



Moseki Ronald Motsholapheko

Donald Letsholo Kgathi

Editors

Flooding

*Risk Factors,
Environmental Impacts and
Management Strategies*

NATURAL DISASTER RESEARCH PREDICTION AND MITIGATION

NOVA

NATURAL DISASTER RESEARCH, PREDICTION AND MITIGATION

FLOODING
RISK FACTORS, ENVIRONMENTAL IMPACTS
AND MANAGEMENT STRATEGIES

MOSEKI RONALD MOTSHOLAPHEKO

AND

DONALD LETSISOLO KGATHI

EDITORS



 **nova**
publishers
New York

Copyright © 2014 by Nova Science Publishers, Inc.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system or transmitted in any form or by any means: electronic, electrostatic, magnetic, tape, mechanical photocopying, recording or otherwise without the written permission of the Publisher.

For permission to use material from this book please contact us:

Telephone 631-231-7269; Fax 631-231-8175

Web Site: <http://www.novapublishers.com>

NOTICE TO THE READER

The Publisher has taken reasonable care in the preparation of this book, but makes no expressed or implied warranty of any kind and assumes no responsibility for any errors or omissions. No liability is assumed for incidental or consequential damages in connection with or arising out of information contained in this book. The Publisher shall not be liable for any special, consequential, or exemplary damages resulting, in whole or in part, from the readers' use of, or reliance upon, this material. Any parts of this book based on government reports are so indicated and copyright is claimed for those parts to the extent applicable to compilations of such works.

Independent verification should be sought for any data, advice or recommendations contained in this book. In addition, no responsibility is assumed by the publisher for any injury and/or damage to persons or property arising from any methods, products, instructions, ideas or otherwise contained in this publication.

This publication is designed to provide accurate and authoritative information with regard to the subject matter covered herein. It is sold with the clear understanding that the Publisher is not engaged in rendering legal or any other professional services. If legal or any other expert assistance is required, the services of a competent person should be sought. FROM A DECLARATION OF PARTICIPANTS JOINTLY ADOPTED BY A COMMITTEE OF THE AMERICAN BAR ASSOCIATION AND A COMMITTEE OF PUBLISHERS.

Additional color graphics may be available in the e-book version of this book.

Library of Congress Cataloging-in-Publication Data

ISBN: 978-1-63117-607-4

Published by Nova Science Publishers, Inc. † New York

NATURAL DISASTER RESEARCH, PREDICTION AND MITIGATION

FLOODING

**RISK FACTORS, ENVIRONMENTAL IMPACTS
AND MANAGEMENT STRATEGIES**

NATURAL DISASTER RESEARCH, PREDICTION AND MITIGATION

Additional books in this series can be found on Nova's website
under the Series tab.

Additional e-books in this series can be found on Nova's website
under the e-book tab.

PREFACE

This book is about flooding, the risk it imposes on human well-being and related activities, and the main approaches used to deal with the impacts. The aim is to derive lessons for flood risk management. The book covers experiences from case studies in the five countries of Argentina, Australia, Botswana, Brazil and Taiwan. It indicates that in most areas around the world, floods disrupt human activities and also pose threats to human well-being whereas in other areas, particularly wetlands around the world, they are viewed as useful for the sustainability of ecosystems and human livelihoods. Due to climate variability and change, floods are expected to increase in frequency and intensity throughout the world. There is need to evaluate the current structural and non-structural approaches for dealing with flood risk and the impacts on human systems. Decision-making on the adoption of either structural or non-structural approaches to flood risk largely depends on information available and the means to achieve the intended objectives. Understanding the risk posed by flooding requires multidisciplinary assessments on the biophysical, socioeconomic and cultural factors underlying the vulnerability of human systems. The book starts by identifying some methods which may be useful for flood assessments. Furthermore, it identifies the impacts of flooding and assesses the pros and cons of the related structural and non-structural responses. The challenges observed from the two main approaches are identified and suggestions are made for promoting flood risk management. Suggestions are made for strengthening support for non-structural approaches which are still inadequate in most developing countries, and require improvement in developed countries, given the increasingly complex nature of flood risk posed by extremes in climate variability.

