CLIMATE CHANGE AND DISASTER IMPACT REDUCTION

Edited by
KOMAL RAJ ARYAL
ZAINA GADEMA

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Foreword

It is with a definite sense of pride that I register another first for the School of Applied Sciences - Komal Raj Aryal and Zaina Gadema's edited volume of the UK- South Asia seminar held in Kathmandu in June 2008.

The event itself focused on young scientists and practitioners, providing a forum to share knowledge, good practice and experiences of building pre and post disaster planning capacity, with a specific reference to climate change. A forum, which I hope will develop further to provide and promote a lifelong collaboration in the exchange of ideas to reduce vulnerability and increase resilience to disasters. Central to this work is the collaboration between academics and "blue light" service personnel who work at the front line of disasters; and I am particularly grateful for the continued support and collaboration of Tyne and Wear Fire Service and the Nepalese Police and Fire Services. I very much hope these relationships are strengthened further in the future, particularly as we widen out our partnerships to other services both in the UK and abroad.

What pleases me most about this publication is the quality of the papers produced, which reflect the high quality of presentations made at the event. I can only applaud your maturity and insight in both written and spoken performance. I would like to thank Professor Phil O'Keefe and Dr Sam Jones for serving as the secretariat at the meeting itself and for providing the support to Komal and Zaina in the production of this volume. Final thanks go to the sponsors of the original meeting, namely DelPHE programme of British Council, DFID and ProVention Consortium. I would also like to pay particular thanks to our hosts: the Ministry of Local Development; Dhankuta Municipality Risk and Resilience Committee; and the Disaster Management and Sustainable Development Centre, Kathmandu University.

With such a significant output from the first meeting, and with the continued involvement of our sponsors and hosts, I very much look forward to the next meeting, which has much to live up to after such an effective and high quality start.

Professor Julie Mennell
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Acknowledgements

Our personal thanks to all the contributors to this volume, who willingly shared their research experiences and participated UK-South Asia Young Scientists and Practitioners Seminar on Climate Change and Disaster Impact Reduction at Kathmandu, Nepal on 05-06 June, 2008.This book is based on the papers presented in the seminar. We gratefully acknowledge the support of International Networking for Young Scientists (INYS) and Development Partnerships in Higher Education (DelPHE) programmes of the British Council and Department for International Development (DfID), UK. Our special thanks go to Oliver Flude, Louise Joyce, Archana Sharma and Smreety Dewan.

Thanks to Professor Phil O'Keefe and Dr. Samantha Jones for their suggestions and comments in helping to structure this volume.

Thanks go to Dr. Andrew Collins, Director, Disaster and Development Centre, Northumbria University, Mr. Pratap Kumar Pathak, acting secretary, Prime Minister's Office, Government of Nepal, Mahndra Khamyahang, Nushraj Shrestha and Bidur KC.

Finally on the behalf of all participants of Kathmandu event we express our special thanks to Ms. Margaret Arnold and Professor Julie Mennell for their participation and valuable remarks at Kathmandu event.

Komal Raj Aryal, Zaina Gadema,
Christmas, 2008 Newcastle, UK

Executive Summary

Recent climate predictions suggest a five degree increase in temperature by 2080, that 50 million people may be at risk of hunger by 2020, that millions of people in South, South East and East Asia will be flooded, and that there will be an increased toll on countries already with high burdens of poverty and infectious disease[1]. Whilst precise predictions on the impact of climate change are far from secure, varied scenarios consistently indicate that temperatures will rise, and that climatic events will become more variable and extreme over much of South Asia. Little research yet specifies the extent to which the development of coping, adaptation and resilience will offset the potential impacts of climate on environment, people and institutions. The issues associated with climate and disasters are complex in that they engage changing hazards, vulnerabilities and security contexts. Specifically, we know that poverty, marginalisation, environmental change (social, economic, and physical), and conflict comprise humanitarian emergencies. Reversing negative trends in this field therefore requires the knowledge and perspectives of a wide range of specialist and lay persons. Disaster impact reduction becomes by necessity an integrated approach and people centred. It seeks to promote wealth and wellbeing, inclusion and reduced vulnerability, manageable environmental change, and conflict mitigation. Some of the challenges are to reduce the uncertainties in risk assessments and identify implementable solutions at the local level, with regard to systems of governance that best facilitate these processes.

This event focused on the link between climate change and disaster impact reduction. It was opened by a high level representation from the Government of Nepal, international development organisations and university leaders. Its purpose was achieved; to consider local and regional perspectives on the climate threat, share and stimulate ideas about how people are reducing climate associated risks, and further engage networks that can contribute towards a more sustainable future. Presentation contributions were made from more than ten countries. The seminar engaged with theoretical, methodological and policy aspects of the subject area based on original research and reviews. There was a genuine sense that presentations were made to a very high standard with a stimulating level of varied and context specific detail.

We engaged with a particularly strong set of examples from South Asia, from the mountain environments of Nepal to the deltas of Bangladesh. Presentations and discussion took place on physical hazards ranging from varied types of flood, landslide, fire and drought. These were addressed alongside analysis of vulnerability, risk and resilience. There have been models of good practice for disaster mitigation from community based protection strategies to institutional responses in the mode of emergency management. Education has emerged as crucial, both formally and

[1] IPCC (2007) Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva: WMO and UNEP.

informally. The importance for universities to engage in research, teaching and learning activities in the climate and disasters field was further demonstrated by this occasion. However, education is for all and extends into the communities, schools and other institutions. Particularly good examples of progress in this respect were presented from Turkey, Japan and Bangladesh.

We frequently noted how climate and disaster impact reduction issues are both global and local, demonstrated also by presentation showing recent flooding events in the United Kingdom. Making distinctions between notions of developed and developing worlds in this respect are not always useful. The threats identified are interrelated both in terms of global climate, economies and political forces. We are all in this together. Furthermore, on a distinctly positive note, we witnessed how the research agenda for both new and established scholars has become and can become further internationalised. We noted the particular strength of contributions combining environmental and social perspectives, in many instances drawing in much wider disciplinary influences. We exposed evidence that climate change and disaster reduction is well on the agenda of the academic community in this region and elsewhere. It is also on the agenda of NGOs, practitioners and Government. However we have seen how we are still in the early parts of a long road ahead not only in terms of there being the political will, but also in terms of building sufficient knowledge and capacity, essentially both specialised and accessible.

There is a need to further understand the full nature of hazard, and the characteristics of resilience that reduces climate change impact. There are many ongoing questions, some of which were posited at the start of this event but which became clearer alongside the case studies provided. How can we better invest in research that will enable a wide variety of concerned groups and civil society to risk assess more fully and to manage risk effectively? What are appropriate forms of governance at local and wider levels that allows this agenda to be appropriately supported?

We know that climate change is not all in this agenda. In many instances a reduction of poverty and marginalisation would reduce climate impact significantly. We know that appropriate preparedness and response systems can prevent major environmental events becoming a disaster. Linking to real world situations, full on and applied, we can make a difference rather than accepting a fatalistic view of what is now inevitable increases in temperature and unpredictability in local and region climate systems. Some of the students contributing to this event and more established academics were associated with the Universities organising the event. Others came from beyond. It has been particularly encouraging to note that a community of new scholars is strengthening in this field. This in itself spells significant hope for the future.

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Contents

Introduction

Komal Raj Aryal and Zaina Gadema

It is with great pleasure to produce this edited proceeding of 'Climate Change and Disaster Impact' which emerged from UK- South Asia young scientists' seminar in Nepal in June 2008.

Three dominant themes link the papers. The first is an emphasis on mapping natural hazard changes as they impact both on natural systems and social systems. The second theme is one of building improved pre-disaster planning capacity by building national and local resilience. The final theme is the role of knowledge and education, including the importance of understanding the role of indigenous knowledge to disaster risk reduction.

Geoff O'Brien and Phil O'Keefe explored the links between climate variability, energy analysis and disaster management. Accelerated climate change and increasing climate variability is the single largest threat to the international goals of sustainable development, the Millennium Development Goals (MDGs) and disaster risk reduction. Global discourses recognise the need for effective and sustainable responses tso produced climate risks. The risk types likely to occur are known, but only in broad terms - their scale, severity, longevity and frequency are not known. The challenge for policymakers is developing an effective framework within which sustainable responses can be formulated. To address the problems of produced risks a comprehensive approach to risk management is necessary. The mechanisms within the climate change, sustainable development and disaster risk reduction discourses are not sufficiently effective or integrated to respond to this challenge. Fundamental reform to current modes of risk reduction is needed, but this can only be achieved through a shift in the dominant perspective on formulating sustainable responses. This requires a shift to an enabling policy framework that encourages bottom-up resilient responses.

Resilience is argued as a tool for policy development that can enhance adaptive capacity to current climate risks and shape energy policy to respond to mitigate future climate risks.

Zaina Gadema explored the link between pesticide use and climate change in Nepal. The pesticide usage scenario in Nepal is typically characterised by highly toxic, inexpensive and generic formulations that frequently do not meet internationally agreed standards. Many are neurotoxic, carcinogenic, tetragenic in nature, and/or are suspected endocrine disruptors. Rice is a valuable cash crop, the principal staple food and major source of nutrition in the Nepalese diet. Increasingly, agricultural intensification under climate change associated with generic pesticides (often viewed by farmers as a panacea to farming difficulty) is shaping and driving food production of primary food staples, essential for food and livelihood security. In the context of chronic exposure, widespread pesticide use is of significant concern as adverse health consequences through cumulative consumption of contaminated food is likely to jeopardise long-term health of the Nepalese population. Additionally, an extensive review of literature revealed a distinct paucity of peer-review literature specifically quantifying and evaluating pesticide residues in rice from Nepal.

