations such as Nairobi or Harare may become vulnerable to malaria epidemics because the malaria parasite may be able to survive in the possibly warmer conditions (IPCC 1996) at higher elevations than the current limits.

Floods and higher rainfall in areas such as Mozambique have also played their part by creating new, or large, breeding sites for mosquitoes that carry the malaria parasite.

Droughts, too, have increased the incidence of malaria in sub-Saharan Africa. A 3 year drought, combined with water extraction for power generation, has led to falling water levels in Africa's largest lake, Lake Victoria. Stagnant pools have formed around the shoreline, which act as prime breeding sites for mosquitoes and affects the cities of Mwanza (Tanzania) and Entebbe (Uganda).

Settlements provide disease vectors and organisms with habitats in the form of stagnant water, garbage dumps, and space sheltered from the elements. Flooding can flush organisms into settlements' clean water supplies, causing disease outbreaks. Heavy rainfall in normally dry areas leads to rapid increases in rodent populations, in turn leading to increases in rodent-borne diseases such as Hantavirus (Glass et al. 2000). Cholera-harbouring marine plankton blooms can also be triggered by riverine flooding, which provides extra nutrients to the coastal environment (Colwell 1996). Extremely dry conditions reduce the quantities and quality of water available for sanitary and drinking purposes, which can also trigger cholera and diarrheal outbreaks. They can also cause respiration and cardiovascular problems, and typhoid.

Controlling disease vectors (such as mosquitoes and ticks), reducing pollution from transport, and efficient land use and water management are all measures that can help. So can improving the supply of clean water and sanitation and bolstering disaster preparedness in vulnerable areas. Full participation of the health sector in national and international processes for mitigation and adaptation to climate change is essential.

5.4.2.1 Threats to City's Infrastructure and Property

Infrastructure in urban areas is already showing evidence of destruction due to climate impacts such as flooding and sea-level rise. Some of the most vulnerable infrastructure includes industrial plants and products; equipment for producing and

distributing energy; roads, ports, and other transportation facilities; residential, institutional and commercial properties; and coastal embankments.

Rising sea levels in the continent could have the most dramatic and direct consequences. Many coastlines are highly developed and contain human settlements, industry, ports, and other infrastructure. Among the most vulnerable are some small island nations like Seychelles, and densely populated coasts that currently lack extensive sea and coastal defence systems. Sea-level rise, storm surges, and flooding could force populations to migrate to new sites, or reverse-migrate to the rural hinterlands, with additional consequences for infrastructure.

Heavy rainfall causes sewer systems to overflow, polluting rivers and seas. Sewage treatment in coastal cities across the continent is geared to a certain range of water levels, and when these levels are passed, there will be impacts on sewers, water pollution control plants, sewage pumping stations, bridges, power generating plants, railway lines, landfills, oil refinery terminals, hazardous waste pipelines and tank farms. All of these would be threatened by rising sea levels. Problems caused by rising sea levels would include water and sewage backing up into the streets, hazardous waste leaks, water pipeline leaks, flooding of transit tunnel air and vent shafts, malfunctions of major electrical and transit systems, erosion and corrosion of road beds and other facilities, and weakened support structures.

Water supply abstraction and treatment works are located beside rivers and are often the first items of infrastructure to be affected by floods. Electrical switchgear and pump motors are particularly at risk. In severe riverine floods with high flow velocities, pipelines may be damaged (Wilbanks et al. 2007). Sanitation can also be affected. Flooding often damages pit latrines (and most of Africa's urban population relies on pit latrines) and floodwaters are usually contaminated by the overflow from pit latrines or septic tanks – and sewers too. Toilets linked to sewers become unusable without a water supply. But most urban centres in sub-Saharan Africa have no sewers – or if they do, these serve only a very small proportion of the population (Hardoy and Satterthwaite 2000). As the IPCC noted, the main significance of sanitation here is that sanitation infrastructure (or the lack of it) is the main determinant of the contamination of urban floodwater, with faecal material presenting a substantial threat of enteric disease (Ahern et al. 2005).

Rather than alter the infrastructure, cities would probably choose to abandon it and relocate in upland areas at a cost of billions of dollars. People and jobs would be forced to relocate, and land use would change dramatically.

There can also be severe economic consequences. In Uganda, the record rains of 1997 destroyed 40% of its 9,600 km feeder road network. Between 1997 and 1998, a prolonged drought in the Seychelles led to the closure of the Seychelles Breweries and the Indian Ocean Tuna Company.

Industry would experience many indirect effects. Because economic activities are so interconnected, an impact on one sector can affect the entire economy. Industry, energy, and transportation are likely to feel knock-on effects via climate-sensitive resource sectors such as agro-industry and biomass production. Climate-sensitive markets will also send signals such as a changing energy demand for heating or cooling buildings. The result will be an aggregation of many individual impacts.

5.4.2.2 Water Pollution

Most cities in the continent are dependent on their hinterland for water. Depending on region, and seasonal and inter-annual variations, climate change will both reduce the availability and reliability of water supply to many of Africa's cities, and in some cases cause damage to water treatment works, septic tanks and other facilities through flooding. This will compound the already polluted water in most African settlements, leading to all sorts of diseases.

5.4.2.3 Air Pollution

Air pollution is a serious problem in many of the world's cities, even under the current climate. The IPCC (2007a) highlights a key concern that motor vehicles are now the main air pollutants in most industrialized cities, and complex effects of climate change are likely to increase the frequency and severity of ozone pollutants and photochemical smog, with direct implications on human health.

Africa has the highest rate of urbanization in the world. This, alongside taxes that encourage dirty fuels, a sharp rise in the importation of often older model cars and out-dated, inefficient industrial plants, is increasing levels of air pollution (UNEP 2002a). Many of the mega cities like Cairo, Alexandria, Dar es Salaam, Johannesburg, Lagos, Nairobi etc. are currently choked with acrid smoke, especially in the morning and evening rush hours as more and more people have embraced the car as a preferred mode of travel rather than walking or cycling.

A study of transport in Senegal found that the health costs associated with vehicle emissions were among the factors costing that country the equivalent of 5% of its Gross Domestic Product (UNEP 2002b).

In Northern Africa, especially where there are refineries and coal power stations, many cities experience levels of sulphur dioxide double the World Health Organization's standard. The number of motor vehicles, many of which are old, in this sub-region has nearly doubled in the past 10–15 years. In Uganda, the number of road vehicles has quadrupled since 1971. Older cars emit up to 20 times more pollution than newer ones.

In 1991, the number of cars in the city of Algiers was approximately 560,000 vehicles, and they polluted the city excessively. This pollution consisted approximately 15% of CO₂, 60–70% of CO, 40–50% of NO, 30% of hydrocarbon non-burnt residues, 5% of SO₂, black fumes, dust, lead, etc. A quantity of 180 t of lead per year is emitted in the streets of the capital at a rate of 0.5 g of lead/litre of gasoline for the vehicles, that is an annual average of 3.8 mg/m³ (average higher than that of the capitals of other countries). The annual average recommended by WHO ranges between 0.5 and 1 mg/m³; whereas lead concentration in the agglomeration of Algiers is 2.01 mg/m³ (Benouar 2004; Aoudia 1991).

Many countries have brought in air quality standards and regulations to control pollution, although lack of resources makes enforcement difficult. In Senegal,

tighter controls on the importation of cars from abroad, including a requirement that they should not be older than 5 years, has been proposed and could provide a blueprint for other African countries.

Renewable energy schemes such as wind, solar, and waste, are being introduced in some countries such as Algeria, Morocco and Mauritius. Many African countries have introduced unleaded petrol. Finally, South Africa has signed the United Nations Motor Vehicle Emissions Agreement.

5.4.2.4 Dust and Sand Storm

Desertification, land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities, is the result of processes that are both complex and variable. Desertification is characterized by a cycle of natural and socio-economic causes and effects.

Sand and dust storms are both a symptom and cause of desertification. They are often an early warning that things are going wrong. Once they progress from slight to serious and to severe categories, they contribute to the spread of desertification through the transportation and deposition of sediments that can destroy crops, habitation and infrastructure and render areas uninhabitable.

Atmospheric dust is a major element of the Saharan and Sahelian environments. It greatly affects urban settlements. The Sahara is the world's largest source of airborne mineral dust, and according to some estimates, up to one billion tonnes of dust is exported from the Sahel-Sahara region annually (varying year to year) (Andreae 1995). It can be transported over large distances, traversing northern Africa and adjacent regions and depositing dust in Europe, Western Asia and the Americas (Moulin et al. 1997).

The frequency of dust storms has increased in some parts of the Sahel, from the wet 1950s/1960s to the dry periods of 1970s and 1980s. Human impacts like over-grazing and deforestation are factors contributing to the increase in dust storms through the creation of a new source of dust; the Sahel is now a more significant source of dust than the Sahara (N'Tchayi et al. 1997).

Dust storms not only affect local communities but are impinging and impacting on people in urban centres. Apart from the inconvenience and the disruption to transport and communications, there is also the increased risk of health-related problems (respiratory diseases, etc.).

There are enormous costs in terms of direct damage to life and property, and in terms of incomes foregone. Development of robust and sophisticated tools to enable economic analysis of the real costs of dust storms is a high priority. Decision-makers need to know, based on cost-benefit analysis, how to respond to the perceived threats.

Combating sand and dust storms demand political, social, biological, economic, educational and engineering approaches, as well as the physical effort that has dominated efforts in the past.

5.4.2.5 Drought

There is evidence that natural disasters, particularly drought in the Sahel, have become more common and more severe, and their impacts are felt on urban settlements when people migrate to the urban areas after fleeing the effects of drought. Countries regularly affected by drought include Botswana, Burkina Faso, Chad, Ethiopia, Kenya, Mauritania and Mozambique.

These repeated drought cycles, along with many others, mainly socio-economic factors, have largely contributed to the high vulnerability of the people of the African Sahel as the number of urban people increased. Adger (2002) made the link between recent environmental changes (in this case, the increasing frequency of drought over the Sahel) and global economic activity. Also, consecutive dry years with widespread disruption are reducing the ability of the society to cope with droughts by providing less recovery and preparation time between events.

5.4.2.6 Higher Temperatures and Heat Waves

Most cities in Africa will experience more heat waves as climate change takes hold. Even small increases in average temperature can result in large shifts in the frequency of extremes (Kovats and Akhtar 2008). For large, high-density cities, the temperatures in central “heat islands” can be several degrees higher than in surrounding areas; in tropical cities, the temperature difference can reach 10° by the end of the night. Many cities will face more problems with certain air pollutants as concentrations of air pollutants change in response to climate change because a portion of their formation depends, in part, on temperature and humidity. There is less information on the impacts of heat stress in Africa, but studies undertaken in North America, Asia and Europe found that heat waves are associated with marked short-term increases in mortality (Confalonieri et al. 2007).

In regard to urban heat islands, higher temperatures occur in urban areas than in outlying rural areas because of diurnal cycles of absorption and later re-radiation of solar energy and, to a lesser extent, heat generation from built/paved physical structures. These increase the frequency and severity of heat-stress events in cities and can affect the health, labour productivity and leisure activities of the urban population. There are also economic effects, such as the additional cost of climate-control within buildings; and environmental effects, such as the formation of smog in cities and the degradation of green spaces – and increased greenhouse gases if additional demand for cooling is met with electricity generated from fossil fuels.

5.4.2.7 Food Security

There is a general consensus that climate change, through increased extremes, will worsen food security in Africa, and this will mostly affect urban areas that are supplied with rural products such as food, fuelwood and animal products. The IPCC

report published in 2007 noted that Africa will face daunting problems: (a) Yields could be reduced by up to 50% by 2020; (b) Arid and semi-arid areas are projected to increase by 60–90 million hectares by 2080 (5–8%), even if this will not apply to every region; and (c) Greater erosion, reductions in crop growth period – overall, reduction of agricultural output could fall dramatically (IPCC 2007a).

In a study on food security in urban settlements in Southern Africa, it was found that 77% of the people were food insecure. Only 20% were food secure. Food insecurity has an impact on morbidity and mortality; and illnesses affect the most productive age-groups, and consequently the national economies of African nations (DCETO 2009).

The continent already experiences a major deficit in food production in many areas, and potential declines in soil moisture will be an added burden. Food-importing countries are at greater risk of adverse climate change, and impacts could have as much to do with changes in world markets as with changes in local and regional resources and national agricultural economy. As a result of water stress, inland fisheries will be rendered more vulnerable because of episodic drought and habitat destruction. Ocean warming will also modify ocean currents, with possible impacts on coastal marine fisheries as is already being experienced in Cape Town, South Africa.

5.5 Government Response to Climate Change at the City Level

Obviously, cities and urban human settlements will need to play a major role in solving the problem of climate change. This section examines some of the ways in which this might occur by looking at some examples of innovative initiatives for promoting sustainable responses to climate change in African cities that are already underway.

In this discussion, response to climate change refers to both adaptation and mitigation to climate change. Adaptation here refers to activities that allow us to cope better with the impacts of climate change; and mitigation refers to reducing the emissions of the greenhouse gases that cause the problem. Many have in the past argued that giving attention to the need for adaptation to climate change is defeatist or, at best, it drives energy and resources away from addressing the root cause of the problem through mitigation. There is however a widespread agreement among scientists that the problem is so serious that even if we start reducing emissions immediately, we will still face a significant amount of climate change during this century; so both adaptation and mitigation responses are unavoidable.

At one level, adaptation is about ensuring that the infrastructure of a city, from buildings and industrial facilities to road and sewerage systems, have the lowest possible vulnerability to potential future climate changes. They should also be as flexible as possible so as to cope with the high level of uncertainty over the actual nature of future climate change. At another level, it involves putting institutional

frameworks in place that are adaptation-“friendly”, i.e. those that are able to build adaptation requirements into a wide range of ongoing planning activities. The Intergovernmental Panel on Climate Change identifies the following major options for adaptation in cities:

- Take advantage of rapidly growing populations by designing new infrastructure that is “climate change proofed” from the onset. For example, it can be less costly to design and build “oversized” flood works in the beginning than to try to enlarge their capacity later.
- Invest in storm water drainage in the built environment.
- Take advantage of replacement schedules on shorter-lived assets such as vehicles and heating/cooling systems.
- Reduce heat island effects through the use of vegetation and light coloured surfaces.
- Develop institutional frameworks that are more “friendly” to adaptation strategies. For example, giving land rights to inhabitants of informal settlements to allow them to develop better infrastructure; and building institutional capacity in environmental management (IPCC 2007a).

5.6 General Efforts to Combat Climate Change Effects in the African Continent

Today, mitigating greenhouse gases (GHGs) and adapting human settlements to withstand the extreme climatic conditions likely to arise from global warming have become the most formidable challenges of our time. Indeed, the IPCC report (2007a) stresses the need for a fundamental transition in the structure and functioning of built environments so as to simultaneously mitigate climate change and adapt to the effects of global warming. However, although there may be synergies between *mitigation* and *adaptation* (e.g. planting of trees in urban areas help to sequester carbon as they grow and hence reduce urban heat stress in summer) conflicts are still likely to surface (e.g. dense compact urban forms reduce GHG emissions by facilitating public transit but, in hot-humid regions, the same form will contribute to human discomfort since in such climatic zones, especially during summer, a tight arrangement of buildings would block the free movement of air needed to lower body temperatures). This apparent paradox poses a conundrum for planners and urban designers at a time when there is urgency to devise strategies to respond to climate change (much of the predicted climatic changes over the next 20–60 years have already been predetermined by past and current emissions of GHGs).

Like most continents, Africa has (a) signed up to international conventions such as the Kyoto Convention to combat climate change; (b) adopted regional agreements and protocols; and (c) some have embarked on various strategies and programmes that address the problem, both in urban and rural areas.

5.6.1 International Agreements

Africa has signed many international protocols and agreements to combat climate change. Below are some of them:

All countries have signed the United Nations Framework Convention for Climate Change (UNFCCC) and the Kyoto Protocol that concentrate the efforts of the international community on fighting climate change and avoiding its consequences.

Fifty-two African countries are party to the United Nations Convention to Combat Desertification, and 16 have now drawn action plans aimed at improving land productivity, land rehabilitation and sustainable management of water resources.

Early warning systems on rainfall and drought have been established across the continent. Mechanisms agreed under the Kyoto Protocol, which is the legal instrument for fighting climate change, could benefit Africa economically and socially by providing cleaner and greener energy sources, and financial incentives to plant carbon dioxide absorbing trees.

Laws requiring carrying out environmental impact assessments before developments can begin have been introduced in many African countries such as Botswana, Egypt, Gambia, Ghana, Kenya, Mauritius, Nigeria and South Africa.

Recently on 4 August 2008, the AU launched the Declaration of Libreville after the summit of the Ministers of Health and Environment in which it acknowledged the importance of climate change and the need for preventive strategies for the protection of public health.

5.6.2 Regional Initiatives and Programmes

Many African countries are now attempting to address some of the root causes of environmental degradation through initiatives such as the New Partnership for Africa's Development (NEPAD).

Regional and sub-regional programmes, and action plans such as UNEP's Regional Seas Programme provide the framework for a more holistic management of Africa's coastal zones. Several important agreements and conventions have been adopted. These include the Nairobi, Abidjan and Jeddah conventions.

The Climate Change Adaptation in Africa (CCAA) research and capacity development programme and the African Risk Analysis Network (ARAN) aim at improving the capacity of African countries to adapt to climate change in ways that benefit the most vulnerable. Building on existing initiatives and past experience, the CCAA programme works to establish a self-sustaining body of expertise in Africa in a bid to enhance the ability of African countries to adapt.

Several governments have sought funds from many sources (NGOs, the private sector and the donor community) to fight the effect of climate change. It is not possible at this stage to identify the total funds available for climate change adaptation and related activities in Africa – a conservative estimate puts the figure at US\$

200 million (this is a programmatic and not an annual total). This figure is expected to rise rapidly, with the AF coming on-board in a year or two, and as major donor initiatives are implemented. By the end of 2010, the funding available for Africa could reach US\$ one billion (IPCC 2007b).

There is, however, a dearth of more trained staff, finance, equipment, research, monitoring, surveillance and enforcement of regulations.

5.6.3 Action at City Level: Current Experiences and Lessons on Adaptation

There are many opportunities to deal with the impacts of climate change at the city level in Africa, mainly through adaptation policies that are related to transport systems, urban planning, building regulations and household energy supply. These are dealt with below.

5.6.4 The Built Environment

Buildings leave a fundamental impact both on people's lives and on the health of our planet. Buildings typically use one-third of our total energy, two-thirds of our electricity, one-eighth of our water; and transform land that provides valuable ecological resources. As the green building sector concept takes hold, more and more building professionals, owners, and operators are seeing the benefits of green building.

Besides making a positive impact on public health and the environment, green design is also economical. However, this practice is mostly common in western countries. In Africa, very few countries have seriously embarked on 'green buildings' or similar projects. These exceptions include (a) The cities of Malindi and Bujumbura, which have embarked on rehabilitation and greening of public open spaces; (b) The city of Cape Town, which has adopted housing energy efficiency improvement; (c) The cities of Durban and Antananarivo, which have adopted innovative solid waste management technologies; and lastly (d) The city of Durban, which has recently prepared a climate impact adaptation master plan.

Many African cities do not feature the various energy efficient building materials that can save the continent a lot of money and stave off climate change. Western style glass-clad buildings that are neither suitable during the summer, nor during winter, can be seen everywhere. Natural ventilation has been replaced by air conditioners that the majority of the city residents can hardly afford. Traditional building materials and methods of construction that are ideal for the African weather have been cast aside in the name of 'modernity'. In a nutshell, buildings in Africa are neither conducive to the climate nor to the people who live in them.

Buildings have average lives of between 50 and 100 years: so those that will be built today will be around for most of this century, and the existing buildings will also last many more years. It is therefore imperative to ensure that new buildings are built in a way that has an optimal impact on reducing carbon emissions, and ways to improve the energy efficiency of existing buildings through retrofitting are found.

For new buildings, it is not just the building itself that is key to reducing emissions, but the associated infrastructure. Care should be taken to ensure that new developments are accompanied by sustainable transport infrastructure that makes it possible for people to walk, cycle, and use public transport rather than just relying on private motorised transport. Efforts should also be taken to make city housing space- and energy-efficient.

However, historically, energy efficiency programmes have met with mixed success as has been the case on the African continent. Municipalities and people react only when a crisis looms. Despite having a payback period ranging from just a few months to a few years, many energy efficiency improvements encounter a variety of behavioural and organisational barriers that impede their implementation.

5.6.5 Climate Change and Urban Planning and Design Adaptation

The built environment is one of the largest current contributors to greenhouse gases. Those who work in the planning, design and building professions should therefore play a key role in reducing atmospheric carbon dioxide. While much work has been done to decrease contributions from individual buildings on the continent, the role of urban design in addressing climate change remains obscure, and increasingly contentious.

In most African countries, urban planning and design is a casual top-down undertaking, which derive from colonial planning norms and standards, inappropriate development control codes and building regulations, planning laws and old outdated master plans. For instance, the Dar es Salaam master plan currently in use dates back to the 1970s. Even where regulations and laws exist, they are either poorly enforced or not enforced at all. Urban development control is compromised by lack of resources and endemic corruption that cripples sustainable development.

Most African cities are poorly planned and designed, resulting in poor compact urban morphologies. These cities sprawl from Kinshasa and Dar es Salaam and cover vast areas, necessitating long travel distances that consume fuel and pollute the environment. Land uses are segregated rather than mixed to save on travel time. The poor are worst affected as they live in teeming squatter settlements, sometimes very far from the main cities (e.g. Soweto, Johannesburg and Guguletu, South Africa) with no power, water reticulation, a proper sanitation system and no storm water drainage. The same poor are not involved in shaping their living environments, nor are they involved in decision making.

There is a need to address the role of urban planning and design in African cities so as to produce what would be a typical African settlement that values local tradition, and only draws from western values when necessary. In this regard, an 'ideal' urban morphology, building densities and possibilities of retrofitting existing settlement patterns to stave off the impacts of climate change should be considered.

Possible options to address these planning and design issues include (a) reducing urban sprawl by building compact settlements; (b) increasing residential densities by going for smaller plots, or building high; and (c) going for mixed land uses.

5.6.6 Energy Supply and Consumption

Power outages are not new in African cities, and the situation is getting worse as urbanisation spreads. Cities like Nairobi, Lagos, Dar es Salaam, Gaborone, Cape Town, Kinshasa, Freetown, Alexandria, and many others face endemic power shortages, at times several times in a day, or even for weeks on end. This affects people's lives and industrial productivity, and consequently the economy.

As indicated below, several countries have attempted to deal with the issue of power shortages; but in a continent with meagre resources, success has been erratic at best.

- Some countries like South Africa have introduced nuclear energy, which only accounts for 8% of the national electricity demand; the rest is generated from ageing coal plants, which spew tons of dust and harmful gases into the air.
- The use of solar electricity industries to generate electricity and potable water is becoming more and more important in Africa, largely because of the continent's above average levels of solar radiation. Many houses in some cities in Africa are now being fitted with solar electricity for heating water and lighting, the only problem encountered being its uptake as the initial cost of equipment installation can be prohibitive; but governments can make them more affordable by reducing or eliminating taxes on solar panels, as has been done in Kenya.
- Many projects are waiting to be launched across the continent; (a) In 2008 a solar thermal power plant integrated in a gas-fired CHP power plant was to be launched in Ain Beni Mathar, 110 km south of the city of Oudja, Morocco. The power plant has a total installed capacity of 200–250 MW with a solar share of 30 MW; (b) Also, in Algeria a 150 MW hybrid power station operated by natural gas, with a solar share of 25 MW, was commissioned in 2009; (c) At present a 150 MW solar hybrid parabolic trough power plant with a solar share of 30 MW is under construction for the New and Renewable Energy Authority (NREA) in the city of Kuraymat in Egypt; and (d) Another project is planned in Uppington, South Africa, where a solar tower with an installed capacity of 100 MW is to be constructed.

- Other countries have opted for energy consumption reduction efforts. For example, according to the mayor of Johannesburg, Maseko, South Africa has set its target on reducing energy demand by 25% by 2011.
- Some regional programmes have adopted electrical power sharing by using hydro-electricity as opposed to fossil fuel electricity, e.g. the South Africa, Botswana, Zimbabwe, Mozambique pool; and the Eastern African countries pool.
- Lastly, there are a number of other alternative energy projects that are being implemented across Africa. These include, *inter alia*, wind power generation in Egypt, Morocco and South Africa, geothermal energy in Kenya, methane gas in Rwanda, and coal-bed methane in Zimbabwe.

Today, many governments are participating in the ICLEI Africa programme (African Cities Climate and Energy (ACCE) Network), which is re-energising and expanding its climate programme to work more definitively on city-wide sustainable energy issues, including climate change mitigation in the African context.

The ACCE Network will build the capacity of the partner cities and help them to address sustainable energy and climate change issues in terms of preparedness, reduction in energy consumption and long-term savings in an African context. Implementation of action plans mobilised and resourced through the Network will build awareness and understanding of tangible local benefits, which, in turn, will constitute a growing basis for the implementation of further projects.

ICLEI Africa also plans to work with more cities in the African region through the development of key partnerships across the continent. African local governments pledged their commitment and support to address sustainable energy and climate change at the UCLGA First Ordinary Congress held in Accra, Ghana, in July 2008 where ICLEI Africa co-hosted a dedicated Commission on Energy and Climate Change with UCLGA.

In conclusion, while energy forms the backbone of functioning cities, and is core to many of the municipal service responsibilities and operations, integrated energy planning is a new concept among local governments in Africa, as are sustainable energy programmes and projects. There are, however, many steps that cities can take to reduce energy consumption and to use cleaner energy. These include:

- Creating building codes and standards that include practical, affordable changes that make buildings cleaner and more energy efficient.
- Conducting energy audits and implementing retrofit programmes to improve energy efficiency in municipal and private buildings.
- Installing more energy efficient traffic and street lighting.
- Implementing localised, cleaner electricity generation systems.
- Developing rapid bus transit and non-motorised transport systems.
- Using clean fuels and hybrid technologies for city buses, rubbish trucks, and other vehicles.
- Implementing schemes to reduce traffic, such as congestion charges.
- Creating waste-to-energy systems at landfills.
- Improving water distribution systems and leak management.

5.6.7 *Managing High Temperatures*

At the conurbation and neighbourhood level, high temperatures can be managed by focusing on the opportunities for reducing UHI effects through large-scale infrastructure. Adaptation should be built into other broad, conurbation scale changes, and multiple benefits should be sought for biodiversity, recreation and flood management objectives.

When constructing buildings, it will be important to avoid mal-adapted design, where energy efficiency measures (e.g. to increase solar gain and reduce winter heat loss) have the potential to exacerbate summer heat risks. Emerging best practice is to reduce cooling load as far as possible using passive solutions and then finding the best mechanical solution to meet any remaining cooling requirement using the option that best fits the other design objectives.

A number of structural solutions offer effective means of managing heat risks and reducing thermal discomfort at this scale. These include:

- Planting, shading and advanced glazing systems to reduce solar heat gain.
- Materials to prevent penetration of heat, including use of cool building materials and green roofs and walls.
- Innovative use of water for cooling, including ground water cooling using aquifers or surface water.
- Mechanical cooling, including chilled beams and conventional air conditioning systems.
- Increasing ventilation and removing heat using fresh air.
- Use of thermal storage or mass to absorb heat during hot periods so that it can dissipate in cooler periods, usually via ventilation.

5.6.8 *Managing Flood Risks*

Many governments in Africa have dealt with city floods or rising sea levels by building barriers, storm water drainage systems and channelling flood waters into city streams and rivers. However, such efforts have largely been half-hearted, disjointed and uncoordinated at best. This is why so much infrastructure and properties are destroyed by floods whenever it rains.

Changes in the catchment such as field drainage and channelization of water courses compound the problem. Areas where drainage capacity cannot cope with current levels of precipitation will be at greatest risk.

Flood risk management measures should provide added health, ecology and leisure benefits by enhancing the quality of public space. The most effective way to manage future flood risks is to reduce exposure, which involves assessing risk over the life of a development and locating and designing developments accordingly.

5.6.9 Managing Water Resources and Quality

Changing patterns of rainfall will have a significant impact on water resources and water quality. In the summer, warmer temperatures will mean that demand for water grows as supply – especially in rivers and underground aquifers – declines due to low rainfall. Urban areas have little capacity to store drinking water and are more likely to experience shortages during droughts.

The experience of African municipal governments in this area is wanting in many countries. Hardly do municipalities save rain water, recycle municipal water, and even the little water they have is lost through illegal water tapping or leakages due to poor management.

It is therefore suggested that municipalities should adopt the above measures so as to reduce the amount of water, and consequently make a significant contribution to the reduction of emissions.

5.6.10 Transport and Climate Change in African Cities

In most sub-Saharan cities, rates for private motor vehicle ownership are low and tend to fall even further since the 1980s due to a substantial drop in the purchasing power of urban populations as has been established in Abidjan (Godard 1992) and Nigeria (Akinlo 1998). With regard to the bicycle, apart from the exceptional case of Ouagadougou and a few other African cities, it does not represent an attractive alternative to majority of the people due to the negative social representations associating bicycle use with poverty and rurality (Pochet 1999).

Wherever they need to leave their residential district, the vast majority of urban dwellers are therefore dependent on public transport (public or privately organised) or walking (Olvera 2003) as shown in Table 5.2.

Of the various modes of transport, the rise in car use, especially in the late 1990s is causing problems as cars emit high levels of carbon dioxide and carbon monoxide. These gases cause air pollution and global warming. In Uganda for example, the total number of vehicles has grown tenfold in the past 2 decades. Most of these vehicles are old models and are usually poorly maintained.

Many governments have attempted several strategies to deal with the adverse impacts of pollution by cars. These include the following:

Deal with the fuel in use to reduce pollution: All African governments have phased out use of lead in petrol, a promise they made at the World Summit on Sustainable Development in 2002. The Partnership for Clean Fuels and Vehicles has now set its sights on reducing the sulphur content in vehicle fuels.

Planning and urban transport – use of public transport: African governments need a revolution in urban management. Although building more roads can help, it is a bit like Parkinson's Law: cars always tend to fill the space available. So, one should look closely at improved urban planning and at public transport. Some

Table 5.2 Mobility and modal choice in SSA cities (Olvera 2003)

City	Country	Mobility (trips/person/ day)	Mode choice, percentage of total trips			Private motorized transport ^b
			Walk	Bicycle	Public transport ^a	
Morogoro	Tanzania	1.7	67	23	12	4
Dar es Salaam	Tanzania	1.9	47	3	43	7
Nairobi	Kenya	2.2	47	1	42	7
Eldoret	Kenya	2.7	48	12	24	16
Kinshasa	Congo	2.2	70	–	20	10
Addis Ababa	Ethiopia	4.9	70	–	26	4
Bamako	Mali	3.1	60	2	17	21
Ouagadougou	Burkina Faso	3.8	42	10	3	45
Harare	Zimbabwe	N/A	63	1	16	20
Niamey	Niger	N/A	60	2	9	32
Dakar	Senegal	3.2	81	1	17	1

^aIncludes privately operated minibuses

^bIncludes motorcycles, taxis and employer buses

countries have come up with sustainable rapid transit systems which are more environment-friendly. For instance;

- In Tanzania, UNEP, with funding from the Global Environment Facility, and in cooperation with a wide range of partners, including the Dar es Salaam City Council, is involved in the new Dar es Salaam Bus Rapid Transit system (DART). If successful, it will be a blue-print for other cities in Africa.
- In South Africa, Johannesburg has introduced a Bus Integrated Rapid Transit system (BRT). Also, The Gautrain rapid-rail link project (currently 60% complete) will lure car users to public transport. The first phase of this project is expected to be operational by the end of June this year, although it may be fast-tracked to May, in time for the 2010 FIFA World Cup.

5.6.11 Lure People from Cars to Non-Motorised Transport (NMT)

Another strategy is to popularise non-motorised transport since majority of city dwellers use this mode of transport. Public transport in Africa is usually disorganized, overcrowded, unregulated, inefficient and unsafe. Unfortunately, in most cases, cities across the continent have inadequate infrastructure to support non-motorised transport. As a result, there are poor levels of NMT accessibility due to unsafe and uncomfortable vehicles. There is therefore a need for purposeful interventions aimed at promoting this mode of travel. Current examples of NMT efforts on the continent include:

- The Uganda NMT Master plan that aims at a fundamental change in urban and non-urban transport policies, both at national and local levels. It is hoped that once it is implemented, it will motivate other African countries to review their national transport policies so as to avail sustainable transportation alternatives.
- In Kenya and Tanzania, four cities (two major cities and two secondary towns) were chosen for a pilot project: Nairobi and Eldoret in Kenya, and Dar es Salaam (Temeke district) and Morogoro in Tanzania. Three distinct types of interventions were planned: building a special infrastructure for pedestrians and cyclists, introduction of traffic calming measures and supply-side interventions aimed at increasing bicycle ownership and use.

The government of Botswana, with the help of the UNDP, has also embarked on a pilot NMT project that will start soon in Gaborone city.

5.6.12 Planning for Pedestrians

Many people who would prefer to walk are discouraged by lack of pedestrian networks in their cities. However, a few cities are now setting up pedestrian networks that are clean, safe and well-lit. These efforts are however mostly disjointed and uncoordinated.

5.6.12.1 Natural Disaster Preparedness

Many disasters in Africa occur in urban areas, affecting millions of people each year; but containing or managing them has often proved to be a difficult undertaking. These disasters are compounded by (a) a high rate of urbanisation and unguided and unplanned urban development, (b) high concentration of people (mostly low income), enterprises and waste in hazardous areas that do not have adequate basic infrastructure; and (c) poor governance (laxity in enforcement of planning regulations and lack of risk reduction and management plans) and lack of resources.

Research has shown that there is lack of disaster risk reduction prioritization by central and municipal governments in Africa. Many of the actions are disjointed and haphazard at times. A few governments (e.g. Botswana, South Africa, Uganda, Kenya etc.) have formulated national policies for disaster management with objectives of prevention, mitigation, preparedness, response and recovery and development, or even establishing disaster management centres like in the case of South Africa.

All in all, remedial actions at the city level need to include: (a) land-use and urban planning that takes into account the vulnerability of urban areas and to prevent urban development where the future impacts will be more critical; (b) coastal defences such as sea barriers, sea walls, protection and *hardening* of key infrastructure and vulnerable hot-spots; and (c) institutional preparedness and resilience to reduce the natural disaster impacts.

Urban centres need multi-hazard analysis and multi-vulnerability analysis as they concentrate multiple risks, which often have complex interconnections that make it harder to identify the risks and act to reduce them.

There is need to integrate into urban management (and urban governance) structures the identification of disaster risks and measures to reduce these risks, and the vulnerability of urban populations to these risks. This calls for a critical shift as to who is seen as responsible for addressing disaster risk, integrate disaster risk reduction into all the departments or agencies within urban governments (and where appropriate national and provincial governments), and to move away from sectoral ‘disaster’ programmes to a multi-sectoral approach to disaster prevention, preparedness and response in large cities.

There is also a need to provide a forum for exchanging information and experiences among planners and emergency experts in large metropolitan areas in the continent, and to stimulate direct cooperation among cities with common problems.

To complement the efforts of municipal governments, it is important to place urban communities, including poor ones, at the centre of disaster management initiatives, and value their traditional knowledge, and utilize their skills as their ability to survive and recover faster will be increased. After all, in the vital first 48 h following disasters, it is communities that save most lives and which support each other. There is, therefore, an obligation to further strengthen their self-reliance.

5.7 Conclusion and Recommendations

Africa’s contribution to climate change through emissions is minimal; but the impacts of climate change are already being felt in the continent, more so in the urban human settlements. To-date, many attempts have been made to adapt and mitigate the impacts of climate change on urban human settlements, but success seems far away. In the future, impacts will be even more critical. Further, the role of African governments, the private sector, civil society, regional and international organizations and donors in combating climate change at the urban level has been stated, but this needs to be properly coordinated for best results.

The link between climate change and cities is a crucial one. Climate change is already happening in African cities and will become increasingly severe in the coming years and decades. Because a majority of the continent’s population will soon be living in cities, it will be impossible to halt global climate change without achieving a fundamental transition in the structure and functioning of our cities. Viewed from this perspective, the low-carbon city is not a utopian idea but rather an imperative that must be achieved by mid-century.

Further, we already know that cities are hubs of development, and that the current rapid urbanization on the continent must be contained. Urban populations and economies are also highly vulnerable to extreme weather events. For instance, slum

dwellers, particularly those living in vulnerable, and low-lying coastal cities, will be seriously affected by climate change, with an expected increase in the frequency of storms and floods, which are predicted to impact negatively on storm drains, water treatment plants, sanitation, roads, houses, etc. There is, therefore, an urgent need to develop capacities to plan and provide appropriate improvements by the municipal authorities in many countries. But this should be done in collaboration with communities.

The following is a summary of possible recommendations that need to be taken on board to fight this scourge in the African continent:

- Plans for urban areas must take into account the potential climate change impacts on human settlements, but national and local authorities must make more effort to implement and enforce plans and regulations. Capacity development and raising awareness among relevant stakeholders is essential. Thus, it is recommended that local governments ensure proper enforcement of city planning regulations, decentralize local government functions to ease congestion in major cities, and upgrade informal settlements and move those settlements in flood-prone areas, or those near the sea, to safer locations.
- Municipal governments in Africa should adopt ideal urban plans that are sensitive to energy saving, less sprawl and more compact shapes, appropriate mixed land uses and transportation modes and networks that take cognisance of non-motorised transport – more use of bicycles, use of footpaths, etc. Buildings should be constructed in a way that conserves energy through the use of appropriate building materials and through ventilation in new buildings and retrofitting existing buildings – most of which will still be around in the next 80–100 years.
- Access to clean and affordable energy is essential for urban populations and industry. It contributes to the resilience of people in urban areas in coping with the effects of climate change. Strategies should therefore emphasise local solutions, renewable energy, cost-effectiveness, and energy efficiency. There are also opportunities for individuals or neighbours to generate their own cleaner energy.
- Regarding water and sanitation, the following is recommended: harvesting rain water from residential houses and from other surfaces; improving and expanding water distribution systems in cities and towns; the need for civil society organizations to sensitize communities on the efficient use of water; and increased support for ecological sanitation.
- Governments should promote investments in climate-resilient infrastructure in urban areas, notably with respect to erosion and flood control, drainage, water treatment, housing and transport systems. In particular, water and sanitation infrastructure must be improved to make it more resilient to climate change effects. This could be achieved through partnerships with the private sector, and thereby creating job opportunities. Construction of efficient drainage systems should be prioritised in the national planning agenda. Civil society organizations and youth groups should be involved in constructing and maintaining community roads so as to foster ownership and longevity. The existing rail, bridge and drainage systems should also be improved.

- To tie all these up, there is a need for increased disaster risk management, especially in urban agglomerations, which must involve community and non-governmental organisations to enhance preparedness and upgrade response systems.

A combination of all the above will go a long way in tackling the adverse impacts of climate change on urban settlements in the continent and ensure a better future for all.

References

- Abam TKS, Ofoegbu CO, Osadebe CC, Gobo E (2000) Impact of hydrology on Port Harcourt-Patani Warri Wari. *Environ Geol* 40(1&2):153–162
- Adger N (2002) Advancing a political ecology of global environmental discourses. *Dev Change* 32(4):681–745
- Adger N, Parry ML, Ganziani O, Palutikof JP, van der Linden PJ, Hanson CE (eds) (2007) *Climate change 2007: Impacts, adaptation and vulnerability: summary for policy makers*. Cambridge University Press, Cambridge and New York
- Ahern M, Kovats RS, Wilkinson P, Few R, Mathies F (2005) Global health impacts of floods: epidemiologic evidence. *Epidemiol Rev* 27(1):36–46
- Akinlo EA (1998) Improved urban transport as a strategy for reducing poverty. In: Freeman P et al (eds) *Urban transport policy: a sustainable development tool*. Proceedings of the International Conference CODATU VIII. Rotterdam, Balkema
- Alam M, Rabbani GMD (2007) Vulnerabilities and responses to climate change for Dhaka. *Environ Urban* 19(2):81–97
- Andreae M (1995) Climatic effects of changing atmospheric aerosol levels. In: Henderson-Sellers A (ed) *World survey of climatology: future climates of the world*, vol 16. Elsevier, Amsterdam, pp 341–392
- Anton DJ (1993) *Thirsty cities: urban environments and water supply in Latin America*. DRC, Ottawa, Canada
- Aoudia T (1991) Pollution atmosphérique dans la région Est d'Alger, in *Etudes Estimation des concentrations dans l'air à l'aide d'un modèle de boîte*. CERHYD, Alger
- Awuor CB, Orindi VA, Adwerah A (2008) Climate change and coastal cities: the case of Mombasa, Kenya. *Environ Urban* 20:339–360
- Barios S (2006) Climate change and rural – urban migration: the case of Sub-Saharan Africa. CORE Discussion Papers No. 2006046, Leuven, Belgium
- Benouar D (2004) The need for an integrated disaster management strategy in North Africa: a case study of Algiers, Algeria. Paper presented at the Conference on strategies for disaster avoidance in urban areas of africa, Lusaka (Zambia), 5–7 May 2004
- CLIVAR (2004) *International climate variability focus, sea technology*. Compass Publications, Arlington, TX
- Colwell R (1996) Global climate and infectious diseases. *Science (NY)* 274(5295):2025–2031
- Confalonieri U et al (2007) *Human health. Climate change 2007: Impacts, adaptation and vulnerability*. Contribution to WA II, IPCC, Cambridge University, Cambridge
- DCETO (2009) *Urban food security and HIV/AIDS in Southern Africa – draft report*. IDRC, Toronto, Canada
- Dossou KMR, Gléhouenou-Dossou B (2007) The vulnerability to climate change of Cotonou (Benin): the rise in sea level. *Environ Urban* 19:65–79
- Douglas I, Alam K, Maghenda M, McDonnell Y, Mclean L, Campbell J (2008) Unjust waters: climate change, flooding and the urban poor in Africa. *Environ Urban* 20(1):187–205
- Economic Commission for Africa (ECA) (2006) *Climate change and the broad mandate of ECA*. ECA, Addis Ababa

- El-Raey M, Fouda Y, Nasr S (1997) GIS-assessment of the vulnerability of the Rosetta Area, Egypt to impact of sea rise. *Environ Monit Assess* 47(1):59–77
- Glass GE, Cheek JE, Patz JA, Shields TM, Doyle TJ, Thoroughman DA, Hunt DK, Enscoe RE, Gage KL, Irland C, Peters CJ, Bryan R (2000) Using remotely sensed data to identify areas at risk for Hantavirus pulmonary. The John Hopkins School of Hygiene and Public Health, Baltimore, MD
- GoB (Government of Botswana) (2004) Environmental issues. NDP mid-term review. Government Printer, Gaborone, Botswana, pp 11–14
- Godard T (1992) Les Transports urbains en Afrique à l'heure de l'ajustement Redéfinir le service public. Karthala, Paris
- Hardoy M, Satterthwaite D (2000) Environmental problems in an urbanizing world. Earthscan, James and James, London, <http://eau.sagepub.com/cgi/content/abstract/20/1/165>; <http://www.unesco.org/most/bpunchs.htm>
- IPCC (2006) Guidelines of national greenhouse gas inventories. Cambridge University Press, Cambridge and New York
- IPCC (2007a) Climate change 2007: the physical science basis: summary for policymakers. Cambridge University Press, Cambridge
- IPCC (2007b) Impacts, adaptation and vulnerability. Contribution of working group II to the Fourth Assessment Report of the IPCC. Cambridge University Press, Cambridge and New York
- IPCC (Intergovernmental Panel on Climate Change) (1996) Climate change 1995: Impacts, adaptations, and mitigation of climate change: scientific-technical analyses. Cambridge University Press, Cambridge and New York
- Jallow BP, Toure S, Barrow MMK, Mathieu AA (1999) Coastal zone of the Gambia and the Abidjan region in Cote d'Ivoire: sea level rise vulnerability, response strategies, and adaptation options. In: Mimura N (ed) National assessment results of climate change: impacts and responses. Oldendorf Luhe, Inter-Research, Germany, pp 129–136
- Kovats S, Aktar R (2008) Climate, climate change and human health in Asian cities. In environment and urbanization. Centre for Global Change and Health, London
- Moulin C, Lambert CE, Dulac F, Dayan U (1997) Control of atmospheric export of dust from North Africa by the North Atlantic oscillation. *Nat Int Wkly J Sci* 387(6634):691–694
- N'Tchayi MG, Bertrand JJ, Nicholson SE (1997) The diurnal and seasonal cycles Nairobi. In: Key information sheet 10/DFID, 2005 vulnerability. Cambridge University Press, Cambridge
- Olvera LD (2003) Transport conditions and access to services in a condition of urban sprawl and deregulation: the case of Dar es Salaam, vol 10(4). *Transport Policy*, Tanzania
- Palus N (20th March 2008) Experts say climate change drives migration in Sub-Saharan Africa. VOA, Dakar
- Pochet P, Cusset J-M (1999) Cultural barriers to bicycle use in West African cities. The case of Bamako and Ouagadougou. *IATSS Res J Int Assoc Traffic Saf Sci* 23(2):43–50
- Report UN (2000) We the peoples: the role of the United Nations in the 21st century. United Nations, New York
- Romero L (December 2006) How do local governments in Latin America Manage Global Warming? Workshop paper. International Workshop on institutional dimensions of carbon management at the urban and regional levels. GCP-IDGEC, Bali
- Rosenzweig C, Solecki WD (2000) Climate change and a global city: the Metropolitan East Coast Regional Assessment. Columbia Earth Institute, New York
- Satterthwaite D (2007a) Adapting to climate change in urban areas – the possibilities and constraints in low and middle income nations. Human settlements discussion paper series. International Institute for Environment and Development, London
- Satterthwaite D, Huq S, Pelling M, Reid H, Romero-Lankao P (2007b) Building climate change resilience in urban areas and among urban populations in low- and middle-income nations. Rockefeller Foundation, Washington, DC
- Scheuren J-M, Le Polain de Waroux O, Below R, Guha-Sapire D, Ponserre S (2008) Annual disaster statistical review, the numbers and trends 2007. CRED, Presses Universitaires de Louvain, Louvain-La-Neuve

- Sokona Y (2001) Climate change and sustainable development: views from the South. Opinion: World Summit on Sustainable Development, International Institute for Environment and Development (IIED) 2000, London
- The Africa Water Vision in the 21st Century (2000) Indicators measuring the progress of the African water vision, 1st edn. The Hague, Netherlands
- The Guardian* (16 November 2008) *The Guardian* (London), p 7
- U.S. Department of Energy (2002) International energy annual. U.S. Department of Energy, Washington, DC
- UNCHS (2001a) Cities in a globalizing world: Global Report on Human Settlements 2001. HABITAT, Nairobi
- UNCHS (2001b) The state of the world's cities 2001. HABITAT, Nairobi
- UNEP (2000) Global environment outlook. UNEP, Nairobi
- UNEP (2002a) The state of Africa's environment chronicled in ground-breaking report: hard facts, tough choices – 30 years. UNEP: Environment for development: people, planet, prosperity, UNEP, Nairobi
- UNEP (2002b) Africa environmental outlook: past, present and future perspectives. Earthscan, London
- UN-Habitat (2003) Water and sanitation in the world's cities: local action for global goals. Earthscan, London
- UN-Habitat (2007) Climate change on world cities. Press Conference by Ms. Anna Tibaijuka, UN, Department of Public Information, News and Media, Nairobi, Kenya
- USAID (2009) The International Disaster Database. Centre for Research on the Epidemiology of Disasters, <http://www.emdat.be>
- Venard JL (1995) Urban planning and environment in Sub-Saharan Africa. UNCED, Paper No. 5 (AFTES). Environmentally sustainable development division, The World Bank, Washington, DC
- Wilbanks TJ, Lankao PR, Bao M, Berkhout F, Cairncross S, Ceron JP, Kapshe M, Muir-Wood R (eds) (2007) Climate change 2007: impacts, adaptation and vulnerability. In: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York, pp 357–390
- World Bank (1996) Africa water resources. Technical Paper No. 331, World Bank, Washington, DC
- World Bank (2000) Managing change in Pacific Island economics. Volume IV: Adapting to climate change. Papua New Guinea and Pacific Islands Country Unit, The World Bank, Washington, DC
- World News* (5 February 1997) Namibia's water shortage threatens African Oasis

Part III
Climate Change and Housing:
Case Studies from Africa and Asia

Chapter 6

Climate Change and the Housing Environment in Ghana

Kwasi Kwafu Adarkwa and Michael Poku-Boansi

6.1 Introduction

The impact of climate change as a developmental issue in Ghana is receiving considerable attention due to the difficulties most inhabitants are facing. The situation has been further compounded by the periodic flooding of Accra and other parts of the country, resulting in loss of life and property. This chapter examines the impact of climate change on the housing environment in Ghana. It reviews temperature, humidity and rainfall figures of Accra and Kumasi, the two major cities in Ghana, over a period of 10 years, in a bid to establish the changes that have taken place, and subsequently link these with the changes in the housing environment in the two cities. The chapter also provides some lessons and recommendations for consideration by policy makers and planners in a bid to avert future difficulties within the built environments in Ghana, which have been brought about by changes in climate.