Chapter 1 – Flooding, which occurs when large bodies of water overflow river channels and banks inundating vast areas within and at times beyond the ‘normal’ river floodplains, is a common phenomenon which occurs in river basins throughout the world. For many centuries to date, floods have been a part of life for many communities and societies which depend on river systems for their development activities and to derive a multiplicity of benefits including water supply, transportation, sewerage disposal, power generation, agricultural production, fishing and so on. As the human population increased, many areas around river systems including floodplains and wetlands have been developed through construction of important infrastructure for public and private use and conversion to agricultural land. Such development has not come without a price; the risk of disruption by floods has been increasing in most areas around the world. Risk itself being the “the

probability of an event and its negative consequences” (UNISDR, 2009: p25), is at the interface of the interactions between any event (including floods) and human systems.

Chapter 2 – Flooding is one of the worst natural disasters that cause notable loss of lives and economic damage in Australia similar to many other countries around the world. In Australia, during the 2010-12 periods alone, flood damage costs were estimated at over \$20 billion and over 25 human deaths. The flood risk assessment is an essential part of development and operation processes which are subject to flood risk, such as design of hydraulic structures, development control and flood insurance studies. This chapter reviews the commonly adopted flood risk assessment methods adopted in Australia. This, in particular, presents the evolution of a holistic approach of flood estimation known as Joint Probability Approach (JPA)/Monte Carlo Simulation Technique (MCST) in Australia. This method considers the probabilistic nature of flood producing variables and their correlation in flood modelling using a runoff routing model. A case study is presented to illustrate the regionalisation and application of the JPA/MCST to an Australian catchment. It is found that the JPA/MCST can be applied successfully in practice with regional input data. This method can easily be adapted to other countries.

Chapter 3 – The northeast region of the Province of Buenos Aires, Argentina comprises a coastal plain along the Rio de la Plata estuary and an adjacent continental plain. This region exhibits a high degree of urbanization associated with continuously growing economic activities. Regional plain features, wet climate, occurrence of extra-tropical storm surges, and land changes carried out without suitable planning have often produced periodic and disastrous floods in highly urbanized areas particularly those located in topographically low-lying sections. Heavy rainfall events of progressively increasing frequency, the diminishing of infiltration due to extensive urbanization and the subsequent increment in surface runoff have aggravated the problem. This chapter aims at analyzing the causes and environmental impacts of flooding in Province of Buenos Aires. The tragic flooding of the 2nd April 2013 in La Plata has been selected as a paradigmatic case study. Hydro-meteorological monitoring for three locally possible flooding scenarios is considered. A series of structural and non-structural measures that would facilitate the mitigation of flood damage were also analysed. Such measures are recommended for implementation in the continental and the coastal plains.

Chapter 4 – This chapter focuses on the relationship between climate change and the impacts of climate events, as well the importance to manage the associated risk. According to IPCC (2012), the impacts of climate extremes and the potential for disasters emerge from the interaction of physical conditions (weather/climate), from the exposure and vulnerability of human and natural systems. With global climate change, extreme weather events such as cyclones and floods are expected to occur with increasing frequency and greater intensity, which contaminates freshwater supplies, heightens the risk of water-borne diseases, and creates breeding grounds for diseases such as leptospirosis. Infectious disease outbreaks have been reported following major flood events in developing countries, and these outbreaks vary in magnitude and rates of mortality. The objective of the study was to evaluate leptospirosis at geographic locations based on environmental factors and produce a predictive disease risk map. The area of study is São Paulo Metropolitan Area (SPMA), one of the largest megacities in the world (with 19,956,590 people). In this case, authors considered the previous analysis of Coelho and Massad (2012), where for each additional 20 mm of precipitation there was an average increase of 15.6 % in hospital admissions, as the precipitation increased from 20 mm to 120 mm. Within this context, authors considered the spatial distribution of the daily