Rationale for this study stemmed from the need to ascertain pesticide usage in food production to assess chronic health exposure in Nepal. Samples of rice were sourced from intensively farmed regions, supplying much of the urban population of Kathmandu and surrounding areas with agricultural produce, extracted and analysed

using liquid solvent extraction (LSE) and gas chromatography mass spectrometry (GC/MS) techniques. Residue concentrations and health hazard risks were quantified and evaluated in terms of chronic exposure using admissible daily intakes (ADIs) and maximum residue levels (MRLs) stipulated by the Food and Agriculture Organisation (FAO) and World Health Organisation (WHO).

Pesticide residues were detected in all locations. Additionally, 13 pesticides were identified, including 2 classified by WHO as extremely hazardous, being Methyl Parathion and Aldrin, both of which are persistent organic pollutants (POPs) and exhibit major health implications even at low levels of exposure. 91% of detected pesticides are classified by WHO as moderately hazardous or above although, 92% of contaminated residues occur below ADIs and 73% of residue concentrations occur below MRLs. However, the pesticides detected have varied toxicological effects to human health through chronic exposure.

Parveen Kumar Chhetri focused on tree analysis to interpret climate change in central Nepal. Anthropogenic climate change is increasingly linked with the rapid increase in overall global temperatures over the last five decades which are in turn, directly attributed to a continual growth in the amount and concentration of greenhouse gases, such as CO2. However, lack of long-term climatic data for local and regional areas can present a major stumbling block in studying climate change. Dendrochronology is a valuable tool with which to study climatic change, as it provides long-term climatic pattern indices. To determine climatic variation patterns, this study involved using 120 tree cores from 60 trees of Abies spectablies from two different sites, Chandanbari and Cholangpati areas, of Langtang National Park. To ascertain the extent to which climate change issues were understood and perceived in the local area, local people were interviewed.

Analyses of increment cores from both sites showed that the trees in questionranged from 100-300 years old. Trees from the Chandanbari site were found to be older than in Cholangpati. The mean tree ring width of Chandanbari was 2.34mm and that of Cholangpati site was 1.70mm. This illustrated that growth rate was highest (2.34mm/yr) at the Chandanbari and lowest (1.70mm/yr) at the Cholangpati site. Series inter-correlation and mean sensitivity were recorded at 0.457 and 0.223 respectively for Chandanbari, and 0.499 and 0.203 respectively for the second site, Cholangpati. The high mean sensitivity value indicated that high inter-annual variability was present in the ring widths and that chronological data was sensitive to yearly environmental changes so that the Abiesspecies was suitable for response analysis. Response analysis for the tree-ring parameter,together with recorded data of climatic change, showed that the ring width was negatively correlated with May minimum monthly temperatures and positively correlated with March and June total monthly precipitation rates.

Interviews revealed that people perceived significant changes in weather patterns, particularly in the form of lower snow fall rates, irregular rainfall patterns, intense rainfall events, the upward shifting of snow lines, decline in productivity of rangelands and early blossoming of rhododendron species over the last decade. This study recommends further studies to be undertaken across more sites and tree species, with greater numbers of samples to enable the reconstruction and formation of climate scenarios using regional climatic data covering longer time periods.

Laura Barba Villaesusa addressed the issue of pre-disaster planning and response in fire management in Spain. Forest fires in Spain are a recurring problem. Every year, forest fires cumulatively cause significant economic, environmental, material, health and mortality costs. Traditionally wildfire plans in Spain have been focused on the response phase. Government funding has been aimed mainly at institutional resilience.

Social prevention and rehabilitation have largely been neglected. As a result, the number of forest fires has risen sharply in the last two decades. In Spain it is imperative that a more holistic approach to the problem of forest fires is adopted to increase resilience. This article focuses on Spanish efforts to fight forest fires and new approaches adopted that aim to make the country more resilient. Spain's resilience and efficacy in dealing with forest fires depends largely on whether modern approaches consider social and physical factors of implementation and whether national policies are sufficiently developed to cope with coordinating and incorporating a combination of factors for integrated fire risk management, via research, prevention, response and restoration.

Nihan Erdogan took the issue of resilience further addressing building capacity in local government. Turkey's complex topography and geographical location makes it prone to many types of geophysical hazard and when these occur in or near areas where people live or rely upon for food and livelihood security, particularly prone to disaster. Weather related disasters are thus high risk with the potential to adversely affect the country at local, regional and national levels. Disasters can cause high mortality rates and substantial economic loss. Various studies have been undertaken to learn more about climate change and its effects in Turkey. Studies indicate the potential for imminent and significant changes in precipitation and climatic temperature patterns. These findings and the Turkish Government's recognition for the need to mitigate adverse impacts of climate change have led to the formation of the First National Communication on Climate Change. Many other actions have taken place in line with the European Union. Numerous stakeholders are now involved in working in the sphere of climate change. Climate change as a stand-alone subject is now also often delivered to students in schools as the educational context is becoming more prominent. This study gives an overview of Turkey's hazard profile and how climate change is perceived. It also informs us how Turkey deals with climate change within the framework of education, how information is delivered to students and of preventative actions championed by the implemented training programmes in question. This paper concludes by outlining the strengths and weaknesses of current training programmes with a discussion of how these can be improved for the future.

Hideyuki Shiroshita provides an international comparison of two very different approaches to disaster education at school level. His paper outlines two distinct approaches to disaster education, namely independent and holistic. It uses examples of disaster education in Japan and the United Kingdom. Based on these examples and in light of the likely increase in the risk of hazard events associated with climate change, the paper explores how two very different approaches might be applied to pre-disaster planning and the mitigation of disasters.

Numerous internal and external factors drive climate change. Global warming, in the context of 'natural', ongoing environmental change, independent of human activity is considered as an internal factor. In contrast, accelerated global warming resulting from, for instance, industrialisation that leads to increased levels of greenhouse gases emissions (GHGs),is considered as an external contributory factor. Relationships between internal and external factors are not always transparent, especially at the local scale. It also remains difficult to project impacts resulting from climate change, although recently, the Fourth Assessment Report of the IPCC suggests that an increase in severe climatic events around the world, especially, the frequency of heavy precipitation events is likely.

There are significant differences between the causal mechanisms of climate change and natural hazards. Anthropogenic mechanisms triggering accelerated global warming can arguably be mitigated. Conversely, many natural hazards cannot be easily mitigated, nor is an increase in natural disasters necessarily attributable to peoples' activities. In the global sense, climate change is more open to effective pre-disaster planning than other environmental hazard risks.

Animesh Kumar Gain and Mozzamel Hoque and Martin J. Booij examine flood risk in Bangladesh. In Bangladesh, flooding has a serious detrimental impact upon livelihood and food security for millions of people. Adverse impacts of climate change in Bangladesh have already been witnessed with the increase of severe climatic events, particularly flooding. The geographical and topographical nature of Bangladesh means that much of the land is at or below sea level. Rising temperatures and sea levels are of major concern, particularly as rapid changes in climate heavily influence weather patterns with the potential to cause catastrophic consequences as a result of increased flooding. Furthermore, Dhaka, the capital city of Bangladesh is surrounded by a network of rivers which makes the city vulnerable to flooding.

In this study, a flood hazard map using Geographic Information System (GIS) and a hydrodynamic model, HEC-RAS of the Balu-Tongi Khal River system, which lies in the eastern part of Dhaka City (that has no protection barriers against flood) has been developed over a 100-year period. A risk map of 100-year flood episodes is presented which outlines a range of potential risks of the study area in the context of economic loss. In comparison to classical inundation maps, the risk map developed as a result of

this study generates more information about flooding events because it brings into account economic impacts of flooding.

The map is a useful reference tool when considering policy alternatives to minimise loss of property brought about as a direct consequence of floods in the study area.

P. K. Joshi explores building Geographical Information Systems to be deployed in preparedness planning. Spatial and temporal variabilities of climate and anthropogenic pressures on natural ecosystems are complicated processes. Nevertheless, it is essential to consider a holistic range of impacts generated by these different processes on the structure and function of ecosystems. Therefore, there is a real need to develop baseline information for biosphere and atmosphere dynamics in order to facilitate greater capability to forecast feedback loops in the context of land use and land coverage change (LULCC) (habitat fragmentation and invasion, species loss, biogeochemical processes and so forth). A range of geospatial techniques for database creation, including remote sensing, geographic information systems (GIS) and grid and pervasive computing (GPC) can be used upon which socio-economic, phyto-sociological data and modelling techniques can also be incorporated to provide more comprehensive insights into often, complex and overlapping issues.

By taking this broad technological approach, alternative approaches both to mitigate and adapt to changes in LULCC can be made. This paper discusses India's national initiatives that are in place for mapping and characterising differences(at the landscape level) in biodiversity across the country. The database generated from this study demonstrates the potential and limits of a range of tools available to assess landscape ecology. The study illustrates the extent to which these tools enable integration of ancillary information (for example, social inventory and climate data) for databases as well as modelling techniques. It also shows the synergistic nature of these tools in the context of information collation and how they can be utilised to predict and assess ecological trends and impacts of climate change, especially with respect to anthropogenic pressure on biological richness. The work is summarised in the form of a Biodiversity Information System (BIS);an interactive Web GIS platform for information dissemination, communication and collation that derives information from a diverse range of sources.