6.2 Geographical Location and Socioeconomic Trends

The Republic of Ghana is situated in West Africa and lies between longitudes 3° 15' W and 1° 12' E, and latitudes 4° 44' and 11° 15' N. It is bounded to the north by Burkina Faso, to the east by Togo, to the west by La Cote d'Ivoire, and to the south by the Atlantic Ocean (Fig. 6.1). The last population census of Ghana held in 2000 gave the country's total population as 18.9 million (Ghana Statistical Service 2000a), but recent estimates (2008) put the population at 23 million with

K.K. Adarkwa (✉)

Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
e-mail: kwasiadarkwa@yahoo.com

M. Poku-Boansi

Department of Planning, Kwame Nkrumah University of Science and Technology (KNUST),
Kumasi, Ghana
e-mail: pakuboansi@yahoo.com

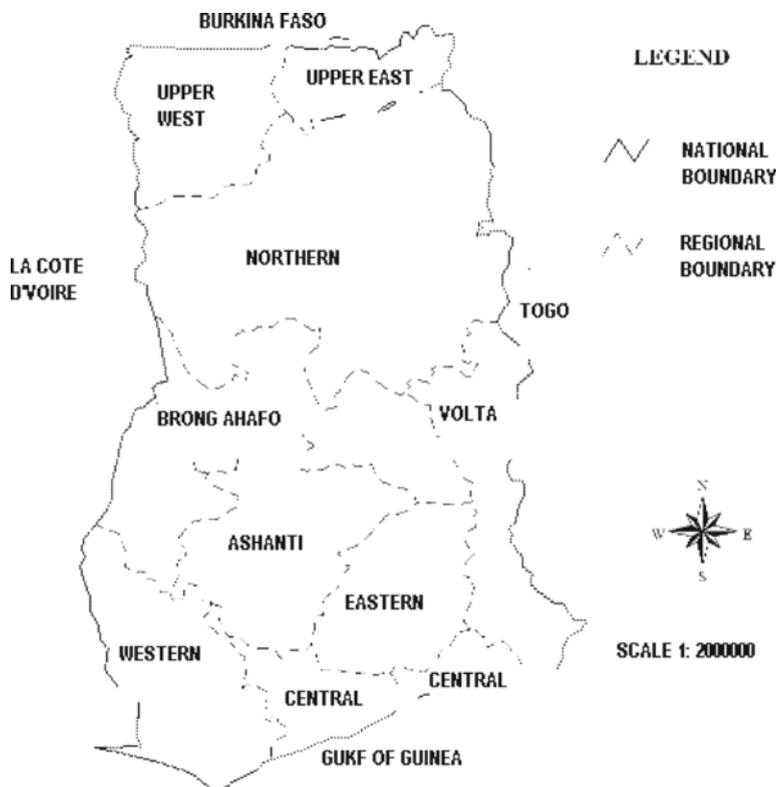


Fig. 6.1 Map of Ghana showing the ten administrative regions (Department of Social Studies (2008), Kwame Nkrumah University of Science and Technology, Kumasi)

a growth rate of 2.1% per annum and a mean population density of 88 persons/km² (World Bank 2008). Politically, the country is divided into ten administrative regions: Ashanti, Brong-Ahafo, Central, Eastern, Greater Accra, Northern, Upper East, Upper West, Volta, and Western. Ethnically, the largest group is the Akan (45%), with other major groups including the Mole – Dagbon (15%) and Ewe (12%). Christianity is the predominant religion in Ghana, followed by Islam and traditional faiths.

Ghana ranks 135 out of 177 countries on the United Nations Human Development Index (HDI). Approximately 32.3% of the population is considered to be poor. Poverty levels are highest in the north of the country, where drought and desertification are prevalent. In this particular region, up to 88% of inhabitants are considered poor (Ghana Statistical Service 2007).

Ghana's GDP per capita is US\$2,700. Contributing to this GDP are agriculture (37%), services (38%) and industry (25%). Major agricultural products include cocoa, rice, coffee and timber. The industrial sector comprises mining, lumbering, light manufacturing, aluminium smelting, food processing, cement, and small

commercial ship building. The country exports gold, cocoa, timber, tuna, bauxite, aluminium, manganese ore, and diamonds.

Ghana has a tropical climate, which is characterized most of the year by moderate temperatures (generally 21–32°C (70–90°F), constant breeze and sunshine. The country experiences two rainy seasons every year: from March to July and from September to October, separated by a short dry season in August and a relatively long dry season in the south from mid-October to March. Annual rainfall in the south averages 2,030 mm but varies throughout the country, with the heaviest and lightest rainfall being experienced in the western and northern regions respectively.

6.3 Recent Trends in Climate Change in Ghana, and Other Major Concerns

Over the past decades, global warming has continued to attract a lot of international attention, mainly in the form of global environmental conferences, culminating in the United Nations Framework of the Convention on Climate Change (UNFCCC) in 1992, and the Kyoto Protocol in 1997.

Generally, the term “climate change” encompasses all forms of climatic inconsistencies, that is, any differences between the long-term statistics of the meteorological elements calculated for different periods but relating to the same area, regardless of their statistical nature or physical causes. Climate change may result from such factors as changes in solar activity, prolonged changes in the earth’s orbital elements, natural internal processes of the climate system, or anthropogenic forces (for example, increasing atmospheric concentrations of carbon dioxide and other greenhouse gases).

According to Manu et al. (2006), the term “climate change” is often used, in a more restricted sense, to denote a significant change such as a change with important economic, environmental and social effects in the mean values of a meteorological element, in particular temperature or amount of precipitation in the course of a certain period of time, where the means are taken over periods measuring a decade or longer.

Climate change is one of the greatest environmental challenges facing the world today. It is characterised by, among other factors, rising global temperatures. This rise in temperatures has changed weather patterns, caused a rise in sea level and has increased the frequency and intensity of extreme weather conditions in most places of the world, including Ghana. Ghana is experiencing the effects of climate change in the form of recent shifts in rainfall patterns, making life very difficult for communities that rely heavily on subsistence farming for their survival. According to projections of the Environmental Protection Agency (EPA), by the year 2080, the rainfall in the country will reduce by 20–40%, while temperatures will rise by 4.5°C (Ghanaian Times 2008).

Table 6.1 Kumasi rainfall figures between 2003 and 2008 (in millimeter) (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	32.9	25.8	12.5	111.1	0.2	0.0
February	74.5	70.8	48.9	98.4	16.4	48.1
March	73.1	164.3	84.2	112.8	56.2	97.4
April	129.5	100.7	146.4	66.9	310.9	44.2
May	188.8	72.3	272.1	187.3	164.2	45.9
June	254.6	41.1	121.3	145.4	176.0	67.9
July	95.3	229.4	18.3	66.7	192.9	27.1
August	26.8	115.0	36.7	65.2	117.7	75.0
September	99.5	243.5	174.1	111.4	534.5	41.1
October	180.1	232.4	236.9	158.4	153.9	13.6
November	163.2	43.5	49.8	32.5	51.7	9.5
December	30.9	76.5	29.8	3.7	19.8	24.2
Average	112.4	117.9	102.6	96.7	149.5	41.2

Table 6.2 Accra rainfall figures between 2003 and 2008 (in millimeter) (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	2.6	14.7	Tr	8.7	0	2.4
February	9.4	17.7	7.5	6	17.4	0
March	25.1	5.3	127	25.8	62.5	53.1
April	215	26.4	32.3	37	84.4	205.6
May	71.2	121.5	109	236.6	145.7	395.3
June	302	116.5	167.2	118.1	166	112.6
July	36.8	38.6	46.5	42.1	117.9	131.2
August	25.9	18.4	27.7	16.1	70.1	29.2
September	39.8	100.2	28	71.1	89.1	29.4
October	102.6	87.5	91	75.6	66.1	61.2
November	41.1	22.6	85.5	11.2	44.4	118.3
December	15.5	4.8	56.2	0.1	4	126.4
Average	73.9	47.9	64.8	54	72.3	105.4

The two largest Ghanaian cities of Kumasi and Accra indicate a reduction of rainfall figures between 2003 and 2008 (Tables 6.1 and 6.2). As a result of this reduction in rainfall figures, the moisture content in the air has also reduced, leading to increased room temperatures. For most of 2006 and 2007, Ghana experienced an electricity supply crisis due to the low water inflows into the Volta Reservoir. Environmental experts have warned that climate change in all the water basins in the country will reduce Ghana's freshwater flows by between 15% and 20% by 2020, and by between 30% and 40% by the year 2050 (Ghanaian Times 2008).

While rainfall figures have decreased over the years, there are other issues of major concern. These include increasing air temperatures, heat waves, a rise in sea level, drought, and storms; among other climatic changes in Ghana, which have had a devastating effect on water resources, agriculture, health, desertification and

coastal zone settlements. For example, the coastal towns of Ada and Keta are gradually being washed away due to a rise in sea level, resulting in calls for a sea defence wall to safeguard buildings and other properties. In Ghana, studies have further revealed that daytime temperatures rose by 0.9°C in Accra, and by 1.2°C in Kumasi in the last 6 years.

Maximum daytime temperatures in the two cities were similar in magnitude and showed almost identical time sequence. There is also a significant increase in maximum temperatures in both cities. Maximum temperatures also showed significant warming trends in both cities. Night-time temperatures rose by 0.03°C per year in Accra and 0.04°C per year in Kumasi, but the temporal trends were similar for both cities. Tables 6.3 and 6.4 present maximum temperature figures for the two cities

Table 6.3 Kumasi mean monthly maximum temperature (°C) over 6 years (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	33.1	31.9	32	32.1	33.8	33.2
February	33.7	33.8	33.9	32.6	34.5	35.1
March	34.9	33.1	33.2	32.5	35	34.2
April	32.3	31.9	33.1	33.3	32.7	32.6
May	32.5	31	31.6	31.5	32.1	32.1
June	29.5	29.6	29.4	31	30.7	30.6
July	28.9	28.1	27.8	29.5	29.4	29.3
August	28.4	27.7	27.4	29	28.7	29
September	29.9	29.9	29.7	29.8	29.7	29.8
October	31.5	30.9	31.2	31.4	31.1	31.5
November	31.7	31.7	32	32.6	31.8	32.8
December	31.5	31.1	31.5	32.9	32.3	32.5
Average	31.5	30.9	31.1	31.5	31.8	31.9

Table 6.4 Accra mean monthly maximum temperature (°C) over 6 years (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	32.3	32.4	32.8	32.5	32.8	33
February	33.2	33.2	33.3	33.2	32.8	33
March	33.5	33.8	33.1	33.2	33	32
April	32.1	32.5	33.2	33.3	33	32.1
May	32	31.4	31.6	31.5	32.3	31.6
June	29.3	29.6	28.7	31	29.4	29.8
July	29.3	28.6	28.6	29.4	31.7	31.7
August	28.2	28.1	28	28.3	28.8	29.9
September	29.7	30.4	29.8	29.5	29.5	29.8
October	31.3	30.8	31.1	31.1	30.9	31.6
November	31.8	32.4	32.1	32.4	31.8	32.1
December	32.3	32.4	32.2	32.9	32.1	32.2
Average	31.3	31.3	31.2	31.5	31.5	31.6

since 2003. From the Tables, it can be observed that average temperature figures have increased, resulting in even higher room temperatures for dwellers in these cities.

The Environmental Protection Agency (EPA), whose mission is to co-manage, protect and enhance the country's environment through its National Action Program to Combat Desertification, has stated that the estimated percentage total land area of Ghana that is prone to desertification is 35% (about 83,489 km²), with the Upper East and eastern part of the Northern Region (78,718 km²), or 33% of the total land area of the country, facing the greatest climatic hazard (EPA 2002). A recent assessment indicates that the land area prone to desertification has almost doubled in recent times. The total land area in Ghana vulnerable to low, moderate, high and very high desertification has been at 7.47%, 48.78%, 15.15% and 1.04% respectively. The corresponding land areas in square kilometres are 17,000, 112,000, 34,000 and 2,000, totalling 165,000 km² (EPA 2002). These figures alarmingly imply that Ghana will most likely lose more of its forest land in favour of various economic development projects. Drought conditions, similar to those experienced in 1982/1983, and which caused wild bush fires throughout most parts of the country, resulting in extensive damage to farms, forests, flora and fauna, are set to cause further desertification in the country. This phenomenon has serious repercussions on Ghana's agricultural sector, which currently employs about 70% of the rural labour force, contributes 45% to the GDP, accounts for over 55% of the country's foreign exchange earnings and is responsible for meeting over 90% of the country's food requirements. The sector comprises five sub-sectors, namely: crops other than cocoa (63% of GDP), cocoa (14%), forestry (11%), livestock and poultry (9%) and fisheries (5%).

Urbanized areas in Accra and Kumasi increased by more than twenty times; and the population increased at rates of 247% and 112% respectively since 1960. Activities of urban dwellers could, therefore, have generated significant anthropogenic heat, resulting in urban warming. It has been found through research that the effect of urbanization on air temperature rise in Ghana has been more pronounced in Accra and Kumasi, especially in the night time temperatures. Another factor causing high urban warming in Accra and Kumasi is the number of sunshine hours. Accra and Kumasi have consistently had higher number of sunshine hours than other cities in Ghana (EPA 2002).

6.4 Urban Housing in Ghana

Like other sub-Saharan African countries, Ghana is rapidly urbanizing. Recent country statistics indicate that there were 43.8% urban dwellers in 2000, against 9% in 1931. At the current growth rate of 2.6% per annum, the urban population is expected to double in 17 years (GSS 2000). Ghana faces a housing shortage, which has worsened due to rapid population growth and increasing urbanization. In addition, recent improvements in urban housing development activities, increasing overcrowding, declining quality and access to services characterize much of the housing stock in the country.

According to the *2000 Population and Housing Census*, nearly 56.6% of Ghana's population lived in rural areas, while the remaining 43.4% lived in urban areas, defined as settlements with more than 5,000 people. It is estimated that those living in rural areas occupied 65.9% of Ghana's total housing stock of 2,181,975. A substantial portion of Ghana's housing stock is, therefore, located outside the urban areas, notwithstanding the high proportions of people living there (Ghana Statistical Service 2005). It is therefore not surprising that between 1984 and 2000, the rural housing stock increased by 53.1% compared with a whooping increase of 159.4% for the urban housing stock. On balance, there was an overall increase of 77.5% in the housing stock, while population increased by 53.8%. The net effect of this was that housing densities reduced from ten persons per house in 1984 to 8.7 in 2000, with the average persons per house reducing from 2.0 to 1.7 over the same period (Ghana Statistical Service 2005).

The total housing stock consists of formal and informal housing units. The housing backlog is simply the difference between the housing need (effectively, the number of households) and the total housing stock at a time. The shortage of housing in Ghana grew faster during the intercensal period between 1970 and 1984. For the country as a whole, the average number of persons per dwelling unit fell from 10.57 to 9.05 from 1960 to 1970, but by 1984 it had increased again to 10.11, only to drop to 5.1 by 2000 (GSS 2000), an indication that some improvement had taken place in the housing situation. The 2000 Population and Housing Census indicate that the total Ghana housing stock is about 2.2 million. The data suggest that the existing housing backlog in Ghana exceeds 500,000 units, and whilst the supply figures vary between 25,000 and 40,000 units per annum, the annual requirement is estimated at 70,000. Obviously, the inability of the housing delivery system to meet housing needs over the years has created strains on the existing housing stock and infrastructure, especially in urban areas.

Table 6.5 presents some basic housing related indicators for Accra and Kumasi. The table indicates that a house in both cities served more than two households, with Accra having the higher figure of 3.4 households. In terms of population per house, about 17 and 13 people live in one house in Accra and Kumasi respectively. The high number in Accra can be attributed to the high number of people living in the area and relatively fewer houses compared to Kumasi.

Table 6.5 Basic housing indicators for Accra and Kumasi (UN Department of Economic and Social Affairs/Population Division World Urbanisation Prospects: 2007 Revision; 2000 Population and Housing Census. Ghana Statistical Service)

Indicator	Accra	Kumasi
2008 population (000s)	2,191	1,708
City growth rate	3.23	3.69
No. of houses	67,434	131,355
No. of households	231,653	365,550
Average household size	5.1	4.5
Household per house	3.4	2.8
Population per house	17.3	12.6

Due to the pressure on existing housing stock, there is the gradual incidence of slums and squatters (Table 6.5) in both cities, although the problem is more pronounced in Accra than in Kumasi.

Additionally, the housing environment is characterized by haphazard developments, inadequate housing infrastructure, poor drainage, erosion and high population concentrations (TASC 2005). Residential housing in the urban centres is structured in consonance with the hierarchy of income levels. These urban centres are melting pots of different categories of people, all scrambling for scarce, often expensive, housing facilities.

Probably an accident of history, poor income-earning people often segregate themselves at certain peculiar enclaves, not necessarily the peripheries, centres or outskirts of the cities. This is due to the widespread poverty and inequality which persist in the cities, pushing millions of poor people to the informal settlements where indigenous segments of the population, as well as rural-urban migrants reside. The slums are, therefore, thickly populated squalid parts of the city which

Table 6.6 Spatial Distribution of Slum and Non-slum Households in Ghana for the year 2003

Type of Household		Non-slum	Slum
Percentage		52.7	47.3
Relative distribution of household by shelter deprivation	Less than 25% of households having at least one deprivation	41.5	6.6
	26–50% of households having at least one deprivation	35.3	23.9
	51–75% of households having at least one deprivation	18.9	31.4
	75%+ of households having at least one deprivation	4.4	38.1
Absolute distribution of household by shelter deprivation	Less than 25% of households having at least one deprivation	21.9	3.1
	26–50% of households having at least one deprivation	18.6	11.3
	51–75% of households having at least one deprivation	10	14.8
	75%+ of households having at least one deprivation	2.3	18
Cumulative distribution of household by shelter deprivation	Less than 25% of households having at least one deprivation	52.7	47.3
	26–50% of households having at least one deprivation	30.8	44.2
	51–75% of households having at least one deprivation	12.3	32.9
	75% of households having at least one deprivation	2.3	18

Source: (UN Department of Economic and Social Affairs/Population Division World Urbanisation Prospects: 2007 Revision)

Note: Shelter deprivation: lack of either improved water, improved sanitation, durable housing or sufficient living area

lack adequate basic social and economic infrastructural services. Examples of these areas include Nima – Maamobi, Agbogbloshie in Accra; and Moshie Zongo and Aboabo in Kumasi.

In slums inhabited by the poorest people, environmental problems associated with urban over-population impact directly on human health. These impacts include inadequate water supply, absence of basic sanitation facilities, improper waste disposal, shortage of essential facilities, disregard for approved land allocation regulations, haphazard housing development structure, overcrowding, poor and inadequate transportation.

According to the United Nations, the following four indicators express the physical conditions of slums: lack of water, lack of sanitation, over-crowding and non-durable housing structures. (United Nations Department of Economic and Social Affairs, 2008) These indicators, also known as shelter deprivations, focus attention on the circumstances surrounding slum-life (Pieterse 2008). Table 6.6 presents data on the distribution of household deprivation for Ghana. It can be observed that households lacking either improved sanitation, water and durable housing or living area constitute a significant proportion of the urban population.

The issues of poor housing structures lead to inaccessibility to potable water, which is mirrored in the axiom that municipal supplies of good drinking water scarcely penetrate the slums. Housing facilities of some poor urban inhabitants is often restricted to sub-standard structures located in unsanitary environments in squatters and slum communities. Various strategies have been undertaken to deal with these housing problems. They include urban renewal programmes, urban upgrading, which seek to create access in these areas, provide water and sanitary facilities, among others. An example of such programmes is the World Bank sponsored Urban I, II, III and IV schemes.

6.5 Climate Change and Housing in Ghanaian Cities

Landsberg (1970:1266) has stated that “... by far the most pronounced and locally far reaching effects of man’s activities on microclimate have been in cities...”. The results of urban expansion are evidenced in the number of buildings, extensive road networks, and other paved surfaces. According to Weng (2001), urban areas generally have higher solar radiation absorption, greater thermal capacity and heat is stored during the day and released by night. Built-up urban areas tend to have relatively higher temperatures compared to those of non-urban areas (Weng 2001). This thermal difference, combined with heat generated through urban houses, burning of fossil fuel in automobile, and industry contribute to the development of urban “heat islands”. This situation is not different in Ghanaian cities as can be seen by the relative humidity figures in Tables 6.7 and 6.8.

From Tables 6.7 and 6.8, it can be deduced that relative humidity for 0900 h for both cities has generally been decreasing over the years (2003–2008) leading to increased evaporation in these cities. Low humidity basically refers to very little moisture content in the atmosphere. With the decreasing humidity in the two cities, the implication is that the moisture content in the atmosphere is also decreasing,

Table 6.7 Kumasi mean monthly relative humidity (%) at 0900 h (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	79	85	62	86	53	43
February	84	73	84	86	80	79
March	79	77	82	83	80	81
April	84	83	83	83	84	85
May	82	83	83	83	84	85
June	86	83	87	85	85	86
July	84	87	88	85	86	88
August	87	89	88	87	87	87
September	89	89	87	89	91	88
October	87	87	84	86	86	85
November	85	85	86	84	84	84
December	83	89	85	81	85	83
Average	84	84	83	85	82	81

Table 6.8 Accra mean monthly relative humidity (%) at 0900 h (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	79	81	65	81	57	55
February	77	75	79	77	78	77
March	77	69	78	75	76	76
April	79	75	76	75	75	78
May	77	76	78	79	75	80
June	84	82	84	80	82	83
July	78	82	82	81	83	82
August	82	83	81	81	80	83
September	79	78	80	82	81	80
October	77	81	77	79	78	78
November	77	76	78	75	77	78
December	77	81	83	78	79	80
Average	79	78	78	79	77	78

resulting in warm but relatively dry conditions in Kumasi and Accra. This has made staying indoors difficult and uncomfortable. The situation during the 1500 h is even intense as can be seen in Tables 6.9 and 6.10.

The problem has been aggravated further by building contractors in both cities who, in their efforts to avoid the direct effects of the sun, orient buildings without giving due recognition to the wind direction. The design and orientation of houses in Ghanaian cities has led to minimal use of natural ventilation and lighting. This has resulted in increased number of lighting hours and artificial cooling systems. This has been mainly fuelled by the growing incidences of houses built without permits from the Planning Authorities, leading to haphazard and uncontrolled development. Another contributing factor is the sprawling nature of suburbs in these cities. This has made it difficult for the propagation of natural vegetation and landscape features that would have otherwise help in improving the moisture content

Table 6.9 Kumasi mean monthly relative humidity (%) at 1500 h (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	42	49	37	53	29	24
February	51	42	49	55	45	38
March	44	50	55	56	45	52
April	60	61	58	58	61	59
May	57	64	62	63	63	62
June	70	63	69	64	66	67
July	66	68	71	69	71	71
August	70	74	71	68	71	69
September	66	66	64	69	73	70
October	62	63	63	64	65	63
November	61	62	58	51	65	55
December	54	64	55	44	50	53
Average	59	61	59	60	59	57

Table 6.10 Accra mean monthly relative humidity (%) at 1500h (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	63	63	48	66	44	40
February	60	58	65	62	62	60
March	62	57	62	62	63	64
April	68	66	66	64	64	68
May	65	68	69	70	65	70
June	73	72	78	71	74	72
July	68	72	73	71	72	71
August	70	72	72	72	70	72
September	69	69	69	71	71	69
October	67	71	67	68	68	67
November	64	66	69	64	66	65
December	63	65	65	61	63	65
Average	66	67	67	67	65	65

in the air, as well as help in reducing the effects of the sun. To the contrary, there is very little circulation in rooms, resulting in increased room warmth, even during periods of high humidity.

The incidence of decreasing humidity has been worsened by the effect of the wind speed as can be seen in Tables 6.11 and 6.12. In Kumasi for example, wind speed has been decreasing, resulting in very poor air circulation in homes and in buildings. Coupled with the low moisture content and increased temperatures during certain times of the year, the level of room comfort has also been decreasing, resulting in the use of other artificial cooling systems such as air conditioners and fans.

The linkage between climate change and housing in Ghana and its associated impacts can be explained in a number of dimensions. These include the climatic conditions such as temperature, humidity levels, rainfall figures and wind speed,

Table 6.11 Kumasi wind speed (Kts) (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007	2008
January	3.3	2.8	2.7	3	3	3.3
February	4.9	3.7	3.6	3.2	3.9	0.3
March	3.9	3.5	3.6	3.4	4	3.7
April	3.8	3.9	3.3	3.5	3.4	3.2
May	4.3	3.9	3.3	2.5	2.9	2.8
June	3.5	3.5	3.4	3.1	3.8	2.7
July	4	3.4	3.7	4.2	4	2.5
August	4.7	3.7	3.8	4.3	3.8	2.5
September	4.1	2.7	3.5	3.5	2.9	2.4
October	2.9	2.5	2.9	3.2	3	2.8
November	2.3	2	2.3	2.1	2.9	1.8
December	2.2	2.1	2.4	2.2	2.7	2
Average	3.7	3.1	3.2	3.2	3.4	2.5

Table 6.12 Accra wind speed (Kts) (Ghana Meteorological Agency 2008)

Year	2003	2004	2005	2006	2007
January	6.0	6.4	6.3	8.9	6.0
February	7.2	7.2	7.2	10	9.6
March	6.7	7.4	8.1	9.2	9.6
April	6.9	7.9	8.3	8.4	9.4
May	7.1	7.1	7.7	7.3	7.8
June	6.6	7.4	9.0	7.0	8.3
July	8.5	9.7	9.3	9.7	9.6
August	9.0	9.2	10.2	10.9	11.1
September	9.2	7.8	10.5	10.3	9.7
October	7.5	6.6	7.8	8	7.4
November	6.3	6.8	7.3	6.9	7.5
December	5.6	7.2	7.0	6.9	6.7
Average	7.2	7.6	8.2	8.6	8.6

which have all contributed greatly to the increasing warmth in buildings and in the housing environment in the two largest cities in Ghana. In addition to these climatic conditions are associated phenomena such as overcrowding in rooms, haphazard development, leading to slums and sprawl in parts of the two cities, and modern architecture, coupled with the use of high heat absorbing materials such as glass. All these have also compounded the effect of global warming on housing in Ghanaian cities. This is manifested in the increased use of air conditioners, which present their own challenges to the country's energy requirements.

6.6 Lessons Learnt and Recommendations

From the discussions on climate change and its effects on housing in the two major cities in Ghana, the following key issues were identified:

- The increased temperature figures, together with an erratic rainfall pattern, decreasing humidity and wind speeds have a corresponding increase in room temperatures, resulting in less comfort for occupants.
- The decreasing humidity in these two cities has also contributed to the warm and increased room temperatures.
- The orientation of some buildings in these cities by some developers has not helped in minimising the effect of these climatic changes on housing.
- Materials such as glass used in building houses in these cities have also had adverse effects on the levels of comfort in buildings.

It must be noted that the effect of climate change on housing in Ghanaian cities has been very gradual, thereby creating the impression that the phenomenon is not an issue for concern. However, critical examination of the climatic conditions over the last 10 years indicates a trend which should make policy makers concerned.

Based on these findings, the following lessons have surfaced:

- The need for proper orientation of new buildings to make use of the wind direction in these cities. This will help in minimising the effects of decreasing humidity and increasing room temperature, as well as reduce the dependency on air conditioners and their associated stress on energy.
- The need to decongest parts of the cities, especially the overcrowded areas, so as to improve air circulation and reduce room warmth.

Since the incidence of temperature increase in Ghanaian cities cannot be controlled, there is a need to legislate and formulate policies to address the challenge of global warming on Ghanaian cities. This will help policy makers and city planners in controlling the generation of anthropogenic heat. The policies to curb these should include the following:

- Minimization of use of building materials with a high heat absorption capacity
- Development of infrastructure (road network, industries) that make efficient use of fossil fuel
- Ensure proper planning of our cities to help reduce the incidence of slum and sprawl
- Encourage tree planting along streets and within the housing environment
- Development of programmes to educate the general public on the effects of urban heat islands

References

- Manu A, Twumasi YA, Coleman TL (2006) Is it the result of global warming or urbanization? The rise in air temperature in two cities in Ghana. Promoting land administration and good governance 5th FIG regional conference. Accra, Ghana, 8–11 March 2006
- National Action Programme Report (2002) Environmental protection agency. Accra, Ghana
- Ghana Meteorological Agency (2008): Rainfall, Temperature and Humidity and Wind Speed figures for Accra and Kumasi. Accra , Ghana.

- Ghana Statistical Service (2000a) Population and housing census – summary report of final result. Accra
- GSS (2000) Ghana Living Standards Survey. Report of the Fourth Round (GLSS 4)
- Ghana Statistical Service (2005) Policy implications of population trends data. Population Data Analysis Reports, vol 2
- Ghana Statistical Service (2007) Poverty and trends of poverty in Ghana, 1991–2006. Accra
- Ghanaian Times (22 August 2008) Climate change: Ghana’s threat to cocoa production
- Landsberg HE (1970) Man-made climatic changes. *Science* 170:1265–1274
- Pieterse E (2008) City futures – confronting the crisis of urban development. UCT Press, Cape Town
- Tel Aviv Strategic Consulting Limited (TASC) (2005) Housing finance in Ghana: market study. International Finance Corporation
- United Nations Department of Economic and Social Affairs (2008) World urbanization prospects. The 2007 Revision. Population Division, New York
- World Bank (2008) Country profiles, Ghana. Bank Information Centre. <http://www.bicusa.org/en/Institution.1.aspx>. Accessed 17 February 2009
- Weng Q (2001) A remote sensing – GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. *Int J Remote Sens* 22(10):1999–2014

Chapter 7

Creating a Sustainable Living Environment for Public Housing in Singapore

Johnny Liang Heng Wong

7.1 Introduction

Singapore, a small island with a land area of 704 km², has housed over 80% of its citizens in public housing towns, comprehensively planned as a total living environment. When Singapore first gained independence in 1965, it was vastly different from what it is today: only a few households had piped drinking water and people bathed at public taps; there was a severe housing shortage, and squatters and slums were a common sight. Over the past 49 years, Singapore has successfully achieved sound economic growth and a high quality living environment. This has, however, been achieved against a backdrop of resource constraints, and its uniqueness as a highly urbanized and densely populated island city-state.

With only 704 km² of land competing for residential, industrial and commercial space, one of the challenges facing the country was to maximise land use by developing high-rise residential buildings. Today, modern high-rise and high-density living is the de-facto Singaporean way of life. Over 80% of Singaporeans live in public housing flats located in towns developed by the Housing and Development Board (HDB). These towns are comprehensively planned as a total living environment.

This chapter discusses HDB's experience in creating a sustainable living environment for public housing in Singapore. First, it provides an overview of sustainable development in Singapore, the impetus for sustainable development, and how public housing fits into the sustainable development framework. Second, the chapter outlines HDB's four-pronged sustainable development strategy. Third, it highlights three initiatives that HDB has adopted to mitigate the effects of climate change, and how it has supported a sustainable development strategy. Finally, the chapter showcases two of HDB's latest sustainable development efforts – an eco-precinct and an eco-district.

J.L.H. Wong (✉)
Housing & Development Board (HDB) Singapore
e-mail: jw4@hdb.gov.sg

7.2 Sustainable Development and Public Housing in Singapore

Singapore's approach towards achieving sustainability has always been pragmatic. First, economic growth is needed to generate jobs and sustain a high standard of living. Such growth allows Singapore to invest heavily on the environment so as to provide a higher quality of life for her people. Sustainable development principles are then factored into the development planning through long-term integrated planning, investment in environmental infrastructure, and setting high environmental standards that are in line with international best practice.

As a small country endowed with few natural and physical resources, it is important for Singapore to optimise the use of its available environmental resources such as clean air, land, water and energy, which are needed to fuel current and future socio-economic growth. Singapore has adopted an action-oriented approach to environmental sustainability that recognizes that its environmental resources are finite and valued. Singapore's development is underpinned by a long-term vision, holistic urban planning, sound environmental policies and high regulatory standard (IMCSD Blueprint 2009).

This approach has enabled Singapore to achieve economic prosperity, social progress and a quality living environment. Moving forward, Singapore will be in a continual race to attract investments and talents against stiff global competition. A thriving economy and an ability to provide ample and good jobs for her people is a good starting point. However, Singapore recognizes the need to minimize the impact of growth on the environment, and the need to use resources efficiently. The ultimate goal will be to build Singapore into one of the most liveable cities in Asia – a country that is clean, green, safe and efficient for current and future generations of Singaporeans.

7.2.1 Impetus for Sustainable Development – Effects of Climate Change

In recent years, climate change has emerged as a major global environmental challenge. According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC AR4 2007), which was released in 2007, there is no longer any serious doubt that the climate is warming. The report concludes that most of the warming is very likely due to increasing greenhouse gas (GHG) emissions resulting from human activities such as deforestation, burning of fossil fuels at power stations during electricity generation, and vehicle emissions.

As a relatively low-lying, densely populated island in the tropics, Singapore will be affected by climate change impacts. Much of the island is less than 15 m above sea level and has a generally flat coast. With a population of about 4.7 million within its 193 km coastline, Singapore is one of the most densely populated countries in the world. In addition, Singapore has a relatively high uniform temperature and

abundant rainfall. Given these circumstances, the potential impacts of climate change on Singapore include:

- Increased flooding
- Coastal land loss
- Water resource scarcity
- Public health impact from the resurgence of diseases
- Heat stress
- Increased energy demand; and
- Impacts on biodiversity

As Singapore's population continues to grow, and as their material well-being improves, more resources will be consumed, and more waste will be generated. Singaporeans will need to lead a more resource-efficient lifestyle. There is therefore a need to look into making the built environment more energy-efficient.

7.2.2 Overview of Public Housing in Singapore

With the majority of Singaporeans living in HDB flats, owning a public housing apartment is considered to be a Singaporean way of life, and a quintessential part of the Singapore experience. Unlike in other countries where public housing is deemed as an undesirable low-class social housing, Singapore's public housing has an international reputation of a successful housing model with a world-class image, culminating with HDB clinching the prestigious United Nations Public Service Award in 2008 for her Home Ownership Programme.

After Singapore attained self-governance, one of the key challenges for the newly elected government was to ease a severe housing shortage. Basic housing was out of reach for most Singaporeans. Only 9% of its 1.6 million people were living in public housing. Overcrowded slums and squatter settlements that lacked proper sanitation, water or basic facilities, were homes to more than half a million people. It was estimated that about 14,000 new housing units were needed annually to cater for the rapid increase in population, and to consequently ease overcrowding in the city and re-house poor families who were affected by the slum clearance exercise.

HDB was set up in 1960 and tasked to provide clean, low-cost housing for the population. In view of the limited land resources, HDB adopted a high-rise, high-density housing model. The apartments built, commonly known as HDB flats, were small, simple and utilitarian. Each apartment was a self-contained unit with adequate living space for families to live comfortably, and came with basic amenities such as piped water and electricity.

In the first 5 years, HDB built about 50,000 flats. Within 10 years, the severe housing shortage was largely resolved. Subsequently, the HDB focused on keeping up with the changing lifestyles and aspirations of the people in terms of bigger, better flats and more comprehensive facilities (Fig. 7.1). While functionality was the focus in the beginning, design, quality and sustainability have all become equally important considerations in HDB's planning efforts today.



Fig. 7.1 Example of New Town Structural Model in Tampines of the 1980s

Initially, the flats were let out at low rates to low-income families. However, to encourage nation-building and community development, the government moved away from rental housing to leasehold ownership of flats by encouraging home ownership. Owning a home helped to build pride and stability among the people, which enabled them to have a stake in nation-building.

Besides meeting social needs and aspirations of individuals, environmental concerns have always been a major consideration in the design of HDB flats. Design guidelines were set to embrace Singapore's tropical climate conditions, utilizing passive design strategies to achieve effective energy, water and waste management. In addition, research and development in green building technologies helped to enhance this further by creating green, sustainable homes for the future.

7.2.2.1 Sustainable Development Strategies for Public Housing

Public housing in Singapore is unique in that it constitutes well-planned, self-contained estates that effectively optimise the use of land. The various strategies adopted to promote environmental sustainability in Singapore's public housing estates are highlighted in the following sections (Lau and Wong 2008).

7.2.3 Comprehensive Town Planning Process

Town planning is a cyclical process, which is continuously evolving to meet the changing needs and aspirations of Singaporeans. Towns have been planned comprehensively to include key facilities so as to create a work-live-play environment that meets residents' day-to-day needs within the town, thus achieving a high level of self-sufficiency (Fig. 7.2).

The planning and design of HDB towns centers on the creation of self-sufficient living environments that meet the needs of HD residents. The comprehensive

Fig. 7.2 Example of a later HDB development in Bukit Batok West



planning approach takes into account: (1) efficient transportation networks; (2) the development of commercial, recreational and industrial centers within the town to cater for the residents' needs; and (3) facilities that promote social bonding.

These planning guidelines have been implemented in all the 23 new towns across the country, each developed with its own distinct identity that can be said to be a microcosm of Singapore. These towns are planned not only as 'dormitory towns', but as places to live, work, learn and play without sacrificing the need to maintain an environmental equilibrium. They are also planned so that sustainable communities can be established.

HDB also continuously re-plans and refines each town, taking into consideration the context and differing needs of the towns. This involves a continuous review of the land use plans, considerations for new transportation networks, and requirements for new facilities. As such, HDB towns and estates are allowed to evolve and grow over time.

7.2.4 Integrated Development Process

On the design of the buildings, HDB has developed strategies for the construction of green buildings in the estates. From the onset, HDB adopts an integrated approach to ensure the environmental sustainability of its estates.

7.2.4.1 Design

The guiding design principles are: (i) to harness the elements of nature to promote sustainable green living; and (ii) to capitalize on green building technologies and universal design (UD) concept that optimise the use of resources, promote recycling and reduce maintenance cost. Greenery is also introduced extensively to soften the harsh urban environment.

7.2.4.2 Construction

The objectives underlying construction that supports sustainable development are to increase build-ability, improve productivity and quality, reduce material wastage and ensure sustainability of construction. HDB has over the years developed and implemented its own fully pre-fabrication system and pre-cast technology. These have achieved a proved record in terms of speed of construction and performance, minimal material wastage and quality of workmanship.

7.2.4.3 Maintenance

Besides providing the physical living environment, regular maintenance is essential to ensure that estates do not degenerate into slums. Public housing in Singapore is well managed and maintained, with daily cleaning and conservancy works being carried out by the local town councils. Together with regular maintenance and repairs to the buildings, this ensures good standards of upkeep for the HDB estates.

7.2.5 Community Involvement

In recent years, the government has been actively looking into ways of expanding the scope of community involvement in public housing development. One of the initiatives to promote community bonding, and a sense of belonging amongst HDB residents is to consult residents on the scope of the projects. Studies and surveys were conducted to keep tab on the changing housing needs, preferences and expectations of HDB residents and stakeholders, in a bid to provide the necessary inputs in the planning and design of housing estates, and the formulation of programmes to promote sustainable development.

7.2.6 Research and Development Excellence

HDB actively carries out R&D on building technology to promote sustainable development in its estates. Due to the size of its developments, HDB is in a position

to introduce new solutions and technologies to the industry. Currently, all R&D activities are conducted at its Centre of Building Research (CBR). HDB is looking into further strengthening its commitment to the sustainable development agenda by setting up a centre of excellence for the environment at the CBR. This centre will provide an integrated one-stop service shop and will serve as a launch-pad for new technologies in the area of environmental sustainability.

7.3 Mitigating Climate Change

As part of its overall strategy towards environmental sustainability, HDB has been driving several key initiatives as it seeks to play its part to combat climate change. These initiatives are:

1. Promoting energy efficiency
2. Reducing urban heat island effect; and
3. Promoting sustainable construction

7.3.1 Promoting Energy Efficiency

Households consume about 9% of the total energy usage in Singapore. Designing energy efficient buildings will help reduce global and local environmental impacts, mainly in terms of reduced use of non-renewable resources and related environmental impacts, particularly emission of air pollutants. Energy efficiency is emphasized in the HDB estates through: (i) optimizing passive design strategies; (ii) capitalizing on new technology in its active design strategies; and (iii) carrying out test-bedding of renewable energy such as solar power.

7.3.1.1 Optimising Passive Design Strategies

Use of solar energy on building surfaces is the most significant energy input into buildings, resulting in immense heat gain. A simple building form with less of its façade facing the east-west direction experiences less heat gain on its surface, which in turn reduces the need for mechanised cooling. Hence, buildings are oriented with the gable end walls facing the east-west direction. The placing of common facilities such as corridors and staircase cores with the east-west orientation also enhances the thermal comfort of the residents.

Design for cross ventilation in buildings will also allow passive cooling and reduce reliance on air conditioning. Effective cross ventilation, an important aspect in the design of HDB flats, is incorporated in all residential blocks, including multi-storey car park buildings. Natural ventilation is capitalized on, with windows and openings facing the prevalent wind direction. In addition, natural daylight is

encouraged to enter into common areas and dwelling units. This minimizes the need for the residents to turn on lighting during the day, hence reducing energy use. External cloth drying racks are also provided in all buildings so as to provide a convenient method for residents to dry their clothes. Such a method is intended to reduce the need for clothes to be dried using energy-intensive methods.

7.3.1.2 Active Design Strategies

While nature is exploited as much as possible in a bid to reduce energy consumption within the buildings, energy is still needed for everyday purpose. The design approach adopted is to select energy efficient technologies that optimise energy use and reduce maintenance cost. The energy consumption pattern in the residential buildings differs greatly from normal commercial buildings, especially during peak occupied hours. Since most residential buildings, especially common areas, are naturally ventilated, power needed for lighting and lift operations are the main sources of energy consumption. The consumption of such energy peaks during the night.

While energy consumption is unavoidable in some circumstances, HDB actively looks for new technologies and solutions to improve energy efficiency. The lighting in the common corridors and car park areas are provided with new energy saving light fittings, which not only help to reduce energy consumption, but also have a longer life span. In addition, motion sensors are introduced in some of the multi-storey car parks to provide on-demand lighting for the driveways after midnight. This increases energy efficiency for the lighting of car park decks.

HDB is also currently working with Town Councils (TCs), the National Environment Agency (NEA) and the Energy Market Authority (EMA) to implement the Energy SAVE Programme in all HDB precincts. Through measures covering both HDB common areas and HDB households, the Energy SAVE programme aims to introduce significant electricity savings in HDB estates. For the common areas, a package of energy efficient solutions pilot-tested at two existing projects has shown that a 30% energy reduction for the common areas is achievable. As part of the programme, test-trials on two 4-room units showed that a household can achieve energy savings of up to 35% by adopting simple energy saving habits, and replacing home appliances with more energy-efficient models.

7.3.1.3 Test-Bedding of Renewable Energy Sources

Singapore's climate and geological conditions present limited recourse to renewable energy options such as hydroelectric, geothermal and wind power; and there is also limited land for biomass crops. In contrast, Singapore enjoys higher-than-average solar insulation all year round, and the densely-built urban landscape offers a significant amount of roof space for solar deployment without further straining its limited land resources. Solar energy therefore offers the best potential for large-scale clean energy in Singapore.

Despite these favourable conditions for solar generation, it is still currently not widely implemented in Singapore, and this is largely due to the high costs involved. Nonetheless, as technology improves and oil prices rise, the cost of solar energy is anticipated to come down, perhaps even to levels comparable to grid electricity. There is scope to look into the development of solar technology capability and innovation as part of Singapore's overall sustainable development strategy.

Being the largest developer in Singapore, HDB is in a unique position to help shore up knowledge and expertise in this area. In addition, HDB will also help to accelerate the development of system integration capabilities of photovoltaic (PV) technology. To achieve these objectives, HDB is currently embarking on a large-scale solar PV test-bedding programme with a total capacity of 3.1 MWp solar PV test-bedding for public housing in 30 HDB precincts island-wide.

7.3.2 Reducing Urban Heat Island Effect

Natural greenery has the effect of providing shade and reducing heat absorption on an otherwise exposed concrete surface. Maximising landscaping in the estates will also help to mitigate urban heat island effect and create an environment conducive for the residents to rest and relax. In addition, the soft organic surface provided by the green helps to absorb environmental noise, as opposed to bare concrete surfaces which tend to reflect noise, thereby creating a cool and quiet environment within the precinct.

The benefits of greenery have resulted in the generation of many ideas that enhance green at every space within a precinct, and cool the living environment naturally. Some of the initiatives introduced in the HDB estates include converting surface car parks to multi-storey car parks to free up more space for landscaping, and introducing high-rise greening through green roofs and green balconies.

Provision of green roofs not only reduces the overall ambient temperature of the estates but also enhances the thermal comfort of the residents living in the units at the top-most storey. The HDB has introduced the Pre-fabricated Extensive Green (PEG) roof tray system, its own patented green roof system in which the system is modular, portable, lightweight and easy to install. The PEG roof tray system ensures no heavy construction work and easy installation at existing estates. The system not only performs well in Singapore's tropical climate but it is also cost-effective and requires very little maintenance. Rooftop greening for 10 existing multi-storey car parks through the use of PEG trays, with an estimated total area of 30,000 m², has recently been carried out.

7.3.3 Promoting Sustainable Construction

To adopt a more sustainable construction process, HDB had embarked on a pre-fabrication programme for all its development work since the 1980s (Lau and Tay 1993). This has accelerated the use of standardized pre-cast components and industrialised construction methods. These components include pre-cast floor

planks, facades, parapet walls, and staircases, refuse chutes and lightweight partitions. To date, for residential buildings alone, more than 30 different types of standard pre-cast building components are being used.

Pre-cast technology has a proven record in terms of speed in construction and performance, ensuring minimal wastage of materials and quality production. In addition to economic and construction benefits, pre-cast technology has environmental benefits: with maximised pre-fabrication usage in HDB projects, most of the pre-cast components are fabricated off-site; this generates less heat and noise on-site compared to conventional in-situ construction, and reduces urban heat island effect and noise disturbance.

The concept of pre-fabrication has also been further extended to steel reinforcement work. The system focuses on the development of innovative and productive methods of laying reinforcement. Working closely with local mesh suppliers, HDB has developed a range of reinforcement fabric meshes for use in slab and wall construction. For beams and columns, the prefabricated steel reinforcement concept has led to the development of cage reinforcement system that has prefabricated link cages with main reinforcement. These prefabricated meshes have increased productivity of structural design and detailing by a hefty 20%, and steel fabrication works by threefold. It also reduces the amount of waste generated on site compared to having steel reinforcement bent, cut and assembled on site.

7.4 Driving Sustainable Development Efforts to New Heights

7.4.1 *Eco-Precinct*

HDB launched its demo ‘Eco-precinct’ at Punggol town in March 2007. The Eco-precinct is a residential housing project that allows HDB to feature all the proven technologies and solutions into one demonstration project. The project aims to show the industry that innovation and sustainable development can be both practical and cost-effective. The development contains a good spread of environmental features that embrace Singapore’s local climate conditions, using passive design strategies and optimizing the use of green building technologies to promote an eco-friendly lifestyle. The project comprises seven residential building blocks with a podium car park that enables a generous provision of green spaces at the precinct level.

7.4.2 *Eco-Districts*

In August 2007, the HDB launched an exhibition entitled: “Remaking Our Heartland” as a preview for the three genres of towns: Young (Realise), Middle-Age (Rejuvenate) and Old (Regenerate).

At the exhibition, the plans for Punggol 21+ as a waterfront town to allow residents to enjoy its natural surroundings and engage with the environment were unveiled. Punggol Waterway (4.2 km) will act as the “blue spine” that links the



Fig. 7.3 Moving forward with Punggol Waterway Development

two rivers, Sungei Serangoon and Sungei Punggol. Great potential to position Punggol as a new generation of eco-town exists. Leveraging on the waterway, the entire east-west development corridor could be defined as an eco-corridor, yielding around 20,000 housing units. The strategy will be to develop this eco-corridor along a common theme by connecting the various key segments, i.e. eco-housing districts to the east, and to the West, eco-town hub (town centre), eco-sports/recreation node (including the town park) and eco-public realm with seamless east-west connectivity integrated with eco-greens (common greens) (Fig. 7.3).

Another eco-initiative is the regeneration of Dawson Estate, which illustrates the concept of sustainable development through the recycling and optimising the use of vacant land in an established residential area. This new generation of public housing seeks to create an enhanced living environment through the “housing-in-a-park” concept, with enhanced connectivity, retention of heartland heritage and improved social mix within the new development.

7.5 Conclusion

As a result of careful and long-term planning and sound policies, Singaporeans today enjoy a clean and healthy living environment that is admired internationally. Going forward, Singapore will continue to be committed to a climate change course of action that allows it to develop in an environmentally sustainable manner that is

compatible with economic growth. The country will continue to review her national climate change strategy in line with advances in technology, further evidence on climate science and international commitment to climate change.

As the largest developer in Singapore, HDB recognises its role and responsibility in leading the industry towards environmentally sustainable development and construction. A sustainable community offers its residents a way of life that is more comfortable, more self-reliant and one that is in harmony with nature.

Every aspect of the HDB public housing programme is long-term in outlook. Just like in the development of Singapore, the achievements of the public housing programme did not happen by chance. When planning towns, the HDB takes a long-term and a comprehensive planning approach, ensuring that all necessary infrastructure and facilities are in place, and that these towns are sustainable.

For a small island country like Singapore where land is scarce, the challenge is even more daunting – the need to balance between providing a shelter for Singaporeans while at the same time preserving the environment. The continuous evolution in the planning, development and renewal of HDB towns exemplifies how Singapore continually keeps pace with the changing housing needs and aspirations of Singaporeans.

Acknowledgments I would like to express my sincere appreciation to Mr. Tay Kim Poh, Chief Executive Officer (Housing and Development Board), for his strong support and guidance in our ongoing green efforts. Through his leadership, we have put in place necessary systems, structures and processes to help reinforce environmental sustainability in our building developments. I would also like to thank all our business partners that include government agencies, private organisations and institutions for working with us all these years to realise our “green dream”.

References

- Lau JM, Tay HH (1993) Public housing achieving aesthetics, buildability and cost effectiveness – the HDB way. International symposium on urban housing issues on environment and technology, pp 24–27, Bangkok, Nov 1993
- Lau JM, Wong LH (2008) Proceedings of the IStructE centenary conference, Celebrating 100 years of excellence in structural engineering. The Institution of Structural Engineers, pp 24–26, Hong Kong, Jan 2008
- Singapore Inter-Ministerial Committee on Sustainable Development (IMCSD) (2009) A lively and liveable Singapore: strategies for sustainable growth. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainableblueprint_forweb.pdf. Accessed 05 April 2010
- The Intergovernmental Panel on Climate Change (2007) The Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) Climate Change – 2007. Cambridge. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1. Accessed 05 April 2010

Chapter 8

Climatic Change and Housing Issues in South Africa

Bornwell C. Chikulo

8.1 Introduction

Climatic change is one of the most pressing global environmental challenges facing humanity in the twenty-first century (Parry et al. 2007; UNDP 2007). Previously, most of the debate on climate change focused mainly on mitigation and adaptation strategies to address its causes and consequences to the environment. However, in recent years, some commentators have expanded the debate by arguing that climatic change is a development issue and that only sustainable development can effectively confront the challenge (Tomlin and Hug 2006; Parry 2009). A greater realization has emerged that climatic change tends to have a greater impact on the poor sectors of the populace, which already suffer from poor health conditions, unemployment or social exclusion. This is due to the fact they have the least capacity to manage risk and thus make long-term adaptations. This has caused a shift in the focus of the climatic change discourse from being primarily concerned with environmental issues to include poverty issues and sustainable development.

The *Human Development Report for 2007* for the first time established a direct linkage between climatic change and poverty. It is unequivocal in arguing that stabilization of greenhouse gas emissions should be an essential part of the overall fight against poverty and for achieving the Millennium Development Goals (MDGs). The fight against poverty and climate change has come to be viewed as interrelated (Parry 2009; World Bank 2010).