number of leptospirosis cases and the probability of flood events in SPMA. Authors used ArcGIS to integrate the spatial information and non-spatial attribute data, where each spatial feature and its attribute information were linked. The ArcGIS also provided the "math" module to perform mathematical operations in order to analyze the geographical patterns and trends of the region. As a result, a map of vulnerability was produced based on the leptospirosis risk evaluation which can enable decisions to be made on strategies and interventions for improving the conditions of people living in disease-prone areas.

Chapter 5 – Due to dense population living along the riverside, river flooding is one of the major hazards in Taiwan. The Taipei metropolitan area is the largest city with more than one-third of the total population of Taiwan. In this area, numerous severe flooding disasters caused by typhoon events have occurred and resulted in heavy losses. To mitigate flood-related disasters, a large-scale flood prevention program was implemented in 1963 and fully completed in 1999, namely the Taipei Flood Prevention System. The specific goal was to protect the Taipei metropolitan area against the 200-year recurrence flood in the Tanshui River. Levees and dykes of 32 km in length were constructed and improved along the river. Mitigation of floods for the Tanshui River system is inhibited by the bottleneck, which occurs at the smallest river width near the Taipei Bridge. Therefore, the Erchung Floodway was established to divert some of the flood water. The specific goal of the Erchung Floodway was to divert 9200 m³/sec peak flood discharge under a 200-year return period flood. However Erchung Floodway's function has been changed over time by urban development and natural alterations including river sand mining, riverine park construction, riverine plant succession, bridge construction and so on. Riverbed elevation changes due to sand mining are believed to have influenced the strength of the Taipei Flood Prevention System and thus were discussed in this study. The current protection criteria and impacts from anthropogenic effects and climate change threats were also examined. Both the physical and numerical models were used and analyzed. The sensitivity analysis of thirty-two scenarios corresponding to four factors has been investigated, including riverbed elevation, riverbed roughness, and water stage at the river mouth under the Q₂₀₀ flood. The simulated results show that the flood diversion capacity of the Erchung Floodway, a key infrastructure for dividing floods in the Taipei Flood Prevention System, has decreased by 30%. Authors also found that the Taipei Flood Prevention System will encounter challenges if the riverbed roughness in the Erchung Floodway increases by over 50%, the riverbed roughness in the Tanshui River increases by over 25%, and the Q₂₀₀ increases by over 13%. Authors conclude that the degrading process of the Taipei Flood Prevention System due to rapid urbanization and the corresponding strategies including river roughness and riverbed elevation control are meaningful lessons especially for developing countries. A comprehensive and effective evacuation program and monitoring system is also suggested.

Chapter 6 – In 2011 in Queensland Australia, floods created considerable financial pressure on regional governments. Many affected households suffered severe economic losses as they did not have flood cover on their home insurance policies. The absence of flood insurance could pose threats to fiscal health and has risen to the national policy agenda. This study contributes to the debates by identifying key subjective factors associated with non-insurance. It is based on a social survey involving a total of 501 residents of Brisbane, the Gold Coast, and the Sunshine Coast. A significant minority of respondents (43.8%) reported to have no flood cover. Perceived flood risk is not statistically related to the likelihood of non-insurance. This means that non-insured households are not restricted to those who are

unaware of the flood risks confronting them. The insured individuals are better educated and tend to recognize the role of flood insurance in financially protecting the household. Non-insurance is also associated with the expressed preference for government compensation over insurance. The study offers two main insights for policy-makers, floodplain managers and insurers. First, raising risk awareness is unlikely to be sufficient to improving the uptake of flood insurance. Second, managing the public expectations about disaster relief may have positive impacts.

