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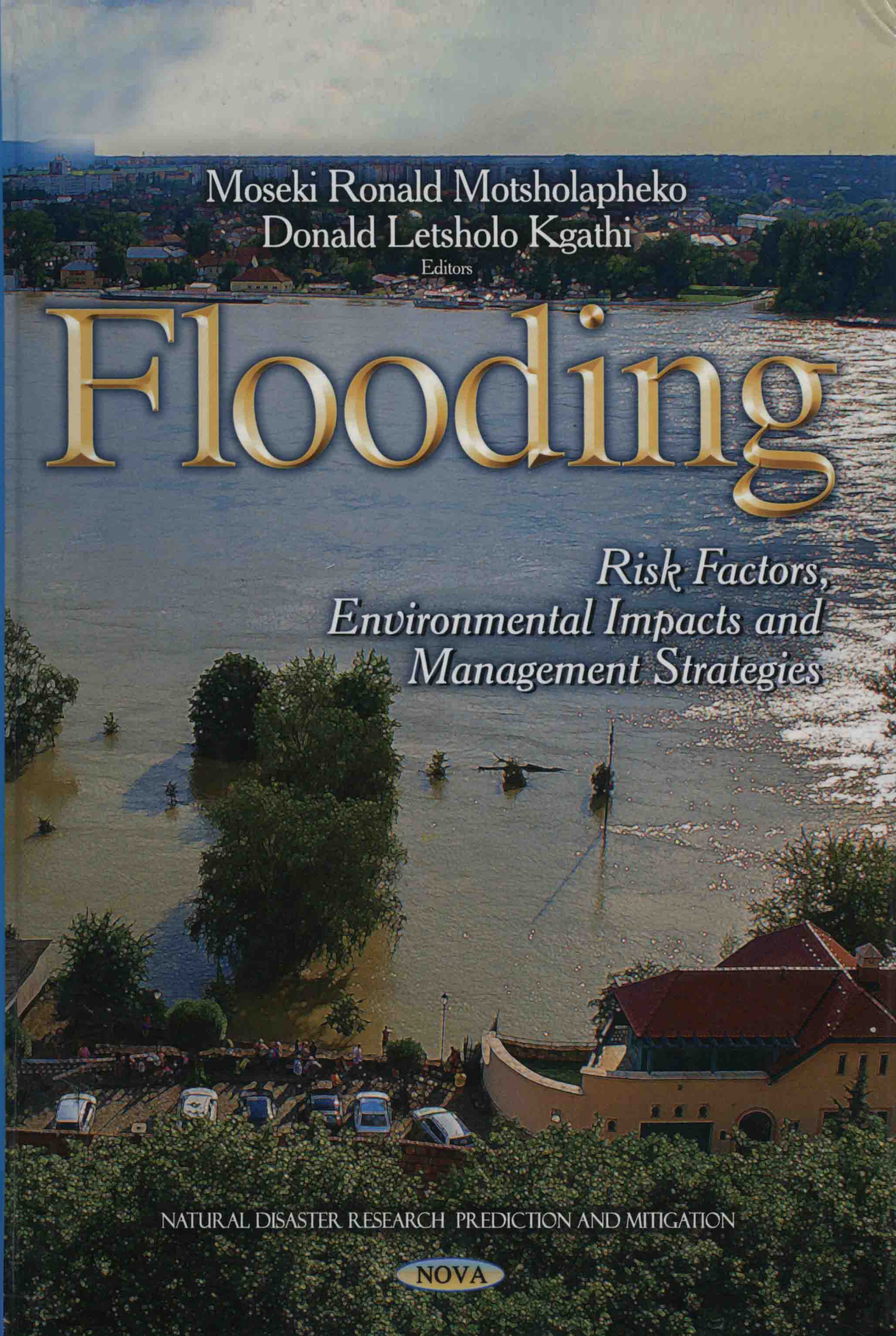
Editors

Flooding

Risk Factors, Environmental Impacts and Management Strategies



NATURAL DISASTER RESEARCH PREDICTION AND MITIGATION

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RISK FACTORS, ENVIRONMENTAL IMPACTS AND MANAGEMENT STRATEGIES

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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 coversion 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 m^3/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 Q_{200} 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 Q_{200} 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 communitors 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

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