In Africa, climate change poses the most formidable long-term threat to poverty alleviation efforts and threatens to undo decades of development efforts (Low 2009; Hope 2009; Toulmin 2009). The challenge facing many African countries is how to reconcile the basic needs by majority of their population with mitigation policies and measures. Climatic change mitigation poses significant challenges for South Africa because it has to juggle the needs of its energy-intensive economy based

B.C. Chikulo (✉)

Professor of Development Studies, Department of Development Studies,
North-West University, Mafikeng Campus, Mmabatho, South Africa
e-mail: bornwell.chikulo@nwu.ac.za

on coal, with the resultant high emissions, with a host of daunting development challenges inherited from the apartheid regime (Winkler and Marquand 2009; Earthline Africa/Oxfam 2009). The Earthline Africa/Oxfam (2009:4) report aptly captures South Africa's predicament: "South Africa is faced with a difficult challenge in trying to juggle three imperatives – development (conventionally based on fossil fuels), poverty eradication and climate change."

This chapter examines climatic change and housing issues in South Africa with a special emphasis on housing for the poor. It starts by outlining the geographical and socio-economic profile, the development challenges and recent development policy responses. Section 8.2 analyses the causes and effects of climatic change. The housing sector policy and sustainable development is discussed in Section 8.3. Section 8.4 discusses the environmental policy goals of the government and the institutional arrangements entailed. The final section provides a summary, lessons learnt and conclusions.

8.2 Geographical Location and Socio-Economic Trends

South Africa is situated at the southern tip of Africa, forming part of the Southern Africa region. It has a total land surface area of 1, 219, 090 km² and is located at the southern extremity of the southern African sub-region. It occupies the southern-most part of the African continent, stretching latitudinally from 22° to 35° S and longitudinally from 17° to 33° E. The country shares common boundaries with Namibia, Botswana and Zimbabwe, Mozambique and Swaziland, while the mountain kingdom of Lesotho is completely enclosed by the South African territory to the south-east. It is surrounded by the Indian Ocean on three sides – to the west, south and east – and has a coastline of about 3,000 km (GCIS 2009).

The general landscape form is that of a tilled plateau with a higher scarp in the east and a lower one in the west. Most of the country lies at over 1,000 m above sea level with only a narrow coastal strip.

The escarpment has a great influence on the country's climate, surface, ground water resources, and landscape erodability. Its surface area falls into two major physiographic categories: the interior plateau and the land between the plateau and the coast. Forming the boundary between these two areas is the Great Escarpment, the most prominent and continuous relief feature of the country. Its height above sea level varies from about 1,500 m in the dolerite-capped Roggeveld scarp in the south-west, to a height of 3,482 m in the KwaZulu-Natal Drakensberg. Inland from the escarpment lie the interior plateau, which is the southern continuation of the great African plateau stretching to the north of the sahara desert. The plateau is characterized by wide plains with an average height of 1,200 m above sea level. The dissected Lesotho plateau, which is more than 3,000 m above sea level, is the most prominent.

The escarpment forms the highest part of the plateau. Between the Great Escarpment and the coast lies an area which varies in width from 80 to 240 km in the east and south, and a mere 60–80 km in the west. At least three major subdivisions are recognized: the eastern plateau slopes, the Cape folded belt and adjacent

regions, and the western plateau slopes. About 70% of the land surface consists of natural and semi-natural ecosystems which provide rangelands for large herbivore species (DEAT 1999; GCIS 2009).

The climate is strongly influenced by the subtropical high pressure belt, topography and the moderating effect of the Atlantic and Indian oceans. As a consequence, conditions are semi-arid over most of the country with an average rainfall of about 500 mm and abundant sunshine. The eastern region receives most of the rain, much of which falls in the summer, while rainfall in the west of the country is sparser and falls mostly in winter. The temperatures are generally mild to warm. The country's climate varies from region to region. The Western Cape experiences a Mediterranean climate while the interior has a semi-desert climate with cold, dry winters and summer rainfall. KwaZulu-Natal has a subtropical climate with humid conditions. Snow is uncommon and is limited to the highest lying regions of the country (DEAT 1999).

The country has nine provinces – Gauteng, Western Cape, KwaZulu-Natal, Eastern Cape, Northern Cape, Limpopo, Mpumalanga, Free State and the North West. Pretoria is the executive capital and Cape Town the legislative capital. Other major cities include Johannesburg, Durban, Port Elizabeth, Bloemfontein and East London.

8.2.1 Socio-Economic Trends

It has an estimated population of 47.9 million people (SSA 2007b) and one of the most sophisticated free-market economies in the African continent, and is characterized as a middle-income developing country. It accounts for approximately 40% of all industrial output, 25% of gross domestic production (GDP), over 50% of generated electricity and 45% of mineral output in Africa (Mqadi and Steynor 2005).

Most of the economic production activity occurs in four metropolitan areas viz: the Witwatersrand and surrounding areas of Johannesburg in Gauteng Province, Durban and Pinetown in KwaZulu-Natal Province, the Cape Peninsula and Port Elizabeth and Uitenhage area in Eastern Cape Province. It is the largest emitter of greenhouse gases on the African continent and the world's biggest single emitter of CO₂ at 7.8 t of CO₂ annually, including non-energy emissions. This constitutes the 37th-highest CO₂ emissions per capita, higher than many OECD countries (Earthline Africa/Oxfam 2009).

While the economy displays many world-class features, including a sophisticated financial and physical infrastructure, good telecommunications and energy supply networks, and one of the top ten stock exchanges in the world, it is plagued with wide wealth disparities. According to the Human Development Report (UNDP 2007), its gini co-efficient ranked the country at 117th most economically unequal out of 126 countries for which data was available. Similarly, its ranking according to the HDI is 121 out of 177 countries. With regard to GDP per capita (PPP), it ranked 53rd, indicating existence of a wide gap between economic wealth and development (UNDP 2007). As a consequence of the apartheid legacy, the country's economic system has the highest marked dualities in the world with a sophisticated industrial economy existing alongside an underdeveloped "informal" economy.

This duality was further complicated by the parallel interracial inequality with the best socio-economic facilities being reserved for whites and the poor facilities reserved for the blacks. Racial segregation in the economic sector, education, health and social welfare “left deep scars” of inequality and poverty: the majority of the population – the black section of the society – was characterized by abject poverty and minimal access to basic social and economic services (Chikulo 2003). The affluent sectors of the society have access to infrastructure, including power, water and sanitation and economic and social facilities comparable to those found in the developed Organization for Economic Co-operation and Development (OECD) countries. In addition, its population has grown from 40 million people in 1994 to nearly 47.9 million in 2007 (SSA 2007b), with the number of households growing faster than the population, from 8.7 million in 1994 to 13.3 million in 2007 (SSA 2007a), posing addition challenges for infrastructural development.

During the same period, its HDI value declined from 0,745 in 1995 to 0.674 in 2005 (UNDP 2008). At the same time, 49% of the population was classified as poor in 1994, but this figure dropped to 47.1% in 2006 (SSA 2008a). Poverty is unevenly distributed amongst provinces. According to 2006 figures, poverty rates range from 24.9% in Gauteng, 28% in the Western Cape, to 57.6% in the Eastern Cape. Poverty is most severe in Limpopo at 64.6%, KwaZulu-Natal at 58.5% and the Eastern Cape, which together house 47.4% of the total population but collectively account for 61.1% of poor individuals in the country (Armstrong et al. 2008).

As shown in Table 8.1, among the population groups, the poverty incidence is highest among the blacks, with 54.8%; Coloured with 34.2%, Indians with 7.1%, and Whites with 0.4% (SSA 2008a). As a consequence of the apartheid legacy, poverty is not only deep-rooted, but the economic structure locks the majority of the population into a poverty trap. Poorer households who are mostly blacks still have unsatisfactory access to basic services such as clean water, energy, health care and education.

It is evident that despite the government’s commitment to poverty alleviation, more than half of the South African population continues to live in abject poverty. Income inequality measures seem to indicate that poverty has actually increased (Luyt 2008; Bhorat and van der Westhuizen 2006). A South African government’s *Millennium Development Goals Mid-term Report* attests to this reality by noting that between 1993 and 2006 “inequality between races has declined, while inequality within race groups has grown” (RSA 2007:15).

Table 8.1 Poverty rate, population share and poverty share by population group

Group Population	Percentage shares	Percentage Shares	
	Poverty rate of individuals	Population	Poor individuals
Blacks	54.8	80.1	93.3
Coloureds	34.2	8.7	6.3
Indians	7.1	2.5	0.4
Whites	0.4	8.6	0.1
All	47.1	100	100

Source: Statistics South Africa 2008a

8.3 Development Policy Framework

Poverty eradication is a key national development priority, which the former President Thabo Mbeki duly signed in the Millennium Development Goals Declaration, which includes the target of halving poverty by 2015. The central objective of the policy framework has been to promote developmental agenda aimed at accelerating economic growth, meeting basic needs and reducing poverty. These critical developmental objectives have been encapsulated in key successive policy frameworks of the Reconstruction and Development Programme (RSA 1994), the Growth, Employment and Redistribution Strategy (RSA 1996b) and the Accelerated and Shared Growth Initiative (RSA 2006). Reconstruction and Development Programme (RDP) is the overarching policy on poverty alleviation to which the government committed itself in 1994. The RDP sets as its key tenets and principles the meeting of basic needs, developing human resources, building the economy, democratizing the state and the civil society.

The RDP was primarily aimed at combating poverty by overcoming the economic marginalization of the majority of the population through key priority programmes such as job creation through public works, meeting a range of basic needs and the delivery of housing, water and electrification (RSA 1994).

The Growth, Employment and Redistribution Strategy (GEAR) focus shifted to macro-economic stability and economic growth, and was based on a policy of opening the economy, encouraging investment and wealth redistribution. It was thought at the time that most of the objectives of RDP could be met through macro-economic reforms (RSA 1996b). The Accelerated and Shared Growth Initiative (AsgiSA) sought to re-invigorate the earlier development policy frameworks by proposing a 'national shared growth initiative' to counter the exclusion from the formal economy of the bottom third of the population. The initiative included tackling the following:

- A strong currency, which undermined the competitiveness of non-commodity sections of the economy
- Backlogs in national infrastructure, which undermined both basic service delivery and high-end economic growth
- A shortage of skills, lack of support for small businesses, and economic concentration in the economy, leading to barriers to entry into various markets in the economy
- The exclusion of a significant proportion of the population from the formal economy

In response to the above constraints, AsgiSA proposed a large-scale state-led infrastructure development programme, specific sectoral development plans (including business process out-sourcing, tourism, bio-fuels and agro-processing), national skills development, an overhaul of regulation and policy-making and measures to eliminate the 'second economy' (RSA 2006).

In addition to the above policy frameworks, two key policies that capture the government's vision for rural and urban development need to be highlighted: the

Urban Development Strategy (RSA 1995) and the Integrated Sustainable Rural Development Strategy (RSA 2000). The Urban Development Strategy was instituted in response to the legacy of decades of social exclusion within cities and the current economic marginalization found in urban settlements. This exclusion was manifested by the proportion of the urban population living below minimum subsistence levels, characterized by high unemployment levels, poor education skills and the spatial separation from the resources of the urban cores of South African cities.

The primary objective of the Urban Renewal Programme was to ensure that government policies on poverty alleviation, economic growth and environmental sustainability were implemented in an integrated manner. It is intended that the programme acts as a model for integrated governance in the future provision of government services. Eight urban renewal nodes were identified and are located in five of the nine provinces. They include two areas in the Western Cape, three areas in KwaZulu-Natal, two areas in the Eastern Cape and one main area in both Gauteng and the Northern Cape. These areas provide major opportunities for piloting development approaches that may be replicated in the rest of the country (DoH 1997b).

The Integrated Sustainable Rural Development Strategy (ISRDS) was introduced with the main objective of empowering rural stakeholders to use the Integrated Development Planning (IDP) process to select developmental activities according to their local priorities. The ISRDS identified 13 specific nodal points in which poverty is being tackled systematically. These were: four areas in the Eastern Cape, four areas in KwaZulu-Natal, two areas in Mpumalanga, one area in the Western Cape, one area in the Free State, and one area in the Northern Cape/North West (RSA 2000).

The ISRDS and the URP provide a framework for addressing poverty. The objective was to institute a sustained campaign against rural and urban poverty and underdevelopment, bringing in and utilizing the resources of all the three spheres of government in a coordinated manner. These programmes entail investment in the economic and social infrastructure, human resource development, enterprise development, enhancement of the development capacity of local governments, poverty alleviation and the strengthening of the criminal justice system.

The Integrated Development Plan (IDP) process and promulgation of the Municipal Systems Act (MSA) 2000 has resulted in a large number of responsibilities being passed on to local government (DPLG 2002). The local government is required to develop a vision for long-term development, assess the existing level of development and identify development priorities. The URP and ISRDS have been integrated into the IDP processes of specific district municipalities.

These entail the conversion of development strategies reflected in municipal budgets. It has a mandate of ensuring sustainable development and integrated environmental management, including disaster management plans and mitigation strategies. With specific regard to promoting sustainable human settlement development, the functions are: to initiate, plan coordinate and facilitate appropriate housing development; prepare local housing strategies and set delivery goals; set aside, plan and manage land for housing; create a financially and socially viable

environment; provide bulk engineering services and to administer any national housing programme if accredited to. While the South African government and all line function ministries are responsible for environmental issues and poverty eradication, the IDP process provides an opportunity for these development concerns to be integrated at the local level (DPLG 2002).

South Africa has thus targeted poverty alleviation and inequality as its highest priority in an effort to promote sustainable development. The underlying philosophy, goals and principles underpinning all its development frameworks are in line with Chapter 7 of Agenda 21(LA 21) and are encapsulated in the *Anti-Poverty Strategy for South Africa* released in 2008 (RSA 2008).

8.4 Global Climate Agreements

South Africa has signed and ratified several international conventions and treaties that address environmental conservation for sustainable development. The United Nations Framework Convention on Climate Change (UNFCCC) is the centrepiece for global efforts to combat globe warming. The country signed the United Nations Framework Convention on Climate Change (UNFCC) in 1993 and ratified it as a non-Annex one country in 1997. Other agreements that South Africa appended her signature to include the following (GCIS 2009; UNCSD 2002):

- The Basel Convention, ratified in May 1994
- The Convention on Biological Diversity ratified in November 1995
- The Convention to combat Desertification and Drought, signed in January 1995 and ratified in September 1997
- The Framework Convention on Climate Change, ratified in August 1997
- The World Heritage Conventions, ratified in July 1997
- The Kyoto Protocol, acceded to in 2002 but as a developing country, South Africa is not required to reduce emissions until after 2012
- Environment of the East and Central African Region and related Protocol (Abidjan Convention), ratified in November 2002 (acceded)
- Convention for the Protection, Management and Development of the Marine and Coastal Environment of the East African Region and related Protocols (Nairobi Convention), ratified in November 2002 (acceded)
- Convention Concerning the Protection of the World Cultural and Natural Heritage or the 'World Heritage Convention', ratified in July 1997
- Stockholm Convention on Persistent Organic Pollutants, signed on 21 May 2001 and ratified in September 2002
- Southern African Developing Countries Protocol on Fisheries, signed on 14 August 2001 and ratified in July 2003
- Southern African Developing Countries Protocol on Wildlife Conservation and Law Enforcement in the Southern African Development Community, signed on 18 August 1999 and ratified in October 2003

- Tran frontier Conservation Areas Initiative:
 - Ais/-Ais/-Richtersveld Treaty, signed and ratified in August 2003
 - Kgalagardi Tran frontier Park Agreement, signed and ratified in May 2000
 - Greater Limpopo Tran frontier Park Treaty, signed and ratified in December 2002
 - Lubombo Tran frontier and Resource Area (Lubombo Protocol), signed and ratified in June 2000

The above international obligations provide South Africa with a broader policy endorsement for climate change mitigation initiatives and the context with which policy makers have to try to reconcile the tension between development and climatic change mitigation objectives.

8.5 Environmental Policy Goals of South Africa

The 2004 National Climate Change Response Strategy for South Africa outlined the main framework for environmental policy for achieving sustainable development objectives and fulfilling the need to respond to climate change. This strategy outlines broad issues that need to be addressed and identifies specific interventions in the affected sectors that should be implemented to address vulnerabilities to climate change. The focus is on the following: adapting to climate change; developing sustainable energy programmes; adopting an integrated response by relevant government departments; compiling inventories of greenhouse gases; accessing and managing financial resources and research, education and training. The main principles for the national climate response are listed as (DEAT 2004:12):

- Ensuring that the strategy is consistent with national priorities, including poverty alleviation
- Access to basic amenities including infrastructure development, job creation, rural development, foreign investment, human resource development and improved health, leading to sustainable economic growth
- Ensuring alignment with the need to consistently use locally available resources
- Ensuring compliance with international obligations
- Recognizing that climate change is a cross-cutting issue that demands integration across the work programmes of other departments and stakeholders, and across many sectors of industry, business and the community
- Focusing on those areas that promote sustainable development
- Promoting programmes that will build capacity, raise awareness and improve education in climate change issues
- Encouraging programmes that will harness existing national technological competencies
- Reviewing the strategy constantly in the light of national priorities and international trends

- Recognizing that South Africa's emissions will continue to increase as development is realized

In devising this strategy, an integrated approach was adopted. As the report points out (DEAT 2004: iii):

Thus South Africa's position is to view climate change response as offering just one specific avenue of opportunity for achieving the sustainable development objectives of the national policies and legislation that are concerned with both development and environmental issues.

The above strategy also supports the policies and principles laid out in the government's *White Paper on Integrated Pollution and Waste Management of 2000* (DEAT 2000) as well as other national policies, including those relating to energy, agriculture and water.

The *National Environmental Management Act (Act 107 of 1998)* provides an enabling framework for the government to meet its environmental responsibilities. The Act seeks to improve environmental management while at the same time facilitating sustainable development and improving coordination and governance of environmental issues. It also provides the general framework and principles through which all environmental management and plans concerning the protection of the environment and its resources as well as the housing policy are formed.

8.5.1 Analysis of the Effects and Causes of Climate Change

Due to the heavy reliance on coal energy sources, South Africa has relatively high emissions per capita at 7.8 t CO₂ annually (including non-energy emissions (Winkler and Marquand 2009:50). According to Earthline Africa/Oxfam (2009:13) South Africa was responsible "for emitting almost 318 million tons of carbon dioxide in 2003." The country's dependency on coal-fired power stations has resulted in a yearly per capita emission rate of about 10 t of carbon dioxide, 43% higher than the global average. Most of the emissions come from just two companies: Eskom (coal-fired power stations) and Sasol (coal-to-liquids company) (Earthline Africa/Oxfam 2009:6). Eskom – South Africa's state-owned power supply utility – is responsible for supplying 95% of the country's electricity; 90% of which comes from coal-fired power stations scattered around the country.

The energy sector is the major source of South Africa's emissions which include a number of key energy-related activities such as the energy industries (responsible for 45% of total gross emissions), manufacturing industries (14%), transport (11%), fugitive emissions from fuels (2%), and other energy-related activities (6.6%), which include commercial (0.2%), residential (2.0%) and agricultural (4.4%) activities (DEAT 2008). The heavy reliance of the South African energy system on coal; the high level of electricity usage; and the energy-intensive synthetic fuels programme are the main drivers of GHG emissions in the energy sector.

Although South Africa is still classified as a developing economy, its dependence on coal-driven energy sources and the energy intensity nature of the economy have resulted in an extremely high carbon emission level per unit of gross national product compared to the rest of the world (Winkler and Marquand 2007; Mqadi and Steynor 2005). It is one of the highest emitters of GHGs in Africa and was ranked as the world's 14th highest carbon dioxide emitter from fuel combustion in 2000. The 'Country Studies Project' (IISD 2004) predicted that climate change will cause the following:

- Mean temperature increases in the range of between 1°C and 3°C by the mid-twenty-first century, with the highest increases occurring in the most arid parts of the country
- A broad reduction of rainfall in the range of 5–10% has been predicted for the summer rainfall region
- Increased incidences of both drought and floods with prolonged dry spells being followed by intense storms
- A marginal increase in early winter is predicted for the winter rainfall region of the country and
- A rise in sea level is also predicted – perhaps by as much as 0.9m – by 2100

The country has already been experiencing the early effects of global warming and climate variability. Average land and sea surface temperatures have increased, sea level is rising, rainfall patterns have changed and the intensity and frequency of extreme weather events such as snow, hail, floods and storms has increased (DEAT 2008). *The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report* indicates that climate change impacts and effects that are being felt will continue to occur even if global greenhouse gas emissions are significantly curtailed (DEAT 2004).

8.6 Housing Policy and Strategy in Post-Apartheid South Africa

With the introduction of a new democratic dispensation in 1994, provision of housing became a key component of poverty alleviation strategy in particular, and development policy in general. The size of the national housing backlog inherited by the new government was estimated to be 1.5 million units in urban areas, including 720,000 shelters on serviced urban sites which needed upgrading, and about 45,000 individuals living in inadequate hostels. There were large numbers of rural dwellings that lacked basic infrastructure and services (DoH 1994:12). Consequently, the government faced two critical challenges in the development of human settlements: delivery to reduce the huge housing backlog and overcoming the spatial exclusion inherited from the apartheid era (Du Plessis and Landmark 2002).

The department of Housing (DoH) has the responsibility of facilitating housing provision for the poor. The key policy documents which are central to housing are the *Constitution*, the *Housing Act*, the *White Paper on Housing* and the *RDP*. The housing policy is based on a fundamental understanding that housing is a critical basic need. The right to 'have access to adequate housing', first articulated in the RDP in 1994, is enshrined in the 1996 Constitution, wherein it is stated that: "(1) Everyone has the right to have access to adequate housing" and "(2) The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of this right" (RSA 1996a:1255). The 1994 White Paper, *A New Housing Policy and Strategy for South Africa*, committed the government to the establishment of viable, socially and economically integrated communities situated in areas allowing convenient access to economic opportunities, health, educational and social amenities.

It states that all South Africans "will have access to a permanent residential structure with secure tenure, ensuring privacy and providing adequate protection against the elements; potable water; and sanitary facilities including waste disposal and domestic electricity supply" (DoH 1994:1). The promulgation of the White Paper established a basic housing policy for post-Apartheid South Africa. It represented the first time that South Africa had a universal housing strategy applicable to the entire country. The RDP proposed to address the housing backlog of some 2–3 million houses by aiming to build 300,000 housing units each year for the first 5 years, mostly in urban areas.

The principles, goals and strategies of the policy were transformed into legislation in the form of the *Housing Act 107 of 1997*. The main aim of the Act is to facilitate the provision of sustainable housing. It also aligns the National Housing Policy with the Constitution, and clarifies responsibilities of the three spheres of government: national, provincial and municipal. This is the central piece of the national legislation that regulates the housing policy in the country. The Department of Housing (DoH 2004a:6) has reaffirmed "restoring and furthering human dignity and citizenship" as one of the critical principles guiding the housing policy and strategy in the country.

Access to housing is viewed as "part of the state's response towards poverty reduction and improving the quality of life for all the South Africans". Poverty eradication is one of the major objective and primary focus of all state departments. These departments are supposed to complement the Department of Housing efforts by providing households with basic services. The Water Affairs and Forestry Departments (DWA 2001) views its 'free basic water' policy of providing poor households with 6,000 L of water per household per month as a major contribution to the housing strategy.

The cornerstone of the above strategy is the institutional subsidy scheme, designed to accommodate social demands, enormous existing and projected backlogs, fiscal constraints and to minimize housing and financial sector market distortions (Khan and Thursman 2001). The scheme offers a lumpsum or one-off 'capital' subsidies for the lower income households earning less than R3,500 (US \$337) per

month. The amount is provided on a sliding scale in relation to income ranging from R5,500 to R16,000 (US\$ 687–2,000).

In 2004, the government introduced the Comprehensive Plan for the Development of Sustainable Human Settlements known as the Breaking New Ground (BNG) Strategy (DoH 2004a). The BNG strategy seeks to redirect and enhance existing mechanisms to move towards a more responsive and effective delivery, and aspires to promote the achievement of a non-racial, integrated society through the development of sustainable human settlements and quality housing.

Specific objectives set out in the BNG Plan include the following (DoH 2004a:7):

- Accelerating the delivery of housing as a key strategy for poverty alleviation
- Utilizing provision of housing as a major job creation strategy
- Leveraging growth in the economy
- Combating crime, promoting social cohesion and improving the quality of life for the poor
- Supporting the function of the entire single residential property market to reduce duality within the sector by breaking the barriers between the first economy residential property boom and the second economy slump
- Utilizing housing as an instrument for the development of sustainable human settlements in support of spatial restructuring
- Promoting and facilitating an affordable rental and social housing market
- Promoting upgrading of informal settlements
- Providing community supporting facilities through housing delivery

The strategy includes a shift in housing policy and aims to create sustainable human settlements as opposed to a mere ad hoc provision of houses. The objective is being integrated into sustainable development, wealth creation and poverty eradication, where present and future inhabitants of such settlements would live in a safe and secure environment with adequate access to:

- Centres of economic opportunities
- A mix of safe and secure housing and tenure types
- Reliable basic services and amenities
- Educational, entertainment, cultural, health, welfare and police services

The new policy builds on the past housing strategy but shifts the strategic focus from simply ensuring delivery of affordable housing to ensuring that housing is delivered in settlements that are sustainable and habitable. The new housing strategy includes a programme specifically designed for informal settlement upgrading. It emphasizes: "...a need to shift the official policy response to informal settlements from one of conflict or neglect, to one of integration and co-operation, leading to the stabilization and integration of these areas into the broader urban fabric" (DoH 2004a:17). The strategy provides for funding instruments to facilitate a "phased in-situ upgrading approach to informal settlements in line with international best practice" (DoH 2004a: 17). Unlike the previous 20–30 m² subsidy (RDP) houses, the BNG house is 40 m² in size and has two bedrooms, a lounge, an open plan kitchen, a fitted bathroom, and it is also equipped with electricity.

The BNG programme is being implemented through the informal settlement upgrading programme. This goes a long way towards recognizing informality. The BNG seeks to redress the Apartheid spatial planning and development through the development of socially, economically and spatially integrated housing delivery.

The strategy to create sustainable human settlements focused on the three programme areas outlined in Chapter 7 of Agenda 21, viz the provision of adequate shelter for all; the improvement of human settlement management and the promotion of sustainable land-use management.

8.7 Impact of Climate Change on Housing and Human Settlements

Climatic variability is already having significant effects on housing and human settlements. Settlements along the coast, informal settlements in urban areas and marginal groups living in rural areas have been identified as the most vulnerable to climate change (DEAT 2008). Housing, formal and informal, low cost and up-market, is at a higher risk due to flooding from heavy rainfall and coastal storm surges. In most formal housing areas storm water drainage is under siege because the infrastructure was not designed for recurrent surge flood events. Heavy rains and strong winds trigger floods and excessive storm water run-offs. In some instances where water drains are prone to blockages, the result is extensive flooding of houses and infrastructure with consequential damage to property and human life. Increased rainfall, especially in the Western Cape, Mpumalanga, Limpopo, KwaZulu-Natal, Gauteng and the Eastern Cape has in recent years resulted in massive flooding that has threatened large areas of these provinces.

It is the informal “squatter” settlements and other low-cost housing estates (RDP houses as they are typically referred to) that are most at risk and have borne the blunt of climate change (DEAT 2005b; Midgley et al. 2005). Courtesy to the Apartheid legacy, most of these settlements are located on the periphery of cities and towns, along flood plains and river banks with inadequate infrastructure. As a result of pressure for residential sites due to rural – urban migration and the relaxation of Apartheid urban planning laws, these settlements, which are normally located on potentially flood-prone areas, have witnessed phenomenal expansion.

It is estimated that there are 27,000 informal settlements in 70 of the biggest municipalities containing 10,85,000 households with an estimated population of 3,560,353 – most of them built below the flood line (SSA 2001). Extensive flooding caused by devastating storms and rain leave many dwellings in these settlements inhabitable, rendering thousands of inhabitants homeless. The Cape Flats in the metropolitan Cape Town and the Jukskei River in Alexandra in the Greater Johannesburg City area have a high number of informal settlements that are prone to flooding.

Poor housing quality in informal settlements exacerbates their vulnerability. About 19% of South African dwellings have been classified as informal “squatter” type or in poor state of disrepair and thus vulnerable to extreme weather conditions. Such structures are easily damaged or washed away during strong storms and floods (DEAT 2005b; Kilian et al. 2005).

The poor quality of the dwellings increases the vulnerability of most poor households to adverse weather conditions and makes them susceptible to storm damage, with several hundred homes being swept away every year. They are normally cleared of natural vegetation to create building space for new dwellings and provide fuel-wood. In most instances, these settlements do not have tarred roads and the unpaved dirt gravel roads are easily washed away, thereby curtailing easy access to these areas. The resultant poor access to services not only leads to an inability to cope and recover from such events, but also to a loss of income as some people cannot go to work.

Even in the case of RDP estates, most of the houses were poorly constructed and are vulnerable to the negative impacts of climatic change. Although 2.7 million homes have been built for low-income communities, they were constructed without insulation, suspended ceilings or orientation towards sunlight. This exposes the inhabitants to the vagaries of the weather. Residents in these estates, as is the case with those in informal settlements, typically use coal, kerosene, wood or liquid petroleum to cook and heat their homes, resulting in poor indoor air quality. In households with poor ventilation, the use of such fuel leads to indoor air pollutant concentrations and their associated health impacts. This is the most persistent and significant local air pollution problem (DEAT 2008).

The poor are disproportionately affected by air pollution (Mail & Guardian 2009). The burning of coal, kerosene, liquid petroleum or wood for home cooking and heating, the abnormally high housing densities also predispose informal settlements to the frequent incidence of accidental intense large fires. Such fires not only destroy hundreds of shacks, but also create hundreds of destitute and homeless people, especially in the winter season (Harris and Krueger 2005; Smith 2005).

Adverse weather conditions also pose additional risks for the impoverished households living in informal settlements with regard to human health and livelihoods. Communities in informal and RDP settlements normally have little or no access to safe drinking water, storm water management or proper sanitation system, which increases their vulnerability to infectious diseases. In such settlements flooding may lead to disease outbreaks due to the poor sewage and storm water infrastructure, which result in huge pools of stagnant water.

The changes in rainfall patterns favour the geographical expansion of the borders of vector diseases such as malaria and dengue fever and an increase in the incidence of water-borne diseases such as cholera and dysentery. Increased temperatures, in conjunction with dusty and overcrowded living conditions also lead to an increase in the occurrence of respiratory problems, skin rashes, dehydration and the incidence of non-melanoma skin cancers. Climatic change worsens existing vulnerabilities. It means that people living with HIV/Aids and TB in particular would be most vulnerable.

Regarding livelihoods, case studies conducted across the country reveal the extent to which environmental impacts such as snow, hail and flooding have negatively impacted on community livelihoods.

Intense and variable climatic events have caused loss of crops and livestock (DEAT 2005b; Kilian et al. 2005). In some settlements, majority of the households rely on household gardens or small plots to supplement their diet. The impact of the erosion of livelihoods and food security among vulnerable communities has resulted in increased malnutrition, with severe impact on children's physiology (DEAT 2005b). From the above discussion, it is evident that vulnerability to climate change is wide-ranging, and it has a profound impact on the marginalized communities living in informal and RDP settlements.

8.8 Achievements of Policies and Major Challenges

The housing policy and strategy is at the centre of the government's effort to alleviate poverty. Since 1994 the South African government has undertaken critical interventions aimed at improving the sustainability of poor housing in order to bring the country in line with the prescripts of Chapter 7 of Agenda 21. Between 1994 and 2008, 3,132,769 housing subsidies were granted and 2.7 million housing units were completed, thereby housing 13 million citizens. The result has been a decline in traditional dwelling from 18.2% to 11.7% between 1996 and 2007, and an increase in formal dwellings from 64.4% to 70.5% (GCIS 2009:v). Black households have been the major beneficiaries of state housing policies. The formal dwellings proportion occupied by blacks increased from 10% in 1994 to 55% in 2008, while the number of blacks occupying informal shacks declined.

However, shack settlements keep on increasing, thereby exerting additional pressure on the housing backlog. This increase could also be attributed to natural population growth, rapid urbanization due to rural – urban migration and inadequate delivery of housing units to meet historical backlogs. The expansion of unplanned informal settlements has not only resulted in the increase of the housing backlog but led to rapid urban sprawl on the outskirts of most metropolitan areas, with negative consequences for environmental sustainability (IDRC 1995; DEAT 2005b). The problem was also exacerbated by the fact that, initially, the housing policy did not provide for a range of options to meet all housing needs; most notably there were no strategies for the upgrading of informal settlements or for the promotion of affordable rental housing.

While decent housing is an important necessity for the poor, ensuring the provision of basic services such as clean water, adequate sanitation and electricity is critical in overcoming poverty.

A review of official reports indicate that since 1994, the government has made significant progress in providing access for all South Africans to basic services such as electricity, water and sanitation. As Table 8.2 reveals access to services has improved substantially (RSA 2003; GCIS 2009).

Table 8.2 Households access to electricity, water and sanitation

Households	1996 (%)	2001 (%)	2007 (%)
Using electricity for lighting	58	70	80
Using electricity for cooking	47	51	67
Using electricity for heating	45	49	59
Water (with at least RDP standard (200 m to communal tap)	62	78	85
With tap in dwelling or on site	60.7	61.3	70
Sanitation (with at least RDP standard)	51.6	62.5	71.7
With flush toilet	50.6	53.8	60

Source: GCIS 2009; SSA 2001

The service deprivation index, developed by the UNDP to measure progress in the delivery of seven basic services in South Africa (UNDP 2003) indicated an increase in the number of households that are considered deprived of access to 'good' quality basic services from 5.68 million in 1996 to 7.24 million (27% increase) in 2001 – especially among black-headed households. Despite improvements in service provision, it has proved difficult to reach many of the poorest districts, informal settlements and farm workers. It is estimated that the backlog of access to sanitation infrastructure is more than 3.7 million households (RSA 2007:44). It is also estimated that half of the poor households still have no piped water on site and a third had no electricity (RSA 2008:38). As a result, they continue to lag behind in accessing government provided basic services.

The poverty alleviation strategy also requires that the national economy generates employment opportunities. In this regard, reports indicate a significant growth in employment levels: formal employment increased by 2–3% annually between 2003 and 2007. The share of working-age people with employment (including self-employment) rose from 39% to 42% and the official unemployment rate fell from 30% to 26% (RSA 2008:26). Despite this growth in job creation, it is insufficient to address the employment needs of the entire country's population.

Regarding sustainable human settlements, the country has taken significant strides to meet Millennium Development Goals (MDGs) by 2015. MDG Seven not only focuses on ensuring environmental sustainability but also relates to housing issues (RSA 2007:3). Targets 9, 10 and 11 of MDG Seven are as follows:

- **Target 9:** Integrate the principles of sustainable development to the country's policies, programmes and reverse the loss of environmental resources
- **Target 10:** Halve the proportion of people without sustainable access to safe drinking water and sanitation by 2015
- **Target 11:** Have achieved by 2020 a significant improvement in the lives of at least 100 million slum dwellers

According to the South African government reports, the country has made significant inroads in the fight against poverty and is on schedule to meeting most of the MDGs by 2015. To this end the 2005 South Africa's Millennium Development

Goals Country Report (RSA 2005) and the 2007 Millennium Development Goals Mid-Term Country Report (RSA 2007) indicate that South Africa has already met some of the MDGs targets and that for those that have not yet been achieved, the country is on course to achieve them. While poverty remains widespread, available evidence indicates a significant reduction in extreme destitution.

8.8.1 Institutional Arrangements to Combat Climate Change

The Department of Environmental Affairs and Tourism (DEAT) is in charge of the National Committee for Environmental Coordination and fulfils a leadership role in sustainable development, which includes climatic change response in South Africa. Climatic change adaptation is viewed as an integrated, cross-cutting issue that needs to be addressed by all government departments (DEAT 2008). These departments have different institutional arrangements to address the climatic change impacts in their sectors depending on their policy mandates.

Most observers have noted that although most expertise in government on climatic change is currently located in the DEAT, it needs to shift into the line-function departments such as Agriculture, Water Affairs, Energy and Minerals.

To effectively address sustainable development, a climate change policy needs to move onto the agendas of the economic cluster of departments such as the National Treasury, the Department of Trade and Industry and the Department of Public Enterprises. It is the responsibility of the Department of Environmental Affairs and Tourism (DEAT) to facilitate the integration and coordination of environmental management in development management decision-making.

The National Environmental Management Act 107 of 1998 provides for a thorough and uniform control of environmental impact management of development projects in the country. It also makes provision for the establishment of a committee for environmental coordination to handle issues related to the environment amongst all the relevant national government departments. A National Committee for Climate Change (NCCC) was established in 1994 to coordinate government work towards forming a climate change policy with the other stakeholders, including the nine provincial governments. The National Climate Change Response Strategy is coordinated by an inter-ministerial committee on climate change and a national committee on climate change, which was established to advise the government on matters relating to national responsibilities with respect to climatic change, and particularly in relation to the United Nations Framework Convention on Climatic Change and the Kyoto protocol. It acts as a review and a networking body and was initially established in the mid-1990s as an interdepartmental committee consisting of representatives from key government departments such as the departments of Agriculture, Science and Technology, Foreign Affairs, Health, Housing, Local and Provincial Government, Minerals and Energy, Trade and Industry and, Transport; and the National Committee on Climatic Change (NCCC), including some provincial and local government representatives, civil society organizations, labour and

business and major GHGs emitters, particularly Eskom and Sasol. The NCCC was mandated by the government to ‘express the concerns of key stakeholders’ and ‘to design and participate in a process leading to the formulation of a national climate response strategy’. In addition, there are two other committees mandated to deal with environmental management issues (Fakier et al. 2005).

8.8.1.1 The National Environmental Advisory Forum

The National Environmental Advisory Forum (NEAF) was established on 24th February 2005. It is a statutory body established under Chapter 2 of NEMA. It is a multi-stakeholder advisory forum that provides the Minister with strategic advice on issues of environmental management and governance, and on appropriate methods of monitoring compliance with the principles set out in Section 2 of Chapter 2 of NEMA. Its membership represents organized labour, organized business, NGOs, CBOs, women, the disabled, youth and persons with relevant specialist skills and knowledge. Some key priorities that the NEAF advises the Minister on include:

- Genetic Modified Organisms
- The National Strategy for Sustainable Development
- Climate Change
- Trans frontier Parks
- Quotas and permits for coastal protected areas

8.8.1.2 The Committee for Environmental Co-ordination

The Committee for Environmental Co-ordination (CEC) is a statutory body established by NEMA to promote the integration and co-ordination of environmental functions by the relevant organs of state. The CEC is chaired by the Director General of DEAT and is represented by the directors-generals of national departments, which conduct activities affecting the environment, heads of departments of the provincial environmental departments. The National Environmental Management Act (NEMA) No.107 of 1998 provides the main framework for integrating good environmental management practices into government activities, and DEAT is the lead agency for coordinating environmental policy in the country.

8.9 Lessons Learnt

Climate change is having a greater impact on South Africa’s poor. It is affecting communities which are most vulnerable through increasing droughts, floods, rising sea levels, decreasing water supply, malaria and extreme weather events. Although the government has built 2.7 million houses, thereby providing shelter to 13 million people

free of charge (GCIS 2009:333), the reality is that development of sustainable human settlements and quality living environments has still not materialized. There has been a rapid expansion of informal settlements around urban centres and peri-urban areas.

The major reason for this is lack of an integrated development approach. In the majority of cases, housing projects were implemented in isolation, not in an integrated developmental manner to include the range of necessary public facilities and amenities. Only in a few instances was integration in terms of social facilities achieved, and this was largely due to additional funding being secured from the special presidential grants or external donor funding. There are several explanations offered for the lack of an integrated approach to housing. These include lack of co-ordination between and within different state agencies (inter-departmental, between different spheres of government and ministries); a paucity of complementary funding for other social facilities and inadequacies in the conducting of integrated budgeting at national, provincial and local government levels (Khan and Thursman 2001:22).

Housing delivery has been characterized by a focus on mass delivery of the product. The concept of 'progressive realization' of housing as defined in the White Paper on Housing has not adhered to the original pledge to deliver a defined product, that is, 'a dignified house with 'reasonable living space and privacy.' The RDP houses had a number of associated problems. These included:

- Many new housing projects lack essential facilities and urban amenities
- The location of new housing projects has tended to reinforce apartheid urban settlement patterns and existing inequities
- The poor location and low residential densities of many of these housing projects could not provide a wide range of activities and services in a sustainable way
- There are problems of poor construction quality

While RDP houses were the first step towards housing millions of South Africans who had no adequate shelter as a result of racial discriminatory policies under Apartheid, the outcome was flawed. The mass delivery of an unacceptable product – a typical 25m² unit with no partitions has resulted in beneficiaries expressing dissatisfaction with the type of houses that have been delivered. Even the Ministry of Housing admits that more than half of the RDP houses built for the poor since 1994 are 'sub-standard'. Reports across the country indicate great dissatisfaction with the quality of the housing provided and the house sizes. One beneficiary in the Northern Province was quoted as having stated that: "These houses are similar to a toilet" (Tomlinson 1996:24); or as the graffiti demanded in a site-and-service area of Khayelitsha on the remote edge of metropolitan Cape Town: "Give us houses not toilets" (Spiegel et al. 2001:12).

8.9.1 Poorly Located Land

Obtaining access to a well located piece of land is a major obstacle to low cost housing development. Most houses provided through the capital subsidy have been built on cheap land and in peripheral locations – areas previously designated

“black” or “coloured”, which are normally located in the less desirable parts of towns. In the early stages, the policy entailed building rows of houses on the outskirts of towns and cities, which merely replicated Apartheid-style housing. Little progress is being made in restructuring, de-racialising and desegregating Apartheid towns and cities through new housing developments.

8.9.2 *Squatting*

The housing policy did not take full cognizance of the problem of ‘illegal land invasions’ or ‘squatter settlements.’ Studies have shown that those who have not benefitted from the housing subsidy have adopted “innovative” ways of solving their housing problems in the form of illegal land invasions or squatter settlements. It is estimated that about 10% of the total large urban populations reside on illegally occupied land or in “squatter camps”.

Until recently, the existing housing policy, through the housing subsidy scheme, had proved rigid and not wholly conducive to the promotion of informal settlement upgrading (Abbott and Douglas 1999).

8.9.3 *Sub-Tenants and Backyard Shack Dwellers*

Until recently the housing needs of sub-tenants and backyard shack dwellers were not, and are yet to be, addressed by the housing policy and strategy. This is a pressing problem in most metropolitan areas in view of the large number of people living under this tenure arrangement. In Gauteng, approximately 1.2 million people are accommodated in this manner and 57% of all township stands have at least one informal dwelling on them.

Khan and Thursman (2001) illustrate the extent of this problem by pointing out that while it is not possible to quantify exactly how many people in the urban areas qualify as sub-letters and sharers, a survey undertaken in six formal African urban townships in Cape Town, Johannesburg, Pretoria, Durban, Springs, and Welkom in 1993 estimated that 40% of the surveyed population lived in backyard shacks, and a further 15% were tenants within the formal dwellings. About 55% of the surveyed population were renters and sharers. A survey in the African areas in Cape Town indicated that in the older formal township of Guguletu, 100% of properties were sub-let; this fell to 86% in the informal settlement and to 68% in the newer formal areas of Khayelitsha (Khan and Thursman 2001).

Informal housing is the most prevalent means by which the poor access shelter. Majority of the poor currently reside in informal settlements. According to the 2001 census, approximately 16.4% of all households live in informal settlements. This translates to a total of 5.2 million people. In urban areas, about one-third of existing housing is informal, and in the Gauteng province, an estimated 80% of newly-built

housing is informal. This is a manifestation of a combination of unplanned informal settlements and backyard shacks. These forms of accommodation are regarded as illegal, have insecure tenure and are characterized by limited services, overcrowding, inadequate and deteriorating physical conditions.

8.10 Conclusion

Although a lot has been achieved in terms of legislation, policies, and programmes, South Africa's human settlements are still characterized by spatial separation of residential areas according to class and population group, urban sprawl, low levels of service provision and the concentration of the poor settlements in the outskirts of urban centres. A growing number of studies indicate that climate change is beginning to hamper sustainable development, undermine poverty alleviation efforts and has negative implications for livelihoods, clean water, environmental health and human settlements.

The sorry state of housing for the poor can be attributed to several factors, which include the lack of access to ideally located land; relatively low levels of infrastructure provision; poor maintenance on the part of local authorities; lack of consolidation or improvement of RDP houses, and the poor quality of the RDP houses. For the poor majority, the struggle for access to housing and integrated development continues call to question the planning and urban management systems currently in use in most municipalities. While the new housing policy has made some significant in-roads in reducing the housing backload, and made a significant break from the Apartheid legacy, a number of weaknesses and tension still need to be addressed in order for the housing strategy to realize its key objectives of, inter alia, establishment and maintenance of habitable, stable and sustainable public and private residential environments, and the creation of viable households and communities, and optimizing its impact on poverty alleviation and inequality.

Over the past decade, the government seems to have displayed ambiguity in its approach to climatic change mitigation and the implementation of sustainable development programmes. While the principles of social, economic and environmental sustainability are entrenched in housing policy and legislation, an inherent conflict has emerged in the implementation process. What is needed is the adoption of a more positive, pro-active integrated approach as stated in the Reconstruction and Development Programme. A national development and urbanization strategy is required to manage the distributional effects of a rapidly growing and urbanizing population and address problems arising from the apartheid legacy.

An integrative approach to sustainable urban management should underpin all aspects of urban environmental policy. There is a need for local environmental policies to be cross-sectoral so as to allow the development of settlements that enable communities' access to socio-economic services to create livelihoods and enjoy a supportive environment. The challenge facing the South African government is how to link the objectives of the housing policy – especially housing for

the poor – with those of climate change priorities within a sustainable development framework.

If implemented effectively, the Breaking New Ground (BNG) strategy has the potential to break the deadlock in housing delivery while at the same time achieving climate mitigation goals. With its emphasis on the development of integrated sustainable housing settlements, the BNG is viewed as the strategy to end South Africa's housing woes. To this end, the strategy not only seeks to eradicate all slums and informal settlements by 2014, but also provides a strong linkage between housing policy, climatic change issues and sustainable development.