Chapter 7 – Floods and flooding events are of central interest in the studies bordering on the Okavango Delta ecosystems, the sustainability of which depends on regular water flow. Nonetheless, as beneficial as flood pulses might be to the river basin and the riparian communities in and around it, extreme flooding events continue to impact on rural livelihood systems and people's well-being in the area. This chapter employs the concept of Pierre Bourdieu's [1930-2002] habitus and the use of qualitative data (obtained through key informant interviews) to analyse and explain how cultural values shape people's perceptions and how they respond to natural phenomena (such as floods), which impinge on their living conditions. Through the application of Kurt Lewin's [1890-1947] field theory and 3-step model of planned change, and in partial combination with Bourdieu's field, the discourse offers insights on how scheduled change agencies could better understand the social forces that perpetuate undesired and desired behaviours of individuals comprising their clientele systems and how this understanding could enhance the application of appropriate planned change program for achieving behavioural change in the periods of emergency triggered by water inundation.

Chapter 8 – Adaptation to flooding is now widely adopted as an appropriate policy option since flood mitigation measures largely exceed the capability of most developing countries. In wetlands, such as the Okavango Delta, adaptation is more appropriate as these systems serve as natural flood control mechanisms. The Okavango Delta system is subject to annual variability in flooding with extreme floods resulting in adverse impacts on rural livelihoods. This study therefore seeks to improve the general understanding of rural household livelihood adaptation to extreme flooding in the Okavango Delta. Specific objectives are: 1) to assess household access to forms of capital necessary for enhanced capacity to adapt, 2) to assess the impacts of extreme flooding on household livelihoods, and 3) to identify and assess household livelihood responses to extreme flooding. The study uses the sustainable livelihood and the socio-ecological frameworks to analyse the livelihood patterns and resilience to extreme flooding. Results from a survey of 623 households in five villages, key informants, focus group discussions and review of literature, indicate that access to natural capital was generally high, but low for financial, physical, human and social capital. Households mainly relied on farm-based livelihood activities, some non-farm activities, limited rural trade and public transfers. In 2004 and 2009, extreme flooding resulted in livelihood disruptions in the study areas. The main impacts included crop damage, household displacement, destruction of household property, livestock drowning and mud-trapping, the destruction of public infrastructure and disruption of services. The main household coping strategies were labour switching to other livelihood activities, temporary relocation to less affected areas, use of canoes for early harvesting or evacuation and government assistance, particularly for the most vulnerable households. Household adaptive strategies included livelihood diversification, long-term mobility and training in non-agricultural skills. The study concludes that household capacity to adapt to extreme flooding in the study villages largely depends on access to

natural capital. This is threatened by population growth, land use changes, policy shifts, upstream developments, global economic changes and flood variations due to climate variability and change.

Chapter 9 – Flooding is a global phenomenon that continues to affect people socially, psychologically and economically and has been a concern for many years. Risk communication has been applied to inform the public about the potential harm caused by different environmental hazards. Literature has suggested that in cases where potential harm is perceived, the effectiveness of the risk communication interventions will depend on a number of factors such as perception of risk, trust, credibility and socio-demographic and cultural factors. The current study aimed at exploring factors that contribute to low adoption of flood risk warning information among local communities living in the Okavango Delta. The qualitative study, using a mixed method approach, was guided by the Mental Models and Trust Determination model to explore the socio-cultural and institutional environment within which flood risk communication took place, using a sample of 55 respondents affected by the floods. Findings revealed multiple factors such as a history of long residence in the area without experiencing floods, socio-cultural, myths, beliefs and perceptions towards water and floods, and low knowledge about floods and floods risks as factors contributing to the low adoption of flood risk warning information among the Delta communities. Others emanating from the sources of risk communicators include issues of trust and credibility. The study suggests that risk communicators and institutions should undertake preliminary synoptic audience assessments to guide communication interventions, participatory communication and land suitability and risk vulnerability before allocations.