Robert Bell, Joseph McFarland, Laura Pole and Matt Innerd have a similar focus on building vulnerability analysis for pre-disaster planning. Natural disasters in the United Kingdom (UK) are rare events. However, over the past ten years the number of emergencies caused by environmental hazards has increased, the worst of which have resulted in significant long-term effects on communities. The UK has well established and resourced response arrangements to manage these emergencies but current capabilities are no longer sufficient to deal with the impacts of large-scale events. The changing climate will affect an increasing proportion of the UK population as the frequency and severity of environmental related incidents rise. There is need to develop better individual and community resilience to changing environmental conditions. Providing comprehensive understanding of the nature of individual and community vulnerability will enable planning and preparation to be accurately targeted to achieve more robust resilience.

Alonso Brenes introduced the work of La Red and talked of building hazard trajectory that could be used by actors and institutions to strengthen pre-disaster planning. He emphasised the research tradition of La Red but also the importance of the exchange of experience and implementation of building resilience capacity across Latin American and the Caribbean. He particularly emphasised the diversity of studies available

One major focus was changes in El Nino. Trying to understand changes over time and developing new methods to measure those changes requires a strong technical applied science. As the limits of the El Nino movement are defined multiple adaptational alternatives can be explored.

Dinanath Bhandari explored the relationship between global climate change and local response. Communities in Nepal are vulnerable to climate-induced hazards such as landslides, floods and unusual rainfall. These hazards impact adversely on the livelihoods and assets upon which poor people depend. This paper discusses how the impacts of climate change are affecting the lives and livelihoods of people living in the mid-hills and Terai of Nepal and how people are reacting to these adversities. Practical

field experience has identified several strategies that increase resilience to these impacts and may be suitable for wider replication.

Information collected through personal interviews, group discussions, field observations and reviews of relevant literature show that the impacts of meteorological events are real and adverse. Erratic patterns of rainfall, increasing frequency of hailstorms, dry storms and prolonged drought are symptomatic of climate change. Poor ecosystem health, due to excessive exploitation of natural resources, has increased the impact of climatic variability. Weather-related disastrous events have noticeably increased in frequency and intensity in recent years.

Communities have traditionally adopted different strategies to cope with the impact of hazards but their success and future sustainability is uncertain. Our study concludes that awareness plays a crucial role in building the confidence and capacity of communities to adopt appropriate strategies that allow them to adapt to the impacts of changing climatic conditions. Appropriate management of natural resources strengthens the resilience and adaptive capacity of ecosystems. Diversification of options for income generation and alternative livelihood opportunities helps families to become more resilient. Institutional and external support is necessary for long-term sustainability of adaptation measures.

Mihir Joshi explored the development of adaptive technologies in dealing with habitat in India. In August 2006, unprecedented heavy rains flooded several villages of the otherwise drought stricken Barmer District of the desert state of Rajasthan in western India. Over one hundred hours of continuous rain inundated several villages in up to thirty feet of water. Such rains and floods had never been witnessed in this region in over 200 years of recorded history. The local communities and administrative systems were not prepared for such an emergency situation. The floods took a toll of 139 lives while almost 50,000 people lost their homes. The impact of this damage was particularly severe because houses in this region are normally built in depressions between sand dunes to protect from sandstorms rather than flood. These low-lying pockets were flooded worst and due to the impervious sub-soils, water flow was restricted and stagnated for weeks. Because the region is sparsely populated and has little in terms of infrastructural facilities, lack of access to services for Barmer residents constrains relief, recovery and rehabilitation phases of the disaster cycle.

SEEDS, a national NGO, immediately visited affected areas and carried out a damage assessment along with a study of the local natural and built environment. The team found that traditional construction practices in the area were based on mud walls and thatched roofs, with circular shelter designs. Materials for house construction were created with the minimum of ecological and carbon footprints. Houses were thermally comfortable and conducive to extreme weather conditions prevalent in the area. The circular design protects structures from strong winds and earthquakes, whilst construction processes are simple and suited to local skills.

It was also realised that though traditional practices were appropriate, the mud structures did have certain shortfalls in water resistance capacity due to which many houses had suffered severe damage during the floods. While traditional wisdom had provided a very high level of performance for generations, support of technological interventions were needed to help face the challenges posed by unprecedented disasters linked with climate change.

Research was carried out on appropriate technologies for supporting traditional construction systems, which led to the Stabilised Compressed Earth Block (SCEB) technology, wherein local mud was stabilised with five percent cement, and compressed into blocks that had high structural strength and water resistant capability. Blocks were designed to be of an interlocking design so that construction was easy for the local population and provided additional strength to resist earthquakes that are a distinct possibility in the region.

Andrea Santos provided a Latin American example of mapping vulnerability analysis in Brazil. Impacts of climate change vary across regions and communities. In general, these are more severe in regions that show high vulnerability on account of a number of factors including social and climatic vulnerabilities. Droughts and desertification processes reduce the

availability of water, which adversely affects agricultural practice and probably reduces the quality of lives of populations in semi-arid regions.

This work presents an evaluation of social and environmental vulnerabilities in six semi-arid districts of Bahia, Brazil. The methodology was developed from the assessment of scenarios from the Intergovernmental Panel on Climate Change (IPCC) and forecasts of the Instituto Nacional de Pesquisas Espaciais (INPE) for regions of Brazil.

The aim was to identify climatic, socioeconomic and environmental indicators to assess social vulnerabilities in the studied districts. Subsequently, a socio and environmental vulnerability index for each respective municipality was developed. As a result, it was possible to identify which municipalities in the semi-arid region of Bahia, Brazil are more prone to social vulnerability in the face of climate change.

Fuad Mallick explored the issues of linking disaster education to development in developing countries. Changes in climate have occurred throughout the history. Climate change is not new. What is alarming is the increased rate of change over a relatively short period of time. Governments and organisations over the last few years have increasingly insisted that climate change is an issue that requires urgent attention. Global temperatures are on the rise as the natural rate of change is compounded by human activity (UNFCCC 2007). Melting ice caps and retreating glaciers have caused further eustatic effects and at the current rate of change, there is risk of permanent inundation across many low lying areas, particularly, those defined as small island developing states. Consequences of climate change coupled with increased global temperatures are likely to have a greater adverse impact on the poorest nations. Lack of awareness, poor technology capability and transfer from Northern countries and vulnerability resulting from poverty and exposure to disasters are just some of the contributory factors that put least developed countries (LDCs) at risk an make them more vulnerable. One seemingly indirect but important factor that makes populations in LDCs vulnerable is the lack of education, particularly, in the context of issues arising as a direct and/or indirect consequence of climate change. This paper highlights the importance of equitable, accessible and relevant education within developing countries as it is argued that education is a fundamental and essential component in dealing with anthropogenically influenced climate change, from local to global scales.

Binod Shrestha focused on the problem of glacial lake overflows. The Himalayas in Nepal extends to 800kms. Within this region lie a number of lakes and tanks of glacial and tectonic origin. Researchers are predicting that the Earth's temperature will increases by 2.3 to 5.6°C this century. A number of geologists believe that glacial melting due to climate change will unleash pent-up pressures in the Earth's crust, causing extreme geological events such as earthquakes, tsunamis and volcanic eruptions. Nepal lies in a very high seismic region and its history is already full of devastating earthquakes. Climate change multiplies the frequency and magnitude of earthquakes occurrence. Increases in temperature simultaneously increases the melting of ice that amplifies lake enlargement and landslides that ultimately cause greater numbers of Glacial Lake Outburst Floods (GLOF) and ice avalanches. Traditionally, essential infrastructure, principally dams and reservoirs were built without assessing climate change and its consequences. However, in Nepal, tremendous efforts have recently been initiated to reduce earthquake risk.

Such efforts concern mitigation and preparedness. Assessment of earthquake hazard and risks form the basis of planning and implementation of earthquake risk management initiatives. Success of initiatives largely depends upon a thorough understanding of hazard and risk, by stakeholders including communities, the private sector and municipalities. For example, the Municipal Earthquake Risk Management (MERMP) and School Earthquake Safety Program (SESP) are benefiting a great deal from the provision of training courses that were developed and implemented for masons, technicians, contractors, and engineers with joint efforts of many organisations including community representatives. Several Community Based Disaster Management (CBDM) programs are being undertaken in earthquake risk management. Likewise, formal sectors are involved in implementing the Program for Enhancement of Emergence Response (PEER). All these programs, implemented by NSET, in partnership with local institutions have significantly contributed in raising earthquake awareness; enhancing local

capacity and preparing communities to better cope with earthquake emergencies.

The Department of Geography team from Durham University led by **Katie Oven** and **David Petley** explored the relationship between livelihoods and risk in the creation of landscape. The occurrence of fatal landslides in Nepal is increasing with time. Possible explanations for this rising trend include land-use change, population growth and civil war, each of which affects community vulnerability. The impact of climate change on monsoon intensity, which strongly controls landslide occurrence in Nepal is poorly understood, raising questions regarding future vulnerability. To address these issues, the research presented here takes an inter-disciplinary, bottom-up approach and asks: 1. Who is vulnerable to landslides? 2. Why do people occupy landslide prone areas? 3. How is risk perceived and understood? and 4. How do people respond to landslide hazard and risk?