References

- Abbott J, Douglas D (1999) Trends in informal settlement in the cape metropolitan area. Report prepared by the Urban GIS Group, Department of Civil Engineering for the Directorate of Planning, Environment and Housing, Cape Metropolitan Council, Cape Town, University of Cape Town, Cape Town
- Armstrong P, Lekezwa B, Siebrits K (2008) Poverty in South Africa: a profile based on recent household surveys, Stellenbosch economic working papers: 04/08. Department of Economics, University of Stellenbosch, Stellenbosch
- Bhorat H, van der Westhuizen C (2006) Economic growth, poverty and inequality in South Africa: the first decade of democracy. Development Policy Research Unit, School of Economics, University of Cape Town, Cape Town
- Chikulo BC (2003) Development policy in South Africa: a review. DPMN bulletin, X (2). <http://www.dpmf.org/pub-bulletin.html>. Accessed 20 March 2009
- DEAT (1999) State of the environment. <http://soer.deat.gov.za/docsport.aspx?m=97yd=14>. Accessed 10 March 2009
- DDEAT (2000) White paper on integrated pollution and waste management for South Africa: a policy on pollution prevention, waste minimization, impact management and remediation. Government Gazette, 417 (20978), DEAT, Pretoria
- DEAT (2004) A national climate change response strategy for South Africa. DEAT, Pretoria
- DEAT (2005b) Chapter 10: human vulnerability to environmental change, background paper. <http://www.soer.deat.gov.za/themes.aspx?m=28>. Accessed 28 May 2009
- DEAT (2008) State of the environment. <http://www.soer.deat.gov.za/frontpge.aspx?m=2>. Accessed 11 March 2009
- DEAT (Department of Environmental Affairs and Tourism) (1998) National Environmental Management Act (Act No.107) of 1998. Government Gazette, 401(19519), DEAT, Pretoria
- Department of Water Affairs and Forestry (DWAf) (2001) Free water implementation strategy. Department of Water Affairs and Forestry, Pretoria
- IDRC (International Development Research Centre) (1995) Building a new South Africa: volume 4. http://www.idrc.ca/en/ev-9323-201-1-DO_TOPIC.html. Accessed 10 Jan 2009
- DoH (1997b) Urban development framework. The Department of Housing, Pretoria
- DoH (2004a) 'Breaking New Ground': a comprehensive plan for the development of sustainable human settlements. Department of Housing, Pretoria
- DoH (Department of Housing) (1994) White paper on housing. A new housing policy and strategy for South Africa. Government Gazette, 345(16178), Department of Housing, Pretoria
- DPLG (Department of Provincial and Local Government) (2002) Integrated development planning local pathways to sustainable development in South Africa: an awareness campaign developed for the world summit on sustainable development Johannesburg 2002. Department of Provincial & Local Government, Pretoria

- Du Plessis L, Landmark K (2002) Sustainability analysis of human settlements in South Africa. Council for Scientific and Industrial Research, Pretoria
- Earthline Africa/Oxfam (2009) Climate change, development and energy problems in South Africa: is another world possible? Earthline Africa, Johannesburg
- Fakier S, Stephens A, Tholin J (2005) Environmental governance, background paper for DEAT. DEAT, Pretoria
- GCIS (Government Communications) (2009) South Africa Year Book, 2008/9. GCIS, Pretoria
- Harris HC, Krueger DLW (2005) Implementing Energy Efficiency policy in Housing in South Africa. *J Energ S Afr* 16(3):38–44
- Hope KR (2009) Climate change and poverty in Africa. *Intl J Sust Dev World Ecol* 16(6):451–461
- IISD (International Institute for Sustainable Development) (2004) South Africa case study: analysis of national strategies for sustainable development. http://www.iisd.org/pdf/2004:measures_sdsip_sa.pdf. Accessed 29 Jan 2010
- Khan S, Thursman S (2001) Setting the stage: current housing policy debate in South Africa. IsandlaInstitute. [http://www.Isandla.org.za.papers/20%.20Housing%20policy%20in20SA%20\(2001\).pdf](http://www.Isandla.org.za.papers/20%.20Housing%20policy%20in20SA%20(2001).pdf). Accessed 12 Feb 2009
- Kilian D, Feihn H, Ball J, Howell D (2005) Human settlements: background paper for the South Africa national state of the environment project. Energy Research Centre, Cape Town
- Low PS (ed) (2009) Climate change and Africa. Cambridge University Press, Cambridge
- Luyt D (2008) Governance, accountability and poverty alleviation in south in South Africa. Paper presented at the United Nations Social Forum on 2 September 2008 in Geneva, Switzerland. <http://www2.ohchr.org/English/issues/poverty/docs/sforum/spresentations/D.Luyt.pdf>. Accessed 21 Dec 2008
- Mail & Guardian Online (2009) Air pollution costs South Africa R4 billion in Healthcare. <http://www.mg.co.za/2009-10-12-air-pollution-costs-sa-r4bn-in-healthcare>. Accessed 16 Oct 2009
- Midgley GF, Chapman RA, Hewitson B et al (2005) A status quo, vulnerability and adaption assessment of the physical and socio-economic effects of climate change in the Western Cape. Report to the Western Cape Government, Cape Town, Report No. ENV-S-C-2005-073, University of Stellenbosch, Stellenbosch
- Mqadi C, Steynor A (2005) Adaption activities report for South Africa. Climate analysis group (CSAG), South South North Group, South Africa Office, University of Cape Town. http://www.southsouthnorth.org/countryreport.asp%3Fcountry_id%305+mqadi+andsteynor/2005,humansettlements,SouthAfrica&cd=18hl=en&cd=clnk&q1=29. Accessed 15 Dec 2008
- Parry M (2009) Climate change is a development issue, and only sustainable development can confront the challenge. *Clim Change* 1.1(1):5–9
- Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) (2007) Climate change 2007: impacts, adaption and vulnerability, contributions of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge
- RSA (1995) Urban development strategy of the government of national unity. Office of the President, Pretoria
- RSA (1996a) The constitution of the Republic of South Africa. Government Printer, Pretoria
- RSA (1996b) Growth, employment and redistribution strategy. Department of Finance, Pretoria
- RSA (2000) The integrated sustainable rural development strategy (ISRDS). Office of the President, Pretoria
- RSA (2003) Towards a ten year review: synthesis report on the implementation of government programmes. A discussion document of the Policy Co-ordination and Advisory Services. Office of the President, Pretoria
- RSA (2004) South Africa: initial national communication under the United Nations framework convention on climate change. Submitted at COP-9. Pretoria. <http://unfccc.int/resource/docs/natc/zafnc01.pdf>. Accessed 15 Dec 2008
- RSA (2005) South Africa millennium development goals country report 2005. <http://www.south-africa.info/about/social/mdg.050805.htm>. Accessed 30 April 2009

- RSA (2006) Accelerated and shared growth initiative for South Africa. <http://www.info.gov.za/asgisa/asgisa.htm>. Accessed 15 Dec 2006
- RSA (2007) Millennium development goals mid-term report. Government of South Africa, Pretoria
- RSA (2008) Towards anti-poverty strategy for South Africa: a discussion document. <http://www.info.gov.za/view/DownloadFileAction?id=92543>. Accessed 30 April 2009
- RSA (1994) Reconstruction and Development White Paper. Office of the President, Pretoria
- Smith HM (2005) The relationship between settlement density and informal settlement fires: case study of Imizan Yethu, Hout Bay and Joe Slovo, Cape Town Metropolis. In: van Oosterom P, Zlatanova S, Fendel EM (eds) Geo-information for disaster management. Springer Berlin Heidelberg, Berlin, pp 1333–1335
- Spiegel A, Waterson V, Wilkinson P (2001) Houses for all? Post-apartheid housing policy and shelter needs in South Africa. In: Polakow V, Guillean C (eds) International perspectives on homelessness. Greenwood Publishing, Westport, Connecticut, pp 289–308
- SSA (2001) Census 2001. Statistics South Africa, Pretoria
- SSA (2007a) General household survey. Statistical Release P0318. Statistics South Africa, Pretoria
- SSA (2007b) Mid-year population estimates. Statistical release P0302.SSA. Statistics South Africa, Pretoria
- SSA (2008a) Income and expenditure survey 2005/06. Statistics South Africa, Pretoria
- Tomlin C, Hug S (2006) Africa and climate change, sustainable development opinion paper. International Institute for the Environment and Development (IIED), United Kingdom. http://www.iied.org/pubs/pdf/full/11_063_IIED.pdf. Accessed 15 July 2008
- Tomlinson M (1996) From rejection to resignation: beneficiaries' views on the government's housing subsidy scheme, CPS research report No: 49, July. Centre for Policy Studies, Johannesburg
- Toulmin C (2009) Climate change in Africa. Zed Press, London
- UNCSD (United Nations Commission on Sustainable Development) (2002) Johannesburg summit 2002: South Africa country profile, CCP 2002-SOUTH. UNCSD, New York
- UNDP (2003) South Africa human development report: the challenge of sustainable development in South Africa: unlocking people's creativity. UNDP South Africa, Oxford University Press, Pretoria
- UNDP (2007) Human development report 2007/2008. Fighting climate change: human solidarity in a divided world. Palgrave & Macmillan, New York
- UNDP (2008) Statistics of human development report. New York: UNDP. <http://hdrundp.org/en/statistics/>. Accessed 20 July 2008
- Winkler H, Marquand A (2007) Energy development and climate: decarbonising growth in South Africa. Human development report 2007/2008, Occasional paper 2007/40. http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/Winkler_harald%20and%20Marquard_Andrew.pdf. Accessed 20 Nov 2008
- Winkler H, Marquand A (2009) Changing development paths: from an energy-intensive to low-carbon economy in South Africa. *Clim Dev* 1(1):47–65
- World Bank (2010) World development report 2010: climate and development. World Bank, New York

Chapter 9

Climate Change and Sustainable Housing in Uganda

Stephen A.K. Magezi

9.1 Introduction

Housing development has become a centre-piece of human existence and livelihood that touches on every sector. Currently, Uganda recognizes at least three important cross-cutting issues relevant to the housing sector. These are the environment, gender and vulnerable groups. There is no specific mention of weather, climate and climate change. At a time when climate change poses the biggest threat to socio economic development, it is important that it is addressed as a major cross-cutting issue within the housing sector. It is commonly evidenced among the poor urban dwellings.

In Uganda, urban areas are defined as settlements with over 5,000 inhabitants. Towns of 5,000 to 15,000 inhabitants are classified as small, while those with more than 15,000 inhabitants are classified as large. Based on these criteria, the 2004 housing census revealed that there were 106 small and 43 large towns. By then the urban population was estimated to be 3.7 million out of a total population of 25 million.

Sustainable housing faces some serious challenges from climatic change and variability. The challenges are long-term and short term. The long-term challenges require the need for climate-proof housing policies, while the short-term challenges of climate variability and change impacts are already a big headache to the current housing infrastructure and setup in Uganda. This chapter examines these key challenges and their implications. Uganda's experience in dealing with these challenges, and lessons learnt, are also discussed.

S.A.K. Magezi (✉)

Registered Environmental Practitioner and Auditor – Uganda,

Member Uganda Meteorological Society, Uganda's Representative to the IPCC

e-mail: sak_magezi@yahoo.com

9.2 Geographical Location

Uganda is a landlocked country that lies astride the equator within East Africa, occupying a 241,551 sq. km, 18% of which are inland waters and permanent wetlands. It is bounded by Kenya to the East, Sudan to the North, and the Democratic Republic of Congo (DRC) to the west, Rwanda to the South West and the United Republic of Tanzania to the South.

It has a favourable climate and fertile soils which are now threatened by the advent of global warming and climate change. The country has a diversity of geographical features ranging from high altitude zones (over 1,500 m) to medium and low altitude zones (under 900 m). Most of the country lies on the plateau, that is, 900–1,000 m above mean sea level. Three quarters of the country receives 1,000–1,500 mm rainfall and enjoys two cropping seasons annually. For this reason, its economic mainstay is rain-fed agriculture, which is greatly vulnerable to climate change and climate variability.

9.2.1 Socioeconomic Trends

Uganda's urban population has been growing faster than that of the rural areas. The overall population growth rate in Uganda, which is one of the highest in the world, is 3.4%, while that in urban areas is 4.1%. In the capital city of Kampala, the population growth rate is about 5%. The housing sector has experienced record growth in the last 20 years in response to the rising need for proper housing (Kayizi 2008). Current official figures indicate that the sector growth has averaged at 7% over the last few years, with the exception of the years 2000 and 2001 when it recorded a 1.8% growth rate. With a GDP growth averaging 6.5% and a population growth average of 3.4% per annum since 1995, the demand for descent and affordable housing has experienced an upward spiral (Government of Uganda 1993–97). Climate change impacts will make this gap wider since planning for climatic change and variability increases the number of challenges faced in the provision of sustainable shelter.

According to the recently conducted National Housing Survey, it has a deficit of 550,000 housing units. 160,000 of this backlog are in the urban areas. Kampala, the capital city, has a deficit of 100,000 units. With a population growth rate of 3.4% per annum and current population of about 31 million, which is projected to grow to 45 million by 2020, and a rapid rate of urbanization, its estimated that 2 decades down the road, Uganda will have a housing shortage of close to 8 million units, of which 2.5 million will be in the urban centres, and 1 million in Kampala. About 87% of the houses in rural areas are reportedly owner-occupied while 49% in urban areas are rented.

9.3 Recent Trends in Climatic Change

Widespread occurrences of extreme weather and climate events as a result of global warming and climate change indicate that no country will escape climatic change

impacts. Unfortunately, the poorest will be the most affected. Uganda like most of the other countries in the world has started to experience definite trends in terms of increased temperatures, increased frequency of severe weather and climatic events in addition to a number of serious impacts, most of which could be attributed to climatic change and climate variability.

The warming has been significant, varying from station to station, but most significant in the highland areas of western and south western Uganda such as the Kabale highland areas. The highest warming has averaged at about 0.3° per decade (National Environment Management Authority 2005). The minimum temperatures have risen faster than the maximum temperatures such that the range between the maximum and minimum has tended to decrease over the years. This has led to a number of impacts that are related to malaria occurrences and mosquito prevalence.

The trend is also evident in the lower lying areas around Lake Victoria as shown in Fig. 9.1 for the Jinja station at the shores of Lake Victoria.

Reports from Rwanda, which is part of the south-western highlands, also indicate a similar rate of warming – one of the highest in the world. Mountainous areas in the tropics seem to be experiencing a faster warming compared to the lowlands within the tropics. In general and across the country, there is a trend towards warmer temperatures, averaging between 0.5° and 0.8° Celsius every quarter of a century.

Regarding rainfall, Global Circulation Models (GCMs) predict a 10–20% increase in the runoff under future climatic change scenarios for most part of the country. In the cattle corridor and the semi-arid areas (north eastern districts), the runoff may reduce (Bwango et al. 1998). These models are coarse, and their skills are not very good because most of the country has limited weather and climatic data to validate climate models.

It is evident that extreme weather events are becoming more frequent, and are predicted to intensify with increasing climatic changes. Between 1991 and 2000, Uganda experienced seven droughts (meteorological droughts) (Fig. 9.2). Recent years have witnessed an increase in the intensity and frequency of heavy rains, floods, landslides in the highlands and outbreaks of waterborne diseases that are associated with floods.

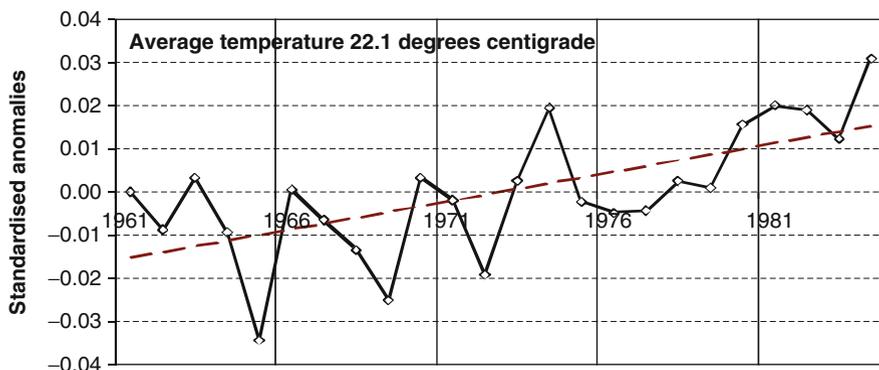


Fig. 9.1 Standardized temperature anomalies and trend line for Jinja Station along Lake Victoria shores in Eastern Uganda (Source: Uganda Department of Meteorology Archives 2007)

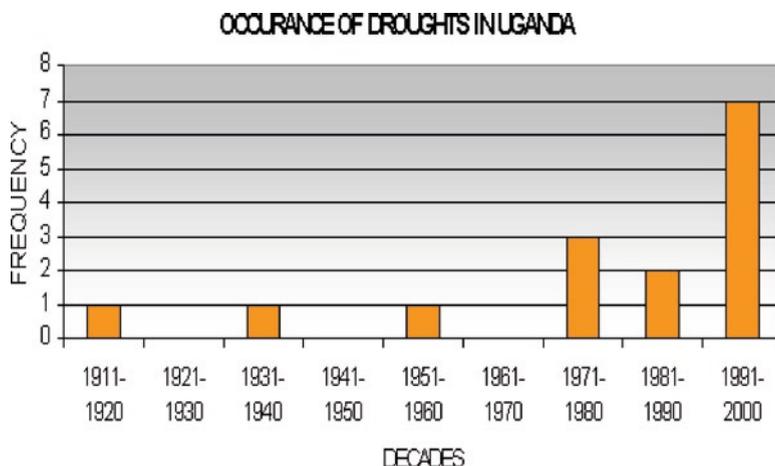


Fig. 9.2 Frequency of droughts in Uganda (Source: Republic of Uganda, Department of Meteorology, Uganda; Climate change, Uganda National Adaptation Programmes of Action 2007)

Despite the GCM model predictions, the trend analysis has revealed that there is no significant trend of either increasing or decreasing rainfall over the past 40–50-year period (Bwango et al. 1998). Since the 1970s to-date, the frequency of severe droughts increased by almost twofold compared to the period before 1970 (Fig. 9.2 below). The frequency and severity of floods has also increased over the same period.

9.3.1 Global Climate Agreements and Their Impact on Uganda

To guarantee Uganda's capacity to manage the climatic change impact, the Uganda government has signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP). It has also signed and ratified the Convention on Drought and Desertification (CDD). This has been done in the context of various policy and legal frameworks for sustainable natural resource management that have been developed.

It is also a signatory to the Universal Declaration of Human Rights; the 1976 Vancouver Conference on Human Settlements (Habitat One), the 1996 Istanbul Conference on Human Settlements (Habitat) and United Nations Global Strategy for Shelter to the Year 2000. Recent protocols that Uganda subscribes to include the Millennium Development Goals (MDGs). MDG Goal Seven (Target Two) is aimed at improving the lives of slum dwellers. With regards to climatic change, the UNFCCC and the KP are the most relevant, although they are yet to be domesticated.

9.3.1.1 Evidence of Climatic Change in Uganda

Climatic change has already been evidenced in terms of rising temperatures, increased extremes of weather and climatic events, in addition to the changing patterns of different disease pathogens such as the malaria-carrying mosquitoes. In general, the change has been manifesting itself through the increased frequency of high or extreme temperatures, which result in heat waves; severe droughts which lead to food insecurity, particularly among the poorest of the poor; scarcity of water resources; severe floods that often lead to outbreaks of water-borne diseases and infrastructure destruction; and increased incidences of malaria and wild fires (Byakika 2009). These extreme weather and climatic events now characterize the weather and climatic patterns in all parts of the world; and the housing infrastructure or shelter has been the most obvious victim.

Climate change impacts have manifested themselves in a variety of ways; which include the melting of ice caps on tropical mountains, especially the retreating ice caps over the mountain ranges in Uganda. The ice cap on the Rwenzori Mountains, which has three peaks (Mounts Baker, Speke and Stanley), is also fast retreating. The rate of ice loss is highest on Mount Baker at 96%, followed by Mount Speke at 91%. Mount Stanley has the lowest rate of ice loss at 68%.

The melting of the ice caps on the tropical mountains has a negative effect on the water catchments downstream, eco-tourism, agriculture and the overall economy. Because of the way it affects the flooding frequency of rivers sustained by the mountain glaciers, it is bound to have a major impact on the settlements downstream due to the increased frequency of flash floods that follow a reduced glacier. The cultural loss cannot be measured.

The poorest in the lowland communities who tend to settle at the lowest points or on landslide-prone areas will be the most affected. There is also an increase in the frequency and intensity of weather-related diseases such as cholera and malaria. The health implications of flooding are likely to be worsened by increased climatic changes, while temperature rise has led to increased malaria episodes among the highland areas, where it was hitherto non-existent.

The costs of indirect impacts of flooding are much higher than those of direct impacts. In addition to malaria incidences, floods may also increase respiratory infections, skin infections and diarrheal diseases.

This health status has a direct impact on housing and settlements. The prevalence of mosquitoes and other pathogens can be checked by adequate housing. The direct impacts on housing by floods include destruction of habitats and other related infrastructure such as roads, housing and water sources. Others include an increased frequency of droughts, increased forest fires, and fires within slum areas in large cities such as Nairobi in Kenya and Kampala in Uganda.

The impacts of drought are different for urban and rural areas. In rural areas, the building materials, which are mostly grass, wood and fibres are rapidly disappearing. The grass-thatched houses are highly vulnerable to bush fires, which are more frequent during drought times.

In the urban environment, the most affected are the poor who live in slum settlements. The fire hazard is real, and a single spark can destroy a huge slum area, affecting hundreds of thousands in some cases. In the affluent areas, the impact is felt in terms of energy bills, lack of water to handle sanitation and inadequate architectural designs of the housing units.

Another impact of prolonged drought is scarcity of water for production and household use. Prolonged and severe droughts lead to low water levels in rivers, underground aquifers and reservoirs, affecting the hydrology, biodiversity and water supply. The 1999–2000 and 2004–2005 drought caused severe water shortage in Uganda, leading to loss of animals, low milk production, food insecurity, high food prices and migration from rural to urban areas by some groups. As the water levels in Lake Victoria went down, people settled on the lake basin, but had to scurry to safety when their settlements were later reclaimed by the lake when floods set in.

9.3.1.2 Climatic Change and the Major Concerns

All developments and housing construction have environmental impacts. The housing construction industry produces buildings and infrastructure, which constitute one of the largest exploiters of natural resources, both mineral and biological – thereby causing environmental impacts of various dimensions. Climatic change and climate variability is intricately related to housing and settlements.

The most important concern for the poor is whether they will survive the negative impacts of climate change. African countries, especially those in sub-Saharan Africa are conscious of the fact that they have done the least to cause climate change; and yet they are the ones who will bear the heaviest impact of climate change. The activities that are commonly associated with housing in Uganda, and the potential climate change impacts or feedbacks or consequences are examined below.

9.3.1.3 Analysis of the Causes and Effects of Climate Change

Global warming is the result of increased anthropogenic greenhouse gases in the atmosphere. The science of global warming has been elaborated elsewhere in greater detail. However, for a small economy like that of Uganda, the general GHG emissions are not significant enough to cause global warming. Some activities in the housing sector can, and do lead to increased warming and subsequently contribute to climatic change, albeit in a small way. These are

- *Building construction materials and resource deterioration:* Construction activities in both developing and industrialized countries consume lots of construction materials. Their production causes loss or deterioration of land and water resources (land degradation). Huge amounts of cement are in use and yet

its production is one of the major causes of GHG emission. This contributes directly to global warming and climatic change. In Uganda, clay bricks and tiles are made using traditional earth kilns whose trademark is the huge consumption of fuel-wood and destruction of forests. Clay bricks are produced from wetlands, which lead to increased methane production (methane is a powerful greenhouse gas). The construction industry is currently the principal user of tropical hardwoods and their products, contributing substantially to the loss of tropical forests and the most important carbon sinks. It is important to revolutionize housing construction in order to take into account the need to increase climatic change mitigation and allow communities to adapt to the negative impacts of climate change.

- *Housing in wetlands and flood-prone areas:* House construction has invaded the wetlands and vulnerable or fragile landscapes in many parts of the country, particularly in the urban centres. This has often resulted in considerable discomfort, loss of property, injury and even loss of life. A good example is houses and buildings which have been constructed in the “drain-off flats” of Ndejje near Zana on Kampala/Entebbe Road, Kinawataka wetlands and along the Nakivubo channel wetlands (Government of Uganda 1992). At the moment there are serious floods whose frequency is expected to increase on account of climatic change. These areas are negatively impacted with settlements flooding and the collapse of sanitation system. The impacts have included a number of health-related impacts such as cholera outbreaks.
- *Clearing of vegetation: deforestation associated* with the construction of settlements and housing can cause loss of land by soil erosion, silting of reservoirs and disruption of aquatic ecosystems. This may in turn lead to sedimentation of rivers, increased flood risks in low-lying areas, pollution of rivers and coastal areas, particularly along the shores of Lake Victoria. Climate change induced floods will be amplified, leading to destruction of settlements within these flood-prone areas. Uganda has experienced an increase in flooding over most wetlands, and to the northeastern districts surrounding Lake Kyoga (Teso region).
- *Removal of soil and cutting of slopes:* In the highland areas such as Kabale, Kisoro, Fort Portal, Kasese, Kapchorwa, Mbale and Sironko, among others, the soils are usually unstable and susceptible to slipping and sliding. Improper placement of houses and settlements can add to soil instability and contribute to land slippage, slides, and avalanches. This was the case during the 2006/2007 El-Nino that saw widespread flooding and land slides in Mbale and Kasese districts, leading to loss of life and settlements. With increased climatic change, these impacts will increase in frequency and magnitude unless mitigation measures are put in place.
- *Urban sprawl/unplanned urbanization:* Currently the expansion of settlements and housing within the towns and rural settings is taking place at the environment’s expense, with significant consequences on climate and climatic change related impacts. This is self-evident around major towns such as Kampala, which is surrounded by a ribbon of wide green valleys, with swamps and low land forests extending into the rural hinterland of the city.

According to Uganda's State of the Environment Report (NEMA 2000), the fast-expanding, unplanned urban settlements and other construction activities pose a serious danger to environmental components such as wetlands, forests, water resources and the natural landscape of Kampala. Proliferation of informal settlements has taken a toll on wetlands and lowland forests in many towns, especially around the major towns such as Kampala, Jinja, Kabale, Mbale and Fort Portal, among others. In Kampala, analysis of land-use land-cover change reveals that agricultural land decreased from 62% in 1994 to 45% in 2004, mainly to give way to housing, settlements and industrial establishments. Lowland forests also changed from 7.6% to 0.4% of the total land area. This change implies the loss of swamp forests to land uses such as industrial and residential developments.

Swamps, which are mainly covered by papyrus, also reduced over the 10-year period, that is, between 1994 and 2004, from 20.6% to 1.9% of the land area. Change rates indicate that industrial land use and built-up cover changed at annual estimates of 8.9% and 15.7%, respectively. This loss rate of natural "cover" is symptomatic of environmental degradation driven by urban expansion. This means that Uganda's contribution to global warming and climatic change is on the rise while at the same time settlements that will be affected by the increased intensity of flooding and severe weather events are on the rise.

9.3.1.4 Effects or Impacts of Climate Change on Housing and Liveable Cities

Climatic change is likely to curtail the attainment of the MDGs by 2015. Housing will be greatly affected, especially in the poor urban areas in Uganda. A report by Robert Byakiika, the Executive Director, Environment Management for Livelihood, states that the urban poor will be the most affected by climatic change. The report states that most cities in Africa, including Kampala, are experiencing an increased frequency of heat waves. This has been attributed to the diurnal cycles of absorption, re-radiation of solar energy generated by buildings. The increased heat frequency stress events in cities have affected the health and lifestyles of urban populations (Magezi SAK 1985). Apart from land use related emissions, there is a high rate of GHG emissions related to transportation within the city. According to a study on UNFCCC and the Transport Sector (Magezi 1998), about 70% of Uganda motor vehicle fleet is accommodated within Kampala city, leading to a serious traffic congestion problem. The same study estimates that up to 15% of the fuel consumed is wasted during traffic jams in the city, a finding that has since been corroborated by Anna Tibaijuka (UN-HABITAT) who observed that urban areas directly account for 50–60% of human green house gas emissions.

The high urban population growth rate, which is almost 5% per annum for Kampala, has resulted in increased pressure on the green areas within the city and increased emission of GHGs. This is evident from the poor waste management, which results in the emission of methane gas (if it is organic) or carbon dioxide (if it is burnt). As stated elsewhere in this report, the second direct impact of climatic

change in Kampala has been the increased frequency of floods. These tend to affect the poorest who build in wetlands and other hazardous or fragile ecosystems. Apart from the waterborne diseases that come with the floods, houses and properties are flooded and destroyed. The flooding of the sanitation system, which mostly comprise of pit latrine further spreads waterborne diseases. There is currently no government attempt to protect the poor. The government lacks the capacity and resources to control or police the construction of illegal settlements. Some local communities attempt to adapt to flooding by raising their pit latrines. Households in the affected zones elevate their beds by propping them on bricks so as to avoid getting their beddings wet in case of floods.

During droughts, the main hazard among the slum dwellers and markets is increased fires.

9.4 Environmental Policy Goals in Uganda

Housing is central to all human activity, productivity and the entire economy. There is therefore a need to be cognizant of the various cross-sectoral policies, legal and regulatory frameworks for harmonization and co-ordination. Currently, there is no comprehensive housing policy, although there is the National Shelter Strategy, which lays out the necessary framework for orderly and integrated development of the housing sector (Government of Uganda 1992). There is no climatic change policy per se as far as housing and settlements are concerned. Various laws and regulations address some of the key climatic change concerns as a matter of routine.

Key among these laws is the Uganda Constitution, which sets the tone for all other legal and regulatory frameworks. It asserts,

Under the National Objectives and Directive Principles of State Policy, the state shall endeavour to fulfil fundamental rights of all Ugandans to social justice and economic development, and shall, in particular; ensure that all Ugandans enjoy, among other rights and opportunities, the right to a decent shelter (XIV).

With the benefit of foresight now, it can be said that decent shelter takes into account climatic change mitigation and adaptation. There are various other legislations which individually address some aspect of housing, from environment to health, town and country planning. None of these directly address the issue of climatic change and settlements.

The UNFCCC and Kyoto Protocol were formulated within the overall context of various policy and legal frameworks for sustainable natural resource management. These laws and policies, taken together and when implemented, are expected to contribute to the achievement of national sustainable development and poverty eradication goals (National Environment Management Authority 2004).

It is important to remember that these guidelines address climatic change by default. They were not specifically designed with the concept of climatic change in mind; hence the need to put in place a separate national climate change policy.

The Uganda government is working towards this option, and a housing policy that takes into account the current knowledge and concerns regarding climate change and climate variability will need to be developed.

9.4.1 Achievements of These Goals and Major Challenges

A sensitization success level has been achieved as there are a growing number of people who are aware of climatic change; although this number is yet to reach a critical mass where mitigation and adaptation measures against climatic change will be taken automatically. Majority of the people are more interested in short-term gains, yet investment in climatic change schemes take longer to mature.

9.4.1.1 Institutional Arrangements to Combat Climate Change in Uganda

In recognition of the challenges posed by climate change, the Ugandan government is establishing appropriate institutional, policy and legal arrangements to handle these issues. Although there has been no specific policy in place, the existing policies and laws were able to handle a number of climate change concerns, particularly in respect to adaptation and mitigation. A climate change unit whose main objective is to coordinate all climate change concerns in the country has been created within the Ministry of Water and Environment. This unit will also spearhead policy formulation.

The unit is guided by a national climate change steering committee and the Minister responsible for policy evolution and matters related to UNFCCC and the Kyoto Protocol. For KP and Clean Development Mechanism (CDM) implementation, a National Designated Authority (NDA) has been put in place. The Environment Minister is the national designated authority, unless legislation is concluded to vest this authority to another body.

9.5 Lessons Learnt and Recommendations

Climate change and climate variability will make it difficult for the country to attain the MDGs by the year 2015. This will affect the whole MDGs range, including certain goals in the housing sector highlighted below.

Due to land shortage and increasing numbers of the urban poor, the poor, who are mainly settled along the wetlands and other fragile ecosystems, will be most affected by climate change and climate variability. Being the ones with the least capacity to adapt to the negative impacts of climatic change, the poor will bear the blunt of climate change effects. In Kampala, a large part of the city lies within a

wetland, and many other regional cities have wetlands within their proximity, where the poor and slum dwellers tend to settle. The poor and slum dwellers are therefore the first victims whenever it floods. Apart from their dwellings being washed off by the floods, they are worst hit by waterborne diseases that come with the increase in the frequency of floods and heavy rains. Such diseases include cholera, malaria and diarrhoea. During drought, it is the same communities that are threatened by fire outbreaks and drought-related diseases such as meningitis and upper respiratory infections. Until now, the concept of climatic proofing development has not been thought of in Uganda.

The rich have also not been spared by climate change impacts. Areas such as the rich neighbourhoods of Muyenga in Kampala are unplanned for, giving rise to the concept of the rich man's slum. The buildings are not built with the concept of the local climate in mind and have not taken into account the rising future temperatures - raising the possibility of the use of artificial cooling systems.

Sanitation in these houses is usually composed of in-situ septic tanks, which are ideal during the normal Kampala rainfall season. However, with increased occurrences of severe rainstorms, the risk of landslides in these areas increases considerably. No one has thought of this so far; but it is easy to imagine a landslide carrying fully loaded septic tanks from the affluent to contaminate a large part of the city.

9.5.1 Uganda's Progress on MDGs

Uganda has made significant strides in reducing poverty. The population living below the poverty line reduced from 56% to 31% between 1992 and 2006 (UNDP Kampala 2007). If this trend continues, prospects of achieving the income-poverty target of less than 10% by 2017 remain high – provided that the 'business as usual' scenario regarding climate change is dropped.

Uganda's approaches the implementation of this goal through a number of initiatives that include:

- Prosperity for All (PFA)
- Poverty Alleviation Fund (PAF)
- Poverty Eradication Action Plan (PEAP) and
- A number of initiatives at national and local levels

PFA focuses on increased agricultural output so as to raise the income of the poorest to at least USD\$ 10,000 per household. It has to be noted that climate change and variability is the main challenge to agricultural production in the country.

Today, increased severe weather events such as droughts and floods are a threat to agricultural production. Increased warming, especially in the highlands, is another threat to agricultural production. If Uganda achieves her target of reducing poverty, it will then be possible to fulfil MDG Goal Seven (Target Two) which is aimed at improving the lives of slum dwellers; but climate change stands in the way of achieving this goal.

9.5.1.1 Possible Initiatives at the City/Country Levels

The most important strategy for addressing the MDGs is that of addressing the biting poverty that affects the poorest, especially the urban poor, who are the most neglected. The physical infrastructure should respond to climate change challenges by observing the following:

- A well thought out urban physical plan that takes into account the disaster-risk-prone areas. It is important to note that up to 90% of natural disasters in Uganda are weather, climate and water related. These will continue to increase, and will mostly affect the urban poor those living within fragile ecosystems.
- Mandatory climate proofing of development, especially in infrastructure development. By doing this, housing developments will not suffer the impacts of floods or other climate related hazards in the future.
- Environmental impact assessments that are now mandatory for large infrastructure developments including housing should expand their horizon to include climate impact assessments.
- Use of renewable energy at the household level should be enforced by law where appropriate, taking advantage of the available renewable energy resources in the tropics and sub-Saharan Africa. In particular, solar energy should be harnessed to supplement traditional energy resources.
- Regarding mitigation, the main challenge in the cities has been traffic congestion, which leads to increased GHG emissions. Various studies have proposed the re-planning of the road networks within the city with the aim of reducing traffic congestion (Otiti et al. 1994). Such a master plan should aim at decongesting the city so that housing and business centres are well spread out.
- In order to reduce traffic jams, over production of GHGs in Kampala city and improve the overall mobility of traffic and people, the authorities will need to re-plan and continuously upgrade the plans by creating satellite urban centres.
- To further reduce poverty and improve climatic proofed urban settlements, it will be necessary to enhance the capacity of urban authorities and stimulate investments for generating jobs and to provide the services and infrastructure necessary to sustain urban living and livelihoods.
- Since women and children are the ones mostly affected by climate change and climate variability, it is important that they are involved or consulted in the planning, design and development of housing projects and programmes, bearing in mind that they are the major users of housing in most households and are therefore most affected when there is poor or un-safe housing or shelter.

9.5.1.2 Mitigation and Adaptation Initiatives

There are two ways to handle climate change. The first one is mitigation, where one tries to remove the emissions from the atmosphere, or adaptation, where one tries to adapt in spite of climate change. Because Uganda's and indeed Africa's emissions are so low compared to the global average, whatever mitigation measures Uganda puts in place, the impact to the overall global emissions is likely to be insignificant. The main

option is to adapt, except in cases where mitigation measures make business sense and are in line with Uganda's sustainable development criteria (Magezi et al. 2002).

Adapting to climate change is increasingly being recognized as significant to the attainment of sustainable development, and essential for the achievement of many global environmental objectives, including the attainment of the MDGs. The capacity to adapt is determined by access to resources, information and technology, skill and knowledge to use them and the stability and effectiveness of cultural, economic, social and governance institutions that facilitate or constrain how human systems respond. This is where the Least Developed Countries (LDCs), with the support of development partners as enshrined in the United Nations Framework Convention on Climate Change, should put their efforts.

The other important aspect enshrined in the convention and to which most of the LDCs in sub-Saharan Africa have only paid lip service is the systematic observations by way of monitoring and assessing climate change and climate variability. Often, local communities do not know how much and what to adapt to. This is because weather and climate observations are not being carried out. When available, such information is not factored in the development process. Unless developing countries factor weather and climatic information in their development processes, and develop adaptation strategies, their development cannot be sustainable. It is becoming increasingly important to climate-proof development; or else it will be difficult to ensure that current developments, including developments in the housing sector, will stand the test of future climate changes – hence the need for accurate weather and climate information as provided by national meteorological services.

9.6 Recommendations and Experiences

It is apparent that climate is at the centre of sustainable development. It has a large impact on housing and personal comfort.

An integrated approach to development that factors climate change into the development process is crucial. Although a lot has been done on housing climatology, more needs to be done. The information provided by the climatologists must be factored into the housing and urban plans. At the end of it all, all development projects, including housing projects, should be climate-proofed.

Finally, most of the cities in the developing world have very few atmospheric monitoring stations. Neither the weather nor the state of the atmosphere is being monitored. It will not be possible to develop climate and environment-responsive urban development models without this vital information.

References

- Bwango A, Magezi SAK, Turyahikayo G (1996) Inventory of sources and sinks of Green House Gases in Uganda. Ministry of Natural Resources, Uganda
- Bwango A, Magezi SAK, Hatanga P, Dribidru E (1998) Vulnerability assessment and adaptation measures to climate change in Uganda. Ministry of Natural Resources, Uganda

- Byakika R (2009) Urban poor most affected by climate change. Daily Monitor, Kampala
- Government of Uganda (1992) A National Shelter Strategy for Uganda, vol 1 (II). Department of Housing, Ministry of Lands, Housing and Urban Development, Kampala
- Government of Uganda (2007) Climate change: Uganda national adaptation programmes of action. Department of Meteorology, Kampala
- Government of Uganda. Background to the Budget 1993/94, 1994/95, 1995/96, 1996/97. Ministry of Finance and Economic Planning
- Kayizzi R (2008) Housing, construction sectors boom: 20 years of economic recovery, New Vision – Uganda
- Magezi SAK (1985) Atmospheric urban pollution potential with emphasis on the tropics. MSc dissertation, University of Reading
- Magezi SAK (1998) Green House gas emissions in the transport sector – Uganda. African Energy Policy Research Network, pp 60
- Magezi SAK, Onduri F, Philip G (2002) Initial national communication to the United Nations Framework Convention on Climate Change. Ministry of Water, Lands and Environment. A Government of Uganda publication
- National Environment Management Authority (2000) State of the environment report for Uganda
- National Environment Management Authority (2004) Environment legislation of Uganda
- National Environment Management Authority (2005) State of the environment report for Uganda (2004/2005)
- Otiti T, Magezi SAK, Turyahikayo G (1994) An assessment of African policy options and responses to climate change – Uganda country report
- United Nations Development Programme (2007) Uganda Human Development Report. UNDP, Kampala
- World Wildlife Fund for Nature (WWF) (2006) An analysis of the glacier surface area loss in the Rwenzori mountains in the last 100 years

Chapter 10

Housing and Climate Change: Adaptation Strategies in Vietnam

Vinh Hung Hoang

10.1 Introduction

Vietnam is one of the most disaster-prone countries in the world. About 70% of the country population is vulnerable to typhoons and tropical storms, flooding and landslides. The most recent climate change projections by the Intergovernmental Panel on Climate Change (IPCC 2007) indicate that Vietnam will be especially hard hit by sea level rise and by more intense and frequent extreme weather. The vast majority of the population is either involved in the agricultural sector or dependent upon natural resources; their livelihoods therefore are influenced by climatic change. Industrial and urban developments are mostly located on the coastal areas and plains that are susceptible to typhoons, tropical storms, sea surges, salt intrusion and sea level rise.

This chapter reviews Vietnam's natural, socio-economic conditions and trends in climate change. It examines impacts of climate change on the country's economic development and housing. It also analyses institutional arrangements and strategies on climate change. The chapter ends with lessons learnt and makes recommendations for building adaptive capacity and effective mechanisms for coordination, mainstreaming the integration of climate change adaptation and disaster risk reduction into socio-economic development strategies, and satisfying resources requirements.

10.2 Vietnam's Development and Climate

Located in a disaster-prone region, Vietnam has made impressive progress in economic development and poverty alleviation during the last 2 decades. However, the recent and future trends in climate change will challenge this progress further, forcing the Vietnamese government and its people to seek adaptive measures.

V.H. Hoang (✉)

Hanoi University of Architecture, Thanh Xuan, Hanoi, Vietnam
e-mail: hvhung.hau@gmail.com

10.2.1 Geographical Location and Socioeconomic Trends

Vietnam is located in Southeast Asia. It has a long, narrow land mass of 330,992 km² that stretches 1,650 km from north to south, with a 1,400 km border to the north with China and, to the west, a 2,067 km border with Laos and Cambodia. To the east and south, a 3,260 km coastline straddles the South China Sea. There are two offshore archipelagoes: Hoang Sa (Da Nang province) and Truong Sa (Khanh Hoa Province) and a further 3,000 small islands. About three quarters of the country is mountainous and hilly (from 100 to 3,400 m in height). The lowland areas include the deltas of two large rivers, the Red River in the north and the Mekong River in the south; there is a complex river network comprising over 2,360 rivers.

Since 1986, Vietnam has shifted economic policy from a centrally planned economy to a socialist, market-based one. Decision-making was decentralized, foreign investment was allowed and individuals began to play a greater role in investment decisions. These factors stimulated significant economic growth, doubling the size of the economy (Swinkels and Turk 2003) and helped pave the way for community-driven rural development projects.

Along with the economic growth, there has been an impressive impact on poverty alleviation for the country's population of almost 85 million. Per capita GDP doubled from US \$200 to US \$400 during the 1990s, before reaching US \$835 in 2007 (GSO 2008). Recent household surveys highlight this success in reducing poverty. From 1993 to 2008, the poverty rate, based on per capita consumption, fell from approximately 58% in 1993 to 12.4% in 2008, indicating a fall of almost 46% over a period of 15 years. The rate of poverty in 2008 was just a fifth of that of 1993¹ in absolute terms – some 30 million people were lifted out of poverty over this period.

10.2.2 Climate and Recent Trends in Climate Change

Vietnam experiences a tropical monsoon climate. Due to the wide range of latitudes and the diversified topography, the climate varies considerably from one region to another. The mean annual temperatures in different regions range from 18°C to 29°C, and a distinct seasonal difference is felt between the dry season from November to April, and the warm rainy season from May to September (MONRE 2008). The northern regions experience more distinct seasonal variations in average temperature than the south. In the northern provinces, average temperatures drop to 15–20°C in winter, down from summer temperatures of 22.5–27.5°C; whilst in the south temperatures drop to 26–27°C from a high of 28–29°C (MONRE 2008; UNDP 2008a).

¹A significant achievement when benchmarked against the Millennium Development Goals of halving extreme poverty over the period from 1990 to 2015.

The mean annual rainfall varies in different regions from 600 to 5,000 mm, about 80–90% of which is concentrated in a short rainy season (from May to September/October), which produces a rapid run-off rate, frequent flooding and landslides. The uneven rainfall distribution during the year is one of the main causes of river flooding and inundation during the rainy season in several regions, whilst in the dry season, drought is often recorded. There are 60–200 rainy days in the year depending on the region (MONRE 2008).

The location and topography of Vietnam make it one of the most disaster-prone countries in the world. It suffers from typhoons, tropical storms, floods, drought, seawater intrusions, landslides and forest fires (Jegillos et al. 2005). The country's topography is divided into three distinct regions: northern, central and southern; which may be further sub-divided into five principal hazard zones, each with a different geography and topography, and principle hazard types (Table 10.1).

Of these disasters, the most damaging and frequent are typhoons, tropical storms and floods. Annually, the northern and central regions are affected, on average, by 6–8 typhoons or tropical storms from the South China Sea; which also occur, albeit less frequently, in the southern areas. Over the last few decades, damage arising from disasters has increased dramatically (Table 10.2), a trend that is likely to continue in the future as climate change is expected to alter the current storm system and rainfall patterns.

As noted in the Report on climate change in Vietnam by the Ministry of Natural Resource and Environment (MONRE 2008), past observations of climate data in Vietnam show the existence of change in climatic factors. The report also provides detailed predictions on climate change and its direct impacts; the most important of which are summarized in (Table 10.3).

A recent study (VARG 2006: 33) stated that: “Climate change is expected to bring increased disaster risk to Vietnam, mainly from changes in precipitation and typhoons. The amount of rainfall is generally expected to increase, and may become more intense. Storms may become more frequent, stronger or patterns of storm tracks may change. If not properly dealt with, such changes in precipitation and storms will lead to an increased frequency and magnitude of flash floods, seasonal river floods and coastal floods in many parts of Vietnam. Sea-level rise of between

Table 10.1 Typology of climate related hazards by region

Topographical region	Zone	Main hazards
Northern	Northern upland region	Flash floods, landslides, earthquakes
	Red River delta	Monsoon river floods, typhoons, coastal storm surges
Central	South central coast	Typhoons, storm surges, flash floods, drought, saline water intrusion
	Central highlands	Flash floods, landslides
Southern	Mekong River delta	River flooding, typhoons, high tides and storm surges, salt water intrusion

Source: CCFSC 2007

Table 10.2 Summary of natural disasters in Vietnam from 1900 to 2008

		Number of Events	Killed	Total Affected	Damage (000 US\$)
Droughts	Droughts	5	–	6,110,000	6,49,120
Epidemics	Unspecified	1	16	83	–
	Bacterial infectious diseases	1	598	10,848	–
	Parasitic infectious diseases	1	200	–	–
	Viral infectious diseases	7	368	17,823	–
Floods	Unspecified	7	836	1,150,175	13,400
	Flash floods	9	293	213,603	59,200
	General floods	36	3173	19,887,410	1,946,925
	Storm surges/coastal floods	6	804	4,353,316	749,000
Insect infestation	Unspecified	1	–	–	–
Mass movement	Avalanche	1	200	38000	–
	Landslides	4	117	1,073	2,300
Storms	Unspecified	9	298	36,780	1,035
	Local storms	7	144	4,450	10,100
	Tropical cyclones	63	18119	41,908,049	3,269,270
Wildfires	Forest fires	1	–	–	–

Source: CCFSC website 2009 and EM-DAT 2009

Table 10.3 Change in climatic factors of Vietnam

Change of climatic factors		Important predictions on the impact of climate change
Temperature	Annual average temperature of Vietnam has increased by 0.7°C in the period 1951–2000.	Average temperature is estimated to increase by 2.5°C in 2070.
	Average temperature in the period 1961–2000 is higher than that of the 3 decades from 1931 to 1960.	Inland average temperature (mainly in the highlands) will increase by 2.5°C.
	Average temperature of the period 1991–2000 in Hanoi, Da Nang, and Ho Chi Minh city is higher than that of the decade between 1931 and 1940–0.8°C, 0.4°C and 0.6°C respectively. Average temperature of 2007 of the three cities is higher than that of the period 1931–1940 by about 0.8–1.3°C, and that of 1991–2000 by about 0.4–0.5°C.	Average temperature of the coastal area may increase by 1.5°C. Annual average high and low temperatures are expected to increase. The number of days experiencing temperatures in excess of 25°C will increase, which will affect the ecosystem and farming season.
Rainfall	The trend of change in rainfall in different regions of Vietnam has not been clear: while in some decades it increased, in some cases it decreased.	Northern and southern areas are affected by the southwest monsoon but the seasonal rainfall decreases in July and August before increasing from September–November.

(continued)

Table 10.3 (continued)

Change of climatic factors		Important predictions on the impact of climate change
Floods and drought		In the centre, the rainfall will increase by 19% by 2070. Evapo-transpiration rate will increase due to increasing temperatures; as rainfall would be concentrated in the rainy season. Rainfall in the dry season will decrease by 2070 in the central zone, where droughts will occur more frequently.
Tropical storms and typhoons	In the last decades, the number of intensified typhoons increased.	Previously, the north experienced typhoons in August, while the centre experienced them in October; the south had typhoons in November. However, typhoons are now occurring later and more southwardly.
	Typhoons were occurring later, more southwardly with abnormal orbit.	Sea surface temperatures are set to increase in the higher latitudes of the Pacific Ocean, causing more typhoons in the North-West Pacific Ocean that will affect Vietnam; a predicted rise in sea surface temperatures would cause wind speed in typhoons to be sustained over a longer period, making their intensity stronger (especially in an El Niño year).
Sea level rise	Sea levels in Cua Ong and Hon Dau gauging stations have increased by 20 cm over the last 50 years	Sea level is expected to rise by about 9cm by 2010, 33 cm by 2050, 45 cm by 2070 and 1 m by 2100.

Source: Dasgupta et al. 2007; MONRE 2008

30 cm and 1 m within the next 100 years is expected, which may increase the flood risk in low-lying coastal areas. As temperatures in Vietnam increase, droughts can become more frequent and intense.”

10.3 Global Climate Agreements and Their Impact on Vietnam

Action for responding to climate change and disaster risk reduction initiatives began simultaneously on the international front as set out in Fig. 10.1. Parallels can also be drawn in the shifting emphasis of policy action in both these fields.

Adaptation, as a response to climate change, was recognised in the early statements on the issue; however, it has been emphasized only recently in international UNFCCC discussions, which stress on facilitating adaptation in developing countries, and on new funds being mobilized to finance adaptation interventions. A similar shift in the focus of disaster risk reduction policies is observed. The initial action on disaster risk reduction focused on relief and response, gradually shifting to the theme of vulnerability reduction.

Recent developments in these fields have addressed the need for, and possibilities of, integrating adaptation to climate change and disaster risk reduction. The IPCC Third Assessment Report (2001) states that adaptation to climate change needs to address climate variability and extremes as well, and not just the long-term changes in average conditions. The approach to adaptation should therefore focus on reducing vulnerability of regions and sectors to climate change, including climate variability and extremes. Integrating climate change adaptation with disaster risk reduction strategies has also been put forth by the Hyogo Framework for Action (2005). In the action plan for risk reduction, the Framework contends that the impacts of geological, hydro-meteorological hazards, and those resulting from climate change and variability, need to be addressed in sector development planning and programmes, as well as in post-disaster situation. These global agreements have had a positive impact on Vietnam’s policies and initiatives on climate change and disaster risk reduction, which is specifically mentioned below.

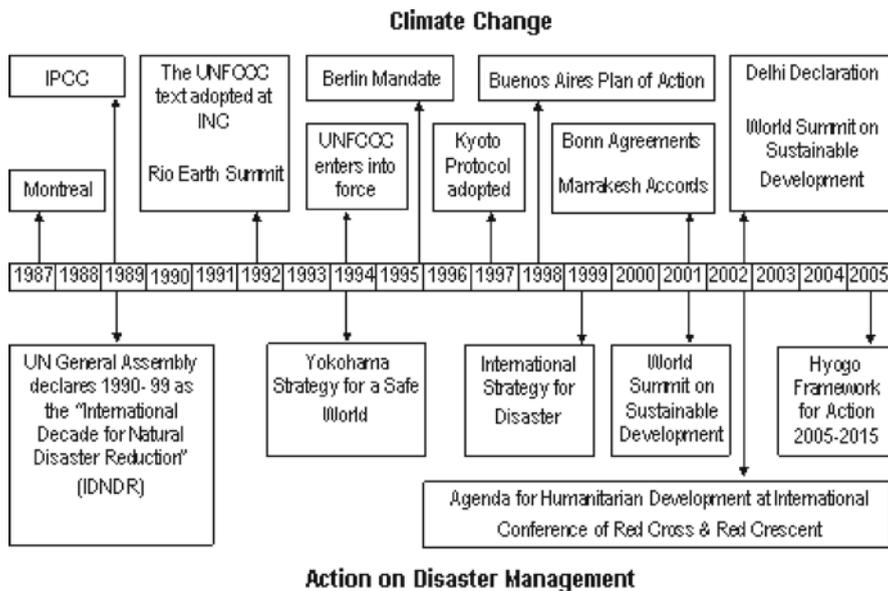


Fig. 10.1 Timeline of developments in climate change action and disaster management (Source: Patwardhan and Meeta 2007)

10.3.1 Climate Change and Major Concerns

Climate change will put the socio-economic development of Vietnam at risk. The number of institutional and policy arrangements have been devised to adapt with the change. However, along with a few achievements, critical challenges to the country's future development still remain.

10.3.1.1 Impacts of Climate Change on Economic Development and the Poor

Expected climate patterns, and how they relate to water resources, agriculture, forestry, aquaculture, fisheries and the coastal zones, energy and transportation, human health and various adaptation options are summarized in the [Annex](#).

Despite significant economic gains, Vietnam remains a low-income country². Economic and social reforms have helped decrease the incidence of poverty from about 58% in 1993 to 12.4% in 2008, but progress remains uncertain. A significant proportion of Vietnamese people – some 28 million – live just above the poverty line; and a slight variation in the definition of poverty can push them below that line, pushing the poverty rate up. The lives, health and property of the country's poor are at greatest risk from hydro-meteorological disasters. Climate change will directly impact on poor people's livelihoods; largely through a decline in common property resources that they depend on (fisheries, rangelands or forests). The poor's health, access to water and natural resources, as well as their property, will also be adversely affected.

Climate change is expected to influence various dimensions of human wellbeing such as: (i) energy, food and water supply and consumption – e.g. supply and demand, structure efficiency, cost; (ii) accessibility – e.g. to businesses and households, infrastructure, transportation; (iii) affordability – e.g. investments, income distribution, housing; (iv) environmental impacts – e.g. climate change, pollution, biodiversity, waste, water; (v) health – e.g. life expectancy, nutrition, health services; and (vi) educational status and access to education – e.g. literacy rates, school enrolment (Swinkels and Turk 2003). Various national development planning efforts and studies have identified the relationship between human wellbeing, Millennium Development Goals (MDGs) and Vietnamese development goals, and in some cases, their relationship with climate change (Fig. 10.2).