Chapter 10 – Fish is a major source of livelihoods for riparian communities. It contributes significantly to food and nutrition security, rural employment and general poverty alleviation. Studying the dynamics of this resource in riverine/flood pulsed systems provides critical information essential for management of this resource. It is also important to understand the impact of extreme flood events on this resource, so that their impact on the rural livelihoods can be established. In the absence of comprehensive data linking the effects of extreme floods to riverine fish dynamics, predictions can be made using holistic environmental flow assessment (EFA) methodologies. Therefore, this approach was used to assess the effect of extreme floods on the Boteti River fishery. Typical of holistic methods in EFA methodologies, baseline information on the biology and ecology of Boteti River fisheries were determined. Fish data were collected using standardised experimental fishing methods, while socio-economic data were collected using structured interviews. Various fish community indices were used to assess spatio-temporal variations in fish community structure and feeding ecology of selected species. Two fish indicators, based on fish guilds, were then used to predict the effect of extreme flooding on fish populations. Qualitatively, results revealed that there were spatio-temporal variations in fish community structure in the river systems, though there were no significant differences ($p > 0.05$) in selected indices among the different sites. However, there were significant differences ($p < 0.05$) in relative abundances and morphometrics of selected species among sites in the river system. This suggests that variability in the fish community is observed at the species level and not the population level. Results also revealed that the terrestrial environment is a major source of energy for the river's fish community, driven by flooding. Understandably, the fish resource in this river is a major source of livelihoods for the riparian community, though fishers had diverse economic activities. It was predicted that while extreme floods had negative impacts on fish

populations, prolonged flooding also contributes to increased fish production for some species. While negative impacts on fish production would have a deleterious impact on fishers, it was also concluded that their diverse economic activities is an adaptation strategy to variability in fish availability. Another major conclusion is that the Boteti River fishery is very resilient (and dynamic), and will always return to normal after any extreme event such as drought or flood.

Chapter 11 – This book highlights the international experience of flood risk in five countries of Argentina, Australia, Botswana, Brazil, and Taiwan. It demonstrates that flooding is one of the worst hazards in both the developed and developing world. Floods are rated the third most common natural disaster after storms and earthquakes. Despite the global efforts to manage floods and mitigate their damages, there is evidence that the losses caused by floods continue to increase. The book indicates that flooding is not only caused by too much water but results from a number of conditions. These include extreme meteorological events and poor land-use planning (Chapter 2). Based on the predictions of IPCC (2012), extreme weather events are expected to increase in the future as a result of climate change and this implies that they are likely to exacerbate the damages resulting from floods. Apart from these challenges, floods have also created opportunities as they enrich the land for agriculture by depositing nutrient-rich sediments in floodplains and therefore contribute to the provision of ecosystem services. Since the 1980s, many countries realised need to live in harmony with the processes of flooding as it is almost impossible to eliminate them. The book supports the view of Sayers et al. (2013) that there is no single solution for addressing floods and that it is necessary to develop a portfolio of measures. Risk-based approaches are recommended as a strategy for addressing the challenges of flooding.

LIST OF ACRONYMS

ABS	Australian Bureau of Statistics
A-D	Anderson-Darling test
ADCP	Acoustic Doppler Current Profiler
ADRC	Applied Development Research Consultants
AHDEL	American Heritage Dictionary of the English Language
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
AUD\$	Australian Dollar
BOM	Australian Bureau of Meteorology
BWP	Botswana Pula
CATI	Computer Assisted Telephone Interviewing
CBNRM	Community-based natural resource management
CEU	Cattle-equivalent-units
CRCCH	Cooperative Research Centre for Catchment Hydrology
CRED	Centre for Research on the Epidemiology and Disasters
C-S	Chi-Square test
CSO	Central Statistics Office
DDMC	District Disaster Management Committee
DEA	Design Event Approach
DSS	Decision support system
DFFC	Derived flood frequency curve
DOD	District Officer Development
EA	Enumeration area
EFA	Environmental flow assessment
EWP	Electronic White Pages
FAO	United Nations Food and Agricultural Organisation
FFA	Flood frequency analysis
FGD	Focus Group discussion
GDP	Gross Domestic Product