The findings to date highlight the impact of infrastructure projects in rural Nepal. Within the Upper Bhote Koshi Valley a clear transition has been seen over time in the settlement pattern, rural livelihoods and thus the occupation of landslide prone areas. Households were seen to occupy these areas through lack of choice as their fixed assets tied them to a particular location; to take advantage of a roadside location; or through a lack of awareness of the risk associated with slope failure. There was both scientific and supra-natural reasoning attributed as causes of landslide activity, with responses reflecting Burton et al's (1993) behaviour patterns. These include risk denial/rejection; passive acceptance of risk; taking action to reduce further losses; or considering drastic changes in land use or livelihood.

Reflecting upon these findings, we argue that it is necessary to step away from the normative agenda to consider the role of human agency and recognise alternative framings of risk. For the exposed communities themselves these risks are largely concerned with human security, everyday needs and wellbeing. This does not mean we should negate the management of landslide hazards but rather that we should seek interventions which reduce landslide risk whilst meeting the basic needs of the exposed populations.

We are extremely pleased that all authors have responded quickly to ensure a prompt publication. What is striking about the contributions is that while they range over a large series of contrasting case materials, they are united by a common core to build resilience. A striking feature of the presentations themselves was the relative youth of many of the presenters, indicating that institutional capacity is being built within the disaster community that, hopefully, will provide stronger pre-disaster planning and post-disaster response systems.

Climate Change and Variability, Energy and Disaster Management:

Produced Risks without Produced Solutions – Rethinking the Approach

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Introduction

Accelerated climate change and increasing climate variability present very serious global risks that demand an urgent global response (Stern, 2006). The risk types likely to occur are known, but only in broad terms. That they are produced by human action is accepted (IPCC, 2007). But their scale, severity, longevity and frequency are not known. The risks generated by climate change and increasing variability can be termed 'produced unknowns', driven by human actions and, at this juncture, with unknown outcomes.

Produced unknowns are a category of 'wicked problems' where answers are incomplete, contradictory and set against changing requirements (Richey, 2007). There are no direct solutions to the problems of produced unknowns. But there are approaches that can build effective responses to produced unknowns. That shift is to a focus on preparedness which requires recognition of the need for change and a change in mindset and behaviour. It is the nature of the shifts and the principles needed to shape the process that are evaluated in this paper. The threat to global welfare is real and there is recognition within the sustainable development, climate change and risk reduction discourses of their common interest in risk reduction. What is lacking is a unifying conceptual approach. Resilience can be used as a tool for policy development for effective and comprehensive responses to produced unknowns. Resilience is not argued as a paradigm but as a tool or common reference point. Conceptually, resilience can be used to develop a set of principles for building responses to produced unknowns. Adaptation is the starting point for this process.

Conceptualising the Argument

Addressing climate change should be an integral part of sustainable development policies, as should disaster risk reduction. This is not yet the case. However, a common feature of the sustainable development, climate change and disaster risk reduction discourses is doing things differently or

change. Change is advocated as being purposeful and promoting positive outcomes, for example, to the energy system to mitigate climate change and within sustainable development to enhance human well-being. This argues that it is desirable to develop an approach that provides a bridge among disaster management, sustainable human development and climate change mitigation and adaptation. Change can often be disruptive and, in such complex areas, there may be fundamental barriers that do not allow, or militate against, change. Conceptually, resilience best captures the process of purposeful change in challenging circumstances, as at its core resilience expresses the ability to respond to and recover from disruptive challenges. In geography resilience was first addressed with reference to land systems (Blaikie and Brookfield, 1987). The resilience perspective as a response to disruptive challenges or contextual change has emerged as a characteristic of complex and dynamic systems in a number of disciplines including ecology, (Holling, 1973), economics, (Arthur, 1990), sociology (Adger, 2000) and psychology (Bonnano, 2004). Resilience as a concept is increasingly used within the disaster management community as a metaphor both to describe responses of those affected as well as responding systems (Manyena, 2006). A resilient system responds and adjusts in ways that does not harm or jeopardise function. Resilience is not a science, it is a process, using human capacity and ingenuity to mitigate vulnerabilities and reduce risks, both of which are socially constructed. Resilience has its focus on resources and adaptive capacity and acts as a counter, or antidote, to vulnerability (O'Brien et al., 2006).

Though the concept of resilience is articulated in all three discourses, it is defined within the disaster risk reduction discourse. The United Nations International Strategy for Disaster Reduction (UN/ISDR) defines resilience as:-

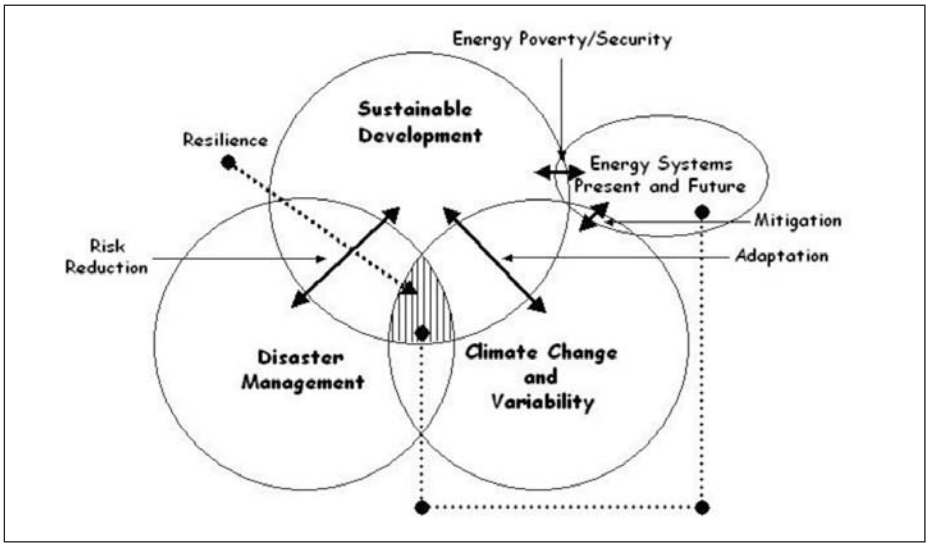

Figure 1. Conceptualising Resilience

The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures(UN/ISDR, 2004, Annex 1).

This definition does not advocate a solution or outcome but a process of learning and change. Conceptually resilience is seen as the overlap between the three discourses as shown in **Figure 1.**

Resilience is not argued as a fixed concept but as process. The shaded area in **Figure 1** can be seen as the resilience 'tool-box' where actors from different discourses are able to draw on the principles established in this submission for policy development. There is also an implicit feedback mechanism. None of the discourses are static and actors can feedback their learning and experiences of what works and why.

Resilience building enhances adaptive capacity through learning that enables positive responses to change; a proactive as opposed to a reactive approach. There is knowledge of this process, but only at a small-scale. Scaling-up is an urgent priority, but local governance structures, in the main, are designed to deliver top-down solutions, not encourage bottom-up engagement. Within the technological context of mitigation, resilience building argues a different

structural approach to energy system development, one that is not wholly source and transmission focused, but has the capacity to adapt to new sources while meeting the objectives of improving energy security and reducing energy poverty. The challenge is not a lack of technological know-how but whether or not there is sufficient political will for purposeful interventions that would shift the focus of energy system development.

Though resilience, conceptually, is being argued within the sustainable development, disaster risk reduction and, more recently, the climate adaptation discourses, there is little evidence of meaningful progress. There is clear need for a policy framework built on developing resilient social responses to cope with future challenges. Resilience, as a bridge building tool between the discourses, requires an enabling framework that encourages bottom-up responses. A focus on building the capacity of people, communities and the systems that support human well-being are needed. What is lacking is a clear, cohesive and comprehensive framework for resilience building. The starting point for analysing this problem is within the sustainable development dialogue and this shows that the pre-dominant approach to sustainable development is governed by economic considerations. Solutions are dominated by technology, often without sufficient recognition of technology as the cause of the problem. This is a weak approach to sustainable development with interpretations dominated by the OECD (Organisation for Economic Cooperation and Development) perspective as shown in **Figure 2**.

(Giddings et al 2002; Hopwood et al 2005). The dominant view OECD has influenced the development of other global dialogues.