10.3.1.2 Impacts of Climate Change on Housing and Liveable Cities

Climate change threatens the socio-economic development of Vietnam as well as the health, livelihoods, and property of its inhabitants (Dasgupta et al. 2007).

²This is expected to change by the end of 2010 as the country's GDP per annum is expected to be above that of a low income country.

Changes in mean climate, variability, extreme events and sea level rise	Impact on poverty	Impact on the MDGs
Increased temperatures and changes in precipitation reduces agricultural & natural resources	Lowered industrial output and labour productivity, high inequality, impacts on trade, and fiscal and macroeconomic burdens lead to reduced economic growth and its poverty-reducing effects	Goal 1: Eradicate extreme poverty and hunger
Change in precipitation, run-off and variability leads to greater water stress	Reduced productivity and security of poor people's livelihood assets , and reduced access for the poor to their livelihood assets	Goal 2: Achieve universal primary education
Increased incidence or intensity of climate related disasters leads to damage to infrastructure	Less effective coping strategies among the poor, and increased vulnerability of poor people	Goal 3: Promote gender equality and empower women
Temperature, water and vegetation changes contribute to increased prevalence of disease		Goal 4: Reduce child mortality
		Goal 5: Improve maternal health
		Goal 6: Combat HIV/AIDS, malaria and other diseases
		Goal 7: Ensure environmental sustainability
		Goal 8: Promote global partnerships

Fig. 10.2 Impact of climate change on poverty and the MDGs (Source: DFID 2001)

A great majority of the country’s urban development lies in coastal areas and flood plains susceptible to typhoons, tropical storms, storm surges, salt intrusion, and sea level rise. Improper local planning and governance, structural poverty, substandard infrastructure, high population densities and concentrations of economic assets intensify these dangers. If such issues remain unaddressed, climate change impacts will multiply current threats, increasing risk to intolerable levels for urban communities in Da Nang, Can Tho, Ho Chi Minh City, Hai Phong, Hanoi and elsewhere (Hung 2008).

Vietnam has been experiencing a rapid urbanization process. Vietnam’s GDP averaged 8.9% per year from 1992 to 1997, 6.8% from 1997 to 2004, and an impressive 8.48% in 2007 (GSO 2008). Most of her economic growth (about 70%) has taken place in the industrial, construction and service sectors, which are concentrated in large urban centres, particularly in Hanoi, Ho Chi Minh City, Da Nang and Hai Phong. As a result of this growth, the number of rural to urban migration has increased, accelerating urbanization and putting stress on urban services and infrastructure, particularly housing. In 1980, Vietnam’s total population stood at 53 million (United Nations 2006). Of this number, 19.2% was classified as

urban – 10.2 million. Between 1980 and 1990, the country's urban population increased by 3.2 million. Between 1990 and 2000, urban population increased by 5.7 million. More recently, between 2000 and 2005, urban population increased by 3.1 million (World Bank 2008). Overall, from 1980 to 2005, the percentage of total population residing in urban areas increased from 19.2% to 26.4%. This trend is likely to continue as the United Nations projects that from 2005 to 2030, Vietnam's urban population will increase from 22.2 to 45 million.

While urban population has been steadily increasing, it is projected that extreme climate events will affect urban areas, particularly coastal cities. The number of severe floods, typhoons and sea surges that damaged Hanoi, Ho Chi Minh City, Da Nang, respectively, from 2005 to 2009 has made this projection more convincing. A study on the impact of sea level rise in Vietnam (Jeremy 2007) found that a 1-m sea level rise inundation would directly affect almost 6 million people, or 7.3% of the national population. The most affected province is Ho Chi Minh City with more than 660,000 or close to 12% of the city's population living in areas likely to be inundated. That figure is likely to be significantly higher if inundation zones are adjusted to account for distortions caused by urban high-rise in modelling of inundation zones. Ho Chi Minh City has 7.5% of the national population, making it the most populated and concentrated city in Vietnam. Much of the country's urban population growth of 1 million per annum is in Ho Chi Minh City and other coastal cities. During 2001–2005, more than 366,400 ha of agricultural land in the coastal plains and deltas around Ho Chi Minh City were converted into an urban area or industrial parks to accommodate this rapid growth (GSO 2006). Those areas are now threatened by sea level rise inundation.

The rapid growth of the urban population in a context of increasing natural disaster is another main challenge facing the country's housing strategy and policies, which focus on meeting the housing standard requirement of about 20 m² per person by 2020 (Office of the Government 2004). According to an assessment by the Ministry of Construction, only 50% of houses in cities and 20% in rural areas can cope with floods and typhoons. By 2020, the whole country will need 1.3 billion square metres (720 million for urban areas) of new housing totalling over 16 million houses. To improve the living conditions of residents and help more people, particularly low-income groups, to own durable houses, Vietnam's current and future housing demands are enormous.

Over the past 15 years, investments in all forms of infrastructure and urban development in Vietnam have escalated, mostly within the coastal zone and in the three economic focal areas of northern, central and southern Vietnam. Annually, about 9–10% of GDP has gone to transport, energy, telecommunications, water and sanitation – a very high figure by international standards. Sectoral plans and forecasts suggest an increase in annual infrastructure investment to 11.4% of GDP. The development planning for these facilities, whether by government or international organizations, usually takes flooding into account, but not sea level rise. In 1996, the Vietnam Coastal Zone Vulnerability Assessment and First Towards Integrated Coastal Zone Management Project, a collaboration of the Vietnam and Dutch governments, estimated that under the prevailing climate and sea level

conditions, US \$720 million of capital value was at risk due to annual flooding. It was predicted that in 30 years, this figure may rise by more than ten times due to developments and capital investments in the risk areas. These figures represent 3 and 5% of the annual GDP in 1995 and 2025. With a 1-m sea level rise, the project estimated that US \$17 billion of capital value would be lost through annual flooding, which is about 80% of yearly GDP. In a 30-year development scenario, the loss of capital value would be close to US \$270 billion, higher than the projected GDP at that time. It appears that the damage wrought by climate change will outstrip the GDP growth rate.

Due to the continued economic development and investments, the rate of urbanization will continue to grow to the year 2030 and beyond. Accommodating additional urban population will place further pressures on infrastructure, housing, education and health services, employment etc. It is, therefore, imperative that strategies, policies and measures of climate change adaptation keep pace with processes of the country's further urbanization and industrialization. Failure to do this will prevent Vietnam from meeting its economic and social development goals.

10.3.1.3 Institutional Arrangement to Combat Climate Change in Vietnam

The Ministry of Natural Resources and the Environment (MONRE) has the responsibility of managing resources such as land, water, minerals, the environment, and hydrometeorology. It is also responsible for measuring and mapping, in addition to managing public services, and representing the state's capital in these sectors. The ministry submits to the government the following: legal proposals, ordinances, standards, regulations and all legislative documents relating to the exploitation of natural resources, and hydrometeorology. It also proposes to the government strategies, long and short-term development plans for natural resources. It also organises and implements these laws, plans, etc.

Under the National Target Program to Respond to Climate Change, approved in December 2008, the National Steering Committee, the Executive Board, and the Standing Office have been established: "(a) The National Steering Committee comprises of the Prime Minister – Chairman; Minister of Natural Resources and Environment – Standing Vice Chairman; Minister of Planning and Investment – Vice Chairman; and the Minister of Finance - Vice Chairman; others are the Minister of Agriculture and Rural Development and Minister of Foreign Affairs. (b) Executive Board comprises of the Minister of Natural Resources and Environment – Chairman; two Vice Chairmen (Vice Minister of Planning and Investment and Vice Minister of Finance); other members are representatives of the Ministries of Agriculture and Rural Development, Foreign Affairs, Industry and Trade, Labour Invalids and Social Affairs, Transportation, Construction, Information and Communication, Education and Training, Home Affairs, Health, Science and Technology, Culture Sport and Tourism, Defence, and Public Security. (c) The Standing Office, located at the Ministry of Natural Resources and Environment is an assisting agency of the

Executive Board and its role is to co-ordinate activities of the National Target Program” (Office of the Government 2008: 8).

MONRE was assigned by the Government to assist the Executive Board to coordinate the activities of ministries, sectors, and provinces in managing and implementing the National Target Program. Ministries, ministerial agencies, other governmental authorities and people’s committees from various provinces, and special cities develop and implement their action plans in response to climate change, carry out tasks assigned by the National Target Program, proactively participates in common coordinated activities under the direction of the Steering Committee (Thuc 2008).

The International Support Group on the Environment was established on 16 June 2001. Following the establishment of the MONRE in 2002, the International Support Group on Environment has been put under MONRE and was renamed ‘the International Support Group on Natural Resources and Environment (ISGE).’ Overall, the objective of ISGE is to assist MONRE, other ministries and international donors towards mobilization and better coordination of ODA resources so as to attain government and MONRE plans, priorities, policies and strategies, all geared towards enhanced sustainable management of the environment and natural resources through facilitating functions and activities. From 2006, the ISGE Working Group on Climate Change held several meetings with a range of stakeholders to discuss climate change related matters that were pertinent to Vietnam.

A number of NGOs in Vietnam have been involved in climate change adaptation by way of conducting grassroots and community awareness activities. Vietnam Red Cross activities (supported by the International Federation of Red Cross and Red Crescent Societies) are carried out with an aim to educate both the VNRC staff as well as local communities on the links between climate change and weather risks (NRC 2006). Projects by CECI aim at similar objectives, by developing safer city plans and implementation of disaster risk reduction and adaptation measures at the local level. Recent projects by ICEM, Oxfam and CARE have actively dealt with vulnerability assessment, the linkages of climate change adaptation and disaster risk reduction, as well as the poor (Miltenburg 2006; Shaw et al. 2007; Oxfam 2008).

Currently, there are about 40–50 civil society organizations in Vietnam, but their voice is weak when it comes to dealing with development issues (Ninh 2008). From the middle of 2008, some organizations, particularly the Centre for Environment Research, Education and Development (CERED), and other private sector organizations, have also been involved in the process of tackling climate change by focusing on adaptation strategies.

10.4 Vietnam’s Policy on Environment

A large number of environmental policies and strategies have been elaborated. The most important of these are listed in Table 10.4.

Table 10.4 Chronological order of Vietnam's policy on environment

Date	Main documents and activities
1994	Superseded Law on Environment Protection
1998	The Ordinance No. 36/CT-TW of the Political Bureau of the Communist Party of Vietnam Five Million Hectare Reforestation Program
2000	National Strategy on Environmental Protection to 2010 and Vision to 2020 Strategy of Socio-Economic Development (2001–2010) Five-Year Plan of Socio-Economic Development (2001–2005)
2001	Vietnam Development Goals (MDGs/VDGs) National Programme 135 on Poverty Reduction in Remote Areas The Strategy for Environmental Protection 2001–2010 and vision to 2020
2003	Comprehensive Poverty Reduction and Growth Strategy The Land Law
2004	Strategic orientation for sustainable development in Vietnam (Agenda 21 Vietnam)
2005	Five-year Plan of Natural Resources and Environmental Protection 2006–2010 The Law on Forest Protection and Development Law on Environment Protection (Revised) National Forestry Development Strategy of Vietnam for 2006–2020 The Decision No. 41/NQ/TW of the Political Bureau on environmental protection in the period of intensification of industrialization and modernization of the country Strategy of Socio-Economic Development (2006–2010) Five-Year Plan of Socio-Economic Development (2006–2010)
2006	Decree No. 80/2006/ND-CP detailing and guiding the implementation of a number of articles of the Law on Environment Protection; Circular 08/2006/TT-BTNMT: Circular on Guidelines for Strategic Environmental Assessment, Environmental Impact Assessment, and Commitments on Environmental Protection National Forestry Development Strategy of Vietnam for 2006–2020 Circular 08/2006/TT-BTNMT: Circular on Guidelines for Strategic Environmental Assessment, Environmental Impact Assessment, and Commitments on Environmental Protection International review on Strategic Environment Assessment (2006) Five-year Plan of Natural Resources and Environmental Protection 2006–2010 National Programme on Safe Water Supply and Rural Sanitation
2007	Decision No. 47/2007/QĐ-TTg of the Government to ratify the Action Plan for implementation of Kyoto Protocol of UNFCCC for period of 2007–2010 National Strategy on Environmental Protection to 2010 and Vision to 2020

10.4.1 Vietnam's Policy on Climate Change

Sustainable development has been in the national strategy and policies from 1991 to date. However, with the increased likelihood of disasters and other extreme climate events, coupled with a rising population, and an expected decrease in land area, urgent and careful consideration of climate change adaptation policy development and appropriate legislation are required. Ten steps suggested at that time, most of which are still pertinent today, are enumerated below:

- Consider different strategies to protect those vulnerable to climate change and sea level rise.
- Control coastal ecosystems.
- Consider protection of biodiversity.
- Pay attention to technical measures to sustain productivity in vulnerable areas.
- Push forward research on climate change and preventive measures.
- Consider the impacts of climate change on health.
- Increase social awareness and arm everyone with knowledge.
- Push forward research on sea level rise.
- Increase co-operation on national and international levels, especially among nations sharing a south-east Asian monsoon climate.
- Modify the current organizational structures to facilitate reactions to climate change and sea level rise.

The main activities on climate change adaptation undertaken in the country since the 1990s are outlined in Table 10.5.

10.4.2 Achievement of These Policies and Major Challenges

Overall, the risk reduction efforts already underway in Vietnam could reduce climate change induced vulnerabilities in the long-term. Though progress remains limited, specific advances that directly or indirectly affect integration of climate change adaptation and disaster risk reduction have emerged in strategic policy, vulnerability and adaptation assessment, institutional coordination and projects.

A strategic policy approach that takes a long-term view of disaster risk reduction is provided by the National Strategy for Natural Disaster Response, Prevention and Mitigation to 2020. While recognizing the need to ensure the long-term benefits of disaster risk reduction, the strategy also reports what changes in climate are expected for Vietnam. Other recent policy approaches include the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020, and The National Target Program to Respond to Climate Change. That climate change is being recognized as a threat in long-term development, and the importance of disaster risk reduction as a part of climate change adaptation, is encouraging for the integration of climate change adaptation among other long-term issues into disaster risk reduction approaches.

Assessment of vulnerability and adaptation to climate change has been developed for the National Communication process to the UNFCCC and the National Target Program. These works, undertaken mainly by the Ministry of Natural Resources and the Environment, have assessed potential impacts of climate change (including extreme weather events) on different sectors and identified adaptation options. As a result of the policies on environment and climate change, the number of projects conducted by government agencies and NGOs that relate to disaster vulnerability or to climate change adaptation are already underway, while others have recently

Table 10.5 A summary of the main activities on climate change adaptation

Date	Main activities on climate change adaptation
mid-1980s	The first National Strategy for Environmental Protection (NSEP) was drafted under the National Environment Agency (NEA) ³ which provided an action plan for the period 1991–2000, including the creation of a system of state management agencies at the national, provincial, and sectoral levels. It also raised awareness among government officials, in addition to that of businesses and communities
1990s	Some progress was achieved, although a review of the first NSEP found that environmental planning need to be integrated into economic development. Also, investments in the environment were limited and spread too thinly across a variety of sectors ⁴
1993	Vietnam National Assembly approved the Environmental Protection Law
June 1992	Signed the United Nations Framework Convention on Climate Change (UNFCCC), which was ratified in November 1994 and enforced in February 1995
December 1998	Signed the Kyoto Protocol (KP) and ratified it in September 2002
until the early 2000s	The focus was on developing greenhouse gas inventories and devising strategies to reduce these emissions. With the realization that climate change was occurring, it became necessary to incorporate climate change adaptation (CCA) into national planning and development
June 2000	The second NSEP was drafted for the period of 2001–2010. The general objectives of the strategy are to protect and improve the environment in order to raise the living standards and health of the people, and to ensure sustainable development by engaging in collaborative activities with the different ministries, provincial People's Committees, businesses, and NGOs
2001	The Central Committee for Flood and Storm Control, and the Disaster Management Unit jointly drafted the Second National Strategy and Action Plan for Disaster Mitigation and Management in Vietnam in the period 2001–2020, ⁵ which states that: "Major consideration will be given to potential changes in weather patterns both globally and regionally. Any global climate change will have adverse and severe effects on Vietnam. The result may be that disasters will occur more frequently and will be more severe for Vietnam in the future"
August 2002	Upgraded the Environmental and Resources Department into a new Ministry of Resources and Environment (MONRE) to specifically tackle environmental problems such as those posed by climate change
December 2003	Completed the Initial National Communication and submitted it to the UNFCCC Secretariat
2006–2009	Preparation for the Second National Communication
November 2007	National Strategy for Natural Disaster Response, Prevention and Mitigation to 2020 has been approved. It states the need to promote international cooperation and integration so as to implement the UNFCCC, KP and Hyogo Framework for Action

(continued)

³NEA was an independent agency in charge of environmental protection; MONRE was later established and combined this agency's functions with others in 2003.

⁴National Environment Agency, 2000.

⁵CCFSC, 2001.

Table 10.5 (continued)

Date	Main activities on climate change adaptation
September 2008	Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020 approved by MARD. This action plan has the general objective of enhancing the government’s capabilities of adaptation and mitigation to climate change in order to minimize its adverse impacts and to ensure sustainable development of the agriculture and rural development sectors, including disaster prevention and mitigation
December 2008	The National Target Program to Respond to Climate Change, prepared by MONRE in collaboration with other ministries and sectors, and approved by the Prime Minister. Being recognized as an immense and complex program, the NTP has strategic objectives: to assess climate change impacts on sectors and regions in specific periods and to develop feasible action plans to effectively respond to climate change in the short and long-term so as to ensure sustainable development of Vietnam; to seize opportunities to move towards a low-carbon economy, and to join the international community’s efforts in mitigating climate change and protecting the climatic system

been proposed. Ongoing projects include those by the Ministries of Natural Resources and the Environment; and Agriculture and Rural Development, UNDP-GEF, the Netherlands Red Cross, the Vietnam Red Cross, CARE, and Oxfam (World Bank 2009).

Climate change adaptation has been addressed during the implementation of the UNFCCC. However, in preparation for the Second National Communication, the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020 and the National Target Program to Respond to Climate Change stock-taking highlighted a number of barriers to climate change adaptation. This was also consistent with the findings of the National Capacity Self Assessment to implement three Multilateral Environmental Agreements. There is an obvious need to adopt a coordinated approach to build capacity to adapt to climate change, given the likely impacts on socio-economic development of Vietnam.

However, data analysis and interviews with experts in the concerned ministries (Ministry of Natural Resources and the Environment, Ministry of Agriculture and Rural Development, Ministry of Planning and Investment, Ministry of Labour, Invalids and Social Affairs, and Ministry of Construction) and other agencies reaffirm a weaknesses in policy analysis, planning and implementation due to a lack of interdisciplinary expertise among agencies in charge of complex tasks such as climate change, poverty alleviation, disaster risk reduction, land use planning, and development strategy (Wilderspin and Hung 2008). This reaffirms that Vietnam’s development policies should be climate-proof.

10.4.3 *Lessons Learnt and Recommendations*

Some of the main gaps, barriers, needs and concerns in climate change adaptation that face policymakers and practitioners are listed below. They include, for example, gaps and opportunities for further participatory research (for policy development) and government/donor/private sector partnerships to enhance institutional capacity building:

- *Vulnerability and adaptation assessment* reports have been conducted during the preparation of Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020, and The National Target Program to Respond to Climate Change (IWRS 2007; MONRE 2008). However, due to a shortage of realistic data for assessing climate change vulnerability, only preliminary vulnerability and adaptation assessment for the main socio-economic sectors, safe for urban development, were undertaken, although not in an integrated manner (Wilderspin and Hung 2008).
- *Initiatives, activities on climate change adaptation and disaster risk reduction.* Analysis of activities and projects on climate change adaptation and disaster risk reduction in Vietnam shows that these projects are mainly donor-driven, and that there may be opportunities to expand the initiation and financial support of these activities to a broader group of actors. This analysis also demonstrates a lack of reliable assessment of technical data on climate change scenarios for Vietnam at the national and regional levels that can be down-scaled to the provincial level so as to produce appropriate policies for the government.
- *Coordination's among government's agencies as well as between the government and the community of international donors and NGOs.* There have been unreliable data on adaptation options and a lack of mechanisms for information sharing and management across sectors. A complex structure in several ministries prevented meaningful interactions among government agencies concerned with climate change adaptation and disaster risk reduction (Wilderspin and Hung 2008; Anh 2008). Besides, there is little support from government agencies for NGOs and civil society organizations, particularly in the area of information sharing. As such, most of the NGOs and civil society organizations prefer working at local levels when conducting projects on climate change adaptation and disaster risk reduction.
- *Adaptive capacity, policy and decision-making.* Several urgent and challenging problems concurrently face the existing development situation. These illustrate that the policies and decisions made by each ministry in response to problems arising within their sectors seem to answer only previous predicaments, rather than anticipate and deal with future issues. Besides, numerous top-down policies have been generated, but which lack an understanding of the perceptions of beneficiaries; and eventually cause difficulties during implementation. The number of shortcomings in terms of vulnerability and adaptation assessment confirms that national expertise to undertake vulnerability and adaptation assessment and integrated assessment is weak. There is limited staff capacity, particularly in analysis, planning, monitoring and evaluation, for assessing trade-offs in development decisions (Wilderspin and Hung 2008).

- *Finance allocation.* There has not been a government budget for climate change adaptation, largely because this issue has neither been fully considered nor understood (Anh 2008). This has been reinforced by considerable concerns that have been raised during meetings with donors and NGOs, and during the launching ceremony of the National Target Program for the allocation of funds. Finding an effective financial mechanism for climate change adaptation and disaster risk reduction has also been a challenge.

10.4.4 Initiatives and Progress Made in Relation to the MDGs

Vietnam's success with the MDGs is well documented. Poverty levels and maternal health figures are already meeting the standards set by the MDGs, and the country is on track to meet several other goals. However, this progress is tenuous and issues of quality, equity and distribution are key in measuring the country's achievements. With so many Vietnamese on the precipice of the poverty line, any major economic or natural disaster could easily set Vietnam back. The United Nations advocates for quality and equity, and ensuring that the MDGs are achieved in every Vietnam commune (UNDP 2008b) as follows:

Eradicate Extreme Poverty and Hunger Vietnam met the target of halving poverty by reducing the proportion of people living below the poverty line to approximately 15.9% in 2006. While these are impressive achievements, the challenge now is to reduce increasing disparities and address the foundations of poverty and hunger in every region of the country.

Achieve Universal Primary Education Vietnam is very likely to achieve full primary school enrolment by 2015, given its 96% primary school net enrolment rate in 2006. However, there are still challenges to improving the quality of education, expanding basic education towards universal primary education targets and reducing disparities in access and coverage in remote areas and among ethnic minority groups.

Promote Gender Equality and Empower Women Vietnam is well on its way to achieving its goal of eliminating gender gaps in primary and secondary education, and has already achieved a gender balanced youth literacy rate. In 2006, some 91% of girls and 92% of boys attended primary and lower secondary schools. Today, women account for 50.8% of the national population and 49% of the workforce, playing an important role in Vietnam's socio-economic development. However, despite these achievements, Vietnamese women continue to face serious obstacles – including poverty, limited access to higher education and employment opportunities, as well as persistent discriminatory attitudes and behaviour.

Reduce Child Mortality Vietnam has successfully reduced its under-five child mortality rate from 58 deaths per thousand live births in 1990 to 25.9 per thousand live births in 2007, and its infant mortality rate from 44.4 per thousand live births in 1990 to 16 per thousand live births in 2007. While the under-one child mortality rate already surpassed the national target of 25 per thousand live births,

reaching the full target of a two-thirds reduction of under-five mortality rate by 2015 will require sustained efforts and assistance, particularly in remote and ethnic minority areas.

Improve Maternal Health It is already a challenge for Vietnam to maintain the current steady progress towards achieving this MDG target by 2015, and its national target to reduce the rate to 70 per 100,000 by 2010, with a particular focus on disadvantaged and ethnic minority areas will also be difficult to achieve.

Combat HIV/Aids, Malaria and Other Diseases While Vietnam has made significant improvements in legal and policy framework in recent years, and besides having a sound national strategy and plans for responding to HIV, the implementation is lagging behind. The impressive progress on prevention and control of malaria shows that Vietnam has already achieved the MDG target on malaria control. However, without a stronger, coordinated response at the national and provincial levels that also brings in civil society groups and the private sector, Vietnam will not be in a position to reverse the spread of TB.

Ensure Environmental Sustainability Vietnam has increased the percentage of the population with access to safe water from 65% in 1990 to 89% in 2006, and the country has also made positive gains in working towards environmental sustainability, increasing forest land coverage by 0.6% annually, now accounting for 38% of the total land area. Integration of sustainable development principles into national development frameworks and plans has been good, although the implementation should be speeded up to effectively deal with the urgent problems of pollution and increasing bio-diversity loss. The slowest progress has been with regard to improving sanitation. However, it is estimated that 20 million children (59% of all children) still lack access to proper sanitation.

Develop a Global Partnership for Development Poverty reduction and sustainable development are clearly linked to trade, debt relief and aid, all of which are better enabled by global partnerships. Fair terms of trade for developing countries are necessary to generate employment opportunities and income. In this regard, Vietnam faces some significant challenges in light of the country's planned accelerated integration into the regional and global economies. Ensuring social equity and sustainability of the country's development process will require considerable efforts.

10.5 Recommendations and Experiences to Be Shared with Other Countries

More investments in initiatives and activities on climate change adaptation by government and civil society organizations are needed. These initiatives should focus on vulnerability and adaptation assessment, and on simulating reliable climate change scenarios. The improvements of the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020 and The National Target Program to Respond to Climate Change provide a

suitable policy and legislative framework for creating synergy in climate change adaptation and disaster risk reduction. Based on the National Target Program, comprehensive implementation plans for climate change adaptation should be developed, and should be mainly concerned with finding answers to the issues mentioned below:

10.5.1 Effective Mechanisms for Coordination and Adaptive Capacity

To implement the National Target Program, the National Steering Committee was established. In order to optimize the operation of the committee and identify a model mechanism for effective coordination among government agencies, and between these agencies and the international community, toward synergy of climate change adaptation and disaster risk reduction, learning from the Central Committee for Flood and Storm Control (CCFSC) experiences is likely to be of value. Besides, an effective mechanism for deepening existing partnerships and creating new ones between the government, international donors/NGOs and civil society organizations concerned with climate change adaptation is needed. Adaptive capacity, policy and decision making by government agencies in charge of climate change adaptation also need to be enhanced, and climate change adaptation policymakers and experts should be co-opted into the different government agencies, either via secondment by the government, or through participation in regular joint meetings or workshops.

10.5.2 Partnerships, Public Participation and Local Communities

Support from donors, the Vietnamese government and the private sector is required to implement a range of sustainable development actions that reduce the risk of historical and future development gains being reversed due to climate change. Floods, typhoons and other weather extremities, as well as increasing climate variability and related ecosystem impacts can drag Vietnamese people into inescapable poverty. Addressing this will require adaptive measures in the form of disaster risk reduction systems, as well as activities that address the more gradual and long-term effects of climate change adaptation. Poor communities will also need support in their transition to more sustainable livelihoods, new climate conditions and viable living conditions in a shifting and less predictable environment. To succeed, this must be grounded in community participation, engagement and empowerment.

The Vietnamese government has taken important steps toward developing an understanding of climate change science and the potential future impacts on

Vietnam. However, further effort is needed to communicate this growing body of knowledge outside of the central agency responsible, and into the implementing agencies providing development services. A greater level of coordination and participation across government agencies and development practitioners is required to ensure that climate change is considered in the broader development planning and the implementation of related policies. Donor and government policies urgently need to be “climate-proofed” so as to ensure that they do not inadvertently lead to negative climate change impacts.

10.5.3 Mainstreaming the Integration of Climate Change Adaptation and Disaster Risk Reduction into Socio-Economic Development Plans and Strategies

In order to foster the integration of the potential impact of climate change and response measures into socio-economic development and sectoral/local development plans for period of 2010–2015, an assessment of climate change impacts, especially sea level rise, on development plans, should be done. Legal and guidance documents on how to comprehensively mainstream climate change adaptation and disaster risk reduction issues into development plans should also be developed. A plan to mainstream climate change adaptation into development plans (including urban development plans) according to the legal decisions issued should also be set in motion.

10.5.4 Resources Requirements

The lack of a government budget for climate change adaptation and difficulties in allocating additional funds for adaptation means that existing knowledge and results of vulnerability and adaptation assessments should be used to convince the Ministries of Planning and Investment, and Finance, that reducing climate change-induced risks could result in economic benefits. Thus, to ensure sufficient funding for climate change adaptation, investment in this area should not be separated from other development investments. Moreover, national budget processes should be used to ensure long-term financial planning for climate change adaptation.

In addition, the Ministry of Planning and Investment and the ministry in charge of sourcing and allocating foreign investment and ODA funds, should, in cooperation with the Ministry of Natural Resources and Environment and the Ministry of Finance, strive to attract and direct more international and domestic budget towards climate change adaptation activities, especially toward prioritized adaptation activities. Support is required from donors and the Vietnamese government to ensure existence of an enabling environment in which these projects can be developed, and

revenues earned are returned to the communities involved. Particular areas of concern include processes for allocating land to communities, the community-level capacity to develop and manage projects, and the institutional capacity for the management of carbon funds.

10.6 Annex

Table showing the impact of climate change on different sectors and adaptation options (Adger 2002; UNEP and Danida 2005; Miltenburg 2006; VARG 2006; Oxfam 2008; Thuc 2008; MONRE 2008; Ninh 2008; Carew-Reid 2008)

Sector	Main expected impacts of climate change	Possible adaptation measures
Water resources	<p>Daily rainfall increases of 12–19% by 2070 in some areas. Floods now occurring every 100 years. By 2070 they would occur every 20 years Sea level rise threatens coastal areas with more flooding, particularly in the Mekong Delta Region (MDR). 17 million people (including 14 million in the MDR) are likely to be affected by annual flooding. Areas such as Central Vietnam may experience droughts from water run-off decreases of 23–40.5% by 2070.</p> <p>Most of the river run-off (80%) occurs during the summer-wet months. Likely that run-off increases in rainy season and decreases in dry season, leading to an even higher percentage of the total annual run-off in summer.</p> <p>Temperature increase of 2.5°C in inland Central Vietnam, evapotranspiration rate may increase by 8%, leading to droughts.</p>	<p>Build reservoirs with total additional capacity of 15–20 billion cubic metres to contain floodwater. Priority areas would be the eastern part of South Vietnam, Central Highlands, and mountainous areas of North Vietnam</p> <p>Upgrade and raise the scale of the drainage system. Build new sea dikes to address rising sea levels.</p> <p>Non-structural measures include the following:</p> <p>Reforestation and afforestation to increase natural water storage and availability during the dry season.</p> <p>Use more effective methods to capture water, especially during the low-flow season.</p> <p>Create natural filtering systems such as wetlands to recycle wastewater for use in irrigation or industry.</p> <p>Conduct studies in long-term water resources prediction.</p>

(continued)

Table (continued)

Sector	Main expected impacts of climate change	Possible adaptation measures
Agriculture	<p>Changes in river run-off could result in lower crop yields and growth rates, hence weakening or extinction of particular crop species. Increased activity by pests and viruses, and a loss of soil fertility.</p> <p>Loss of valuable land due to sea level rise, flooding, and storm events, accelerated erosion along the coasts and in river mouths, and increased salinity.</p> <p>Salt intrusion lowers the availability and quality of water resources for irrigation, drinking, and canals in deltas. The most fertile agricultural lands, together with 50% of the population, are centred on the low-lying Red River and the Mekong delta regions. The salinity of the main tributaries of the Mekong River would increase to 10 km inland.</p> <p>Change in absolute minimum temperature and the number of days at extreme cold or hot temperatures are significant for certain industrial crops such as coffee, rubber, tea, and fruit trees. Crop calendar and crop rotation in the north and mountainous areas may be affected.</p> <p>Tropical crops may migrate northwards by 100–200 km and to higher altitudes in the mountains by 100–550 m in the 2070s.</p> <p>Some species may become extinct because of changing climatic conditions, and it is predicted that yields of summer rice will decrease by 3–6% by 2070 compared to the 1960–1998 period.</p>	<p>Adjust cropping calendars (when to plant), cropping patterns (where), crop varieties (what), taking climate change into consideration. For example, adjusting the calendar for short season crops such as rice, maize, sweet potato, soybean, groundnut and others may allow more crops per year, due to the extension of the growing season. Use irrigation water more effectively.</p> <p>Develop crop varieties that can cope with climate extremes.</p> <p>Other inputs and management adjustments, such as added nitrogen and other fertilizers, may be utilized so as to take full advantage of the enhanced CO₂ effect.</p>
Forestry	<p>In the early 1940s, Vietnam's forests covered 43% of the land. About 50 years later, that figure had dropped to 28%. In mountainous regions, the area covered by forest has decreased to only 10–30% of the total land. The mangrove ecosystem is threatened by industry, development, and sea level rise. Increased salt intrusion is causing a gradual change in species distribution in the mangrove forests. Resources such as timber, fishing, and honey are threatened. Mangrove forests also provide protection from sea surges, and they reduce the costs of dike maintenance.</p>	<p>Enhance reforestation in watersheds and on bare hills. Protect and developing mangroves.</p> <p>Prevent forest fires.</p> <p>Establish a seed bank of valuable forest tree types.</p> <p>Process timber more efficiently, limiting the use of wood as a material, and other sustainable forestry practices.</p> <p>Conduct public awareness campaigns to enhance appreciation of the indirect benefits of forests.</p>

(continued)

Table (continued)

Sector	Main expected impacts of climate change	Possible adaptation measures
Fisheries, aquaculture and the coastal zones	<p>The numbers of tropical fish with a low commercial value (except for tuna) will increase, and the numbers of subtropical fish with a higher commercial value will decrease. Coral reefs are expected to degenerate and fish living in these habitats are expected to disappear. Economic sea production capacity of Vietnam would be reduced by at least one-third.</p> <p>Due to sea level rise and climate change impacts, aquaculture farms will have to be relocated and coastal fisheries could disappear; saline water intrusion and the reduction of the mangrove area will create loss of habitat for fresh water creatures.</p> <p>Increased rainfall intensity might affect some species, such as dual crust molluscs.</p> <p>More frequent and more extreme flooding increases pressure on the remaining land and exacerbates problems associated with forest destruction and ecosystem degradation as new agricultural tracts are created. The total cost of sea dike maintenance in 1996 was US \$4.3 million per year, with the highest cost in Nam Ha province at US \$579,000.</p> <p>Upstream lands are threatened by sea level rise due to the possible movement of saltwater into freshwater lenses.</p>	<p>Research to predict the movement of fish and equipping fishermen with monitoring devices. Import or develop aquaculture species to adapt to high temperatures and changed salinities, e.g. prawns, green-clawed crayfish, white bass, etc.</p> <p>Implement fish-rice rotations in areas that are currently rice monocultures</p> <p>Enact existing land-use guidelines for integrated coastal zone management.</p> <p>Raise houses to accommodate higher sea levels.</p> <p>Pump in the Mekong and Red River deltas (at costs ranging from US \$700 per hectare in the South to US \$6000 per hectare in the North, according to MHC estimates).</p> <p>Enhance awareness of flood preparedness measures, drawing upon the experiences of several NGOs, such as the Red Cross study, "Living with the Floods."</p>
Energy and transportation	<p>Oil exports are currently among the largest foreign currency earners for the country. Rising sea levels and increased or intensified typhoon activity will threaten energy infrastructure. Railways, other transport infrastructure, and transmission lines near the sea will face increased maintenance and repair costs. Run-off regimes for hydropower stations will also be affected.</p>	<p>Planning and infrastructure projects for these sectors should take into account climate change factors. Implement demand side management based on high efficiency, energy security, and safety.</p> <p>Promote renewable energy technologies, as Vietnam has a high potential for solar power.</p> <p>Promote public transportation.</p>

(continued)

Table (continued)

Sector	Main expected impacts of climate change	Possible adaptation measures
Human health	<p>The most obvious direct impacts are death and injuries resulting from extreme events, e.g. typhoons, storm surges, and floods. High solar radiation intensity results in heat illnesses and sunstroke.</p> <p>With decreased humidity, the body may lose water and the mineral balance could be disrupted. Conversely, with increasing humidity, the body's natural heat regulation is impeded and people may suffer heat exhaustion.</p> <p>Cold winters in the north lead to frostbite and pneumonia; prolonged cold and damp air also encourages chronic diseases of the respiratory system – one benefit of rising temperatures would be the reduction of these diseases.</p> <p>Hot and humid environments present favourable conditions for the development of bacteria, insects, and other disease carriers such as flies and rats.</p> <p>Health would also be affected through decreased access to food due to reduced agricultural production and higher food prices.</p>	<p>Planning for health care and associated facilities taking into account the possibility of the changing incidence of disease and other health problems. Promote the existing programme for “Eliminating hunger and reducing poverty.”</p> <p>Promote household sanitation and multi-purpose spaces (“Garden-pond-fish breeding facilities”).</p> <p>Monitor disease incidences in high risk areas.</p> <p>Establish green, calming public gathering spaces.</p> <p>Promote public awareness on the links between climate change and health.</p> <p>Implement measures to prevent the migration of pests and disease carriers.</p>

References

- Adger N (2002) Indicators of social and economic vulnerability to climate change in Vietnam. Centre for Social and Economic Research on the Global Environment, Working Paper 98–02, London
- Anh TT (2008) Preparedness for disaster related to climate change. Paper presented at a workshop, Climate Change: Innovations in Public-Private Partnerships with Global Economic Uncertainty, Hanoi, 14–15 Oct 2008
- Carew-Reid J (2008) Rapid assessment of the extent and impact of sea level rise in Vietnam. ICEM – International Centre for Environmental Management, Queensland
- CCFSC (2001) Ministry of Agriculture and Rural Development. Second Strategy and Action Plan for Disaster Mitigation and Management in Vietnam 2001–2020, Hanoi
- CCFSC (2007) Ministry of Agriculture and Rural Development. National Strategy and Action Plan for Disaster Mitigation and Management in Vietnam to 2020. <http://www.ccfsc.org.vn/ccfsc/?ln=en&sid=NDMP#>. Accessed 2 March 2009
- Dasgupta Susmita, Laplante Benoit, Meisner Craig, Wheeler David, Yan Jianping (2007) The impact of sea level rise on developing countries: a comparative analysis. World Bank Policy Research Working Paper 4136

- DFID (2001) Poverty and the environment: what the poor say, environment policy, Key Sheet No.1. Department for International Development, London
- EM-DAT. International Disaster Database. <http://www.em-dat.net>. Accessed 2 March 2009
- GSO (2006) Government Statistical Office. Statistical Yearbook of Vietnam, Hanoi
- GSO (2008) Government statistical office. Statistical Yearbook of Vietnam, Hanoi
- Hung HV (2008) Sustainable adaptation – challenges and potential of Vietnam’s cities. Paper presented at the Green Building and Climate Change Adaptation Workshop, Hanoi, 4 Dec 2008
- IPCC (2001) Climate change 2001: impacts, adaptation, and vulnerability. Summary for Policymakers. Report of Working Group 2 of the IPCC, Geneva
- IPCC (2007) 4th assessment report. Intergovernmental Panel on Climate Change
- IWRS (2007) Climate change – impacts and issues for agriculture and rural development. Institute of Water Resource Science, Hanoi
- Jelligos SR, Lunde G, Kawate H, Dzung TV (2005) Final evaluation: Vietnam Red Cross mangrove and disaster preparedness in the Red River Delta and Northern Coastal Vietnam (1994–2005). The Danish Red Cross
- MARD (2008) Ministry of Agriculture and Rural Development. Decision No. 2730/QĐ-BNN-KHCN: Issuance of the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector Period 2008–2020, Hanoi
- Miltenburg M (2006) Preparedness for disasters related to climate change. A pilot project in 5 provinces. The Netherlands Red Cross in Vietnam
- MONRE (2008) The report on climate change in Vietnam. Ministry of Natural Resources and Environment, Hanoi
- NEA (2000) National strategy for environmental protection 2001–2010. National Environment Agency, Hanoi
- NEA (2001) Summary of activities in Vietnam and the Asian region on biodiversity, climate change, and international water issues, GEF Projects in Vietnam. National Environment Agency, Hanoi
- Ninh NH (2008) Climate change: overview of adaptation, vulnerability & resilience in global and Vietnam context. Paper presented at a workshop on Climate Change: Innovations in Public-Private Partnerships with Global Economic Uncertainty, Hanoi, 14–15 Oct 2008
- NRC (2006) Final narrative report: preparedness for disasters related to climate change in Vietnam. Netherlands Red Cross and Vietnam Red Cross Society, Hanoi
- Office of the Government (2004) Decision No. 76/2004/QĐ-TTg on approval of the Direction for housing development to 2020. Hanoi
- Office of the Government (2008) Decision No. 158/2008/QĐ-TTg on approval of the National Target Program to respond to climate change. Hanoi
- Oxfam (2008) Vietnam climate change, adaptation and the poor. Hanoi
- Patwardhan A, Meeta A (2007) Disaster prevention, preparedness and management and linkages with climate change adaptation, technology information. Forecasting and Assessment Council, New Delhi
- Shaw R, Prabhakar SVRK, Nguyen H (2007) Drought management considerations for climate change adaptation: focus on the Mekong region. Oxfam Vietnam, Graduate School of Environmental Studies of Kyoto University, Japan
- Swinkels R, Turk C (2003) The relationship between the development goals for Vietnam and the Millennium Development Goals. World Bank, Hanoi
- Thuc T (2008) The National Target Program to respond to climate change. Paper presented at a workshop on Climate Change: Innovations in Public-Private Partnerships with Global Economic Uncertainty, Hanoi, 14–15 Oct 2008
- UNDP (2008a) Climate change country profiles: Vietnam. <http://country-profiles.geog.ox.ac.uk>. Accessed 19 March 2009
- UNDP (2008b) Human development report 2007/2008. New York
- UNEP, Danida (2005) Climate check in Vietnam. Final country report. Hanoi
- United Nations (2006) World urbanization prospects. New York
- VARG (2006) Linking climate change adaptation and disaster risk management for sustainable poverty reduction: Vietnam country study. The European Union, Hanoi

- Wilderspin I, Hung HV (2008) Climate change and the poor in Vietnam. PEP/UNDP, Hanoi
- World Bank (2008) National Urban Upgrading Strategy and Overall Investment Plan for Urban Upgrading to Year 2020 (draft). Hanoi
- World Bank (2009) Vietnam Climate Change Matrix. <http://www.worldbank.org/vn>. Accessed 14 April 2009

Part IV
Climate Change and Its Effect on Cities:
Case Studies from Africa and Asia

Chapter 11

Climate Change and Cities' Actions in China

Xiaodong Pan and Zhenshan Li

11.1 Introduction

China has population of 13 billion, the highest in the world. It occupies a land area of 9.5 million square-kilometres, making it the fourth largest in the world. It has a coastline of 14,500 km. This rapidly-urbanising country has for the past 2 decades been building 20 new cities every year, exacting a profound impact on the environment in many places. This chapter seeks to develop a detailed understanding of the impact of climate change on China, especially its urban environments. The challenge to China's development pattern and energy performance is discussed, and issues of climate adaptation, mitigation and lessons learnt are also examined.

11.2 Climate Change Trends in China

The most up-to-date information released by the China Meteorological Administration shows that the average temperature of the earth's surface in China has risen by 1.1°C over the past century, from 1908 to 2007, and that China experienced 21 warm winters from 1986 to 2007 (SCPR 2008). The national distribution of precipitation in the past half century has undergone marked changes, with increases in Western and Southern China, and decreases in most parts of the Northern and North Eastern China. Extreme climate phenomena such as high temperatures, heavy precipitation and severe droughts have increased in frequency and intensity.

The number of heat waves in summer has grown, and droughts have become severe in some areas, especially in Northern China. Besides, heavy precipitation

X. Pan (✉)

The Administrative Center for China's Agenda 21(ACCA21)

e-mail: panxd@acca21.org.cn

Z. Li (✉)

Department of Environmental Engineering, Peking University, China

e-mail: lizhenshan@pku.edu.cn

has increased in Southern China; and the occurrence of snow-related disasters has risen in Western China. In China's coastal zones, the sea surface temperatures and sea level have risen by 0.9°C and 90 mm, respectively, over the past 30 years (SCPR 2008).

11.2.1 Impact on Socioeconomic Development of the Country, Particularly on Poverty

Some researchers have demonstrated that higher temperatures substantially reduce economic growth in poor countries, but have little effect in rich countries (Dell et al. 2008; Fankhauser et al. 2005). Higher temperatures appear to reduce growth rates in poor countries and have wide-ranging effects in poor nations; reducing agricultural and industrial outputs and aggregate investments, and heightening political instability. Analysis of decade or longer climate shifts also shows substantial negative effects on the economies of poor countries.

Should future impacts of climate change mirror these historical effects, the negative impact on poor countries may be substantial.

China is one of the countries most susceptible to the adverse effects of climate change, mainly in the fields of agriculture, livestock breeding, forestry, natural ecosystems, water resources, and coastal zones.

11.2.2 Impact on Agriculture and Livestock Breeding

Climate change has already produced visible adverse effects on China's agriculture and livestock-raising sectors, manifested by increased instability in agricultural production, severe damages to crops and livestock breeding caused by drought and high temperatures in some parts of the country, and has aggravated spring freeze injury to early-budding crops due to climate warming, decline in the output and quality of grasslands, and augmented losses caused by meteorological disasters.

11.2.3 Impact on Forestry and Other Natural Ecosystems

The impact of climate change on China's forestry and other natural ecosystems are mainly manifested in the following aspects: the northward shift of the northern boundaries of eastern subtropical and temperature zones and early phenol-phase, upward shift of the lower boundaries of forest belts in some areas, elevation of lower line of highland permafrost and decreased area of permafrost; rising frequency of animal and plant diseases and insect pests with marked changes in the distribution of regions, reduced area and the overall shrinking trend of glaciers in north-western China, and the ever-present threat to the oasis ecosystem posed by accelerated melting of glaciers and snow cover (SCPR 2008).

11.2.4 Impact on Water Resources

Climate change has already destabilised the distribution of water resources all over China. Over the past 2 decades, the gross amount of water resources of the Yellow, Huaihe, Haihe and Liaohe rivers in Northern China has been visibly reduced, whilst that of rivers in Southern China has slightly increased (SCPR 2008).

11.2.5 Impact on Coastal Zones

In the past 30 years, China has seen an increase in sea-level rise, which has caused sea water intrusion, soil salinization and coastal erosion – aspects that have damaged the typical marine ecosystems of coastal wetlands, mangrove swamps and coral reefs; besides diminishing the service functions and bio-diversity of coastal zones. Sea temperature rise and seawater acidification, resulting from climate change, has precipitated a lack of oxygen in some maritime areas, the degradation of marine fishing resources, and threatened the survival of rare and endangered species (SCPR 2008).

11.2.6 Impact on Society, Economy and Other Fields

Climate change is expected to adversely impact all aspects of life in China, ostensibly precipitating huge losses to the national economy. The country will have to meet the costs of mitigating the resultant economic and social impacts wrought about by climate change.

In addition, there will be higher chances of disease occurrence and spread, exacerbating risks to human health, raising possibilities of geological and meteorological disasters, and the consequent threat to the security of major projects.

The eco-environment and bio-diversity such as natural reserves and national parks will also be affected. Inevitably, natural and cultural tourism resources will be affected; and so too will the normal order and stability of social life.

11.3 Global Climate Agreements and Their Impact on the Country

The Kyoto Protocol encourages China to take the lead in the utilisation of safe energy and to promote an environment strategy that seeks a balance between economic development and environmental protection for sustainable development. According to data gathered from relevant international research institutions from 1904 to 2004, carbon dioxide emissions emanating from fossil fuels in China made

up 8% of the world's total emissions over the same period. In terms of cumulative emissions per capita, China is ranked 92nd in the world (Chow 2007).

China's carbon dioxide emissions emanating from energy consumption in 2004 totalled 5.07 billion tons (SCPR 2008). As a developing country, China still has a long way to go in its industrialization, urbanization and modernization progress. To advance further toward its development objectives, it will have to strive for the rational growth of energy demand, which is the basic precondition for the progress of all developing countries. Its coal-dominated energy mix cannot be substantially changed in the near future, making the control of greenhouse gas emissions difficult.

11.3.1 Major Challenges to China's Climate Change Prospects

China has a large population and a relatively low level of development. Its economic development has long been constrained by the scarcity of per capita resources, and this is likely to continue for a long time. With the current level of technological development, to attain the development level of industrialized countries, it is inevitable that per capita energy consumption and CO₂ emissions will reach a fairly high level. In the development history of human beings, there is no precedent where a high per capita GDP is achieved with low per capita energy consumption.

China is one of the few countries whose energy mixes are dominated by coal. In 2005, 68.9% of China's primary energy consumption was coal, while the world average was only 27.8% (Dell et al. 2008). Compared with oil and natural gas, coal's carbon content per unit calorific value is 36% and 61%, respectively (Yang 2010). China will face more difficulties than other countries in decreasing its carbon intensity per unit of energy due to three main reasons: (1) Its energy mix adjustment is constrained by the mix of energy resources to a certain extent; (2) Its energy efficiency improvement is subject to the availability of advanced technologies and financial resources and; (3) its coal-dominated energy resources and consumption structure will not change substantially in the foreseeable future (Du 2010).

One of the main reasons for China's low energy efficiency and high GHG emission intensity is the backward technologies of energy production and utilization being used in the country. On one hand, there are relatively large gaps between China and the developed countries in terms of technologies of energy exploitation, supply and transformation, transmission and distribution, industrial production and other end-use energy; while on the other hand, outdated processes and technologies still occupy a relatively high proportion of China's key industries (Yang 2010). As China undergoes large-scale infrastructure construction for energy, transportation and buildings, the features of intensive emissions associated with these technologies will exist for the next few decades if advanced and climate-friendly technologies are not availed on time. This poses severe challenges to China in addressing climate change and mitigating GHG emissions.