GIS	Geographic Information Systems
HDI	Human development index
HIV/AIDS	Human immunity virus/Acquired immunity deficiency syndrome
ICA	Insurance Council of Australia
IED	Inter-event duration
IFD	Intensity-frequency-duration
IFRC	International Federation of Red Cross
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Probability Approach
IRI	Index of relative importance
K-S	Kolmogorov-Smirnov test
LIPW	Labour-intensive-public-works
MCST	Monte Carlo Simulation Technique
MSL	Mean sea level
NCWE	National Committee on Water Engineering (Australia)
NDIR	Natural Disaster Insurance Review (Australia)
NGOs	Non-governmental organizations
N-NW	North-northwest
NSW	New South Wales
RDD	Random Digit Dialling
RORB	Australian Rainfall Runoff Routing model
SADC	Southern African Development Community
SE-SSE	Southeast south-south-east
SHN	Servicio de Hidrografia Naval
SNWA	Seven Natural Wonders of Africa
SPF	Strategic Programme Fund
SPSS	Statistical Package for Social Sciences (software)
SPMA	São Paulo Metropolitan Area
TAR	Third Assessment Report
TP	Temporal patterns
TPT	Total Probability Theorem
UK	United Kingdom
UNDP	United Nations Development Programme
UNISDR	United Nations International Strategy for Disaster Reduction
UNESCO	United Nations Education Scientific and Cultural Organisation
URBS	Unified River Basin Simulator
US\$	United States Dollar
VDC	Village development committee
WMO	World Meteorological Organisation
ZST	Zambezi Safari Travels

LIST OF TABLES

- Table 4-1: Parameters considered for development of the risk analysis
- Table 4-2: Qualitative criteria assigned to the areas susceptible to floods
- Table 4-3: The qualitative criteria assigned to intervals of leptospirosis and flood values
- Table 4-4: Criteria considered in qualitative analysis
- Table 5-1: Historical water level recordings of the diversion channel stations
- Table 5-2: The riverbed slope of each river reach of the Tanshui River system in different years
- Table 5-3: Comparison between different physical model experiments results.
- Table 5-4: Scenario settings for systematic sensitivity analysis.
- Table 6-1: Percentage of responses by household composition against census data
- Table 6-2: Percentage of responses by gender, age, education, and household income
- Table 6-3: Percentage of responses reported to have no flood insurance by study area
- Table 6-4: Percentage of responses by perceived flood risk
- Table 6-5: Percentage of responses to statements about attitude towards flood insurance
- Table 6-6: Binary logistic model for non-insurance
- Table 8-1: Population size, number of households and sample size for each of the study villages and their associated localities.
- Table 8-2: Determinants and indicators of access to capital in all the study villages
- Table 8-3: Number and type of livestock abandoned in some affected settlements
- Table 9-1: Respondents' age groups