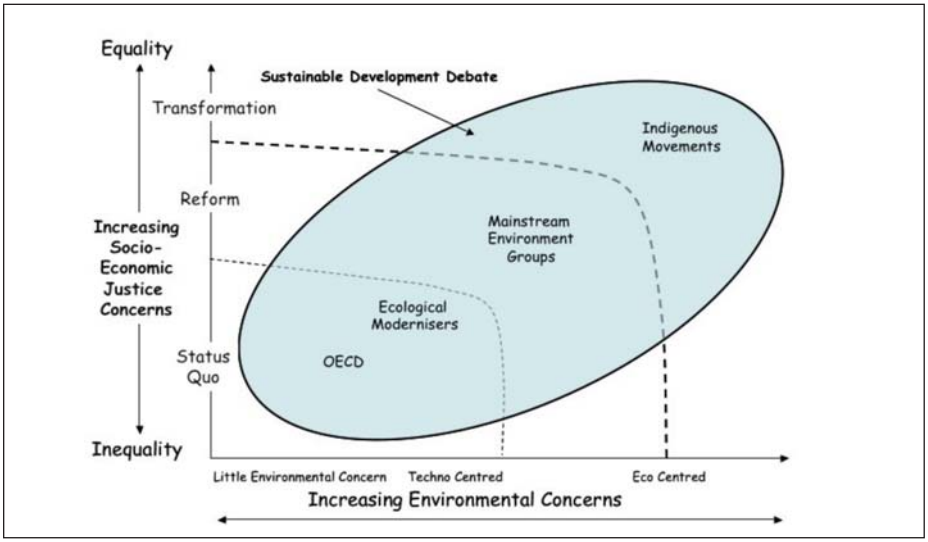

Figure 2. Mapping Sustainable Development

Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) approaches climate risk reduction from two perspectives; first, mitigation or reduction of greenhouse gas emissions to stabilise concentration levels at a safe level; second, adaptation, or adjustment to, climate driven change. Mitigation aims to reduce future climate risk. Adaptation aims to reduce current climate risk. Mitigation as a strategy has dominated the climate debate, whilst adaptation has received, comparatively, less attention. The focus on mitigation is not surprising and, similarly, focuses on technological solutions. The dominant OECD world-view has clearly steered the way in which the Convention addresses the climate problem.

Though TAR did bring about a shift in views of many Convention signatories as shown by arrow 1, the Fourth Assessment Report has brought about a global consensus that a real shift in thinking is needed as shown in arrow 2 (IPCC, 2007). The culmination of this is the Bali Roadmap agreed at COP 13 (Convention of the Parties) (UNFCCC, 2007). This is the first hesitant step to finding a successor to the

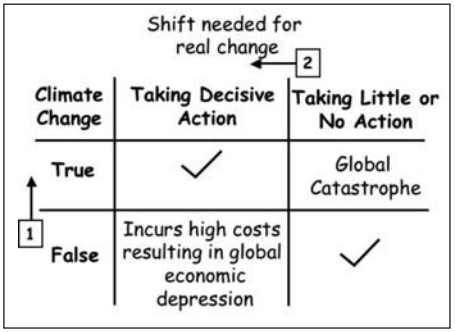

Figure 3. Decision Grid

Kyoto Protocol, but more importantly it signifies a global consensus of the need to fight climate change. The key areas in the Bali Roadmap are recognition that deep cuts in global emissions are needed to avoid dangerous climate change, measures to enhance forests, support for urgent implementation of adaptation measures for poorer nations along with disaster risk reductions measures and consideration of methods for removing obstacles and the provision of financial and other incentives for scaling up the transfer of clean technologies. A more detailed agreement is expected for the 2009 UN summit in Copenhagen.

Learning the Lessons

There are questions surrounding institutional willingness to change that will need answers in the run up to Copenhagen. Using energy as an example it is clear that fundamental reform is needed. The dominant energy model is technically complex and capital intensive and has inherent technical vulnerabilities (Perrow, 1999; Lovins and Lovins, 1982). This is compounded by geopolitical uncertainties of security of supply and more recently to instrumental threats (O'Brien & O'Keefe, 2006).

Renewable resources are diffuse and intermittent and usually have lower energy densities. As opposed to supply on demand, a renewable approach requires "capture-when-available" and "store-until-required" strategies. There are exceptions, such as hydro-electric schemes, but typically renewable systems function best at small-scales near to point of use. They are not focused on a particular fuel type but use indigenous resources (O'Brien et al, 2007). Though a renewable approach is vulnerable to source intermittency, its does not have the same system vulnerabilities associated with the dominant model. For example top-down interconnected electrical systems are vulnerable to cascading faults, a regular occurrence in Europe and North America. Small-scale and distributed systems can be interconnected but the direction is typically horizontal, a structure not prone to cascading faults. Use of indigenous resources minimises geopolitical risks. This implies a very different structure to the current system as shown in **Figure 4.**

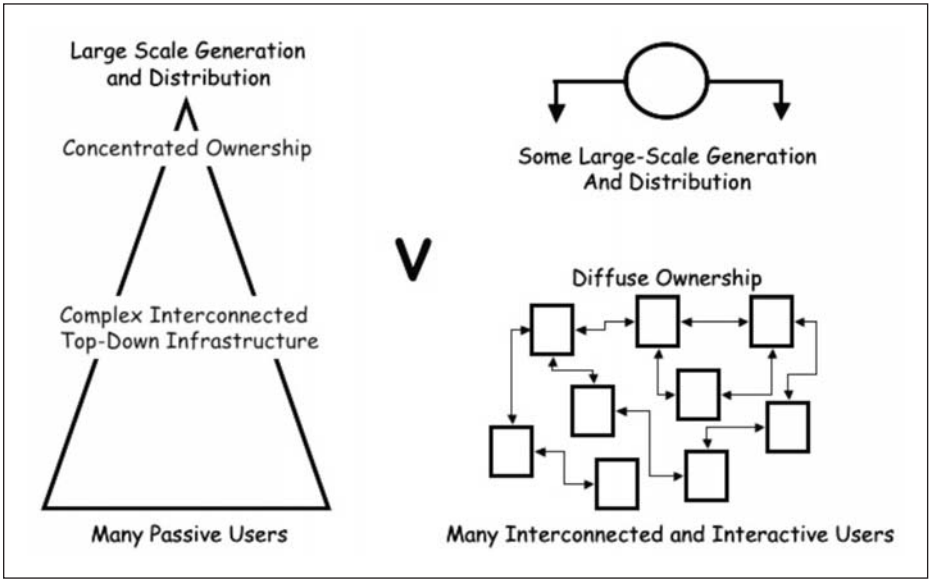

Figure 4. Contrasting Models of Energy System Structure

As Figure 4 suggests, there is considerable opportunity for a mix of scales and there is no suggestion of total abandonment of large-scale systems provided they are appropriate. But what is clear is that technological innovations are driving the development of smaller and more flexible energy technologies and users are increasingly using them driven by fears of the vulnerability of sensitive systems to power failure interruptions or prolonged failure (O'Brien et al, 2007). There are many renewable technologies and new technologies being developed and it is possible that a new energy carrier such as hydrogen will become commonplace. The question however, is what is needed to shift the direction energy system development to a more sustainable basis?

Without a shift in public attitudes towards the environment then technology cannot solve the interrelated problems of energy and climate change (IEA, 2003). Addressing energy system development requires purposeful intervention to guide the development as well as re-connection of the

user with the energy system. Where such interventions have been used the results have been impressive (O'Brien & O'Keefe, 2006). Reconnecting users encourages active participation in tackling the problems we face. This is best realised in a top-down enabling environment that encourages bottom-up innovation. This embeds resilience.

Disaster Management

To respond to current and ongoing risks requires building resilience into adaptation and disaster response and preparedness platforms. The Hyogo Declaration of the United Nations International Strategy for Disaster Reduction (UN/ISDR) recognises the linkages between disaster risk reduction and sustainable development (UN/ISDR 2005). The Hyogo Framework for Action (HFA) posits resilience as a key attribute in building communities able to withstand and cope with adverse events. The starting point for resilience building is vulnerability (Hyogo, 2005).

Within the global discourses of reducing the risk of produced unknowns, resilience building, particularly for poorer and vulnerable communities, is seen as a means of helping them to help themselves. At the core of this discourse is recognition, though not stated, that in the event of multiple simultaneous disaster occurrences, response capacity would be overwhelmed. The international disaster community has called for resilience building along with the establishment of disaster management platforms. The focus of disaster management is risk reduction of all hazard categories; a generic or "all-hazards" approach (Quarantelli, 1992; Sikich, 1993; Alexander, 2005). This generic approach is a feature of disaster management in the developed world and is effectively the dominant model. There is a considerable literature describing this approach to disaster management. It can be characterised as legally based, professionally staffed, well funded and organised. It aims for a return to normality, that is, to re-establish conditions as they were prior to the event (Perry and Peterson 1999; Alexander 2000, 2003; Schaafstal et al 2001; Paton and Jackson 2002; Cassidy 2002; Perry and Lindell 2003). **Table 1** typifies the dominant model. Though resilience and preparedness are embedded within the terminology of the dominant model the reality is that the focus is on institutional resilience and preparedness (O'Brien & Read, 2005). This top-down structure is incompatible with the notion of resilience building. Furthermore, in many cases, it will not be appropriate to promote a return to 'normal' conditions, for example where people are concentrated in unsafe slum areas that are vulnerable to a range of hazards.

Recently the approach in Europe and North America towards disaster management has been skewed towards a securitisation agenda stemming from the September 11th 2001 terrorist attacks and in the USA and the London (2005) and Madrid (2004) bomb attacks (O'Brien & Read, 2005; O'Brien 2006). It is the duty of government to protect the public. But too great an emphasis on one source of threat can divert attention, both of government and the wider public, from other pressing problems. The current focus and emphasis needs to change to reflect the wider agenda of preparedness. It is this aspect of raising awareness, public education and risk communication that is lacking in the way the dominant model as typically practised. In the UK, for example, little has been done in this respect (O'Brien & Read, 2005). In terms of

Table 1. Technocratic Model of Disaster Management

Dominant Paradigm	Comment
Isolated event	Disasters usually regarded as unusual or unique events that can exceed coping capacity
Risk not normal	Risk is socially constructed and risk management aims to reduce risk to within proscribed levels realised through governance structures
Techno-legal	The legislative framework, regulatory system and the technologies used for risk reduction and disaster response
Centralised	Realised through a formal system such as a government department or state funded agency
Low accountability	Typically internalised
Post event planning	Internal procedure for updating and validating plans based on lessons learned
Status Quo restored	The overall aim – a return to normal

Source: Adapted from O'Brien & Read, 2005

the risk management chain an important actor, the public, has been distanced. This is the antithesis of resilience building.