11.3.2 Challenges on Conservation and Development of Forest and Other Natural Resources

To combat climate change, it is necessary for China to strengthen her forest and wetland conservation so as to enhance capacities for climate change adaptation; and to strengthen forest and wetland restoration and afforestation so as to enhance capacities for carbon sequestration. Forest resources in China are far below the needs for social and economic development. With the acceleration of industrialization and urbanization, the quest for forest and wetland conservation is increasing. Acidification, desertification, soil erosion, and wetland degradation are severe environmental problems. Land available for afforestation/reforestation is mostly located in areas suffering from sandy or rocky desertification, which pose a daunting challenge to forestation and ecological restoration (NDRC 2007a, b).

11.3.3 Long-Term Challenges on Adaptation to Climate Change in China's Agricultural Sector

China encounters not only frequent agricultural meteorological disasters that cause prolonged instability in agricultural production, but also features low per capita cultivated land, a less developed agricultural economy and a very limited capacity for adaptation. In coping with climate change, some of the aspects that pose long-term challenges for the Chinese agricultural sector in terms of improving its capacity to adapt to climate change and resist climatic disasters include how to rationally adjust agricultural production distribution and structure, how to improve agricultural production conditions, how to control the prevalence of plant diseases and pests or insects and spread of weeds, how to reduce production costs, and how to prevent the potential desertification expansion and ensure sustainable development of China's agricultural production (NDRC 2007a, b).

11.3.4 New Challenges on China's Water Resources Development and Conservation in Terms of Adapting to Climatic Change

There are two objectives for development and conservation of water resources in adapting to climate change in China: (1) To promote sustainable development and utilization of water resources and, (2) To enhance the adaptive capacity of the water resource system so as to reduce its vulnerability to climate change. Some of the long-term challenges on water resources development and conservation in terms of enhancing climate change adaptation capability include how to enhance water resources management, optimize water resources allocation, strengthen

infrastructure construction, ensure the anti-flood safety of large rivers, key cities and regions, promote nationwide water-saving program, guarantee safe drinking water and sound social and economic development and make good use of river functions while protecting the aquatic ecosystem (NDRC 2007a, b).

11.3.5 Challenges on China's Coastal Regions in Terms of Adapting to Climate Change

The coastal regions in China are characterized by a dense population and a robust economic activity. Since most of these coastal areas are low and flat, they are vulnerable to marine disasters due to sea-level rise. At present, China clearly lacks capacity in marine environment monitoring, resulting in insufficient capacity of early warning and emergency response to ocean disasters associated with climate change. Lower standards for coastal anti-tide engineering also weaken the country's ability to resist ocean disasters.

11.4 Measures for Addressing Climate Change in China

China has taken the following measures to address climate change (NDRC 2007a, b; Liu 2007):

- Accelerating the development of the service sector. The government issued opinions on the acceleration of the development of the service sector in 2007 in which it set the goal of raising the proportion of added value from the service sector in the GDP by three percentage points from 2005 to 2010.
- Making low-carbon and high-tech industry larger and stronger. In 2007, the government issued the 11th Five-year Plan (2006–2010) for high-tech, e-commerce and information technology sectors, suggesting that the proportion of added value from the high-tech industry to that of the total industrial added value be raised by five percentage points from 2005 to 2010.
- Accelerating the pace of eliminating backward production capacity. In 2007, the government announced a timetable for closing down backward production facilities among 13 industries during the latest Five-year Plan period.
- Limiting the excessively rapid expansion of industries that consume a large amount of energy and discharge heavy emissions. By raising the standard of entry by industries for high energy consumption, enhancing the entry threshold of energy conservation and environmental protection, and by adjusting tax rebates for exports and customs duties, the government is working to restrain the export of commodities that consume large amounts of energy, discharge large quantities of emissions and use precious raw materials.
- November 26, 2009, China officially announced the decision to reduce 40% – 45% carbon dioxide emissions per unit of GDP by 2020 compared with 2005.

11.4.1 Efforts to Save Energy and Raise Energy Efficiency

To place energy conservation and emission reduction in a more prominent position, the State Council has set up a prominent committee on energy conservation and emission reduction. It has also issued the Comprehensive Work Plan for Energy Conservation and Emission Reduction to guide work in this field. Below are the highlights of the Plan (NDRC 2007a, b):

- A responsibility system that establishes goals for energy conservation and emission reduction is in place. The State Council has issued the plan and method regarding the monitoring of energy conservation, emission reduction and evaluation.
- Accelerating the construction of major energy conservation projects. Technological transformation spearheaded by enterprises under the direction of local governments resulted in an energy-conservation capacity of 60 million tons of standard coal. With subsidies from the government, 50 million energy-saving bulbs are now being distributed to households in the country, and within the next 3 years, more than 150 million energy-saving bulbs will have been distributed.
- Promoting energy conservation and emission reduction in key fields. An energy-conserving campaign has been launched among more than 1,000 enterprises to encourage them to audit their energy use, formulate energy-saving plans and make public their energy consumption figures. The government is earnestly promoting “green” and environment-friendly buildings that save energy and maximise on land use.
- Raising the efficiency of energy development and conversion. More high-efficiency, energy-conserving equipment is being used in the power-generating and coal-producing sectors; and the government has quickened its pace to eliminate small thermo-power stations and coal mines. Energy and electricity consumed per production unit of raw coal in 2007 dropped by 5.9% and 5.1% compared to the previous year.
- Implementing economic policies conducive to energy conservation. The resources tax for some mineral products, and prices for refined oil and natural gas have been adjusted.
- Policies aimed at saving energy in power generation and distribution have also been adopted.
- Strengthening the construction of the legal system. The Energy Conservation Law has been amended. The General Office of the State Council has issued a circular on strictly following the temperature control standards for air-conditioners in public buildings.

As a result of these efforts, energy consumption per unit GDP in 2006 and 2007 across China was lowered by 1.79% and 3.66% respectively (SCPR 2008). In 2007, key enterprises in the power-generating, iron and steel, building materials and chemical industries, which consume 10,000 t of standard coal or more

annually, saw energy consumption of 33 of their 35 major products drop (SCPR 2008). Only in two products did energy consumption rise. The energy thus saved was equivalent to 38.3 million tons of standard coal. In total, the energy saved in 2006 and 2007 by these enterprises was 147 million tons of standard coal (SCPR 2008).

11.4.2 Developing Renewable Energy and Optimizing the Energy Mix

The Law on Renewable Energy and Related Policies was enacted in 2005 to give priority to renewable energy when transmitted on the state power grid, to purchase renewable energy at full price, to give price discounts to users of renewable energy and to share the utilization of renewable energy among the whole society. By the end of 2007, the annual installed capacity of hydropower was 145 million kilowatts, generating 482.9 billion kilowatt hours of electricity (The Office of SCG 2004). An average of 26 million kilowatts of installed capacity was added in 2006 and 2007, with an average increase of 12% in each year. The scale of wind power increased several-fold. In 2006 and 2007, some 3.05 million kilowatts of installed capacity were added, an average annual increase of 148%. Solar energy collectors occupied 110 million square metres, making China the world leader in this field for many years. The installed power generating capacity using biomass is 3 million kilowatts, and the annual production capacity of ethanol as a bio fuel is more than 1.2 million tons.

11.4.3 Developing a Recycling Economy to Reduce Greenhouse Gas Emissions

Attaching great importance to developing a recycling economy, the Chinese Government is doing its best to reduce the amount of resources consumed, and reuse and recycle items so as to reduce greenhouse gas emissions from their sources, and during the course of production. The state has enacted laws and regulations such as the Clean Production Promotion Law, Law on the Prevention of Environmental Pollution by Solid Wastes, and Law on a Re-cycling Economy and Methods on Management of Urban Garbage.

In addition, the regulation regarding the management of the recycling and treatment of discarded electrical equipment is to be promulgated soon. The state has formulated policies that encourage the recycling and utilization of landfill gas, and has promulgated industrial standards such as the policies on technologies for the treatment of urban garbage and pollution prevention and technical standards on sanitary landfill of garbage, which promote the retrieval and utilization of landfill gas and reduction of emissions of methane and other green-house gases.

Meanwhile, research is being carried out to popularize advanced technologies for garbage burning and recycling and utilization of landfill gas. Relevant technological standards are being promulgated and the garbage collection and transportation system is being improved. Garbage classification has begun in some areas; comprehensive utilization of garbage as a resource has been raised to promote the industrialization of the treatment of garbage. Supervision is being tightened on enterprises engaged in garbage treatment. As a result, the detoxification rate of garbage was raised from 2.3% in 1990 to 52% in 2006 (SCPR 2008).

11.4.4 Reducing Greenhouse Gas Emissions in Agriculture and Countryside

In 1,200 counties across the country, fertilizers are applied according to the results of tests of local soil. Crop stalks are also used to feed domestic animals, the manure and urine of which are then applied to fields to add organic carbon to the soil. A compensatory mechanism for grassland ecology has been created. Balance is maintained between the grass and livestock; a system is adopted to prohibit grazing, to have a stretch of grassland rest for a while; or grazed on in rotation, and controlling the number of livestock grazing on the land to prevent deterioration (SCPR 2008).

Meanwhile, renewable energy technologies are being vigorously developed in the countryside. By the end of 2007, there were over 26.5 million households using marsh gas, saving 16 million tons of standard coal annually, tantamount to a reduced emission of 44 million tons of carbon dioxide. China has constructed 26,600 breeding farm marsh gas projects, and installed 42.86 million square metres of solar-powered heaters in the countryside, 14.68 million square metres of solar energy houses, 1.12 million solar energy stoves and more than 200,000 small wind-driven generators. It has established some demonstration spots for the gasification and solidification of crop stalks. It has also installed firewood- and coal-saving stoves in 151 million households, and energy-saving stoves in 34.71 million households (SCPR 2008).

11.4.5 Promoting Afforestation and Strengthening the Capacity of Carbon Sinks

In the past 20-odd years, some 4 million hectares of trees have been planted annually with the help of the central government, which has consistently increased funding towards this end. The state also encourages citizens to take part in tree planting. By the end of 2007, millions of people had planted 51.54 billion trees all over the country (SCPR 2008).

In recent years, through the reform of the collective forest right system, farmers' enthusiasm for tree planting and forest protection has been aroused. Currently, it has 54 million hectares of man-made forests, its timber volume reaching 1.505 billion cubic metres, with the country's rate of forest coverage going up from 12 % in the early 1980s to 18.21 % currently. In 2006, some 35.1 % of China's urban areas, or 1.32 million hectares, were covered with grass or trees. It is estimated that the tree-planting activities between 1980 and 2005 effectively absorbed 3.06 billion tons of carbon dioxide, while forest management absorbed 1.62 billion tons of carbon dioxide, reducing carbon dioxide emissions by 430 million tons, courtesy of improved forest protection (SCPR 2008).

11.4.6 Intensifying R&D Efforts to Deal with Climate Change

To deal with climate change, a number of scientific measures should be taken. These are (Zhang et al. 2009):

- Factoring response to climate change in the plan for scientific development. The Outline of China's Mid- and Long-term Development Plan for Science and Technology promulgated in 2006 prioritised energy and environment in the development of science and technology. China's Special SciTech Campaign to Cope with Climate Change enacted in 2007 set forth phased goals for scientific work as a response to climate change during the 11th Five-year Plan period (2006–2010) and long-term goals up to the year 2020.
- Strengthening the cultivation of personnel and construction of research bases. Thanks to efforts made over the past 20 years or so, a contingent of specialists has been formed in the field of climate change. This group is conducting basic and applied research across fields and disciplines. They have made pioneering research achievements, providing important scientific support for China to cope with climate change. A batch of national-level scientific research bases have been established, and a large observation network system, including the National Climate Monitoring Network, have been set up.
- Continuously increasing investment in scientific and technological work related to climate change. During the 10th Five-year Plan period (2001–2005), the government invested more than 2.5 billion yuan in scientific and technological research dealing with climate change through national science and technology plans such as the Gongguan Plan One, 863 Plan Two and 973 Plan Three. By the end of 2007, the National Science and Technology Plan for the 11th Five-year Plan period (2006–2010) had appropriated more than 7 billion yuan for scientific research into energy conservation and emission reduction. In addition, the state, through other channels, has invested large amounts of funds for scientific research into climate change.
- Key areas of scientific research. These include technologies that save energy and enhance its efficiency; technologies for renewable energy and new energy; technologies that can control, dispose of or utilize greenhouse gases such as carbon dioxide and methane in major industries; biological and engineering carbon

fixation technology; technologies for the clean and efficient exploitation and utilization of coal, petroleum and natural gas; technologies for manufacturing advanced equipment for coal- and nuclear-generated power; technologies for capturing, utilizing and storing carbon dioxide; and technologies that control greenhouse gas emissions in agriculture and how land is used.

11.5 Adapting to Climate Change

China has successfully applied policies and has taken actions to adapt to climate change in natural ecological systems such as agriculture, forestry and water resources, as well as ecologically fragile areas such as coastal zones and regions.

11.5.1 Agriculture

The state has made considerable efforts to establish and improve a law regime for agriculture to adapt to climate change, which include the Agriculture Law, Grassland Law, Fisheries Law, Law on Land Management, Regulations of Responses to Major Emergent Animal Epidemics and Regulations on Grassland Fire Prevention. The state has strengthened construction of agricultural infrastructure and capital construction of farmland water conservancy, enlarged irrigation areas, improved farmland irrigation and drainage efficiency and capability, and promoted dry farming and water-saving technologies, making agriculture better able to deter and mitigate natural disasters, hence increasing overall agricultural productivity. Through the "Seed Project," China is cultivating stress-resistant varieties of seeds with high yield potential, high quality and specific abilities of resistance to drought, water logging, high temperatures, diseases and pests.

11.5.2 Forests and Other Natural Ecosystems

For years, China has made commendable efforts to protect forests and other natural ecosystems by formulating and enforcing relevant laws and regulations such as the Forest Law, Law on the Protection of Wildlife, Law on Water and Soil Conservation, Law on Prevention and Control of Desertification, Regulations on Conversion of Farmland to Forests, Forest Fire Prevention Regulations and Regulations on Forest Diseases and Insect Pest Prevention and Control. The state is now working hard to draw up laws and regulations on the protection of natural reserves, wetlands and natural forests, and is pushing forward the all-round implementation of a national program of eco-environment development and protection.

11.5.3 Water Resources

China has worked out and enforced laws and regulations in this regard, including the Water Law, Flood Control Law and Regulations on River Administration. It has formulated and completed the program of flood control on major rivers and other water-conservancy programmes; and has set up an elementary law regime and a programme on water conservancy commensurate with China's conditions. It has also established an elementary flood-control and disaster-alleviation system for major rivers, and a water-resource allocation and protection system. Great efforts have been made to control soil erosion. By the end of 2007, efforts were being made to bring soil and water erosion under control over an area of 1 million square kilometres, thus effectively protecting the soil and water resources and improving its eco-environment.

11.5.4 Coastal Zones and Coastal Regions

In accordance with the Marine Environment Protection Law, Law on the Use and Administration of Sea Areas, General System Development Plan for the Air-Sea Interaction among others, China has worked out the objects and contents of a system to deal with climate change in marine areas. It has also established a decision-making and a coordination mechanism of comprehensive management, striving to slow down and adapt to the adverse impacts of climate change. Work has also been done to increase the capability of the coastal zones and coastal regions to adapt to climate change. Through investigations and research, China has strengthened the study on air-sea interaction so as to deepen understanding of air-sea interaction, and has initially formed an all-dimensional observation network pertaining to the marine environment, thus improving its capacity to control and prevent marine disasters.

Further, China has enhanced her capacity to monitor and issue early warnings over extreme climate events and has established mechanisms to deal with extreme meteorological emergencies, including their derivative and secondary effects. Great progress has been made in countering the effects of extreme climate phenomena like typhoons, regional intense thunderstorms and floods, and a comprehensive monitoring system for climate and climate change has taken initial shape.

11.5.5 Enhancing the Capacity of Adaptation to Climate Change

By improving the multi-disaster monitoring and early warning mechanisms, the policy-making and coordination mechanisms with more than one department involved, the action mechanism with extensive public participation, the capability of monitoring and forecasting meteorological disasters will be strengthened.

By shoring up farmland capital construction, adjusting cropping systems, breeding stress-resistant varieties, developing bio-technologies and other adaptive measures, by 2010, about 24 million hectares of grassland will be improved, while 52 million hectares of grassland suffering from degradation, desertification and salinity will be restored, and the efficient utilization coefficient of agricultural irrigation water will be raised to 0.5 (Gao 2002).

Courtesy of a strengthened natural forest conservation and natural reserve management, continuing key eco-protection projects, establishing important ecosystems and stepping up natural ecological restoration by 2010, some 90% of typical forest ecosystems and key national wildlife species will be under effective protection; natural reserves will account for 16% of the national territory; 250,000 km² of land suffering from water and soil erosion will have been improved; 300,000 km² of land will have been ecologically restored, and 22 million hectares of deserted land will have been put under control (SCPR 2008).

By following through a rational development and optimized allocation of water resources, improving new mechanisms for farmland water conservancy, strengthening measures for water conservation and hydrological monitoring, the vulnerability of China's water resources to climate change will have been alleviated by 2010; and concrete progress towards building a water-conserving society would have been achieved; an anti-flood system of large rivers will be in place, and the standard for drought resistance farmlands will have been raised.

Ultimately, by scientifically monitoring the trend of sea-level change, controlling marine and coastal ecosystems, rationally exploiting the coast, protecting coastal wetlands and planting coastal shelter belts, China will restore the mangrove swamps by 2010 and raise the coastal areas' capacity to resist marine disasters.

11.5.6 Institutional Arrangements to Combat Climate Change in China

In 1990, the Chinese government set up special institutions to deal with climate change. It also established the National Coordination Committee on Climate Change (NCCCC) in 1998. In order to further enhance the leadership of the work on climate change, the National Leading Group to Address Climate Change headed by the Chinese premier was set up in 2007 to draw up important strategies, policies and measures related to climate change, and to coordinate the resolving of major problems in this regard.

During the institutional reform in 2008, the number of member units of the National Leading Group increased from 18 to 20. The National Development and Reform Commission (NDRC) was to undertake the general work in respect to climate change, while the general office of the National Leading Group was placed under the NDRC. A special institution responsible for organizing and coordinating work on climate change all over the country was established within the NDRC. The Experts Committee for Climate Change has been set up to improve scientific

decision-making on climate change. It has done a great deal of work towards supporting government decision-making and boosting international cooperation and non-governmental activities.

In 2007, the State Council called on all regions and departments to strictly implement the National Plan for Coping with Climate Change in the light of their actual conditions. They were required to build and improve management systems, coordinate mechanisms and special institutions on climate change, organize teams of local experts to deal with climate change, make corresponding policies and measures in light of the local geographic environment, climate conditions and economic development level, set up statistical and monitoring systems on climate change, and organize and coordinate local actions to slow climate change (SCPR 2008).

From 1990 to 2005, China has decreased its GDP carbon intensity by 46%, while the industrialized world has only lowered theirs by 26%. China has also launched a voluntary reduction program for the period 2006–2010, including 20% reduction in energy intensity per unit of GDP (Zhuan 2007). To achieve this, it amended the Law on Energy Saving and Renewable Energy. It also set up a strict evaluation system for energy efficiency. Industries were required to achieve clean development. Projects with high emissions can no longer be allowed to go ahead, and some existing high emitters are being phased out. This translates into job losses for many who need them. It has cut down average consumption of coal per unit of power by 20% by demolishing the high-polluting and inefficient power plants, the impact of which has been the loss of 400,000 jobs.

China is ranked first in the world for solar heating and photovoltaic generation as well as installed hydro-power capacity. One in ten families already uses solar energy. China's medium-term target is to expand her non-fossil energy in primary energy consumption to 15% by 2020. 2.6 billion trees have been planted, more trees than by any other country in the world, translating into two trees per person.

Cities contain the largest concentration of the urban population where sources of resource and energy consumption are concentrated. Global warming aggravates urban heat island effect and severely impacts the urban ecosystem, water cycle, atmospheric environment, human health and, urban infrastructure. Global warming leads to an increase in the frequency of infectious diseases, especially in densely-populated urban settlements.

At around 2050, three-quarters of the Chinese population may be living in cities. The concentration of infrastructure, especially human and financial resources, will focus on cities.

As the biggest developing economy in the world, sustaining economic growth must be the first priority. Although the Chinese society is aware of the impacts of climate change, this awareness is not strong. Nonetheless, more and more city governments have realized that climate change is not a far-away issue. They fully understand that besides the politics surrounding the issue at the international and national levels, climate change also has local ramifications; and besides being a scientific issue, it is also an economic and social issue. It is not surprising that over the last several years, Chinese cities such as Beijing, Shanghai, Hangzhou, Baoding and Anji amongst others have started making low carbon action plans and adopting activities on climate mitigation and adaptation (Bao et al. 2008).

One of the leading Low Carbon Cities' demonstration programmes applies low carbon technologies within the country's network. Sustainable Communities (CSCs), a Local Agenda 21 pilot programme, are supported by over 18 central departments, such as the Ministry of Science and Technology (MoST), and the National Development and Reform Commission (NDRC). The CSCs programme has a membership of over 100 cities and counties distributed in over 28 provinces (<http://www.acca21.org.cn/local/experi/intro.htm>).

11.6 Lessons Learnt and Recommendations

Methane emissions can be controlled by continuously spreading low-emission and high-yield rice varieties, semi-drought rice cultivation, scientific irrigation and application of fertilizers according to soil type; and by strengthening R&D on fine ruminant animal breeds, large-scale breeding and management techniques, strengthening the management of animal waste, waste water and solid waste, and expanding the utilization of methane.

Sustained efforts should be made to realise the target of a 20% increase in forest coverage by 2010, and to reduce the annual volume of carbon dioxide by 50 million tons. This could be done through a continuation of key projects in afforestation, reclaiming farmland into forests and grasslands, farmland capital construction, and implementing relevant policies.

There is a need to provide strong scientific support towards efforts to address climate change so as to enhance public awareness and improve management. This can be achieved through:

- Sustained publicity, education and training by means of modern information dissemination technologies to encourage public participation. By the end of 2010, it is expected that public awareness on climate change will be universal, and that a social environment conducive to addressing climate change will be in place.
- Improving the multi-ministerial decision-making coordination mechanism and building an action mechanism involving a wide range of enterprise and public participation. China aims to establish an efficient institutional and management framework to address climate change.

11.7 Conclusion

China is at a crucial stage of the construction of a moderately prosperous society. This stage necessitates the speeding up of the country's industrialization and urbanization programme. The onerous task of developing the economy, improving people's livelihoods, building Liveable cities, and mitigating the impacts of climate change rests heavily on China and other developing nations than on developed countries.

The whole world, without exception, faces the challenge of climate change. The solution demands the joint efforts of the entire international community. China will work tirelessly for sustainable global development with other countries and continuously contribute to the protection of the climate system, which is the common wealth of all mankind.

References

- Bao J, Miao Y, Chen F (2008) Low carbon economy: revolution in the way of human economic development (in Chinese). *China Ind Econ* 2008(4):153–160
- Chow GC (2007) China's energy and environmental problems and policies. <http://www.princeton.edu/ceps/workingpapers/152chow.pdf>
- Dell M, Jones B, Olken BA (2008) Climate change and economic growth: evidence from the last half century. National Bureau of Economic Research Working Paper No. 14132
- Du Q (2010) Strengthening legal and policy frameworks for addressing climate change in Asia: People's Republic of China. <http://hqweb.unep.org/DEC/PDF/Casestudies/StrengtheningLegalPolicyFrameworksCCAsia.pdf>
- Fankhauser S, Tol RSJ (2005) On climate change and economic growth. *Resour Energy Econ* 27(1):1–17
- Gao G (2002) Mitigation of global climate change and China's strategy. *Energy of China* 7:4–12, in Chinese
- Information Office of the State Council of the People's Republic of China (2008) China's policies and actions for addressing climate change, Beijing
- Liu W (2007) China's challenges for addressing climate warming. *China Environmental News*, China announces targets on carbon emission cuts (2009). http://news.xinhuanet.com/english/2009-11/26/content_12544181.htm
- National Development and Reform Commission (NDRC) (2007a) China's national climate change program, Beijing
- National Development and Reform Commission (NDRC) (2007b) The state council the comprehensive work plan for energy conservation and emission reduction, Beijing
- The Office of State Coordinating Group for Combat Climate Change (2004) Global climate change: the challenge to human beings. Business Publishing House, Beijing, in Chinese
- Yang Yi, Professor at the School of International Relations and Diplomacy, Beijing Foreign Studies University, was delivered at the Nautilus Institutes international workshop on January 26th, 2010 in Paju, Korea on Interconnections of Global Problems in East Asia: Climate Change Adaptation and its Complexity from the Perspective of Civil Society
- Zhang H, Ma L, Li H, Ye Q (2009) Analysis of the development and mechanisms for actions in climate change by China's local governments. *China Public Adm Rev* 8(1):80–97, in Chinese
- Zhuan G (2007) Low carbon economy- the development approach to China in the context of climate change. Meteorological Publishing House, Beijing, in Chinese

Chapter 12

Climate Change and Its Effect on Cities of Eastern African Countries

Samuel Kerunyu Gichere, George Michael Sikoyo,
and Ally Matano Saidi

12.1 Introduction

This chapter seeks to provide a brief overview of predicted climate change in East Africa, and its effects on her cities. Due to the vastness of the region, this chapter will focus mainly on the anticipated impacts of climate change on cities within the East African Community (EAC) partner states, which comprise of Uganda, Kenya, United Republic of Tanzania, Rwanda and Burundi. Although they are members of one Community, these countries are marked by contrasts and incredibly diverse ecosystems, natural resources, economic activities and types of settlement (Eriksen et al. 2008). The estimated combined population of the broader EAC Partner States is 120 million people. Agriculture constitutes the economic mainstay of the region, which is dependent on the vagaries of climate. The region is also characterized by high levels of poverty.

The Intergovernmental Panel on Climate Change (IPCC) has predicted that the global mean temperature is likely to rise by 1°C by 2100, with associated changes in the hydrological cycle (IPCC 2001). The change in temperature will cause several impacts worldwide, and the EAC partner states will be no exception. The IPCC predictions show that the annual mean rainfall in East Africa will increase, but its pattern of occurrence is expected to keep changing, and thus becoming even more unpredictable. This will impact on all aspects of society, including rural communities, urban centres and cities in the region.

Despite their relatively low contribution to global warming, East African cities are already suffering from the effects of rising greenhouse gas emissions elsewhere in the world. There are over 15 cities with populations of about 15 million people within the EAC. Nairobi alone has over three million people.

Whereas three of these cities (Mombasa in Kenya; Tanga, in Zanzibar and Dar es Salaam in the United Republic of Tanzania) are located along the coast of East

S.K. Gichere (✉), G.M. Sikoyo, and A.M. Saidi
East African Community, Lake Victoria Basin Commission Secretariat,
Reinsurance Plaza 6th Floor, P. O. Box 1510-00100, Kisumu Kenya
e-mail: gichere@lvcsec.org; sikoyo@lvcsec.org; matano@lvcsec.org

Africa, the rest are located inland (these include Kampala, Uganda; Mwanza, Dodoma, Arusha, United Republic of Tanzania; Bujumbura, Burundi; Kigali, Rwanda; and Nairobi, Kisumu, and Nakuru, Kenya). These cities are characterized by complex interaction of social, political, economic, cultural and environmental factors. A change in climate will therefore be expected to impact on these factors with subsequent negative consequences to the cities.

This chapter is divided into five sections. The first part is an introduction while the second section provides an overview of the anticipated climate changes in East Africa. The third section discusses the on-going initiatives and actions aimed at mitigating and promoting adaptation to climate change risks. The fourth and final section draws together the observations and arguments presented in the previous sections and discuss their implications for policy and decision-makers.

12.2 Climate Change Effects on the Cities of East Africa

It is anticipated that an understating of the predicted impacts of climate change will lead to a better understanding of its effects on cities. East Africa is expected to warm by about 2–4°C by 2100, somewhat less than the Mediterranean north-Western Africa and the inner South Africa. The inner parts of East Africa are predicated to experience higher temperature increases than the coastal areas. Rainfall is predicted to decrease by about 0–20% in the inner parts of East Africa, with dry seasons becoming longer and having less rainfall. In contrast, rainfall is predicted to increase by 30–50% in the coastal areas. The increase will take place during the rainy seasons and during the primary rainy seasons in the equatorial region, which has two rainy seasons in a year (Hulme et al. 2001; IPCC 2001; Mwandosya et al. 1998: 1–24).

To-date, East Africa has experienced periodic droughts and flooding. In Africa, it's generally observed that rainfall increases from normal in the first year of a 2-year *El Nino* episode, and then decreases from normal in the second year of the cycle. However, rainfall patterns in East Africa follow the opposite cycle: first year of *El Nino* brings less than normal amount of rain while the second year brings more than usual. *El Nino* influences the length of the rainy seasons in a year. *La Nina* normally reduces rainfall all over Africa during its first year before increasing it in the second year. *La Nina* influences the amount of rainfall, especially during the primary rainy season. However, its effects on East Africa are less pronounced than those of *El Nino*. Finally, the variations in rainfall are strongly related to sea surface temperature variations in the Indian Ocean and the Atlantic, which may sometimes alter standard oscillation outcomes (Clark et al. 2003; IPCC 2001; Nicholson 2001; Nicholson and Kim 1997; Nicholson and Selato 2000).

The variability of rainfall is therefore predicted to increase as a result of the increased frequency of *El Nino* events (IPCC 2001). Changes in mean temperature and the increased variability of rainfall are together likely to prolong the length of the dry season every year, and to increase the severity of periodic droughts. This is more pronounced in the interior parts of East Africa, which experience reduced rainfall, and the coastal areas which are expected to be less exposed to droughts. However, the

increased mean annual rainfall, coupled with cyclical variations, is likely to result in more frequent and severe flooding. The predicted sea level rise of 0.10–0.90 m is expected to aggravate flooding in the coastal region of East Africa.

12.2.1 Floods

Increased rainfall in East Africa, mainly induced by climate change, will result in flooding and storm surges in many areas, with subsequent impacts on cities, some of which have already started to experience extreme climatic conditions. There are four major types of flooding that are currently being observed in most of the cities within East Africa (Mendel 2006). The localized flooding which takes place several times in a year, particularly in slum areas such as Kibera (the largest slum in sub-Saharan Africa with a population of about 700,000 people) in Nairobi, Kenya; and Kibuli, Kisenyi and Katanga in Kampala, Uganda. The few drains, the highly compacted ground and pathways between dwellings reduce infiltration and hence lead to run-offs that eventually become streams after heavy rains. Such drains and culverts are often blocked by solid waste and debris due mainly to poor solid waste management in most of the cities.

Rapid and unplanned structural changes in urban areas and storms intensity now produce higher flows, exceeding the initial design capacity. The channels sometimes carry a lot of debris, making them narrower and smaller than they were 2 decades ago. Major rivers flowing through urban areas are affected by land use changes and engineering works upstream. Whereas dams trap sediments, causing rivers to erode their banks downstream, their operation may lead to high flows when stored water is released suddenly. Further, city growth in East Africa has expanded into flood plains, putting parts of the cities below flood level and ruining the area into which floods can naturally overflow. In lowland and coastal cities of Mombasa, Zanzibar, Tanga, and Dar es Salaam, wet season flooding occurs for 2 or more months because rain and river water combine to raise the levels of water in swamps that would have naturally been inundated at certain times of the year.

Mombasa has a history of disasters related to climate extremes such as floods, which cause serious damage nearly every year and, often, loss of life. The floods experienced in October 2006 were particularly serious, affecting some 60,000 people in the city and the wider Coast Province. In addition, around 17% of Mombasa could be submerged by a sea-level rise of 0.3 m, with a larger area rendered uninhabitable or unusable for agriculture because of water logging and salt stress. Sandy beaches, historic and cultural monuments and several hotels, industries and port facilities would be negatively affected, and inevitably damage the tourism industry in Mombasa.

Dar es Salaam is vulnerable to floods, sea-level rise and coastal erosion, water scarcity and outbreak of diseases. Over 70% of settlements are not planned. Such areas include Msasani, Bonde la Mpunga, Msimbazi valley and Jangwani, and are prone to flooding. Jangwani slum, which is located along Morogoro road on the way

to the city from Magomeni, is a low-lying area characterized by folds during the rainy season, which occur almost every year. The Mizimbazi River passes through this valley, further risking the lives of dwellers settled at the mouth of the river. The area was declared unsuitable for residential purposes by the Ministry of Lands and Human Settlement Development due to its susceptibility to environmental threats.

The risks from the abovementioned four major types of flooding stem from a number of factors, which include the predominance of impermeable surfaces that cause water run-off, the general scarcity of parks and other green spaces to absorb these flows, rudimentary drainage systems that are often clogged by waste, and which in any case are quickly overloaded with water, and the ill-advised development of marshlands and other natural buffers (Mendel 2006). Generally, urban planning in most cities in East Africa has been ad hoc and short term in terms of planning strategy. The situation has been exacerbated by rural to urban migration, which has led to unplanned habitats such as slums.

12.3 Increased Population and Development

Kampala, Nairobi and Dar es Salaam are some of the fastest growing cities in Africa with an average of 3.5–6% growth rates. Population growth and its associated development affects warm air near the surface at night by disrupting the formation of a cool, shallow layer of air that often collects near the ground after sundown, while warmer air is suspended above it. Economic development and population growth disrupt the boundary layer and bring warmer air down to the surface since buildings increase the surface “roughness,” which increases turbulence in surface breezes; asphalt and concrete absorb more solar radiation than the natural landscape. They release that energy as heat after sunset (perhaps more efficiently than soil and plant cover). This heat warms the air near the surface, delaying or preventing the cool boundary layer from forming; and small particles (called aerosols) emitted as exhaust fumes from cars and trucks as well as smoke from cooking and heating fires may trap heat that would otherwise radiate into space. This is similar to the warming caused by low-lying night clouds.

12.3.1 Poverty

Poverty levels in the EAC partner states remain a key challenge to the achievement of faster EAC’s economic development, considering GDP per capita is estimated at US\$345. The population living below the poverty line is estimated at about 44%. Climate change is therefore not only a threat, but also a challenge because social groups, households (in rural as well as urban areas) have a limited capacity to adapt to climate variability and change (Paavola 2003 and Satterwaite 2008).

The cities of East Africa account for about 60% of the region's gross domestic product and are important centres of employment, trade, and education. However, contrary to expectations, these centres also account for over 55% of those who live below the poverty line of US\$1 per day. The city dwellers are vulnerable to multiple impacts of climate change. For example, the coastal city dwellers of Dar es Salaam, Zanzibar, and Mombasa are vulnerable to heat stress, sea-level rise and the destruction of coastal livelihoods, price volatility in local markets, water shortages due to drought and salt water intrusion, and shortages of fuel-wood. With floods and other problems related to increased precipitation on the rise, the poverty situation in most of East African cities will get worse. Housing challenges, spiralling food prices, access to utilities, among others, will leave the poor city dwellers worse off and more vulnerable.

The rural – urban migration has led to an increase in the demand for agricultural produce and other rural-based products such as vegetables, forest products (including fuel-wood and charcoal) and traditional medicine. The increased demand and commercialization of these products in turn leads to an increase in the degradation of forests and savannah ecosystems (Paavola 2003).

12.3.2 Increased Energy Costs

Climate change has impacted on energy generation in all the five East African Community partner states. There have been reported cases of declining hydro-power generation due to a fall in water levels in key lakes and rivers attributed to climate change. According to Uganda's Ministry of Energy, Lake Victoria's shallowness is very prone to climatic changes, especially hot conditions. Since 2004, the water level of Lake Victoria alone declined by 4 m in depth, leading to a power crisis in Uganda. The Nalubaale/Owen Falls Dam and Kira Dam on River Nile, whose power generation capacity has hitherto been 380 MW had gone down to less than 120 MW by the end of 2005. The Owen Falls and Kira dams can no longer produce enough electricity to meet the demand in Uganda. This has led to an increase in thermal power generation that has subsequently led to an increase in power tariffs from US 10 cents in 2004 to US 30 cents in 2007, with the poor feeling the heaviest impact. Though it has not yet been established how climate change will impact Kampala's energy costs, the current trend indicates that increasing clean energy costs is forcing sections of the population to resort to less clean and unsustainable wood fuel sources.

Most of the electrical power demand in Kenya is hydro based. This dependency became poignantly clear during the 1999/2000 drought, which was the worst recorded since 1947–1951, when the contribution of hydro-electric energy to the national grid was reduced to 41%, from 3062.5 GWh in 1999 to 1,793 GWh in 2000 (Mogaka et al. 2006). The monthly cost to the hydro power industry as a result of lost generation in hydro power is estimated at \$68 million. The cost to the economy, arising from imported electricity, increased investments in thermal generation, as well as from the

lost revenue and lost jobs in industries, where replacement energy could not be arranged, was very high indeed. In addition, due to strong urban – rural linkages, loss of employment opportunities in Nairobi has increased vulnerability of rural households that depend on remittances from the city.

12.3.2.1 Impact on Social and Physical Infrastructure

Climate change and variability has contributed to a reduction of water levels from lakes and rivers that service the East African cities. In particular, the capacities of the different water boards in each of the partner states to provide clean safe water is constrained by infrastructural problems. The situation is worse in informal settlements, which already lack appropriate infrastructure and have limited access to water, electricity, and sanitation. A case in point is the reduction in water levels of Lake Victoria, which is constraining the capacity of the National Water and Sewerage Corporation (NWSC), the supplier of safe and clean water to Kampala residents, to supply enough water. In 2008, the NWSC was forced to extend water pipes deep into the lake at a cost of Uganda shillings 7.5 billion (US\$4.4 million). This has led to water price escalation amidst deteriorating water quality and poor supplies.

12.3.2.2 Impact on Human Health

Altered temperature and rainfall patterns could increase incidences of cholera, malaria and a host of other diseases, and reduced nutritional status. Increased morbidity and mortality in sub regions where vector-borne diseases increase following climatic changes would have far-reaching economic consequences (Shongwe 2009). For instance, in Kampala, due to frequent floods, it is reported that human waste is getting into the water as most of Kampala's sewage flow untreated into Lake Victoria through the Nakivubo Channel, a huge open watercourse that cuts across the city. The Nakivubo wetland, which used to serve as a natural filter for waste water, is rapidly shrinking due to rampant encroachment. The situation is complicated by the fact that only 8% of the residents have access to sewer pipes operated by NWSC. The rest use pit latrines – or in some cases dispose faeces in polythene bags, which are thrown into garbage pits or water channels. According to Robert Odongo, an environment inspector with the Uganda Ministry of Health, elevated levels of faecal coliforms cause cholera, diarrhoea and dysentery (Mendel 2006). Levels lower than 50 colonies per 100 ml are considered safe.

12.3.2.3 Food Security

Although the effects of mean temperature changes, increase in atmospheric carbon dioxide and mean precipitation changes will be severe in the longer term, in the short-term there is a growing consensus that the most ominous impacts of climate

change, especially on agriculture, will be felt through increased frequency and severity of extreme events such as droughts, floods and heat waves. Since the East African cities are not islands, their inhabitants will need a constant supply of food. Most of the farming activities in East Africa depend entirely on the quality of the rainy season. This renders populations vulnerable to climate change and climate variability. In 2007/2008, excessive flooding occurred in Uganda when rivers burst their banks in the eastern part of Uganda, washing away bridges and causing untold socio-economic interruptions. The unexpected heavy rains occurred during harvest time, resulting in lots of food rotting and going to waste. This had the result of negatively affecting food supplies to major towns, especially Kampala, with escalating food prices flying out of the reach of most poor people in the city.

12.4 On-Going and Proposed Actions

The principal and urgent challenge in East African cities and towns is adaptation to climate change and management of its impacts; and maximizing development outcomes (i.e. minimizing negative impacts and seizing opportunities to maximize the positive impacts (WRI 2007)). The following measures are being implemented by the East African cities to mitigate, as well as adapt to, climate change.

12.4.1 Mitigation

The cities are involved in a number of initiatives in a bid to mitigate the effects of climate change. In 1999, for example, Kampala City Council embarked on the rehabilitation of the Nakivubo channel under the Nakivubo Channel Rehabilitation project with a view to alleviate the frequent flood incidences on the road network, which affects traffic flows and adversely impacts on economic activities and living conditions in Kampala. Institutionally, the project enhanced the Kampala City Council (KCC) management capacity, helping establish the infrastructure investment policies, and ultimately, supporting KCC's reform program. The project components included civil works on the rehabilitation of the main channel, construction of auxiliary drains, and the rehabilitation of priority drainage.

Consulting services such as construction supervision were financed by the project, as were the required programme and policy studies, namely the Kampala Drainage Master Plan Study, and the Kampala Urban Transportation Improvement Program Study. Institutional strengthening supported both the KCC reform programme under the strategic framework for reform, and the revenue enhancement programme. To facilitate outsourcing of basic delivery functions, seed funds were availed and training and implementation support was provided.

In Dar es Salaam, initiatives are being spearheaded through community infrastructure upgrading programmes, which were being implemented by the Dar es Salaam Water

and Sanitation Board. The intention is to improve the physical infrastructure such as storm water drainage networks, and strengthen the adaptation capacity of the community, especially those living in unplanned settlements. The programme is being piloted in Manzese and Hanna Nassif areas. Revision of city master plans and development planning frameworks to accommodate the growing populations as well as meet the infrastructure needs and services is underway. These include the management of “hazards lands” (flood susceptibility, erosions, steep slopes associated with rivers) and open space, and formulation of flood plain management by-laws, and relocation of families whose houses are at risk. There are also comprehensive plans that focus on the use of land and water resources in coastal towns. For instance, in Dar es Salaam, the Kinondoni Coastal Area Management project (KICAMP) has, among other things, banned excavation of sands in Kunduchi-Mtongani as a way of preventing further erosion along the coastal area.

12.4.2 Adaptation

There is substantial overlap between climate change adaptation and “conventional”, sustainable development practices (WRI 2007). All the five East African partner states (Burundi, Kenya, Rwanda, Tanzania and Uganda) have prepared the National Adaptation Programme of Action (NAPA). The implementation of these programs of action has been hampered by inadequate funding for the proposed adaptation projects. Besides, coordinated mechanisms for implementation of the NAPA are still pegged on the Environmental Management Authorities, although the adaptation approaches proposed are multi-sectoral.

The East African cities are undertaking the following measures to enhance adaptation to climate change:

- Addressing drivers of vulnerability (reducing poverty, addressing capability shortages, etc.).
- Building response capacity (by improving weather and water resource information systems, natural resource management practices, etc.).
- Managing climate risk (through disaster risk reduction, climate-proofing of investment schemes and programmes, particularly among the poor in cities).
- Confronting climate change by relocating communities and fields, and building dykes to counter rising sea levels.
- Mainstreaming adaptation into existing city infrastructural development frameworks and master plans, and policies in key areas such as infrastructure, water resource management and disaster preparedness. The cost of adaptation has to be factored into investment strategies.
- Strengthening mechanisms and arrangements for early warning and disaster preparedness so as to reduce the vulnerability of the poor.
- Most of the EAC partner states have national disaster and emergency policies, with special ministries being responsible for disaster preparedness and response. For instance in Uganda, the overall objective of disaster preparedness and

management is to save lives and livelihoods, reduce Uganda's vulnerability to potential disasters, in cooperation with local communities, NGOs, local and international donor organizations; and to enhance the country's ability to contain or minimize the social and economic effects of disasters. Therefore, what is imperative within the regional framework is the harmonization of approaches to ease information sharing and approaches, which the EAC Climate Change strategy, currently under preparation, is likely to propose.

- Planning that integrates adaptation needs; and which should be promoted in the following areas:
 1. At the EAC level, the completion of preparation of the climate change strategy will enhance joint management, research, knowledge and information, and the development of common early warning systems
 2. At the national level, this will involve mainstreaming climate change into policies, plans and budgets
 3. At the local level, it will entail integrating adaptation into city and urban planning, disaster preparedness, etc. and
 4. At the individual household level, the emphasis will be on increasing resilience, particularly in informal settlements.

12.5 Conclusion

A critical consideration for improved adaptation to climate change is to ensure effective governance and decision-making under conditions of uncertainty. Thus, it is important to invest in good governance, institutions and decision-making processes that can provide a solid foundation for action, including priority setting, trade-offs, resolving conflicts, and building resilience. Access to reliable information and knowledge is important in order to be able to make good decisions and to foster accountability: to improve weather and climate data and forecasts, develop technologies for water storage and flood protection in the cities, etc.

The EAC partner states have focused on the preparation of the National Adaptation Programme of Action. However, in the EAC/LVBC context, there is need to coordinate responses to climate change in line with defined national strategies, in conjunction with the UNFCCC. There is also a need to harmonize climate change adaptation efforts by integrating climate change adaptation and disaster risk reduction into development plans for the cities of East Africa.

References

- Clark DA, Piper SC, Reeling CD, Clark DB (2003). Tropical rainforest tree growth and atmospheric carbon dynamics linked to inter-annual temperature variation during 1984–2000. *Proceedings of the National Academy of Sciences* 10:5852–5857

- Eriksen S, O'Brien K, Rosentrator L (2008) Climate change in Eastern and Southern Africa: impacts, vulnerability and adaptation. GECHS Report 2008:2. Department of Sociology and Human Geography, University of Oslo, Oslo
- Hulme M, Dorherthy R, Ngara T, New M, Lister D (2001). African Climate Change: 1900–2000 Intergovernmental Panel on Climate Change (2001) Climate change 2001: impacts, adaptation, and vulnerability. Cambridge University Press, Cambridge
- Mogaka H, Gichere S, Richard D, Rafik H (2006) Climate variability and water resources degradation in Kenya: improving water resources development and management. World Bank Working Paper No. 69. The World Bank, Washington, DC
- Mwandosya MJ, Nyenzi BS, Luhanga ML (1998) The assessment of vulnerability and adaptation to climate change impacts in Tanzania. Centre for Energy, Environment, Science and Technology (CEEST), Dar es Salaam
- Mendel G (2006) Climate change, urban flooding and the rights of the urban poor in Africa: key findings from six African cities. A Report by Action Aid. Action Aid International, Books for Change, London
- Nicholson SE (2001) Climatic and environmental changes in Africa during the last two centuries. *Clim Res* 17:123–144
- Nicholson SE, Kim J (1997) The relationship of the el nino-southern oscillation to African rainfall. *Int J Climatol* 17:117–135
- Nicholson SE, Selato JC (2000) The influence of la nina on African rainfall. *Int J Climatol* 20:1761–1776
- Paavola J (2003) Variability to climate change in Tanzania: sources, substance and solutions. Paper Presented at the Inaugural Workshop of Southern Africa Vulnerability Initiative (SAVI), Maputo, Mozambique, 19–21 June 2003
- Satterwaite D (2008) Climate change and urbanization: effects and implications for urban governance. United Nations Expert Group Meeting on Population Distribution, Urbanization, Internal Migration and Development, United Nations Secretariat, New York, 21–23 Jan 2008
- Shongwe SV (2009) The impact of climate change on health in East, Central and Southern Africa (ECSA) region. Common Wealth Ministers' Update: Regional Case Study, Arusha
- World Resource Institute (2007) Weathering the storm – options for framing adaptation and development. World Resources Institute, Washington, DC

Chapter 13

Climate Change and Liveable Cities in Malaysia

Kamalruddin Shamsudin and Suan Siow Neo

13.1 Introduction

This chapter presents research findings and recent policy initiatives on climate change that have been undertaken in Malaysia. It highlights climate change scenarios, physical planning policies, and to a smaller extent efforts on green building initiatives aimed at promoting sustainable and liveable cities. The chapter aims at answering the following questions: How do cities contribute to global warming? How should cities operate so as to combat global warming by creating economic and social opportunities that are sustainable and resilient to climate change? How can physical planning play an effective role in reducing the impact of climate change? Has Malaysia and her cities experienced the impacts of climate change? This chapter responds to these questions from a physical planning perspective, and from a number of scientific researches carried out by local and international research institutions.

13.2 Liveability Cities

Liveability is defined as the quality of life as experienced by residents within a city or region. Liveability, sustainability and resiliency define the quality of life of current and future residents. A liveable city in Malaysia as defined in its National Urbanization Policy is one that creates “a visionary city with a peaceful community and living environment through sustainable urban development” (Federal Department of Town and Country Planning (FDTCP) 2006). Through such urbanization policy, cities are meant to be efficient and sustainable; resilient, dynamic and competitive; with integrated

K. Shamsudin (✉) and S.S. Neo
Federal Department of Town and Country Planning, Ministry of Housing
and Local Government Malaysia, Kuala Lumpur, Malaysia
e-mail: kldinkldin@yahoo.com; snsio@yahoo.com

and efficient urban transportation systems; quality urban services, infrastructure and utility services, good quality of life and effective urban governance.

Sustainability issues within the physical planning perspective are addressed in various statutory documents (Structure, Local and Special Area Plans) and policy documents, i.e. National Urbanisation Policy, National Physical Plan and the 5-year rolling National Plans. These documents attempt to put sustainability concepts into action by way of measures (in particular, in local plans and National Physical Plans), and proposed various projects and infrastructures that support such concerns. However, as this study reveals, a lot of concerted effort and a more workable framework for communication and consultation are required.

13.3 Geographical Location and Socioeconomic Trends in Malaysia

Malaysia is a coastal nation, rich in biodiversity and natural resources. It covers an area of 329,733 km², and is situated in the equatorial region, with Peninsular Malaysia lying between latitudes 1.5°N and 7.6°N, and longitudes 99.5°E and 104°E. East Malaysia is located between latitudes 1°N and 6.5°N, and longitudes 108°E and 120°E (Fig. 13.1).



Fig. 13.1 Geographical location of Malaysia (Ministry of Science, Technology and the Environment (2000); Ministry of Natural Resources and Environment (NRE) (2005))

13.3.1 Population and Urbanisation

In 2007, Malaysia had a population of 27.23 million. This figure is estimated to increase to 28.24 million in 2010. The level of urbanisation is expected to increase to 63.8% in 2010 from 63% in 2005. The population is concentrated in three major conurbations: Kuala Lumpur with a population of about 5.0 million, George Town and Johor Bahru with an approximate population of two million people each. It is expected that 75% of the population will be living in urban areas by 2020.

13.3.2 Economic Trends

Being a highly open economy, Malaysia is not completely insulated from global financial shocks. The projected GDP growth in 2009 was between -1% and 1%, way below the earlier estimate of 3.5%. The government had introduced stimulus packages worth RM67 billion to ride the economic slowdown. The economic slowdown has impacted four factors of the economy, i.e. a decline in exports, a drop in commodity exports, decline in foreign direct investment (FDI) and the global meltdown of the equity markets. Per capita income in current terms increased by 10.6% per annum to RM23,060 or US\$6,714; and per capita income in purchasing power parity increased by 14% per annum to US\$13,529 in 2007 (Economic Planning Unit 2008).