LIST OF FIGURES

- Figure 2-1: Schematic diagram of the adopted MCST methodology.
- Figure 2-2: Selected 86 pluviograph stations and seven study catchments in NSW, Australia.
- Figure 2-3: Derived flood frequency curve (DFFC) for the Orara River catchment in NSW, Australia.
- Figure 3-1: Location map. The light shaded area corresponds to the northeast region of the Province of Buenos Aires.
- Figure 3-2: Geologic and topographic outline of the area around La Plata, showing the coastal plain features. Note the width of the coastal plain that has been occasionally affected by extreme surges.
- Figure 3-3: Synoptic weather chart of the severe storm surge event of 15th April 1940 (modified from Balay, 1961).
- Figure 3-4: The storm of 21st March 2001 striking the seawall and coastal road at Punta Lara, the coastal zone of La Plata (Photo courtesy of El Dia newspaper, La Plata).
- Figure 3-5: Two photographs of the 2nd April 2013 flood in La Plata.
- Figure 4-1: Cases of leptospirosis after flooding.
- Figure 4-2: Analysis of themes (schematic flow).
- Figure 4-3: Estimation of areas susceptible to contracting leptospirosis in the SPMA.
- Figure 5-1: The location of the Taipei metropolitan area and the Tanshui River system
- Figure 5-2: The Tanshui River in northern Taiwan, its three main tributaries of Dahan Creek, Hsindian Creek and Keelung rivers, and the 32km system of dykes and levees
- Figure 5-3: The dykes of the Taipei Flood Prevention System constructed along the Tanshui River system. The red, green, blue and yellow lines represent the first phase of the original prevention project, and the first, second, third phases of the modified prevention project, respectively.
- Figure 5-4: Aerial photo of the inlet of Erchung Floodway.
- Figure 5-5: Annual differences in riverbed elevation in different river reaches of the Tanshui River system.
- Figure 5-6: Spatial variations of sediment deposition/ erosion between the years 1969 and 1981.

- Figure 5-7: Spatial variations of sediment deposition/ erosion between the years 1982 and 1989.
- Figure 5-8: Spatial variations of sediment deposition/ erosion between the years 1990 and 2012
- Figure 5-9: The physical model photo of the Tanshui River network system
- Figure 5-10: Map showing current vulnerabilities of the Taipei Flood Prevention System in the left bank of Shihtzutou, the right bank of Shezi , and the left bank of Wugu.
- Figure 5-11: The relationship between roughness of the Erchung Floodway, the Q200-Erchung Floodway, and water stage at T024A (the Taipei Bridge).
- Figure 5-12: The relationship between the Q₂₀₀-Erchung Floodway and different sectional riverbed roughness of the Erchung Floodway
- Figure 5-13: The relationship between roughness of the Tanshui River (Taipei Bridge section), the Q200-Erchung Floodway, and water stage at T024A.
- Figure 5-14: Figure 14: The relationship between water stage at T000 (river mouth), water stage at T024 and the Q200-Erchung Floodway.
- Figure 7-1: Okavango Delta map showing riparian communities exposed to flood situations.
- Figure 8-1: The Okavango Delta and the study villages.
- Figure 8-2: Variations in annual inflow into the Okavango Delta for the period 1933-2010. Source: Department of Water Affairs and HOORC (2010).
- Figure 8-3: Variations in access to capital in the study villages.
- Figure 8-4: Proportion of households by types of livelihood activities in the study villages.
- Figure 8-5: Proportion of households variously affected by extreme flooding in 2009 in all the study villages.
- Figure 8-6: Household coping strategies in the study villages.
- Figure 8-7: Types of non-agricultural skills possessed by households in the study villages.
- Figure 9-1: Trust Determination Model (adapted from Lundgren & McMakin, 2004; Slovic, 1999; Fessenden-Raden, Fitchen, & Heath, 1987)
- Figure 9-2: Map showing study area in Ngamiland District Botswana.
- Figure 10-2: Temporal variations in (a) catch rates, (b) mean length, (c) diversity, and (d) biomass at the three sampling stations from the Boteti River between October and February.
- Figure 10-3: (a) Temporal variations in the feeding rates (numbers/fish) behaviour of *B. lateralis* and frequency of occurrence of empty stomachs, (b) Temporal variations in the feeding rate of *B. lateralis* using weight of food items/fish.
- Figure 10-4: Temporal variations in the diversity of food items for *B. lateralis*.
- Figure 10-5: (a) Temporal variations in the feeding rates (numbers/ fish) behaviour of *S. intermedius* and frequency of occurrence of empty stomachs over time, (b) Temporal variations in the feeding rate of *S. intermedius* using weight of food items/ fish.
- Figure 10-6: Temporal variations in the diversity of food items for *S. intermedius*