Linking Disaster Management and Adaptation

Effective preparedness is a partnership between government strategies and individual and societal behaviours (Berman and Redlener, 2006). Effective preparedness is the key to resilience building. Essential to effective resilience building is an enabling environment that assigns local communities an active role as agents of change in their own right such as assessing priorities, scrutinizing values, formulating policies and carrying out programmes (Sen, 2005).

Applying this rationale more broadly to disaster policy response to climate change depends on a number of factors, such as institutional and social capacity and willingness to embed climate change risk assessment and management in development strategies. These conditions do not yet exist universally. Reducing vulnerability is a key aspect of reducing climate change risk. To do so requires a new approach to climate change risk and a change in institutional structures and relationships (O'Brien et al, 2006). A focus on development that neglects to enhance governance and resilience as a prerequisite for managing climate change risks will, in all likelihood, do little to reduce vulnerability to those risks.

Where there has been a willingness to re-think responses to disastrous events the results have been positive. For example storms in 1970 and 1991 in Bangladesh resulted in deaths of 500,000 and 138,000 respectively. Following the 1970 disaster, the government along with agencies initiated the Bangladesh Cyclone Preparedness Programme, a bottom-up programme aimed at reducing the vulnerability of communities and resilience building through social learning processes. This strengthened self-help capacities based on indigenous knowledge of vulnerabilities and using participatory methods to develop programmes such as community training in disaster preparedness (Yodmani, 2001). This exhibits willingness at the institutional level to undertake a new approach and to learn from experience. This is institutional learning. Examples of the measure implemented are Early Warning Systems, evacuation procedures and shelter provision. In the 1991 cyclone fatality rates were 3.4 percent in areas with access to cyclone shelters compared to 40 percent in areas without access to shelters. Because of improved preparedness during another strong storm in 1994, three quarters of a million people were safely evacuated and only 127 died (Schultz et al, 2005; Akhand, 2003).

Institutional learning explores how learning takes place in response to changing conditions. There are two forms of learning that are applicable to disaster management; single-loop and double-loop (Argyris and Schon,1996). Single-loop learning or adaptation is the adaptation of new knowledge to existing frameworks of objectives and causal beliefs. In essence, this is learning to do something better. Double-loop learning includes single loop learning but also questions the framework of beliefs, norms and objectives. It is about re-thinking the way things are done.

Single-loop learning is a predominant

Table 2. Characterising Adaptation as Disaster Risk Reduction

Adaptation Paradigm	Comment
Part of development	Adaptation is not an add-on but should be an integral part of societal development
Risk of disaster is an everyday condition	Climate change and variability is a known category of natural hazards amplified and accelerated by anthropogenic activities that will occur
Social capacity	Enhancing the ability of societies to both respond to hazards and adjust to change
Participatory	Learning to enhance capacity
Transparent	Undertaken in an enabling environment
Pre disaster plans	Aimed at prevention
Transformation	Move society to a new set of conditions – enhance coping capacity and improve baseline condition, for example, decrease levels of poverty

Source: Adapted from O'Brien, 2006

characteristic of disaster management within the developed world (O'Brien, 2006; O'Brien & Read, 2005). Whilst this embeds resilience within the disaster management function and acts to improve response capability and institutional capacity, there is a danger that this internal focus will not challenge culturally accepted beliefs, associated precautionary norms set out in laws or codes of practice and custom and practice. Failure to make these changes contributes to disasters (Turner and Pidgeon, 1977).

Learning can change the way in which responses to threats are constructed. Adaptation to current and ongoing climate risks can be more effectively developed within an enabling framework that recognises that local knowledge of vulnerabilities is the starting point for developing effective responses. Resilience building not only strengthens self-help capacity to respond to threats but also the capacity to plan for and undertake changes that will reduce risks. Planning prior to disaster occurrence can use adaptation to construct an effective response paradigm. This is illustrated in **Table 2.**

Constructing a global response model to the challenges of adaptation that embeds resilience argues for both top-down and bottom-up perspectives. The starting point for planning adaptation responses is vulnerability. Embedding resilience argues for a pre-disaster focus to ensure that effective responses are developed and that societies are able to adjust to change and recover from disruption.

Adaptation will be challenging. It is a long-term and costly process likely to result in disruption, for example, the relocation of people and infrastructure away from hazardous areas. In terms of scale adaptation requires decisions from individuals, firms and civil society, to public bodies and governments at local, regional and national scales. Building adaptive capacity will include communicating climate change information, building awareness of potential impacts, maintaining well-being, protecting property or land, maintaining economic growth, or exploiting new opportunities. **Table 3** brings together those aspects of the dominant and adaptation paradigms and develops a set of principles for adaptation planning and resilience building.

Failing to build a meaningful global response to climate change risks an unbalanced global response. **Figure 5** illustrates that linking vulnerability, societal resilience and burden-sharing provides a framework for learning at all levels that has the potential to lead to a fair and equitable climate agreement.

Table 3. Pre-Disaster Planning Principles for Adaptation

Pre-Disaster Planning Principles	Comment
Sustainable Development	An approach that focuses on reducing risk both now and in the future
Risk Avoidance	Developments should be evaluated from a risk reduction perspective
Embedded in Policy and Practices	Adaptation should be normalised
Distributed to the appropriate level	It is both top down and bottom up
Shared responsibility	The basis for renewing the preparedness partnership between government and people
Learning from scientific evidence, indigenous knowledge and experience	All knowledge is important, but of equal importance is effective communication and dissemination
Adjusting to changes	A recognition that the future may be very different
Organisational and Social Learning	Thinking differently and learning about how we approach problems related to adaptation should be the norm

Source: Adapted from O'Brien, 2006

Concluding Comments

There is a considerable evidence base that disaster risk is increasing and impacting the most vulnerable. However the 'democratic' nature of climate change and variability means that all populations throughout the world will be impacted in one way or another. Adaptation to the consequences of climate change and variability is an urgent priority for public policy. The challenge for public policy is on many levels; nationally within the developed world to develop sustainable responses; within the developing world to

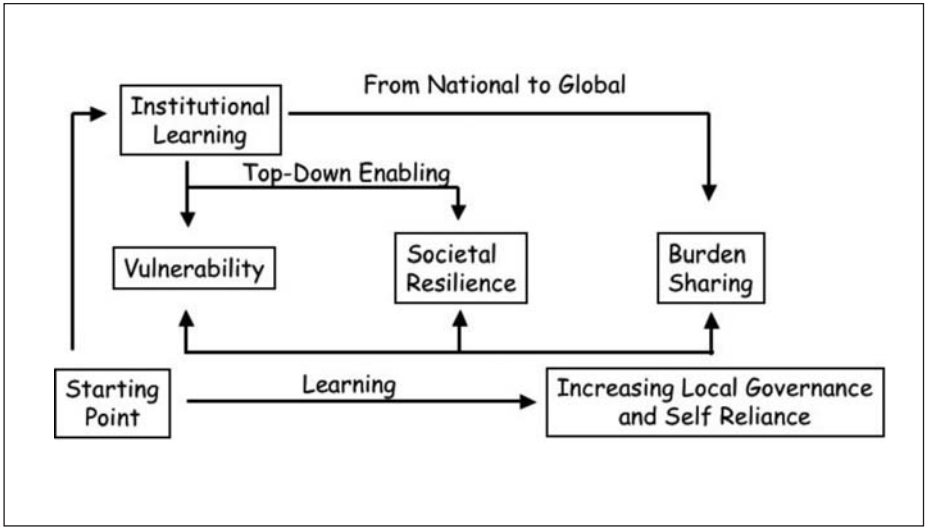

Figure 5. Linking Concepts for Climate Risk Reduction

enhance institutional and social capacity for disaster risk reduction; and for the international community to ensure that developmental policies are aimed at working to meet internationally agreed goals both for poverty reduction and climate risk reduction.

The agreement between UN/ISDR and UNFCCC to collaborate is welcome. Though there are concerns about the appropriateness of the dominant model of disaster management as an appropriate vehicle for resilience building, recent changes in UK government thinking in the National Security Strategy, indicate the potential for positive change (BBC, 2008). The new approach involves improving local resilience, building and strengthening local capacity and engaging households in preparedness strategies. This is the right rhetoric and is welcome. The challenge will be turning the rhetoric into reality.

Responding to produced unknowns driven by a changing climate requires resilience building. Resilience building is needed in pre-disaster planning and sustainable development in order to develop the social and institutional capacity to respond to produced unknowns. Resilience building is a process that aims to reduce harm, both now and in the future. The focus of resilience is on well-being. Resilience building is a learning process at all levels. Institutional learning empowers at the local level and strengthens governance. This is negotiation not imposition. Responding to the threat of produced unknowns require both current and future strategies. Strategies are needed to adapt to disruptive challenges generated by a changing climate. Strategies are needed to shape energy policy to minimise future risks. A focus on resilience recognises that there is no steady-state or end result. It is process without end that has, at its core, the notions of entitlements and governance.