13.3.3 Land Utilization

Malaysia has undergone rapid economic development since achieving independence in 1957. This was largely fuelled by the sustainable utilization of its natural resources, and also through the development of human capital. In 2007, approximately 59% of the total land area (33.1 million hectares) was forest land, and 14.5% was covered by tree crops such as oil palm, rubber, cocoa and coconut. The remaining 26.5% was used for agriculture, housing, construction and industry.

13.4 Climate Change Scenarios in Malaysia

13.4.1 Temperature and Precipitation

Most climate change projections, scenarios and impacts on the socioeconomic developments of Malaysia are obtained from the Initial National Communication (INC) Report 2000. However, recent projections have been profiled in a study titled "Impact of climate change on hydrologic regime and water resources of Peninsular Malaysia" (2006), which was undertaken by the National Hydraulic Research

Institute of Malaysia (NAHRIM), Ministry of Environment and Natural Resources Malaysia. The study indicated that climate change is expected to raise surface temperatures by an average of 1.5°C in most regions in Malaysia, and could by 2050 trigger changes in the amount of precipitation and seasonal patterns.

The study indicates that Malaysia will experience extreme weather conditions and unequal distribution of rainfall. In regions such as Kelantan, Terengganu and Pahang (the main food-producing areas of Malaysia), the annual rainfall will be higher by 10%, and river flows are expected to rise by between 11% and 43%. On the other hand, other regions such as Selangor and Johor (the more densely populated areas in the country), the annual rainfall is expected to be lower by 5% and the river flows down by about 31–93% (Table 13.1; Figs. 13.2 and 13.3). Extreme weather events such as cyclones, lightning and heavy precipitation events are also expected to change in intensity and pattern. The expected changes in the hydrologic regime may require careful planning of water resources and management of demand

Table 13.1 Hydro climate projection for Peninsular Malaysia (NAHRIM [2006])

	Projected (For the period 2025–2034 and 2041–2050 relative to 1984–1993)
Averaged annual air temperature	+1.5°C
Average annual rainfall	+10% (Kelantan, Terengganu and Pahang) –5% (Selangor and Johor)
River flows (monthly)	+11% to +43% (flood flows) –31% to –93% (low flows)

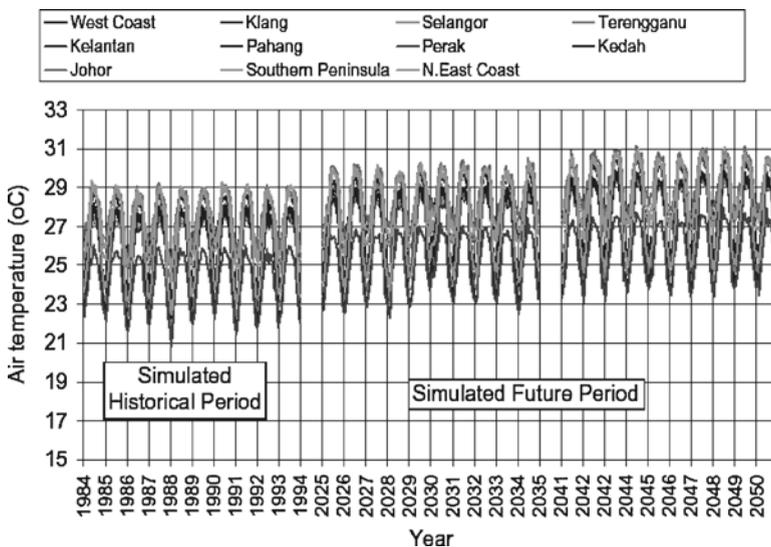


Fig. 13.2 Simulated monthly mean air temperatures at every sub-region of Peninsular Malaysia during the simulated historical (1984–1993) and future (2025–2034 and 2041–2050) periods (NAHRIM [2006], p 130)

and supply of water for irrigation and domestic consumption. Already, water supply is being sourced from Pahang, which neighbours Selangor. The changes will have an impact on the existing and future land use development, whereby appropriate mitigation and adaptation measures will have to be instituted.

13.4.2 Sea-Level Rise

Malaysia, with a coastline of approximately 4,800 km sits on the geological stable Sunda Shelf. Based on the Coastal Vulnerability Index Study (CVI) of 2007, at the rate of sea-level rise (SLR) of between 1.3 and 10.0 mm per year, the predicted sea-level rise (SLR) by year 2100 is between 0.13 (observed-local scenario) and 1.0 m (worst-case scenario), respectively (Table 13.2).

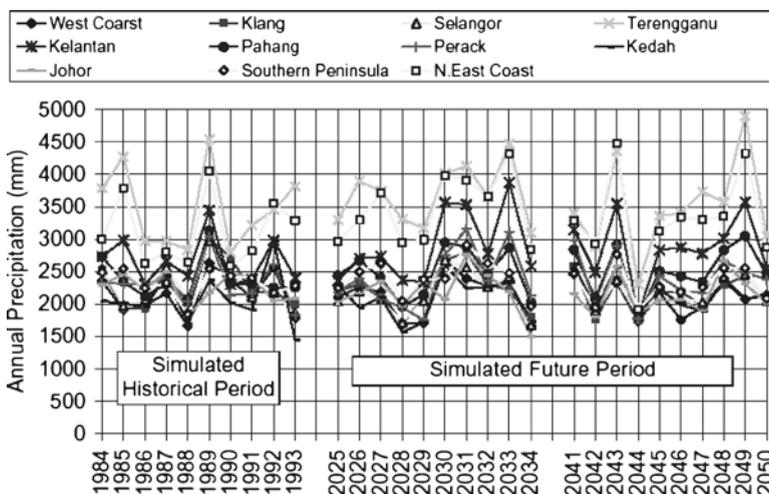


Fig. 13.3 Simulated annual precipitation at every sub-regions of Peninsular Malaysia during simulated historical (1984–1993) and future (2045–2043 and 2041–2050) periods (NRE [2006], p 132)

Table 13.2 Future SLR scenarios for impact analysis (Department of Drainage and Irrigation [2007] National coastal vulnerability index study. Ministry of Environment and Natural Resources Malaysia)

Case No.	SLR scenarios	Rate of SLR	Predicted sea levels		
			2000	2050	2100
1	Observed (local)	1.3 mm/year	0.0 m	0.065 m	0.13 m
2	Global-low	3.0 mm/year	0.0 m	0.15 m	0.3 m
3	Global-average	5.0 mm/year	0.0 m	0.25 m	0.5 m
4	Global-high (worst-case)	10.0 mm/year	0.0 m	0.50 m	1.0 m

13.5 Impacts on Socioeconomic Development

13.5.1 Coastal Resources

The INC 2000 established and summarized the likely impacts of sea-level rise into four broad categories: tidal inundation, shoreline erosion, increased wave action and saline intrusion. SLR of 0.9 cm/year, about 1,200 km² of the coastal polder land in Peninsular Malaysia will be submerged by 2100, subsequent to bund failure. Shoreline erosion is projected to increase by another 30% above the present rate of about 30%. Other SLR-related impacts include:

- Nation-wide loss of about 80,000 ha of land planted with rubber due to flooding caused by a combination of increased rainfall and SLR of 1.0 m
- Abandonment of about 100,000 ha of land planted with oil palm
- A loss of between 15% and 20% of mangrove forests along the coastline and
- Possible relocation of shore-based power stations and settlements

The socioeconomic impacts include:

- Loss of agricultural production from eroded/inundated lands estimated at RM46 million, specifically for low-lying areas such as Western Johor Agricultural Development Project Area
- Long-term annual flood damage is estimated at about RM88 million for Peninsular Malaysia and RM12 million for Sabah and Sarawak and is informed by the displacement and relocation of flood victims and associated disruption of business and economic activities. If the flood frequency is doubled, the annual flood damage will be increased by 1.67 times
- Loss of fisheries production due to mangrove loss, estimated at RM300 million (based on 20% loss of mangrove, resulting in a loss of about 70,000 t of prawn production)

13.5.2 Agriculture

At least a third of the country's population depends on the agriculture sector for their livelihood. It was estimated that changes in average temperature and rainfall could affect key crops such as rubber, oil palm, rice, animal husbandry and aquaculture; and jeopardize the sustainability of food supply. About 273,000 ha of land, or 15% of current rubber land could be affected, and rice grain yields may decline by 9–10% for every 1°C rise.

13.5.3 Forestry

Forests are important to an ecosystem for two very unique features: as a reservoir for carbon (known as carbon sink from photosynthesis process) and as an

integral part of the global biological system (1 ha or 10,000 m² of tree can absorb 6 t of carbon dioxide/year) (UNEP 2006). Through Sustainable Forest Management, Malaysia's gazetted permanent forest reserves have increased to 14.4 million hectares in 2003, while national parks and wildlife sanctuaries expanded to 2.4 million hectares in the same period. The conservation of forest and its resources is also in tandem with the commitments outlined in the convention on Biological Diversity, which Malaysia ratified in 1994.

13.5.4 Water Resources

Rapid urbanization and industrialization has led to a higher demand for water resources from the industrial sector, agriculture (through irrigation) and for household and commercial uses. Malaysia could face two possible scenarios: on one hand, flood intensity and frequency could increase with higher storm magnitude. More floods essentially mean destruction of property and infrastructure and loss of livelihoods. On the other hand, Malaysia could experience lower rainfalls that could affect the availability of water, straining households, the agriculture sector and industries. When viewed against the backdrop of rising demand, mainly fuelled by rapid population growth and industrialization, this scenario is worrying. According to 2007 records, the average urban Malaysian uses 285 L per capita per day, compared to the international average of 165 L per capita per day. The figures for Singapore and Hong Kong are 157 and 219 L, respectively.

13.5.5 Human Settlements and Land Use

In a research conducted for Malaysia by Laplante (2009), a 1-m rise in sea level will lead to the submersion of 745 km² of land area (Table 13.3).

The research also estimated that as many as 16 major cities in Malaysia, mainly along the coast, will be affected by storm surges. This is further supported by a study (though inconclusive) conducted by the FDTCP (2008) to establish a Physical Plan for Coastal Zones in Peninsular Malaysia which estimated that by 2050 about, 27% of Peninsula's population within the 5-km belt along the coast would be affected by sea level rise.

13.6 Has Malaysia Experienced the Impacts of Climate Change?

Though Malaysia has yet to experience the extreme ravages of climate change, mild climate related disasters such as floods, droughts, storm/wave surges, wildfires, wind storm and landslides are happening frequently. According to Disaster Profile

Table 13.3 Sea-level rise and storm surges (Laplante [2009])

		Impacted area (in sq km)				
		1 m	2 m	3 m	4 m	5 m
Vietnam	328,535	16,977	28,090	38,860	47,080	52,926
Taiwan China	36,223	574	868	1,204	1,552	1,882
Indonesia	1,898,776	13,861	22,150	35,090	53,526	77,205
Myanmar	669,310	4,826	7,363	11,948	19,371	27,257
Philippines	295,408	1,735	2,837	4,526	6,709	9,078
Cambodia	179,492	1,034	1,892	3,319	5,220	7,565
South Korea	98,977	536	895	1,350	1,927	2,637
China	9,198,103	31,598	49,384	70,304	93,815	116,606
Thailand	513,618	1,607	3,685	7,578	12,924	18,498
Brunei	5,901	17	21	29	52	99
Malaysia	329,941	745	1,334	2,500	4,305	6,638
North Korea	122,440	262	481	868	1,496	3,038
Papua New Guinea	464,043	659	925	1,359	2,029	3,121

of Malaysia, based on the CRED EmDat record, 49 cases of natural disaster events were reported from December 1965 to January 2007. About 1,062 people were killed and 1.24 million were affected, while the total damage loss was estimated at about US\$155,000.

For the last 6 years, climate change has contributed to a series of disasters in Malaysia. For instance, Kuala Muda District, which is located in the northern region of Peninsular Malaysia, experienced serious flooding in 2003 and 2007. Heavy rainfalls, coupled with the back-flow of Terus River caused Muda River to overflow, flooding the surrounding areas.

Kota Tinggi and Johor Bahru cities, which had never experienced flooding, were seriously flooded on December 2006 and January 2007, causing damages to property and forced as many as 134,000–148,000 people to flee their homes, and displaced 30,000 people to shelter relief centres. Total losses amounted to RM107.8 million, (Mazlin Mokhtar 2007) whilst social implications included loss of jobs and income, increase in crime rate and psychological trauma among affected victims. The economic impacts of both disasters include the cost of rehabilitation and displacement of people to new shelter homes, and reconstruction in terms of new bridges, roads, houses and utilities.

The tsunami which hit Malaysia on 26 December 2004, and which was triggered by a 9.0 Richter scale earthquake, occurred in north-west Sumatra, Indonesia, affected settlements in four states in Malaysia: Penang, Kedah, Perak and Selangor. The tsunami burst past the coastline, inundating areas which were up to 350 m away from the coastline. The main biological impacts included the destruction of mangroves; death of shallow sea and mudflat habitats as fish and shells were transported inland, together with swathes of mud. The tsunami also damaged nearby agriculture areas, which were affected by the increased salinity left behind by the retreating floods. The estimated death toll was 68. Besides, a total of 3,733 fishermen were affected, while the total damages and losses in monetary value amounted to RM73.1 million.



Fig. 13.4 Tsunami-affected areas and the resettlement scheme for tsunami victims (Sungai Petani Municipal Council [2009])

Since then, the government has resettled those affected (from the District of Kuala Muda) to a safer location (Fig. 13.4). Integrated resettlement schemes that incorporate social and community facilities, housing and employment areas have improved the well-being of the people. The scheme has also provided many opportunities for the residents to earn supplementary incomes with the support of local community and the provision of small-medium scale industrial centres.

13.7 Malaysia's Initiatives

13.7.1 Environmental Policy Goals of the Government

Climate change is a cross-sector issue; it should be mainstreamed into national policies, programmes and plans for better efficiency and greater effectiveness. Integration of the climate change agenda into the development planning processes is a foregone conclusion. Developing economies such as Malaysia are committed to uplifting the socioeconomic status of their people through creation of needed job opportunities through enhanced access to efficient infrastructure, industrialization and provision of housing facilities.

For Malaysia to attain her vision of becoming a developed country by 2020, environmental concerns are being emphasized in Five-Year Plans. The overarching

framework for sustainable development goals that is embodied in the Third Malaysia Plan (1976–1980) is being continuously pursued. The current Ninth Malaysia Plan (2006–2010) has been further strengthened by the inclusion of green technology portfolio in the recently re-organized Ministry of Energy, Green Technology and Water.

Malaysia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, and the Kyoto Protocol in 2002. The INC charted a carbon emissions pathway, with avoidance and minimization of impacts to potential climate change beneficial to economic and environmental sustainability in line with the First and Fourth Thrusts of the National Mission. Relevant agencies and research institutes are encouraged to carry out studies to determine climate change scenarios, vulnerability areas, and mitigation and adaptation measures for the country.

Completed and on-going studies by a number of agencies with spatial implication include:

- Study for the sustainable development of highlands of Peninsular Malaysia
- Integrated river basin management
- Conservation and sustainable use of Peat Swamp Forest and associated wetlands and water regimes
- Preliminary Coastal Vulnerability Index study
- Integrated Shoreline Management Plans (ISMP)

Recommendations from these studies have since been taken-up and embedded in various hierarchy of statutory development plans in Malaysia. Indeed, stakeholders' discussions and dialogue have been crucial in forging a united approach to policy coordination and their implementation at the national, regional and local levels.

13.7.1.1 Physical Planning Initiatives in Relation to Millennium Development Goals (MDGs)

The involvement of the Federal Department of Town and Country Planning (FDTCP) in climate change issues is relatively new, although since 1976, through the establishment of the Town and Country Planning Act, the planning system had placed sustainable development and conservation of environment on its agenda. To-date physical planning has been recognized (by many research and scientific communities in Malaysia) as playing a crucial role through sustainable utilization of resources and cities' development initiatives. Planners who attend climate change workshops and meetings at the national level have been asked to take up climate-change friendly policies and strategies in their statutory development plans; although the FDTCP is not a member of the national or working group in such deliberations.

In line with goal 7 of the MDGs: to “integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources” physical planning in Malaysia has incorporated the Integrated Planning and Resource Management Framework. It promotes holistic and systematic

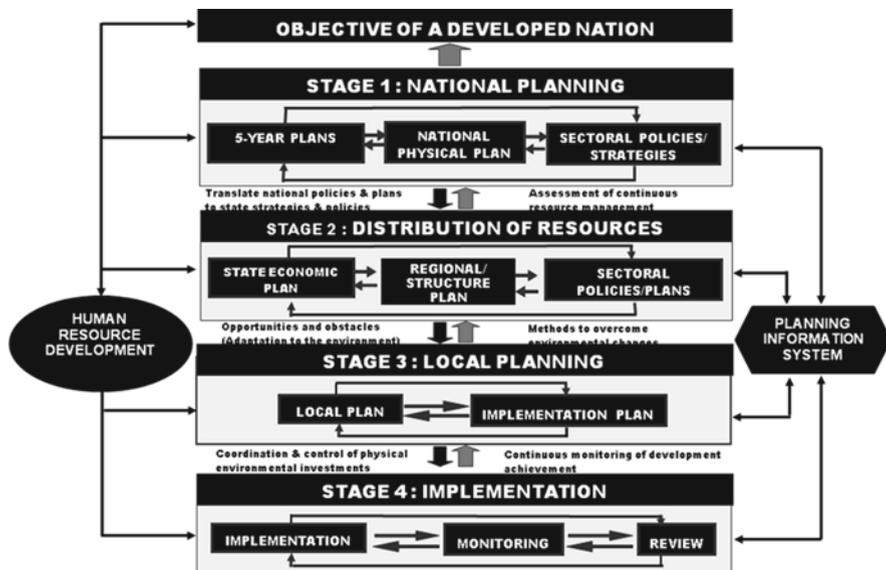


Fig. 13.5 Integrated planning and resource management framework (Federal Department of Town and Country Planning [2005], p 1 National Physical Plan)

integration of resource management through the coordination, rationalization and translation of sector policies at the federal level. Balanced treatment of spatial development, rational arrangement and use of space to create conducive living environments for people living and working there is therefore welcome (Fig. 13.5).

Initiatives by FDTCP to reduce the impacts of climate change through adaptation measures have been incorporated into its spatial development policies, i.e. through the National Physical Plan 2 (to be completed in 2010), the National Urbanization Policy and various statutory development plans (Structure, Local and Special Area Plans).

13.7.2 National Physical Plan

The National Physical Plan (NPP), which was approved in 2005, is the national blueprint for strategic spatial planning in Peninsular Malaysia. It adopts the integrated resource planning and management system by integrating physical planning and natural resource utilization within a management process aimed at achieving sustainable development goals and a better quality of life. The goal of the NPP is to “establish an efficient, equitable and sustainable national spatial framework to guide the overall development of the country towards achieving developed nation status by 2020” (FDTCP 2005). This goal is supported by four objectives:

1. To rationalise national spatial planning for economic efficiency and global competitiveness
2. To optimise utilization of land and natural resources for sustainable development
3. To promote balanced regional development for national unity
4. To secure spatial and environmental quality and diversity for a high quality life

Several policies in the plan contribute to the reduction of carbon emissions. These policies aim to:

- Establish an integrated national transportation network in recognition of the inter-relationship between land use and transport (NPP 23)
- Promote Transit Orientated Development (TOD) concepts as the basis of urban land use planning and ensure viability of public transport (NPP 27)
- Establish an integrated public transportation system in major urban centres (NPP 28)

Other policies that are linked to climate change agenda state that the concentration of urban growth in the conurbations shall be anticipated and accommodated (NPP 9) and the conurbation shall be planned as integrated regions (NPP 11). These policies first intended to manage and develop sustainable cities by promoting compact urban development and optimum utilization of existing and future infrastructure and utilities. They also aimed at ensuring the viability of the public transportation system, and arresting the encroachment of urban development into environmentally-sensitive areas, designated agricultural and food production areas. These policies aim at maintaining Malaysia's ecological footprint at the 2003 level of 2.2 global hectares (gha).

To protect the country's water resources, the coastal ecosystem, highlands, and bio-diversity, and to conserve the forest to act as carbon sink, the following spatial policies are proposed:

1. Environmentally Sensitive Areas (ESAs) shall be integrated into the planning and management of land use and natural resources to ensure sustainable development (NPP 18)
2. The establishment of Central Forest Spine (NPP 19), presently in consultation with various state governments, due for completion in 2010
3. Sensitive coastal ecosystems shall be protected and used in a sustainable manner (NPP 20)
4. Land development in highlands shall be strictly controlled to safeguard human safety and environmental quality (NPP 21)
5. All surface and ground water resources are strategic assets and are to be safeguarded and used optimally (NPP 22)

These policies will ensure that the proportion of forested areas is retained at 44.4% of the total land area of Peninsular Malaysia (Fig. 13.6).



Fig. 13.6 National spatial framework 2020 (Federal Department of Town and Country Planning Peninsular Malaysia [2005], pp 5–3 National Physical Plan)

13.7.3 National Urbanization Policy

The National Urbanization Policy (NUP) was approved in 2006. It detailed the NPP policies, and set the framework towards achieving sustainable and Liveable cities in Malaysia. A few key proposals include an efficient and sustainable urban development, an integrated and efficient urban transportation system as well as the creation of a conducive living environment that promotes the green building concept towards energy saving and efficiency, and the Hyogo declaration initiatives through NUP 23.

Other planning documents supporting the management of climate change include:

- State structure plans – translation of the NPP and NUP as a means to improve the physical environment and the management of traffic
- Local plans – translation of structure plans for the purpose of protection and improvement of the physical environment, preservation of the natural topography, improvement of the landscape and preservation and planting of trees. Monitoring on the outcome of such policies and strategies is done on a yearly basis
- Local plan making process – consideration of physical, economic, environment and social aspects and initiatives to implement sustainability assessment. The plan making process stresses the vigorous negotiations and public participation of various stakeholders such as local and federal agencies and residents in a bid to achieve sustainable communities within local planning authorities
- Development guidelines – planning guidelines for green building have been incorporated in to housing planning guidelines towards the reduction of energy utilization and the promotion of energy saving construction

13.7.4 Land Use Planning Appraisal for Risk Areas (LUPAr)

In anticipation of increased hazards and risks due to extreme weather, LUPAr has been developed to identify and map out critical disaster-prone areas, including those subject to serious flooding, landslides, tsunamis, forest fires and hazardous industry. The main objectives of LUPAr are to achieve safety and sustainability in land use planning with effective disaster mitigation strategies, and to provide general guidelines for development control and mitigation measures in hazard-prone areas based on the Hyogo Framework of Action 2005–2015. Within the Ninth Malaysia Plan, LUPAr has been applied in the local plan of Kuala Muda and Kota Tinggi (Mohamed and Suraya (2007)). Other strategies include creating awareness among planners and decision-makers, and incorporating measures and an integrated approach for disaster risk reduction in land use planning.

13.7.5 Malaysian Urban Indicator Network (MURNI-Net)

In 2003, Malaysia developed the MURNI-Net to measure and report the progress of cities in achieving their sustainable development objectives. It consists of 56

indicators, grouped into 11 key sectors/components, i.e. sustainable population, housing, urban economy, utilities and infrastructure, community facilities, environment, sociology and social impacts, land utilization, urban design and heritage, transportation and accessibility and urban governance. The indicators provide a snapshot of the status of these sectors, and local authorities are encouraged to seek Federal funding to improve weak indicators.

13.7.6 Green Building Initiatives

Besides promoting green agenda through policy statements and action plans, a task largely undertaken by the government, individual Malaysians, companies or associations have initiated many green start-ups for building construction, including Smart and Cool Homes Technology, the green building rating system, etc. The green building rating system provides the opportunity for developers to design and construct green, sustainable buildings that provide energy savings, water savings, healthier indoor environment, better connectivity to public transportation and use recyclable materials in their projects. The government has progressively promoted the green agenda. Currently, the building industry and its related professional institutions have taken up the green agenda.

13.7.7 Green Building Rating Tools

In 1990, the Building Research Establishment of UK introduced the first green building rating tools or assessment method called BREEAM. Other countries quickly followed suit. Recently, this awareness has finally come to Malaysia's shore where the Green Building Index (GBI) was established. Table 13.4 is a comparison of selected established assessment methods.

GBI was developed recently by the Malaysian Architect Association and the Association of Consulting Engineers in Malaysia with the objective of leading the property industry towards becoming more environment-friendly. It is intended to promote sustainability in the built environment and raise awareness among developers, architects, planners, designers, contractors and the public on environmental issues. Buildings are rated along the following six criteria: energy efficiency; indoor environmental quality; sustainable site planning and management; materials and resources; water efficiency and innovation. The buildings are then graded as GBI Malaysia platinum, gold, silver or certified rating depending on the scores achieved.

13.7.8 Smart and Cool Homes Technology

Buildings are the world's biggest energy guzzlers, using more than two-thirds of electricity and contributing 40% of global carbon footprint, from the construction to

Table 13.4 Comparison of Malaysia Green Building Index with other selected tools (Lembaga Jomutera Malaysia [2009])

Name	Breem	Leed	Green Star	Green Mark	Green Building Index
Country	UK	USA	Australia	Singapore	Malaysia
Year	1990	1996	2003	2005	2008
Assessment criteria	<ol style="list-style-type: none"> 1. Management 2. Health and comfort 3. Energy 4. Transportation 5. Water consumption 6. Materials 7. Land use 8. Ecology 9. Pollution 	<ol style="list-style-type: none"> 1. Sustainable site 2. Water efficiency 3. Energy and atmosphere 4. Material and resources 5. Indoor environmental quality 6. Innovation and design/Construction process 7. Materials 8. Indoor environmental quality 9. Innovation 	<ol style="list-style-type: none"> 1. Management 2. Transport 3. Ecology 4. Emissions 5. Water 6. Energy 7. Materials 8. Indoor environmental quality 9. Innovation 	<ol style="list-style-type: none"> 1. Energy efficiency 2. Water efficiency 3. Environmental protection 4. Indoor environmental quality 5. Other green features 6. Innovation 	<ol style="list-style-type: none"> 1. Energy efficiency 2. Indoor environmental quality 3. Sustainable site and management 4. Materials and resources 5. Water efficiency 6. Innovation

maintenance of the building itself. The green building initiative requires government facilitates, related agencies and the private sector to be innovative in designing environment-friendly buildings. In this context, a local developer has developed environment-friendly residential homes by incorporating used rubber tyres into the buildings' foundation. Using the Smart and Cool Homes Technology, about 50–60% of electricity can be saved. Solar photovoltaic system is incorporated with the system to generate electricity for the common areas and excess electricity is reconnected to the national grid. This system helps to re-use discarded tyres and hence reduce pollution.

13.8 Institutional Arrangements to Combat Climate Change

13.8.1 National Steering/Coordinating Committee

Malaysia ratified the UNFCCC on 17 July 1994 and established a National Steering Committee on Climate Change to formulate and coordinate national policies and actions. The committee is chaired by the Ministry of Environment and Natural Resources in partnership with representatives from other agencies. Under the stewardship of this Committee, Malaysia prepared and submitted its INC to the UNFCCC in 2000. Upon establishing the Cabinet Committee on Climate Change in 2008, it was renamed the National Coordination Committee.

13.8.2 Cabinet Committee on Climate Change

The Cabinet Committee on Climate Change was established by the government in January 2008 to spearhead Malaysia's commitment in addressing climate change issues and integrating the climate change agenda into national development planning. The Cabinet Committee, chaired by the Prime Minister, primarily determines the policy direction and strategy for addressing climate change issues, both in terms of mitigation and adaptation.

13.8.3 Steering Committees

Several steering committees have been set up to determine programmes and activities that consider impacts of climate change. These committees also propose necessary adaptation and mitigation measures. Besides government agencies, representatives of the corporate sector, non-governmental organizations and academia will be incorporated into the steering committees.

13.8.4 State Governments and Local Authorities

Although an effective implementation mechanism is yet to be established at the state and local government levels, the State Planning Committee (established under the Town and Country Planning Act 1976) has provided planning policies, strategies and action plans with regard to climate change concerns. State and local agencies participation is largely passive during the implementation of federal policies and strategies on climate change. This could be due to lack of information and consultation between federal, state and local governments besides other issues.

For national policies to be adopted and implemented by the state and local authorities, an effective consultation mechanism should be established, particularly in the policy planning and development stages. Participation and consultation of state stakeholders in the process of policy planning and plan making under the Town and Country Planning Act for various plan making hierarchies could facilitate and steer timely implementation (presently, all Local Plans and Structure Plans are being monitored on a yearly basis, and auditing activities are being initiated; this has been a new programme in the Ninth Malaysia Plan, 2006–2010).

Local governments could play a role in implementing the adaptation responses through good governance. This could include effective zoning to discourage the encroachment of housing on slopes that are prone to erosion and landslides; and promote adequate investment and maintenance of infrastructure, thereby making settlement development less vulnerable to weather extremes. Much could be achieved if private and public sector development agencies wholly embraced environmental friendly operations (e.g. valuing and maintaining matured trees instead of levelling sites to pave way for development projects (Ministry of Science, Technology and the Environment 2001).

13.9 Lessons Learnt and Recommendations

13.9.1 Mainstreaming Policies and Strategies Within a Trans-Disciplinary Framework

Presently, initiatives to implement the obligations of numerous conventions are taken individually by a number of ministries, private and non-governmental bodies by virtue of their direct involvement in international conventions. This implementation scenario is rather ad hoc, ineffective and insufficient. The climate change agenda should be addressed within the framework of the governmental planning and development policies formulation.

The establishment of diverse stakeholders' dialogue and consultation is of utmost importance in mainstreaming climate change action plan. Therefore, current approaches will have to move towards a trans-disciplinary framework for understanding conflicts, different value systems and diverse cultural orientations – all

aimed at arriving at a win-win scenario. The trans-disciplinary model implies the crossing of disciplinary and cultural boundaries that require sound knowledge of one's discipline (and the attendant limitations), open-mindedness, great patience, and sincere efforts from all around.

13.9.2 Strengthening the Role of Physical Planning in Climate Change Responses

Physical planning can play an effective role in coordinating and translating scientific findings and technical responses into spatial dimension. Areas in the cities or along the coast and rivers that are vulnerable to sea-level rise, storm surges, flooding and critical risks can be identified and mapped out. Appropriate adaptation and mitigation measures in the form of land use zoning and development guidelines (within the Town and Country Planning Act 1976) provide the legal framework for implementing climate change responses at the city and local authority levels. In this context, the National Physical Plan, National Urbanization Policy and other overarching socioeconomic development plans (from various ministries) require continuous dialogue for their mutual development arrangement and commitment – a good forum for political and administrative leadership commitment, particularly through the National Physical Planning Council (chaired by the Prime Minister with major (and senior) ministries and chief ministers in attendance) will be a good place to start. A National Physical Planning Panel has been proposed in the NPP2 study with a wider input from NGOs, experts in various disciplines and players from major industries.

13.9.3 Effective Participation

Although the relevant institutions in Malaysia are capable of addressing and managing climate change, there is still room for improvement, particularly at the state and local authority levels as follows:

- Improve collaboration via efficient communication and coordination among all stakeholders
- Increase awareness and public participation to promote required behavioural responses to climate change
- Establish effective communication and consultation mechanisms among all stakeholders and
- Strengthen current legislative provisions for public participation and promote community-based climate change responses through Local Agenda 21, and within the sustainable assessment framework of the plan-making process of the Town and Country Planning Act 1976

13.9.4 Intensify Climate Related Research and Development and Capacity Building of Human Resources

The establishment of a national research and development agenda on climate change to support informed and knowledge-based decision-making within a trans-disciplinary framework needs to be pursued in the following priority areas:

- Agriculture and food security
- Water security and services
- Forestry
- Sustainable bio-energies
- Public health
- Urban and land use planning
- Localised model for projection of future scenarios
- Innovative socioeconomic and financing mechanism
- Vulnerability due to extreme weather events and disasters
- Policy analysis, harmonising national and international issues
- Carbon capture and storage

13.9.5 International Involvement: Common but Differentiated Responsibility

Malaysia will continue to strengthen its involvement with climate change within international activities, mainly based on the principle of common but differentiated responsibility. A mechanism shall be institutionalized for coordinating consultation on national positions and responses for international negotiations, continuous capacity building programmes to support negotiation and implementation of international obligations, and promote regional cooperation within existing inter-governmental and non-governmental mechanisms.

13.10 Conclusion

The town planning statutory plans constitute only one of the few documents dealing indirectly with climate change. However, as a discipline and service, it is mandated to handle matters of liveability and sustainability (through public involvement in statutory plans preparation); and also to establish what climate change responses incorporated in such statutory plans have largely been due to their wisdom of tying it up with liveability. Mainstreaming of climate change within the physical planning processes (for example energy saving and utilisation of renewable resources) and its institutionalisation by various development agencies are areas requiring further

concerted effort. The recent commitment by the government at the Conference of Parties (COP15) on climate change in Copenhagen, Denmark (2009) would provide the impetus for a clearer direction and concerted initiatives, fashioned in a holistic and trans-disciplinary framework.

References

- Economic Planning Unit (2008) Mid-term review of 9th Malaysia plan 2006–2010. Prime Minister's Department, Malaysia
- Federal Department of Town and Country Planning (2005) National Physical Plan. Ministry of Housing and Local Government, Malaysia
- Federal Department of Town and Country Planning (2006) National Urbanization Policy. Ministry of Housing and Local Government, Malaysia
- Federal Department of Town and Country Planning (2008) Rancangan Fizikal Zon Persisiran Pantai Negara, Draf Laporan Teknikal Bab 2. Ministry of Housing and Local Government, Malaysia
- Laplante B (2009) Sea-level rise, storm surges and the economics of adaptation. World Bank, Washington, DC
- Lembaga Jurutera (2009) Malaysia Ingenieur, 41
- Mazlin M (2007) Forum global warming impact on drainage strategies in Malaysia, impact of climate change and global warming: some research and suggestions for adaptation. Institute for Environment and Development (LESTARI), Universiti Kebangsaan, Malaysia, slide 14
- Ministry of Natural Resources and Environment (NRE) (2005) Climate change in Malaysia. Conservation and Environmental Management Division (CEMD)
- Ministry of Natural Resources and Environment (NRE) (2006) Study of the impact of climate change on the hydrologic regime and water resources of peninsular Malaysia
- Ministry of Science, Technology and the Environment (2000) Malaysia initial national communication, Figure 2.1, p 4
- Ministry of Science, Technology and the Environment (2001) Malaysia: national response strategies to climate change, p 568
- Mohamed JA, Suraya B (2007) Climate change or extreme weather on human settlement and land use conference. Department of Town and Country Planning. Ministry of Housing and Local Government
- NAHRIM (2006) Working Group 2 (WG2). Climate projection support group for the draft National Communication 2 (NC 2). Ministry of Environment and Natural Resources, Malaysia, p 24
- Sungai Petani Municipal Council (2009) Draft Local plan for Kuala Muda district 2020: report 1, p 5.1.28. Sungai Petani Municipal Council
- Timmer V, Nola-Kate S (2006) The World Urban forum 2006 Liveable city. International Centre for Sustainable Cities (Vancouver working group discussion paper)
- UNEP. The plant for the planet: billion tree campaign. <http://www.unep.org/Documents>. Accessed 8 Nov 2006

Chapter 14

Climate Change and Its Effect on Urban Housing and Liveable Cities: The Case of Harare, Zimbabwe

Rodreck Mupedziswa

14.1 Introduction

This chapter focuses on the effect of climate change on the urban population in Zimbabwe with particular focus on the capital city of Harare and its environs. Its purpose is to show how the phenomenon of climate change has over the years become a major threat to human security in this city and its surroundings in particular, and in Zimbabwe in general. The chapter shows how climate change has been intensifying over the years, and how this development has resulted in increased and more intense episodes of pollution, flooding, deforestation, drought and shortage of water. It also demonstrates how changes in climate have exacerbated urban poverty. Urban agriculture, in particular, has been badly affected, robbing residents of a major survival strategy.

The chapter further notes that while a plethora of pieces of legislation aimed at mitigating or at least curbing some of the triggers of climate change (e.g. pollution) are in place in Zimbabwe, numerous obstacles still remain; they include challenges associated with serious lapses in the rule of law, the insidious cancer of corruption, poor management of resources and, in recent years, outright lack of resources as the country's economy has experienced a complete meltdown due to the unhealthy political climate obtaining in the country. The chapter ends with a discussion of the way forward, noting, inter alia, that the main challenge lies in identifying adaptation strategies capable of mitigating the diverse and complex impacts of climate change in Zimbabwe and beyond.

R. Mupedziswa (✉)

Professor and Head Department of Social Work, University of Botswana, Botswana
e-mail: mupedziswa@mopipi.ub.bw

14.2 Zimbabwe and Its Environs

Zimbabwe is a landlocked country situated in Southern Africa. It is bordered by South Africa to the south, Mozambique to the east, Zambia to the north and north-west, Botswana and the Caprivi strip and Namibia to the west. It covers an area of approximately 390,000 km². It has a population of around 12.5 million. Another 3.5 million people are thought to be living in various parts of the world, including neighbouring South Africa, Botswana, Namibia, the UK, Canada, the USA, Australia and New Zealand.

Economically, the country once had great agricultural potential and used to be known as the “bread basket of Southern Africa”. It also had fairly sophisticated mining, industrial and manufacturing sectors. However, Zimbabwe’s fortunes changed for the worse as her economy began to crumble in 2000. A country that only a few years earlier was known as the “bread basket of Southern Africa”, suddenly became the “basket case of Southern Africa”. A poverty assessment study conducted in 1995 showed that about 60% of Zimbabweans were poor or very poor and could not meet their basic needs (Kaseke and Gumbo 2001). Recent accounts however indicate that 75% of the population are poor, while 47% are very poor (Kisner 2008). Over the last decade, unemployment levels have ballooned from decent figures to the current unprecedented rate of an estimated 94%, essentially due to political instability, which has precipitated a severe economic meltdown in the country (Mupedziswa 2009).

Skyrocketing inflation rates have strained families’ ability to acquire food. The official rate of inflation as at June 2008 had shot up to 11.2 million percent (*New Zimbabwe*, 9th October 2008). Incidentally, on 21 January 2009, IRIN (The United Nations Office for the Coordination of Humanitarian Affairs) carried an article on its website headlined: “Zimbabwe: Inflation at 6.5 *quindecillion novemdecillion* percent”. In 2009, a government that incorporates the ruling party (ZANU-PF) and the country’s two opposition political parties represented in parliament (the two MDC formations) was constituted. The new inclusive government proceeded to abandon the local currency, the Zim Dollar in April 2009 in favour of hard currencies such as the US Dollar, the South African Rand, the Botswana Pula and the British Pound. Poverty however remains a critical issue. Besides massive unemployment numbers, those who are lucky to have salaried employment receive wages that are too low to lift them out of the poverty bracket. The economic decline, recurrent droughts, poverty and HIV have emerged as the country’s worst enemies. Life expectancy is pegged at 44 years for men and 43 years for women, courtesy largely to the HIV and AIDS pandemic, which has also spurned numerous orphans and other vulnerable children (OVC).

The capital city of Harare, with a population of around two million, is the focus of this chapter. Harare, which is the country’s seat of political and administrative power, has a history of a modern city that dates back to 1890 when it was first established as a fort by settler colonialists sponsored by the British South African Company (Mbiba 1998). In terms of residential structure, the city is divided into

high income areas with a (low) density of 1,000 people per km², and low income areas with a (high) density of over 2,000 people per square kilometre. High income residential areas are on lot sizes of about 1 acre each, while low income people are on lot sizes of about 300 m² each (Mbiba 1998). Legally, informal settlements are discouraged. Often, excessive force is employed when dispersing informal settlers. This notwithstanding, overcrowding and a housing crisis have led to the emergence of informal settlements, mostly along Harare's main rivers that feed into Lake Chivero.

The city of Harare is situated on a watershed plateau between two major rivers, the Limpopo and Zambezi, yielding some of Zimbabwe's best agricultural soil (Kisner 2008). Located in the northeast on what is referred to as the high veld, Harare has a population growth rate of 5–7%. The high veld is characterised by a savannah grasslands terrain that is relatively flat. It has a cool climate and annual temperatures of 10–26° Celsius, and an annual rainfall of 800–1,000 mm. The main natural hazard however is the recurring droughts. Although floods and severe storms are rare, they are increasingly becoming an issue due to climate change.

14.3 Recent Trends of Climate Change in Zimbabwe

The term climate change has been defined as a statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period (IESC 2009). Global warming has been a major cause of climate change worldwide. The global warming phenomenon, which entails an increase in the earth's temperatures, is fuelled by use of fossil fuels such as wood, coal, oil, petrol, and other industrial processes, which lead to a build-up of greenhouse gases (carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons) in the atmosphere (CYP n.d.a.). According to the UNEP/WMO Intergovernmental Panel on Climate Change (IPCC), global mean temperatures will increase by between 1.5°C and 6°C; while sea levels are projected to rise by between 15 and 95 cm. In the twentieth century, a warming of approximately 0.7°C was recorded over most of the African continent. By the end of that century, there was general agreement that most variables associated with climate had changed in response to warming (UNEP/GRID n.d.a.). Sustained global warming and changes in climate in Africa have resulted in changes in natural vegetation, with grasslands being replaced by either thorn scrub savannah, seasonal and dry forests. There has been reduced run-off in parts of the continent, a situation that has exacerbated the food security challenge.

In Southern Africa, changes in climate have had many impacts, not least droughts and flooding. Intermittent droughts have been witnessed in the region over the years. As recently as March 2009, heavy rains were reported in Southern Africa, with floods affecting countries such as Namibia, Angola and Botswana. Other countries in the region – Zambia, Malawi, Mozambique and Zimbabwe – were also threatened with flooding. One of the worst flooding incidences occurred when the Okovango River burst its banks in a way that had not happened in more than 45

years, displacing over 400,000 people on both the Botswana and Namibian sides of the river (Cochrane 2009).

Nyathi (2009:17) says that “The Zimbabwean government is concerned about the effect of climate change on the country...” He further observes that “the high frequency of droughts and floods (experienced in the country) is linked to global climate change”. For instance, the country has been experiencing more hot days and fewer cold days, and the amount of precipitation Zimbabwe receives has deviated from the mean more frequently than was hitherto the case (Rekacewicz 2002).

Experts observe that Zimbabwe was a warmer country at the end of the twentieth century than it was at the beginning of the same century. They point out that annual mean temperatures have increased by approximately 0.4°C since 1900, while the 1990s recorded the warmest decade (CRU and WWF, n.d.a.). The warming has been especially pronounced during the dry season; while day-time temperatures have warmed more than night time temperatures during the wet season. In terms of rainfall, a 5% decline was observed across the country at the close of the twentieth century, and the trend appears to be continuing.

According to the Environmental Management Agency, Zimbabwe has been experiencing an unprecedented series of extreme weather events which have had severe implications on the country’s economy. Six of the warmest years recorded in the country have occurred since 1987. Besides, the increased frequency of droughts since 1990 has adversely affected crop yields in the country (Russell 2008). Other effects wrought about by climate change include severe thunderstorms and floods, and unpredictability in the timing and duration of drought (Ziyomo 2009).

14.3.1 Causes and Effects of Climate Change

According to experts, climate change may be precipitated by natural internal processes or external forces, or by persistent anthropogenic changes in the composition of the atmosphere; or by land use (IESC 2009). Consequently, causal factors of climate change in Zimbabwe, as elsewhere, essentially fall into two broad categories – natural and human-made. With regard to natural causes, Srinivas (2008) highlights a number of natural factors that are responsible for climate change, which include the continental drift, volcanoes, ocean currents, the earth’s tilt, comets and meteorites. With regard to natural causes of climate variability in the Southern African region (which includes Zimbabwe), the El Nino-Southern Oscillation (ENSO) has been identified as one of the main factors. Apparently from 1976, there has been a tendency for negative warm phases of ENSO in Zimbabwe. Other factors include concentrations of greenhouse gases. Causal factors in the natural phenomena category include biological, physical and chemical processes that take place both within and without the region. Globally, fossil fuels such as oil, coal, and natural gas are equally culpable. Again, Zimbabwe has not been spared in this regard.

The human/anthropogenic category encompasses human activities that precipitate climate change. In Zimbabwe as elsewhere, these human activities, which are many and varied, include industrial activities that cause atmospheric pollution (e.g. carbon dioxide) gaseous emissions (from bio-fuel combustion), and transportation (gas emissions from bio-fuel combustion). In many parts of the country, land covered with vegetation has been cleared to make way for housing and industries, and natural resources are being used extensively for construction, industries, transport and consumption.

Mountains of waste have been created, while the country's population has increased over time. Srinivas (2008) notes that such factors contribute to greenhouse gas emissions. According to IESC (2009), it is not just man-made pollution which can cause climate change; changes in the way the ocean water circulates around the world can also influence climate since oceans store more heat than the atmosphere. However, human activities are said to be responsible for the speed at which climate change has occurred.

Human-induced pollution has had a profound impact on Zimbabwe. Failure to enforce regulations on the part of the Zimbabwean government, the existence on the country's roads of ageing vehicles, mostly acquired from Japan, Singapore and other countries (due to the country's inability to access foreign currency to import new vehicles or spare parts), the lack of spare parts for industry, lack of modern equipments for measuring emissions, etc., have all compounded the climate change situation in Zimbabwe. Other factors that have exacerbated climate change include deforestation, soil erosion, and air and water pollution. Srinivas (2008) observes that globally, the energy sector has contributed to three-quarters of carbon monoxide, which influences chemical cycles in the atmosphere to produce or destroy greenhouse gases. Zimbabwe's Harare has not been spared.

Climate change in Zimbabwe has produced more erratic weather patterns that have eroded the river banks, spreading pests and waterborne diseases. Adverse weather conditions have manifested themselves in the form of erratic rainfall and increased average daily temperatures. The air, especially in Harare, is 'infested' with extremely high levels of carbon dioxide and other carbon-based gases. The city has in recent years experienced rapid expansion in the motor vehicle population, a development that has resulted in increased air pollution. Gaseous emissions from industrial and commercial activities have exacerbated an already bad situation. The city's air quality monitoring data show that sulphur dioxide (SO²) concentration has consistently exceeded the WHO guidelines (APINA, n.d.a.). Domestic refrigeration too has been blamed for adding large amounts of other gaseous emissions in the city.

The chaotic land reform programme, which started in 2000, resulted in an unprecedented prolonged destruction of vegetation, in particular cutting down of trees and incessant fires. In areas surrounding Harare, laws governing wanton cutting down of trees have been disregarded. In many cases, what has mattered is one's political affiliation; that is the political party that one belongs to. There has also been an unprecedented destruction of grass as the poor struggle to survive. This has resulted in permanent loss of vegetation cover over extensive areas near

the city, which has in turn caused a reduction in soil moisture, and has curtailed biodiversity.

Some of the large fires witnessed in the outskirts of Harare were started in the former commercial farming areas that were vacated by white commercial farmers after they were forcibly removed by the ZANU (PF) government¹ under the land reform programme alluded to above. In some instances, the veld fires were started by the new occupants, sometimes in the process of engaging in activities such as trapping of mice (rodents) for domestic consumption. Fires have also been started by newly resettled farmers in the countryside as they clear the grassland and forests to pave way for subsistence farming. This has resulted in the emission of large volumes of gases, in particular carbon dioxide, into the atmosphere, which have negatively affected Harare. According to experts, these gases negatively affect the ozone layer, aggravating the greenhouse effects in the process, and consequently fuelling climate change.

In Zimbabwe, especially in Harare, climate change has impacted sectors of the economy such as hydrology, water resources, the natural ecosystem, biodiversity and forestry. It has had a marked impact on agriculture, especially in dry land cultivation of crops. Besides, climate change has also negatively affected the health of the people through the spread of diseases such as cholera. The changes that have occurred in and around Harare have affected daily temperatures, rainfall patterns, and wind speed and direction. These changes are believed to be at least partly responsible for the drought episodes experienced in the area, besides other natural disasters such as flooding.

14.4 Impact of Climate Change on Harare

The city of Harare has experienced flooding, high temperatures, drought, deforestation and pollution. These impacts have had a devastating toll among the citizens, particularly the poor. Let us consider the impact of each of these in some detail.

14.4.1 Flooding

Excessive flooding in Harare due to intense rainfall has affected the city's energy infrastructure, in particular transmission pylons and poles, which are felled by the heavy rains. At times, homes and foot-bridges are washed away. Flooding has been known to cause enormous traffic congestion, greatly inconveniencing commuters. At independence in 1980, Harare had beautiful paved roads and an efficient drainage

¹ZANU (PF) has ruled the country since Independence from Britain in 1980, until the formation of the inclusive government with the two formations of the MDC party in early 2009.

system. This situation has however deteriorated over the years. In some instances, the drainage system has not been tended for years, resulting in blockages, which cause flooding on the roads whenever the city receives heavy rains, making it difficult for motorists and pedestrians to navigate their way through.

Flooding has also been responsible for destruction of livelihoods in the city's environs. Most affected has been urban agriculture (Zvigadza 2008). Sewer lines and water pipes have been destroyed by heavy rains. At one time, gaping manholes and the heavy rains experienced in Harare increased the load of sand in the water pipes, costing the city council dearly when it attempted to de-sludge the soil (Herald 2008:5). The health hazard posed by the sewer content that has found its way into broken water pipes is too shocking to contemplate. The danger of water-borne diseases such as cholera has been ever-present whenever heavy rains have been received. Vandalised manholes become death traps for pedestrians whenever it rains heavily.

In some instances, people have been swept away right in the middle of the city. In places such as the low income suburb of Budiriro, persistent flooding during the rainy season has resulted in the rising of the water table. Erratic supply of potable water has in turn forced domestic consumers to dig shallow wells, making themselves vulnerable to water-borne diseases such as cholera. The flooding situation has further been compounded by mountains of uncollected garbage, the end result of which is a major health time-bomb. In 2008–2009, there was a serious cholera outbreak, which according to the World Health Organization (WHO) had at the time of writing this paper claimed more than 4,200 lives (Shoko 2009) in the city.

In some cases, flooding has resulted in homes being destroyed, or families having to temporarily abandon their flooded homes. While some of these victims come from informal settlements, others were from properly built, conventional homes that had been constructed with the blessings of the city authorities. As the demand for land to construct houses increase, the city council has embarked on a number of measures to satisfy this demand. These measures have included in-fill residential development in open spaces, high rise development in the city centre and informal settlement upgrading. Thus, the city of Harare has targeted for housing construction green belts, land in-fills, and low lying areas, some of which are prone to flooding. Most of these areas had previously been adjudged unsuitable for human habitation. Laxity in regard to the enforcement of existing laws regarding housing standards has exacerbated the situation.