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Climate Change and Pesticides in Nepal: Adverse Effects?

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Introduction

This paper outlines an initial study on the impact of pesticide use in Nepal. It focuses on rice production from 6 different farms in the Panchkhal Valley. It outlines the results of this initial survey and relates the results to agricultural intensification under climate change in Nepal. It must be emphasised that this is a preliminary study.

In this study, 'risk' is considered in the context of pesticide residues found in rice. It incorporates hazard as the toxicity of residues and exposure through consumption. These are assessed via a comparison of residue levels and maximum residue levels (MRLs) , followed by calculating admissible daily intakes (ADIs). Unless stated otherwise, residues were assessed using the average concentration level across all samples in order to provide an overall view of the pesticide usage scene in this study.

Rice is the primary staple food group of the Nepalese population, providing at least 50% of the daily calorific intake supplied by cereals to individuals (Pokhrel, 1997). Nepal is characterised by a predominantly agrarian society. This is reflected in the fact that agriculture is Nepal's primary economic activity (Atreya, 2006), contributing approximately 41% towards the total gross domestic product (GDP) per annum (Pokhrel, 1997). Over the last couple of decades, agricultural practice in Nepal has shifted from traditional labour-intensive pest control towards a growing trend of synthetic pesticide application to boost yield outputs (Atreya, 2006; Atreya, 2007; Palikhe, 2005; and Blaikie et al., 2001). Types of pesticide used, however, are often significantly more toxic than those used in Western countries and more likely to adversely affect the environment and human health (Palikhe, 2005).

Extensive investigation of literature has exposed a severe lack of epidemiological research specifically concerning public health in Nepal related to diseases resulting from chronic exposure to pesticide contaminants in rice. An in depth literary review also found a distinct paucity of peer-review literature specifically quantifying pesticide residues in rice from Nepal to assess chronic health exposure risks to the general population. This is probably a result of a complex range of factors, including ongoing political instability and lack of access to many of the rural regions due to conflict (Economist, 2008; Economist, 2007; and Deraniyagala, 2005). The alarming rate at which highly toxic pesticides are being used within farming (Palikhe, 2005), indicates a real need for research into the toxicity of residues, likely to be consumed by the majority of the population over the long-term.

In the global context, synthetic pesticide use in farming practice since the 1950s has led to chemical dependence in agricultural production of unprecedented proportions. Modern agricultural production methods based on chemical inputs are simultaneously associated with high outputs. Chemicals used to enhance food production and their adverse impact on human health as well as to the

environment, have gained increasing prominence in the public sphere (Carvalho et al., 2006).

Nepal, one of the poorest countries in the world, classified as a least developed country (LDC) and often thought of as harbouring some of the world's most pristine environments, is witnessing a growing trend in pesticide use (Atreya, 2006; Atreya, 2007; Palikhe, 2005 and Blaikie et al., 2001). As Nepal is predominantly an agrarian society (ADB, 2004 and Blaikie et al., 2001), pesticide use in Nepal gives reason for significant concern regarding the potential impact to health of the general population consuming contaminated produce and quality of the environment on which farmers rely to maintain food and livelihood security.

The heterogeneous nature of Nepal's topography limits access to resources and basic infrastructure (Pandey et al., 2001). Many subsistence farmers in Nepal have also been limited by conflict, poor infrastructure, and need to reduce risk and vulnerability to environmental disasters associated with climatic change in order to maintain sustainable livelihood security encompassing, most urgently, food security (Erenstein et al., 2007; Bhandari and Grant, 2007 and ADB, 2004).

Both China and India are the largest producer countries of synthetic pesticides in Asia (many of which do not meet internationally recognised safety standards) (Atreya, 2007; EJF, 2003, EJF, 2002; Ecobichon, 2001; IOMC, 1998). Pesticide use in agricultural production within the Terai and neighbouring Mid-Hills is prevalent due to a number of factors, including proximity to India. Furthermore, an open and porous border with India facilitates lucrative trade in unregulated generic pesticides. Greater road infrastructure in comparison to other regions and the presence of the majority of private pesticide resellers (IOMC, 1998) also contribute to considerable economic trade of pesticides in the Terai and Panchkhal regions. Pesticides from India are not subject to import license regulations raising concerns as to the quality, volatility of active ingredients and toxicity of many of chemical formulations (IOMC, 1998).

The attraction of 'quick-fix' solutions for pest eradication in farmer fields and 'miracle', high-yield seeds has significantly transformed the way in which many farmers cultivate their crops (Atreya, 2007 and Paudyal, 2007). Poor regulation, lack of governance and education in the dangers and need of appropriate application of chemical pesticides have cumulatively assisted sustained unregulated trade of pesticides across the reasonably porous borders of India and China (ADB, 2004).

Agriculture in Nepal

Nepal has a nascent industrial base dominated by the agro-processing sector, coupled with widespread dependence on subsistence farming for livelihood security. Subsequently, Nepal is often characterised as a predominantly isolated agrarian society, reliant mostly on subsistence orientated farming with low productive agricultural output (NSSD, 2001 and New Agriculturalist, 2007).

There are 3 distinct agro-ecological zones dividing the landscape of Nepal that run in parallel bands from east to west. These distinctive landscapes and differing elevations mean that climatic variation and crop diversity in Nepal is high. Only about 25% of the total area is cultivable; another 33% is forested; most of the rest is mountainous (Pariyar et al., 2001).

The Terai is the southern most agro-ecological band, bordering India. Its topographical nature is shaped by low-lying, flat land, with elevation not above 750m, forming an extension of the Indo-Gangetic Plain. As such, the Terai has the greatest agricultural potential in Nepal. However, recently, due to severe inundation, deforestation, and subsequent episodic droughts, the Terai Plains have experienced a series of poor harvests, leading to food aid reliance (WFP, 2007).

The Panchkhal Valley lies within the densely populated Mid-Hills region, forming part of the Kathmandu Valley, home to fertile valleys, predominantly utilised for agricultural production, growing a wide variety of crops, including staples such as rice, maize, millet and root vegetables. These subsistence crops are increasingly grown as cash crops. Rice is grown as the main food crop, rice, being the staple food of the Nepalese diet. Agricultural surpluses are marketed widely, particularly, to the urban Kathmandu population and surrounding provinces. Some rice outputs are also supplied to food-deficient hill areas (ADB, 2004). Land parcels are small, used primarily for subsistence farming, typically being smaller in the Mid-Hills (0.5 hectares) than in the Terai (around 1.5 hectares) (NSSD, 2001).

The Challenge of Pesticide Use in Nepal

Since Nepal is not a producer of pesticides, all products are imported. Despite lack of data, it is thought that a steady increase of pesticide use has entered the agricultural sector (Bhakat, 2005) with an increase of

imported costs equating to an annual growth rate of U.S.$2.1 million, the greatest use being on vegetables and cash crops in the Kathmandu Valley areas, served with a good road network and infrastructure, enabling access to markets (Kansakar, 2002).

In Nepal, farming of crops is widely understood to be subject to non-judicious use of pesticides:

"All types of pesticides are not only repeatedly used but also carelessly used."
Source: (Bhakat, 2005, p.6)

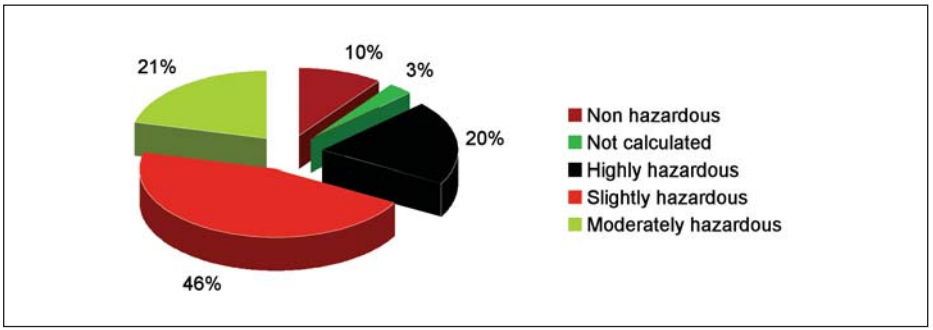


Figure 1- Hazard Level of Registered Insecticides in Nepal

Source: Adapted from (PRMD, 2004), cited by Paudyal (2007)

Non-essential use of pesticides is becoming increasingly common, exacerbated by the advertising of pesticides as a panacea to agricultural difficulty, farmers fearing crop losses and the demand for more attractive, immediate and prolonged results in crop quality (Atreya, 2006; Bhakat, 2005 and Kansakar, 2002). Presently, approximately 319 types of pesticides have been registered for use under the Pesticides Act (1991) and Rules (1993) of Nepal. A total of 3450 trained resellers, of which, 2543, are licensed resellers have been recorded (Bhakat, 2005).