14.4.2 High Temperatures

As temperatures rise, water sources have diminished in Harare, largely due to evaporation and rising demand (Zvigadza 2008). With official sources of potable water supplying water erratically, mainly due to lack of resources to replace ageing infrastructure, many residents of Harare have been forced to look for alternative sources of water, including fetching the precious commodity from shallow wells.

Those with means have proceeded to sink bore-holes, implying that the water table for the city has been negatively affected.

It is incontrovertible that a rise in temperature leads to increased demand for electrical appliances such as air conditioning equipments in office buildings and at home (Zvigadza 2008). This has often put an enormous strain on an already over-subscribed electricity grid, causing intermittent power black-outs in the city. Besides, load-shedding has caused havoc, even damaging domestic electrical appliances due to electric power surges. Many electrical gadgets that are not mounted on surge protectors have been damaged beyond repair in the process.

The unusually high temperatures experienced at times have affected crops on the outskirts of the city, creating a food deficit among many poor residents. Coupled with heavy rainfall and humidity, high temperatures have been a health hazard, increasing chances of contracting diseases such as malaria and cholera, for example. The anopheles mosquito, which causes malaria, thrives under such conditions. Zvigadza (2008) has confirmed the existence of incidences of malaria in Harare. With medical facilities in Harare having virtually ground to a halt, the plight of the city's residents – particularly the poor – and their ability to fight malaria and other diseases, is too grim.

14.4.3 Drought

According to Nyathi (2009:17), “Several climate studies (in Zimbabwe) suggest that water resources in the country are expected to dwindle and the evergreen forests of the Eastern Highlands of Zimbabwe may be reduced to seasonal forests”. Nyathi further observes that there are fears that some parts of the country, especially in the Matabeleland region, may gradually become deserts. Reduced rainfall levels that have been experienced in the city have at times resulted in severe drought, which in turn has had a major impact on life in the city as water sources diminish. Water sources such as Lake Chivero (the main source of potable water for the city of Harare) have had less precipitation, which has in turn meant that water sources have failed to spill, a failure which has led to eutrophication,² which has in turn promoted the growth of algae (Zvigadza 2008).

The blue-green algae on Lake Chivero poses a major challenge to the city authorities as it threatens to devour the entire lake by choking it in a blanket of blue/green. It has also been established that the algae produces toxins which cause outbreaks of gastronomic diseases in the city. Attempts to clear this mess have not been successful. Left un-cleared, the algae are capable of destroying the entire lake, robbing the city of its main source of water. If not checked, it is also capable of robbing (what is left of) industry and commerce their source of water, grinding activities to a halt.

²Nutrient pollution, which may promote excessive plant growth and decay, weedy species, and hence reducing quality of water (Tsiko 2007).

In Zimbabwe, the cost of health services has spiralled beyond the reach of the poor, with even some among the middle class finding it difficult to access basic health services. In April 2009, the government abandoned the local currency, the Zimbabwe dollar, in favour of hard currencies. While this may have had the effect of halting run-away inflation, the down side has been that many civil servants currently earn across-the-board salaries of US\$100 per month, hardly enough to pay for basic services (Moyo 2009b). For instance, hospital fees currently work out to approximately two to three times the total monthly salary of many middle-income workers. Given the spiralling costs of health, many poor people no longer go to hospitals for treatment. They have instead turned to traditional herbal doctors. Unfortunately, intermittent droughts have meant that at times the herbs have whittled, or completely withered, meaning that the poor cannot access traditional medicines.

Drought has also affected yields from urban farming activities in Harare. It should be noted that urban agriculture is an important activity in Harare, where many poor and middle class families tend to depend on urban agriculture as a source of livelihood. Unfortunately, as is the case elsewhere in the country, the local authority has tended to view urban agriculture as impacting negatively on the quality of urban life, and contributing to a decline in the aesthetic quality of urban space, and increasing costs of urban environmental management (Kisner 2008; Mudimu 2001). Consequently, the local authority has frowned upon urban farming, although a gradual shift away from this position has been noted over time. The reality in Harare as elsewhere in the country is that urban agriculture provides an opportunity for households to improve their food production and incomes, and reduces their vulnerability to food insecurity (Mudimu 2001). Droughts have therefore adversely affected urban agricultural activities in Harare, negatively impacting the livelihoods of poor households.

14.4.4 Deforestation

Deforestation is a major problem in Zimbabwe, especially in Harare. According to an internet source (www.mongabay.com), between 1990 and 2005, Zimbabwe lost 21.1% of its forest cover, or around 4,694,000 ha. The scale of cutting down trees has increased since. Zimbabwe's rate of deforestation has doubled over the last few years. Lane (2007) put the area destroyed per year at 860,000 ha, while the *DailyGreen* (n.d.a.) indicated that one-million acre of trees were being destroyed every year. In Zimbabwe, the erratic electricity supply, coupled with the fact that poor people cannot afford it, has resulted in increased demand for firewood. While it is true that the entire Southern African region has a deficit of electricity, the situation in Zimbabwe is dire, having been exacerbated by the prevailing socio-economic meltdown and political malaise. For years, load-shedding has been the order of the day in Harare and elsewhere in the country. Sustained power-outages have

resulted in an increase in deforestation as domestic consumers fall back on firewood as a source of energy (Zvigadza 2008).

Some residents of Harare live in areas with no electricity supply at all, and these in most cases depend solely on firewood. As the demand for firewood increases, the distances covered to fetch the firewood have also lengthened. The cost of purchasing firewood from vendors, where available, has become prohibitive. As a result, many poor residents have had to spend a lot of time everyday in search of firewood – time that could have been gainfully utilised for other more productive purposes.

The erratic supply of electricity in Harare and elsewhere, which has fanned deforestation, has essentially been as a result of reduced generation capacity at the main source of hydro-electricity power in the country – Lake Kariba. According to experts, the main reason for the reduced generation capacity of hydro-electric power has been the low water levels in the Zambezi River on which the Kariba Hydro-electric Power Station is built. The Kariba power plant has consistently been at risk due to persistent droughts in the country and upstream. Water levels on the Zambezi River have been receding over time, creating problems with generation of electricity.

Over the years, the demand for electricity for both domestic and industrial/commercial use has increased. Zimbabwe currently generates about 1,100 MW locally. It has had to supplement its energy needs by importing 35% of its energy (i.e. 350–500 MW) from Mozambique's Hydroelectrica Cahora Bassa (HCB), and from the DRC's Snel, and Zambia's Zesco (Chiremba 2009a). Needless to say, the reduced supply of energy has also been occasioned by chronic foreign currency shortages. The electric energy imports have at times been erratic, largely due to delay or non-payment of dues. "Like most major national infrastructure, ZESA's³ power stations and transmission grid have crumbled due to underfunding and downright neglect after a decade of acute recession that has left Zimbabwe requiring billions of dollars in aid....." (Moyo 2009a:3).

Deforestation has been partly due to chaotic farm invasions alluded to earlier. These invasions have brought about lawlessness as people invade private properties (mostly commercial farms) in search of firewood and other flora and fauna. Initially, the invasions were seen as a protest for the slow pace of land reform in the country, and were meant to force the government to expedite land redistribution (Kaseke and Gumbo 2001). However, with time, it was clear that the focus had changed with the exercise being used for what critics say is personal political aggrandisement on the part of certain top politicians. Needless to say, these farm invasions have resulted in loss of lives, reduced farm productivity, and destruction of property, which includes large tracts of forests and wood lots. In some instances, farms have been left barren with no trees, no grass, nor wild animals.

³ZESA (Zimbabwe Electricity Supply Authority) is the national electricity utility.

14.4.5 *Pollution*

While pollution can essentially be viewed as a cause rather than a consequence of climate change, it is pertinent that we discuss this phenomenon because of its impact and implications on the lives of the poor in Harare. Two main forms of pollution are evident in Harare; namely water and air pollution. While both forms of pollution have not necessarily been caused by climate change, they have contributed enormously to climate change in the country; it is therefore important that their impact be interrogated.

With regard to the quality of water, uncollected garbage, laxity in policing and enforcing laws that regulate the disposal of industrial effluent and related waste have constituted some of the main sources of pollution. Algae too has been blamed for polluting Lake Chivero, so do firms that have deposited their effluent in such rivers as Nyatsime, Marimba and Manyame, all of which are feeder tributaries to this lake, and which have destroyed fauna and flora in the process. According to Tsiko (2007:6), “the latest episode of massive fish deaths in Lake Chivero due to de-oxygenation compounded by excessive pollution indicates the gravity of the ecological disaster on Harare’s principal water dam”. The ecological disaster in the lake has led to increased water treatment costs, rising costs of maintaining water treatment works, water shortages and loss of biodiversity (Tsiko 2007). Self-purification by this lake has not happened, largely due to environmental degradation. Mtisis (2008) observes that Lake Chivero has been so heavily polluted that the authorities had to use a total of eight different chemicals to treat the water so as to make it safe for drinking. In the current economic environment, the Zimbabwe government cannot afford a constant supply of chemicals to treat the putrid water. The lake is a source of drinking water for three million people,⁴ and hence it deserves better handling.

Srinivas (2008) notes high yielding varieties of crops are being used in Zimbabwe to insure agricultural output. These require large quantities of fertilizers, translating into more emissions of nitrous oxide, both on the field where it is used, and from the manufacturer’s premises where it is produced. This obviously increases water pollution levels. Mbiba (1998) corroborates this observation by indicating that chemical pollution emanating from urban agricultural activity in Harare cannot be ruled out. This is happening in the form of lead up-take of crops, courtesy of exhaust fumes and vegetation toxicity from industrial effluent, among others. Scientists contend that extensive use of synthetic pesticides derived from chlorinated hydrocarbons to combat insect pests has had disastrous environmental side effects (CYP n.d.a.). These chemicals sometimes enter the food chain, obviously posing a real threat to the health of the people of Harare and beyond.

Potable water availability in most of Harare is erratic, largely courtesy of the ageing infrastructure and lack of resources to acquire water treatment chemicals.

⁴Lake Chivero also supplies water to residents of the dormitory town of Chitungwiza, as well as surrounding peri-urban areas.

Leakages along the water infrastructure and lack of manpower have been identified as some of the many reasons why affected areas continue to go without water for prolonged periods (Shoko 2009). It is estimated that Harare City Council needs at least US\$46 million to rehabilitate the Morton Jaffray and Prince Edward water works that supply water to the Greater Harare, an amount that is obviously out of the reach of the authorities. Residential areas go for weeks without potable water. Sadly, the situation has worsened over the last couple of years. In an article titled, “*Harare water woes worsen*”, Shoko (2009) reported that residents of some areas of Harare such as Ruwa, Hatfield, Budiro, Glen View, Msasa Park, Mabvuku, Chitungwiza and Greendale often go for months without water. In one block of flats in the medium density suburb of Eastlea, residents had not had water for over 12 months, and at the time of writing this paper, the situation had not improved.

One resident, a marketing executive with a reputable company, was quoted as saying that her day routinely started at 4 a.m. when she has to wake up to beat the long queues to ensure that she is among the first at a communal borehole to fetch 20 L of water. While those in more affluent suburbs can rely on boreholes, this is hardly the case with residents of low income areas. Shoko (2009) further notes that in some areas of Harare that are ‘lucky enough’ to have water supplies, the quality of the water was poor – in some instances actually dirty. Evidently, the government, after years of political turmoil, has failed to raise funds to upgrade the water works. It has also failed to upgrade the sewerage treatment works in Harare, Chitungwiza and Ruwa, which have become overloaded, owing to the rising urban population (Tsiko 2007). As a result, it is becoming exceedingly difficult for the quality of the city’s water to reach World Health Organization standards.

The erratic water supply has meant that residents in some suburbs of Harare have, by and large, had to, *inter alia*, abandon the use of conventional (water system) toilets, resorting instead to using the bush for the same purposes. With broken water pipes being the order of the day throughout the city, large scale contamination of potable water by various foreign objects has been reported; and continues to pose a health hazard of immense magnitude. In addition, pollution of rivers has been an issue of great concern. The laxity in policing regulations has meant that some firms have inappropriately disposed of their effluent. It has also been observed that pollution of water from Lake Chivero has been partly due to the fact that the city of Harare lies in the lake’s catchment area, and hence most of the pollution problems being experienced there are a result of poor planning. Indeed, the city’s waste, which pass through the heavy industrial and densely populated areas, flow into the lake (Tsiko 2007). This has compromised the quality of water available to residents of Harare.

Other than water, air pollution has also been identified as an issue of particular concern in the environs of the city. Air pollution refers to the introduction into the atmosphere of substances or surplus energy as waste products resulting from human activities, which directly or indirectly adversely alter or destroy the quality of the environment, or cause undesirable effects on humans, animals, vegetation or materials (Chipindu, n.d.a.). Much of the air pollution experienced in Harare comes from industry and from motor vehicles. Emissions from industrial concerns have

often surpassed the stipulated WHO levels. In Harare's context, very little happens in terms of trying to address this problem, especially in view of the country's economic meltdown.

In the few occasions where companies have been called to account for such violations, they have usually gotten away with bribing the officers concerned. As a result, the cases are mysteriously dropped. In many other cases, combustible materials such as old vehicle tyres are set ablaze in large numbers, badly polluting the atmosphere; yet, according to experts, it is difficult to indicate instances where the culprits in such cases have been called to account for their actions. On many occasions, Harare residents have woken up only to be greeted by an ugly, thick layer of smog hovering over the city.

The laxity in enforcement of the existing statutes has essentially been a consequence of the perpetual bickering and squabbling in the inclusive government, and a brain drain of immense magnitude (which has continued in spite of the inclusive government) that has left many arms of local and central government, as well as the private sector, with limited skilled personnel. Reports (Sparks 2003; Donnelly 2004) indicate that the country has lost thousands of skilled personnel to neighbouring countries and to other parts of the world.⁵ While in some cases this laxity has taken the form of either lack of skilled manpower or abrogation of responsibilities on the part of those meant to enforce the statutes. In other instances, it has taken the form of outright corruption. After accepting bribes, the officers feel obliged to look the other way while effluent and other toxic substances are inappropriately disposed of.

14.5 Legislation and Its Impact

It is perhaps fitting to commence this section by stating that Zimbabwe is party to several international and regional agreements, including those to do with climate change, ozone layer protection, law of the seas, biodiversity, endangered species, etc. The country has ratified key international conventions, including the Convention on Climate Change (1994), the Vienna Convention for the Protection of the Ozone Layer (1993), the Montreal Protocol for CFC Control (1993), the United Nations Convention on the Law of the Sea (1994), and the Convention to Combat Desertification, etc. Regionally, Zimbabwe is party to such conventions as the African Convention on the Conservation of Nature and Natural Resources (1998), among many others.

Of the various treaties and conventions to which Zimbabwe is a signatory, the most crucial is probably the Declarations of the Rio Earth Summit of 1992. The country is therefore expected to adhere to the stipulations of the Summit, including Agenda 21, which focuses attention on global strategies for cleaning the environment

⁵Zimbabwe has lost an unprecedented number of professionals, often trained at a great expense to the country, including doctors, engineers, lawyers, chemists, etc. By 2003, 60% of trained professionals had left the country (Sparks 2003). The numbers have continued to skyrocket.

and ensuring environmentally-sound development. Article 10 states that environmental issues are best addressed with the participation of all concerned citizens, at the relevant level. To date, very little effort has been put in place to facilitate citizen participation in environmental protection issues in Zimbabwe, particularly in Harare.

A plethora of legislations relating to issues of pollution control exist in Zimbabwe. Interventions by the city of Harare have essentially been predicated on two pieces of legislation: the Zimbabwe Regional Town Planning Act 1996, Chapter 29:12, revised edition, and the Zimbabwe Urban Councils Act 1996 (Chapter 29:15, revised edition). With regard to air pollution, the main pieces of legislation were for many years the Atmospheric Pollution Control Act 1971, the Hazardous Substances and Articles Act, and the Atmospheric Pollution Prevention Regulations 1975. Under these Acts (two of which are no longer in operation), zones were declared to be 'gas control areas' (or smoke or dust control areas) and were subject to regulation by the local authorities. Unfortunately the statutes neither required motor vehicles to be fitted with emission control equipment, nor did they specify the maximum concentration levels of pollutants to be emitted into the atmosphere.

The other pieces of legislation are the Hazardous Substances and Articles Act (1977) and the Public Health Act. These two pieces of legislation are enforced by the Minister of Health. As is the case with the pollution statutes, a key weakness with these two pieces of legislation has been their failure to specify the maximum levels of pollution permissible.

The Environmental Management Act (EMA), which is under the stewardship of the Ministry of Environment and Tourism, was promulgated in 2002, and was meant to replace the Atmospheric Pollution Control Act, and the Hazardous Substances and Articles Act. EMA has a provision for the establishment of Environmental Quality Standards, and Air Quality Standards. Under the Act, there is also provision for a Standards and Enforcement Committee whose role is to advise and recommend to the Environment Management Board all issues pertaining to quality, standards (including emission standards) and air control for both mobile and stationary sources. According to APINA (2003), the Act also includes the "polluter pays" principle, licensing of emissions and control of emissions by motor vehicles and other conveyances.

Legislation with regard to regulation of water quality include the Water Act (Chapter 20:2), the Water (Waste and Effluent Disposal) Regulations 5.1 274/2000, the Public Health Act (Chapter 15:09) and the EMA. In addition, there are a number of by-laws provided by the local authority. Some of these statutes criminalise the disposal of waste effluent without a permit from the Pollution Control Unit. Effluent discharge permits are meant to ensure compliance with water quality legislation.

Critics point out that the problem with the various pieces of legislation relating to pollution in Zimbabwe is that most of them do not force polluters to bear the cost of their activities and, besides, the penalties are too low to act as a deterrent (Tsiko 2007). Government actions taken in the name of enforcing the statutes sometimes tend to be grossly unreasonable. One such policy was the Murambatsvina (informal

settlement destruction) policy of 2005, which rendered over 700,000 poor people homeless. Many poor people were deprived of their livelihoods since they had used their (informal) shelter as a base for income generating activities. Sadly, they never recovered from this human-induced *tsunami*. While it is necessary to enforce statutes, including those that affect livelihoods of the poor, this has to be done in a humane, sensitive way.

Other statutes, be they to do with water and air pollution, or building standards, should be enforced. These include regulations to do with the disposal of industrial effluent, among others. Laws relating to cutting down of trees also need to be enforced; otherwise the entire country will soon be turned into a desert. Enforcement will need to be tempered with efforts to find alternatives for the affected people – for example, alternative sources of energy for domestic use by poor households.

The country has put in place a number of structures whose work has to do with environmental management. These include the National Climate Change Committee, which is made up of 13 members from different institutions, both government and non-government. The Committee's role is to promote standards of environmental quality and to provide information on the environment. Another player worth mentioning is the Environmental Management Agency whose mandate is to bring to book environmental offenders. However, these institutions do not have teeth to bite, given that many violations of environmental statutes occur on a daily basis. For example, with regard to land degradation and deforestation, many residents in Harare and other places have continued to cut down trees with impunity. Others are practicing stream bank cultivation and triggering water pollution.

A number of voluntary agencies have been registered by the Zimbabwe Environmental Review Association (ZELA) under its Urban Environment Programme. These groups exist as legal entities for the purposes of improving and assisting local authorities in waste management (ZELA 2009). ZELA also operates a Water Quality Law Research Project aimed at enforcing water quality legislation in Zimbabwe. To date, the impact of these measures has been negligible, essentially due to political meddling and sheer negligence on the part of those concerned. To make progress, it will be critical to root out corruption, a cancer that has seen officers looking the other way while regulations are being violated with impunity.

14.6 The Way Forward

It will be extremely difficult for Zimbabwe to tackle any of the challenges discussed in this paper until and unless the poisoned political climate has drastically changed, and resources massively mobilised. Otherwise no amount of effort on the socio-economic front is likely to bear much fruit. The discord in the current inclusive government has not helped matters; with the main opposition constantly threatening to pull out of the government. Structural issues therefore need to be adequately addressed and resolved before meaningful change can be anticipated.

One area that requires special attention is the identification of survival alternatives, especially among the poor in Harare and in the Greater Zimbabwe. The authorities must explore survival alternatives for the marginalised in the society. For instance, it was noted that the poor have been forced to destroy the environment in order to eke out a living, especially to secure energy or to grow food for domestic consumption. The Government of Zimbabwe (2008) has noted an increase in indiscriminate cutting down of trees in most urban areas in Zimbabwe (Harare included) due to frequent electricity outages. Something therefore ought to be done about this anomaly without delay.

In Harare, load-shedding is the order of the day as ZESA, the energy firm, has been unable to cope with the demand, especially since it relies on archaic power stations. The state energy utility has also failed to pay for coal from Hwange Colliery Company Limited (HCCL), resulting in some of its thermal power stations operating below capacity (Moyo 2009a). Incidentally, it was recently reported that the country's largest thermal power producer, Hwange Thermal Power Station, is in a crisis after it shut down two of its operational generators due to non-availability of coal. The reason for the shortage of coal was reportedly non-payment of its dues to HCCL (Moyo 2009b). The country badly needs to tap its vast coal reserves for progress to be realised, but non-availability of resources makes this virtually impossible.

The possibility of use of appropriate technology, especially in the area of energy supply, ought to be prioritised. At some point, the *tsotso* stove (among other types of appropriate technologies), which used only a small amount of firewood to cook a meal, was introduced in the country. However, it appears that funding constraints have stalled this programme.

It has been observed that change in rainfall patterns has affected agriculture, apart from impacting the social fabric of communities (Ziyomo 2009). As an alternative source of livelihood, urban agriculture needs to be encouraged, but it must be properly managed. In Harare, open spaces account for 10% of land in the city. According to Kisner (2008), in 25% of the city's poor households, urban agriculture contributes 60% of food consumption. This being an enormous contribution, there is a need to create proper institutions to manage urban space for agricultural activities in and around the city. To date, political interference has been a major concern in this regard.

In 1993, the government made a decision to relax by-laws governing urban agriculture in an attempt to alleviate poverty. Since then, local authority provisions appear to somewhat accommodate urban food production; but the discretion to determine the desirability and the extent of the activity at any point in time was left with the same authorities (Mbiba 1998). This has continued to cause uncertainties among poor urban farmers, making it difficult for them to seriously consider urban agriculture as a viable option. For instance, "there are accounts of government authorities burning urban plots of maize or other crops because the official view still depicts urban agriculture as bad for the environment and public health" (Kisner 2008:3). The government has thus behaved in an unpredictable way. The Murambatsvina policy alluded to earlier, which resulted in the displacement of thousands of the marginalised, is a case in point. Poor people may run short of money,

but their memories are not as short; they vividly remember what happened during that fateful winter when they were rendered homeless and left, literally, in the cold.

Expansion of agricultural activities in the city would imply increased demand for water, which is in constant short supply. Yet, as the saying goes, water is life. Water is also badly needed for agricultural purposes. This suggests the need to explore more efficient and appropriate technologies for intensive production (Mudimu 2001).

In the area of energy, it has been noted that Zimbabwe has been in the throes of a severe economic and currency crisis, with ruinous inflation rates that have dampened opportunities to import foreign energy (Lane 2007). Residents have had to turn to firewood for energy; and there is therefore a need to sensitise them on the negative impact of deforestation. People need to be made aware that wanton cutting down of trees causes soil erosion and may trigger siltation of the rivers; a scenario that would threaten water supply. They also need to be made aware of the dangers of soil erosion, which is a serious threat to the environs of Harare. The immense pressure brought to bear on land around Harare has transformed the soil structure, effectively decreasing the growth and flourishing of grasses and shrubs that hold soil together and check soil erosion. On paper, the task of sensitising residents on the dangers of this ought to have been the responsibility of the Zimbabwe National Water Authority (ZINWA),⁶ which has been responsible for water supply in Harare and elsewhere. Unfortunately, ZINWA's efforts have been hampered by shortage of resources, although critics say inefficiency has been rampant. Some ZINWA employees have been transferred to local authorities. In the context of Harare, former ZINWA employees have recently been absorbed by the Harare City Council (Chiremba 2009b). This, *inter alia*, has resulted in limited efforts and resources going towards awareness campaigns. Much will therefore need to be done to promote alternative sources of energy, including the promotion of solar power.

In the 1990s, the government was sold to the idea of promoting solar energy. In 1997 alone, over 6,000 solar panels were installed countrywide under the auspices of a UNDP-funded programme. The government even proceeded to remove import duties on solar panels, and much headway was made (UNDP and World 1997). However, for some reason, not much has happened in this regard in the last few years. There is clearly a need to revisit this initiative. The major challenge at the moment appears to be lack of hard currency to facilitate the process.

One other area that needs particular attention is that of educating the different "stakeholders" who comprise the three "Ps" – people (residents), politicians and planners (i.e. professionals or officers serving in the government). This has to happen in a spirit of 4Cs – cooperation, consultation, communication, and coordinated effort. Zvigadza (2008) has confirmed that mainstreaming of education and

⁶ZINWA has over the years been solely responsible for water affairs in Zimbabwe's urban areas, an arrangement bitterly opposed by residents in many urban areas. Apparently, there are moves to transfer the responsibility from ZINWA back to local authorities because ZINWA has struggled to deliver.

information on climate change is critical if change is to be realised. It is important for ordinary people to appreciate, for instance, that apart from firewood, trees are important for carbon sequestration and prevention of soil erosion.

There is also a need to mainstream climate change issues in everyday planning. Ordinary residents should be encouraged to take measures that are 'climate-friendly'. For example, the Forestry Commission in Zimbabwe has called on local councils to allocate pieces of land for people to plant woodlots for use as energy sources in the future. In the past, the Commission would maintain woodlots, which it later handed over to the local authorities, who in turn failed to sustain them, resulting in their destruction. In Harare, the Forestry Commission has in the recent past assisted the city council in re-establishing an 80-ha woodlot in Dzivarasekwa high density suburb, of which 20 ha were planted in 2008. This is how things ought to be, if the situation is to improve.

With regard to educating the masses on issues of climate change, the mass media will be expected to play a critical role. It may well be that the reporters themselves too (among other professionals) do not have sufficient grounding on this subject matter, which suggests they too may need educating and sensitisation. Once the scribes are educated, they will be in a better position to report accurately on the subject of climate change and its devastating impacts, and what residents can do to mitigate these impacts.

Emergency preparedness is critical in ameliorating problems caused by flooding, for instance; and yet this appears to be lacking. It is true that the country has a civil protection unit whose role, at least on paper, is to manage emergency disasters such as flooding. However, the unit lacks capacity. Flooding provides an environment conducive to rapid transmission of cholera and other water-borne diseases. Water treatment facilities are therefore essential. That the government has failed to find resources to upgrade sewerage treatment works in Harare,⁷ Chitungwiza and Ruwa, is cause for great concern since it can easily compound the dangers associated with flooding as burst pipes discharge raw sewage, contaminating drinking water.

Emergency preparedness also entails keeping the right equipment on the ready at all times. In this regard, water bladders of the right capacity; jerry cans for storage, chlorine, aqua tablets and soap, among other items, should be readily available. Funds for emergency relief need to be handled transparently and accountably to avoid misappropriation. Measures should therefore be put in place to revamp the unit and ensure adequate emergency preparedness. Lack of preparedness was clearly evident during the recent cholera outbreak in the city, which, as noted earlier, claimed thousands of lives.

⁷In September 2009, the author noticed that work had started in the city of Harare to replace some ageing underground pipes. It could not be established, however, whether this was part of a bigger programme to upgrade the entire water and sewer systems.

14.7 Conclusion

The foregoing illustrates that climate change has wrought havoc on life in Zimbabwe's city of Harare, especially with respect to lack of access to such basic needs as food security, health, availability of shelter and related infrastructure. While some of the impacts of climate change have affected both the rich and the poor, it would appear that the poor have felt the devastating impact of climate change more than the rich. Among the poor are women and children, vulnerable groups that include older people; the indigent (homeless and street children), the sick, etc., all of whom have been negatively impacted by climate change. Sadly, these vulnerable groups tend to be powerless and voiceless in these matters.

Local authorities in the city of Harare have an obligation to ensure that residents live in a clean and healthy environment (Shauri 2002). Often, the poor are left to suffer from the effects of pollution and related hazards. It is important that they be protected at all times. Needless to say, it is heartening to note that some agencies have taken it upon themselves to defend the poor in their battles with the city fathers. In the case of Harare for instance, an organization called Zimbabwe Environmental Law Association (ZELA) took the city of Harare (among other urban areas) to court on behalf of poor residents affected by water pollution, uncontrolled waste and discharge of sewerage into residential areas and rivers (ZELA 2009). Such action should be lauded.

However, a local authority worth its salt will not wait to be dragged to court by the very residents that it purports to service, or to be compelled by a court of law to deliver services to the residents. But then again, Harare is the capital city of a country that has within a decade evolved from a 'bread basket' to a 'basket case'; anything is possible. A basket case scenario, coupled with major climate changes, is a recipe for disaster. Arguably, the main challenge for Harare, and Zimbabwe in general is how to come up with adaptation strategies capable of mitigating the diverse and complex impacts of climate change.

References

- APINA (2003) Air pollution information network – Africa. Country fact sheet, Zimbabwe. Ministry of Environment and Tourism, Harare, pp 1–2
- Chipindu B (n.d.a.) The status of air pollution in Zimbabwe. Department of Physics, University of Zimbabwe, Zimbabwe (Unpublished paper)
- Chiremba T (2009a) Zesa in trouble. *The Sunday Mail* (14 June 2009):1
- Chiremba T (2009b) ZINWA workers face disciplinary action. *The Sunday Mail* (14 June 2009):4
- Cochrane M (2009) Northern Namibia swamped as river bursts banks. International Federation of Red Cross and Red Crescent (IFRC), Southern Africa
- CRU (Climate Research Unit) and WWF (World Wide Fund for Nature). (n.d.a.) Climate change scenarios for Zimbabwe
- CYP (Commonwealth Youth Programme) (n.d.a.). Sustainable development and environmental issues. Commonwealth Youth Programme, Module 13. University of Botswana, Gabarone
- DailGreen.com (n.d.a.) 1 million acres of trees destroyed in Zimbabwe. <http://dailygreen.com/environmental/news/latest6038>. Accessed 25 May 2009

- Donnelly J (2004) Zimbabwe woes spill across border. *ZW News* (2 March 2004):2
- GoZ (Government of Zimbabwe) (2008) Zimbabwe: plant trees to curb deforestation. *The Herald* (31 Dec 2008):7
- IESC (2009) Climate change. International Environmental Exchange Centre. www.international-profs.org/iesc/climate-change-2.html. Accessed 25 May 2009
- Kaseke E, Gumbo P (2001) Landlessness and farm invasions in Zimbabwe: lessons for social workers practicing community work. *Reg Dev Stud* 7:79–86
- Kisner C (2008) Urban agriculture case study: Harare, Zimbabwe. In: *Green roofs for food security and environmental sustainability*, Climate Institute, Chicago, IL
- Lane J (2007) Zimbabwe deforestation concerns mount as oil prices force villagers to burn wood for fuel; biofuels seen as solution. *Daily Biofuels Digest Newsl* (18 Sept 2007)
- Mbiba B (1998) Urban agriculture in Harare: between suspicion and repression. In *City Case Study*, Harare, pp 285–301
- Mongabay.com (n.d.a.) Zimbabwe deforestation rates and related forestry figures. <http://rainforests.mongabay.com/deforestation/2008/Zimbabwe.htm>. Accessed 23 May 2009
- Moyo A (2009) Move to alley fears of embarrassing blackouts at Victoria Falls because of power rationing. *ZimOnline* (28 May 2009):2
- Moyo A (2009b) Hwange station down...as Zesa fails to pay for coal. *The Sunday Mail* (14 June 2009):B2
- Mtisi S (2008) Promoting water quality laws enforcement and implementation in Zimbabwe urban areas. In: *Proceedings of the International Network for Environmental Compliance and Enforcement (INECE)*, Cape Town, pp 505–513, 5–11 Apr 2008
- Mudimu G (2001) The political economy of urban agriculture in Zimbabwe. In: *Proceedings of the MDP/IDRC Workshop on the Political Economy of Urban and Peri-urban Agriculture in East and Southern Africa*, held at Bronte Hotel, Harare, 28 Feb – 2 March 2001
- Mupedziswa R (2009) Modelling leadership responses to HIV and AIDS in Southern Africa. In: Fombad C, Mupedziswa R, Mookodi G, Maundeni T (eds) *AIDS, human rights and development in Botswana*. Made Plain Communications Publishing, Cape Town, pp 104–134
- Nyathi S (2009) Climate change is serious – Govt. *The Zimbabwean* (18–24 June 2009):17
- Rekacewicz P (2002) Climate change in Zimbabwe: trends in temperature and rainfall. http://maps.grida.no/go/graphic/climate_change_in_zimbabwe_trends_in_temperature_and_rainfall. Accessed 19 May 2009
- Russell J (2008) Zimbabwe: country at risk of climate change effects (Email correspondence, 22 May 2008)
- Shauri V (2002) Protecting the urban environment through litigation and advocacy in Southern Africa. Workshop on Protecting Africa's Urban Environment held at Mandel Training Centre, Harare, 5–7 June 2002
- Shoko B (2009) Harare water woes worsen. *The Standard* (23 May 2009):3
- Sparks A (2003) Saving Zimbabwe's sick economy. *The Star* (7 May):2
- Srinivas S (2008) Climate change. International Environmental Science Centre. www.internationalprofs.org/iesc/climate-change.html. Accessed 25 May 2009
- The Herald* (2008) Deforestation damage to Harare water (7 Feb 2008):5
- Tsiko S (2007) Lake Chivero: a polluted lake. *The Herald* (15 Jan 2007):5
- UNDP, UNEP, & World Bank (1997) Photovoltaics for household and community use – Zimbabwe. Global Environment Facility
- UNEP/GRID (n.d.a.) Vital climate graphics Africa. www.grida.no/publications/vg/africa. Accessed 16 March 2009
- ZELA (2009) Urban environment programme. Zimbabwe Environmental Review Association. <http://www.zela.org/site/urban/%Environment%20programme.asp>. Accessed 16 March 2009
- Ziyomo C (2009). Reality of climate change: to see its effect, look at Zimbabwe. Accessed 16 October 2009
- Zvigadzwa S (2008) Climate change vulnerability mapping: the case of the city of Harare, Zimbabwe. Paper presented at Cities and climate change workshop, Sheraton Hotel, Poznan, Poland, 5 Dec 2008

Index

A

Adaptation, 9, 10, 14–16, 31–34, 38, 50–53, 70, 80, 85–90, 92, 129, 145, 161, 162, 164–165, 167–190, 199, 206–208, 212, 217–219, 225, 230, 231, 237–239

Affordable housing, 11, 140, 154

Agriculture, 4, 10–12, 14, 17, 28, 31, 45–46, 49, 52, 62, 70–72, 104, 106, 137, 145, 154, 157, 173, 188, 196, 203, 205, 211, 213, 217, 223, 226–228, 240, 248, 249, 251, 258

B

Biodiversity, 4, 5, 17, 29, 92, 119, 158, 173, 179, 222, 248, 253, 255

Botswana, 38, 43, 76, 78, 79, 84, 87, 91, 95, 130, 244–246

By-laws, 164, 218, 256, 258

C

Cambodia, 6–8, 60–62, 65, 168, 228

Capacity building, 11, 17, 182, 240

Carbon dioxide (CO₂), 5, 10, 13, 15, 22, 26, 30, 37, 38, 69, 82, 87, 89, 93, 105, 131, 137, 138, 160, 188, 197, 198, 200, 203–205, 209, 216, 227, 245, 247, 248

Carbon footprint, 235

Child mortality, 58, 174, 183–184

China, 6, 7, 10, 15, 38, 57–60, 62, 63, 168, 169, 195–210, 228

Climate proof, 153, 164, 165, 181, 186, 218

Coastal areas/zones, 3, 4, 14, 27, 28, 39, 46–47, 52, 53, 61, 75, 87, 107, 159, 167, 170, 171, 173–175, 187, 189, 196, 197, 200, 205–207, 212, 218, 227

Community action planning, 66

Community involvement, 122

Community networking, 66

Coping strategy, 17, 70, 174

D

Deforestation, 38, 69, 83, 118, 159, 247, 248, 251–252, 257, 259

Desertification, 5, 50, 71, 79, 83, 87, 104, 106, 108, 199, 205, 207

Disaster mitigation, 27, 180, 234

Disasters, 3, 11, 14–16, 27, 29, 31, 34, 65, 74–75, 80, 84, 95–96, 98, 134, 164, 167, 169–175, 177–183, 185, 186, 196, 197, 199, 200, 205–207, 213, 218, 219, 227, 228, 234, 240, 248, 253, 260, 261

Diseases, 3, 5, 13–15, 17, 26, 27, 33, 42–44, 48, 72–75, 80–83, 119, 142, 155, 157, 161, 163, 170, 174, 184, 190, 196, 197, 199, 205, 208, 213, 216, 247–250, 260

Drainage, 11, 27, 74–76, 86, 89, 92, 97, 110, 141, 187, 205, 214, 217, 218, 249

Droughts, 8–12, 14–17, 22, 23, 26, 27, 29, 34, 41, 43, 46, 47, 49, 50, 53, 70, 74, 77–81, 84, 85, 87, 93, 104, 106, 108, 135, 138, 146, 155–158, 161, 163, 169–171, 187, 195, 196, 205, 207, 212, 215, 217, 227, 243–246, 248, 250–252

E

East Africa, 4, 15, 45, 71, 74, 76, 154, 211–219

Ecological footprint, 31, 232

Economic growth, 4, 6, 7, 10, 14, 21, 24, 29–30, 41, 44, 48, 57, 61–63, 66, 117, 118, 128, 133, 134, 136, 168, 174, 196, 208

Eco-precinct, 12, 117, 126

Ecosystems, 4, 28–31, 33, 73, 131, 159, 161, 162, 164, 170, 179, 185, 188, 189, 196, 197, 200, 205, 207, 208, 211, 215, 226, 232, 248

Electricity, 12, 13, 65, 84, 88, 90, 91, 106, 118, 119, 124, 125, 131, 137, 139, 140, 143, 144, 201, 202, 215, 216, 235, 237, 250–252, 258

El Nino, 159, 212

Energy efficiency, 11, 12, 88, 89, 91, 92, 97, 123–125, 198, 201–202, 208, 235, 236

Environmental management, 12, 31, 33, 86, 134, 137, 145, 146, 251, 257

Environmental policy, 17, 130, 136–138, 146, 149, 161–162, 229–231

Evictions, 65

F

Farming areas, 248

Food, 9, 15, 16, 23, 27–28, 45, 46, 49, 64, 71, 74, 76, 79, 84, 85, 104, 108, 157, 158, 173, 190, 215, 217, 224, 226, 232, 244, 250, 251, 253, 258

Food security, 10, 14, 45–46, 52, 84–85, 143, 216–217, 240, 245, 261

Foreign direct investment (FDI), 7, 60, 62, 63, 223

Forest/forestry, 4, 8, 16, 27, 108, 157, 169, 170, 173, 184, 188, 189, 196, 199, 204, 205, 207, 209, 215, 223, 226–227, 230, 232, 234, 240, 248, 251

Fossil fuels, 25, 69, 91, 111, 115

G

Gender, 153, 174, 183

Ghana, 11, 12, 38, 45, 77, 87, 91, 103–115

Global warming, 12, 22, 25, 28, 32, 37, 39, 69, 73, 77, 86, 93, 105, 114, 115, 138, 154, 158–160, 208, 211, 245

Governance, 10, 17, 21, 22, 30, 33, 34, 50, 52, 63, 65, 66, 79, 95, 96, 134, 137, 146, 165, 174, 219, 222, 235, 238

Green building, 88, 120–122, 126, 221, 234–236

Greenhouse gas (GHG) emissions, 3, 5, 9, 22, 25, 26, 30, 32, 37–39, 50, 85, 86, 118, 129, 131, 137, 138, 158–160, 164, 198, 202–203, 205, 211, 247

H

Hazards, 11, 26, 29, 31, 34, 44, 48, 73, 74, 108, 158, 161, 164, 169, 172, 218, 234, 245, 249, 250, 254, 261

Health, 4, 8–11, 13, 14, 22, 23, 25–27, 31, 34, 43, 46, 48, 52, 58, 72, 73, 79–85, 87, 88, 92, 106, 111, 119, 129, 132, 136, 139, 140, 142, 145, 149, 157, 159–161, 173, 174, 176, 179, 180, 183, 184, 190, 197, 208, 216, 235, 236, 240, 248–251, 253, 254, 258, 261

Heat stress, 73, 84, 86, 119, 215

Heat waves, 12, 14, 21, 23, 26, 29, 34, 53, 75, 84, 106, 157, 160, 195, 217

HIV/AIDS, 42, 142, 174, 184, 244

Housing, 3–5, 8–14, 16, 25–27, 33, 43, 57–67, 71, 73, 88, 89, 97, 103–115, 117–150, 153–165, 167–190, 215, 223, 229, 234, 235, 238, 243–261

Housing policy, 13, 14, 62, 137–141, 143, 148–150, 161, 162

Humidity, 11, 12, 84, 111–113, 115, 190, 250

I

Inclusiveness, 65, 66

Incremental development, 66, 67

India, 3, 6, 10, 25, 27, 28, 38, 57, 58, 60, 64

Indonesia, 6–8, 61, 64, 66, 228

Industry, 11, 13, 28–30, 42, 62, 73, 81, 97, 104, 111, 123, 126, 128, 136, 158, 159, 187, 188, 200, 213, 215, 223, 234, 235, 247, 250, 254

Informal sector, 62–66

Informal settlements, 4, 8, 10, 12, 13, 44, 65, 66, 73, 86, 97, 110, 140–144, 147–150, 160, 216, 219, 245, 249

Infrastructure, 5–9, 11–14, 16, 17, 21, 22, 25, 27, 29–30, 33, 34, 42, 44, 47, 50, 52, 53, 59, 63, 67, 73, 75, 76, 80–81, 83, 85, 86, 89, 92, 94, 95, 97, 109, 110, 115, 118, 128, 131–134, 136, 138, 141, 142, 144, 153, 157, 158, 164, 173–176, 189, 198, 200, 205, 208, 216–218, 222, 227, 229, 235, 238, 248, 249, 252–254, 261

Intergovernmental Panel on Climate Change (IPCC), 21–23, 28, 31, 37, 41, 69, 77, 79–82, 84–86, 88, 118, 138, 167, 172, 211, 212, 245

K

- Kenya, 15, 38, 48, 76–78, 80, 84, 87,
90, 91, 94, 95, 154, 157, 211–213,
215, 218
- Kyoto Protocol, 50–52, 87, 105, 135,
145, 156, 161, 162, 178, 180,
197, 230

L

- Land sharing, 66
- Legislation, 13, 137, 139, 149, 161, 162, 178,
243, 255–257
- Life expectancy, 43, 58, 173, 244
- Lifestyles, 9, 21–23, 25, 32, 119, 126, 160
- Liveability, 221, 240
- Liveable cities, 16, 118, 173–176, 221–241,
243–261
- Local authority, 239, 251, 256, 258, 261

M

- Malaysia, 6, 7, 16, 61, 221–241
- Megacities, 6–8, 28, 59, 60
- Migration, 10, 23, 42, 43, 46, 49–50, 59, 60,
63, 66, 72–74, 77, 79, 141, 143, 158,
174, 190, 214, 215
- Millennium Development Goals (MDGs), 57,
58, 129, 132, 133, 144, 145, 156, 160,
162–165, 173, 174, 178, 183–184,
230–231
- Mitigation, 9, 10, 15, 17, 27, 31–34, 44, 53, 70,
74, 80, 85, 86, 91, 95, 129, 134, 136, 149,
150, 159, 161, 162, 164–165, 179–181,
208, 217–218, 225, 230, 234, 237, 239

N

- Namibia, 45, 79, 130, 244–246
- National Climate Change Response Strategy,
13, 51, 136, 145

P

- Pakistan, 58, 65
- Participation, 64–66, 80, 185–186, 206, 209,
234, 238, 239, 256
- Philippines, 6–8, 61, 64, 66, 228
- Pollution, 5, 8, 13, 32, 62, 72, 80–82, 93, 137,
142, 159, 173, 184, 202, 236, 237, 243,
247, 248, 253–257, 261

- Population growth, 6, 10, 23, 26, 43, 44, 59, 63, 71,
72, 108, 143, 154, 160, 175, 214, 227, 245
- Poverty, 4, 5, 7, 8, 10, 14, 17, 43, 44, 57–67,
70, 79, 93, 104, 110, 129, 130,
132–136, 138–140, 143–145, 149, 161,
163, 164, 167, 168, 173, 174, 178, 181,
183–185, 190, 196, 211, 214–215, 218,
243, 244, 258
- Poverty alleviation, 129, 132–136, 138, 140,
144, 149, 167, 168, 181
- Power, 5, 13, 17, 29, 46, 62, 64, 74, 75, 80–82,
89–91, 93, 118, 123, 124, 132, 137,
189, 201, 202, 205, 208, 215, 223, 226,
244, 250–252, 258, 259
- Pre-fabrication, 122, 125, 126
- Public housing, 12, 66, 117–128

R

- Rainfall, 5, 11, 12, 14–16, 39–41, 45, 48, 49,
70, 72, 75–77, 79–81, 87, 93, 103, 105,
106, 113, 115, 119, 131, 138, 141, 142,
154–156, 163, 169, 211–213, 216, 224,
226–228, 245–248, 250, 258
- Recycling, 122, 127, 202–203
- Renewable energy, 11, 74, 83, 97, 123–125,
164, 189, 202–204, 208
- Research, 4, 32, 38, 48, 49, 59, 79, 87, 88, 95,
108, 120, 122–123, 136, 177, 179, 182,
196, 197, 203, 204, 206, 219, 221, 223,
227, 230, 235, 240, 257
- Resilience, 4, 95, 97, 219
- Risk, 3, 8, 11, 16, 26–30, 45–47, 50, 52, 61, 70,
73, 75, 76, 81, 83, 85, 87, 92, 95, 96, 98,
129, 141, 142, 159, 163, 164, 167, 169,
171–174, 176, 177, 179, 181–183, 185,
186, 197, 212, 214, 218, 219, 234, 239, 252
- Risk management, 11, 92, 98
- Rural areas, 6, 14, 23–25, 43, 49, 50, 58–60,
62, 63, 70, 77, 79, 84, 86, 109, 141,
154, 157, 175
- Rural development, 50, 63, 136, 168, 181
- Rwanda, 15, 76, 91, 154, 155, 211,
212, 218

S

- Sanitation, 3, 4, 8, 13, 25–27, 33, 44, 47, 52,
64–66, 74, 78–81, 89, 97, 111, 119,
132, 142–144, 158, 159, 161, 163, 175,
178, 184, 190, 216, 218

- Sea level rise (SLR), 3, 11, 12, 16, 46–47, 53, 70, 73, 75–77, 80, 81, 167, 169, 174–176, 179, 186, 197, 200, 213, 215, 225–228, 239
- Singapore, 4, 7, 8, 10, 12, 57, 58, 61, 66, 117–128, 227, 247
- Slums, 3, 8, 10–12, 25, 27, 33, 44, 47–49, 58, 62, 64–67, 78, 96, 110, 111, 114, 115, 117, 119, 122, 144, 150, 156–158, 161, 163, 213, 214
- Slum upgrading, 10, 11, 66, 78
- Solid waste, 3, 33, 44, 62, 65, 76, 88, 202, 209, 213
- South Africa, 13, 38, 39, 45, 47, 51, 52, 69, 71, 74, 77, 83, 85, 87, 89–91, 94, 95, 129–150, 212, 244
- Spatial development, 231
- Squatter settlements, 13, 58, 62, 65–67, 89, 119, 141, 148
- Sri Lanka, 66
- Sub-Saharan Africa, 3
- Sustainability, 12, 118–123, 128, 134, 143, 144, 149, 174, 184, 221, 222, 226, 230, 234, 235, 240
- Sustainable construction, 12, 123, 125–126
- Sustainable development, 8, 13, 15, 16, 37, 89, 93, 117–123, 125–130, 134–137, 140, 144–146, 149, 150, 161, 165, 178, 184, 185, 197, 199, 218, 230–232, 234
- T**
- Tanzania, 25, 38, 47, 71, 76, 77, 80, 94, 95, 154, 211, 212, 218
- Technology, 5, 23, 30, 32, 104, 122, 123, 125, 126, 128, 145, 165, 176, 200, 204, 205, 209, 222, 230, 235–238, 258
- Temperature, 5, 9, 11–17, 21–23, 26, 27, 29, 37, 39–41, 48, 73–75, 80, 84, 86, 92, 93, 103, 105–108, 111, 113, 115, 118, 125, 131, 138, 142, 155, 157, 163, 168, 171, 195–197, 201, 205, 211, 212, 216, 223–226, 245–250
- Thailand, 6–8, 59–61, 64, 228
- Transportation, 9, 11, 21, 22, 29, 32–34, 42, 73, 81, 83, 95, 97, 111, 121, 160, 173, 176, 198, 203, 217, 222, 232, 234, 235, 247
- U**
- Uganda, 13–15, 76, 80–82, 93, 95, 153–165, 211–213, 215–219
- Urban heat island, 12, 26, 72, 84, 111, 115, 123, 125, 126, 208
- Urbanization, 4–10, 24, 41–50, 52, 53, 57–59, 61–63, 77, 79, 82, 96, 108, 143, 149, 154, 159, 174, 176, 198, 199, 209, 221, 227, 231, 234
- Urban management, 8, 33, 60, 93, 96, 149
- Urban planning, 5, 8, 34, 61, 73, 88–90, 93, 95, 118, 141, 214, 219
- V**
- Vietnam, 6–8, 14, 61, 62, 167–190, 228
- Vulnerability, 13, 25, 52, 74, 76, 84, 85, 95, 96, 142, 143, 172, 174, 177, 179, 182, 184, 186, 199, 207, 216, 218, 219, 225, 230, 240, 251
- W**
- Wastewater, 75, 187
- Water supply, 4, 8, 33, 46, 65, 71, 74, 78, 81, 82, 111, 146, 158, 173, 225, 249, 254, 259
- Weather, 3, 5, 11–13, 16, 17, 21, 23, 26, 27, 29, 31, 37, 40, 48, 50, 61, 69, 73–75, 88, 96, 105, 138, 142, 146, 153–155, 157, 160, 163–165, 167, 177, 179, 185, 218, 219, 224, 234, 238, 240, 246, 247
- Z**
- Zimbabwe, 16, 17, 38, 45, 78, 91, 130, 243–261