Pesticides sold in Nepalese markets include insecticides, fungicides, herbicides, rodenticides and acaricides, often sold under different trade names. OCs, OPPs, synthetic pyrethoids and carbamates are widely used insecticides, with common forms traded as Endosulfan, Acephate, Chlorphyrifphos, Quinalphos, Dichlorovos and Phorates (Paudyal, 2007). A study by Paudyal (2007) found almost all the fungicides, herbicides, bactericides, acaricides and seed treatment pesticides sold were fell under the WHO non-hazardous category (Paudyal, 2007). However, one in five insecticides used in Nepal are categorised as highly hazardous, having a high oral or dermal lethal effect and less than half are categorised as moderately hazardous, see **Figure 1,** (Paudyal, 2007).

Over 71% of the population is employed in agricultural production, which as a stand-alone sector contributes approximately 38% of the total annual GDP (WHO, 2005). Approximately 75% of the population is involved in rice farming for at least six months of the year (Pokhrel, 1997). Many smallholders are women, the proportion of which is growing as men increasingly migrate to urban areas to generate income. In Nepal, remittances, cash crops, and urbanisation are significant factors shaping food, livelihood security, and poverty alleviation (HMG, 2005).

Cash crops make up 30% of agricultural production (New Agriculturalist, 2007). Both the large proportion of agricultural production towards total GDP and high employment within the low productive agricultural sector are two key indicators of development. Based on given criteria, Nepal has some of the highest figures in terms of poverty even among poorer countries of the world (WHO, 2005).

Dependency by rural people on traditional subsistence farming methods is thought to be the chief cause of poverty and environmental degradation (Bhandari and Grant, 2007). Additionally, overpopulation and growing population rates are contributory factors attributed to the degeneration of scarce land resources, high unemployment, greater poverty and overall economic decline. These elements in turn, lead to livelihood insecurity, a primary cause of socio-economic deprivation and political instability (Deraniyagala, 2005 and Seddon and Adhikari, 2003).

Methodology

Collection of primary matter (rice) was undertaken at the end of the harvest period in Nepal (October, 2007) as the majority of rice is sold to the general population during the final stages of harvest. All samples were taken from different locations in the Panchkhal Valley **(see plate 2)**, which serves much of the urban population of Kathmandu and surrounding areas with agricultural produce. Assessment of chronic exposure to the general population was then made possible by analysing pesticide residues detected in rice samples.

The methodological approach for residue extraction and analysis encompassed 7 broad steps, outlined in **Figure 2** (Gadema, 2008).

Main Findings

Pesticide residues were detected in all 6 locations, translating to 95% of rice samples (18 out of 19) comprising pesticide residues, varying in toxicity classification from not acutely toxic to extremely hazardous. 2 highly persistent and equally toxic insecticides, Methyl Parathion and DDT, which regularly featured in both the literature review and Nepalese Government studies of food commodities, were detected. In total, 13 different pesticides, including broad-spectrum fungicides and insecticides were found. These encompassed, Cypermethrin, Deltamethrin, Maneb, Myclobutanil, Pentachloroanisole, Aldrin, Chlorpyrifos, DDE/DDT, Edifenphos, Endosulfan, Firponil, Monocrotophos, and Methyl Parathion. Information regarding each of the detected residues in terms of environmental behaviour and persistence, class, and toxicity to health, is outlined below in **Box 1**. With respect to LD50 values (lethal dose for 50% of a rat population), all refer to oral intakes and mg/kg body weight unless otherwise stated, stipulated by WHO/FAO (2001) and (2005). Toxicity classifications refer to WHO (2005) evaluations.

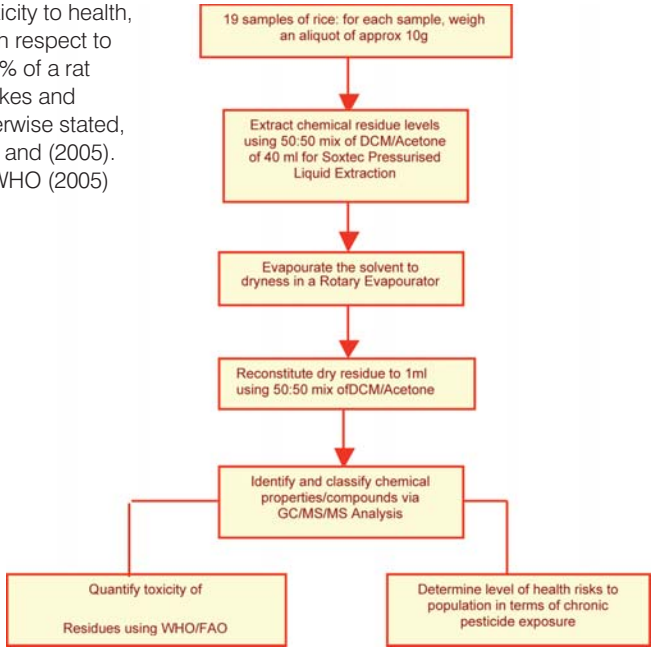
Panchkhal Valley: Intensively farmed area supplying the local and urban population of Kathmandu

Plate 1 Map of Nepal

Source: (SANOG, 2004)

Figure 2

7 Step Methodolgical Approach



Box 1 Details Characterising Toxicity, Action and Persistence of Detected Pesticide Residues

Cypermethrin:	Cypermethrin is a broad-spectrum synthetic pyrethroid, moderately toxic and acts as a stomach and contact pesticide by interfering with receptors in the nervous system. It is photostable (not volatile) and quickly degrades within the environment with a half-life of 2-4 weeks. Chronic exposure includes brain and locomotory symptoms, polyneuropathy and immuno suppression. In terms of acute toxicity, LD50 is 82. Views differ as to the carcinogenicity of Cypermethrin, however, it is classified by the U.S. EPA as a weak category C, carcinogen.
Deltamethrin:	Deltamethrin is a moderately toxic broad-spectrum pyrethroid that acts through ingestion and by contact. It is not volatile, and can persist from 1-2 weeks within the environment, less if in direct sunlight. It is a suspected endocrine disruptor. Especially characteristic of Deltamethrin poisoning (unlike other pyrethroids) are rolling convulsions. The sequence of signs of Deltamethrin poisoning is clearly identifiable, progressing from chewing, salivation and pawing, to rolling convulsions, tonic seizures and death (ETN Deltamethrin, 1995). LD50 is <5000 in aqueous solution. Symptoms of poisoning in humans include: ataxia (loss of coordination); convulsions; muscle fibrillation (twitching); paralysis; and diarrhoea.
Maneb:	Maneb is a broad-spectrum dithiocarbamate, often available as a wettable powder, flowable concentrate, and in ready to use formulations. It is easily broken down within the environment (with a half-life of 12-36 days) and has very low persistence. It has low acute toxicity (LD50 is >5000) and is not easily accumulated in the human body. However, target organs affected by Maneb are the heart, kidneys and thyroid gland. In the context of chronic exposure, Maneb is carcinogenic, tetragenic and a suspected endocrine disruptor.
Myclobutanil:	Myclobutanil a broad-spectrum fungicide pyrethroid with low persistence in the environment. In humans, Myclobutanil is classified as not slightly hazardous (LD50 is 136-$>$4.42 g/kg in corn oil), but it is neurotoxic, tetragenic and a suspected endocrine disruptor.
Pentachloroanisole:	Pentachloroanisole is a fungicide and POP, an aromatic chlorinated compound that is highly persistent within the environment. Human health effects are not known, although, toxicity via bio-accumulation in fatty tissues has been confirmed in studies of Channel Catfish (Ictalurus punctatus) and Rainbow Trout (Oncorhynchus mykiss).
Aldrin:	Aldrin is an OC, highly persistent within the environment with high potential for bio-accumulation. Toxicity to humans includes carcinogenesis, reproductive and developmental toxicity. It is highly neurotoxic and extremely hazardous in terms of acute toxicity with an LD50 of 37-167.
Chlorpyrifos:	Chlorpyrifos is an OPP insecticide with broad-spectrum effects, is moderately toxic, acts as a contact poison, with some action as a stomach poison, is neurotoxic (causes cholinesterase inhibition) and is a suspected endocrine disruptor. LD50 is 2000. It is available in granule, wettable powder, dustable powder, and emulsifiable concentrate form. It is carcinogenic, tetragenic, and neurotoxic, acting as a cholinesterase inhibitor. It is moderately persistent within the environment with a half-life in soil between 60 and 120 days, although, this is dependent on pH, soil type and climate.
DDE/DDT:	DDE/DDT is an insecticide and POP, highly persistent with the environment, with a half-life of around 15 years. It is a contact toxin but can affect non-target species. DDT is moderately toxic but can bio-accumulate within fatty tissues and biomagnify, becoming more toxic over time with an LD50 of 150-420. It is carcinogenic, highly neurotoxic, a suspected endocrine disruptor and tetragenic. It is a cheap, easily manufactured and an effective toxic insecticide. It is widely available in developing countries, although it is banned or restricted for use in 56 countries due to its highly toxic and persistent characteristics.

Box 1	Details Characterising Toxicity, Action and Persistence of Detected Pesticide Residues.. cont
Edifenphos:	Edifenphos is an OPP insecticide with low persistence in the environment, classified as highly hazardous with an LD50 of 150. Edifenphos has been found to have accumulation properties and high mortality in mammals, acts as a cholinesterase inhibitor, is highly neurotoxic and is a suspected endocrine disruptor as well as a suspected tetragen. It is not registered for use or manufactured in the U.S.
Endosulfan:	Endosulfan is an insecticide and POP, highly persistent within the environment, has an LD50 value of 80 but classified as moderately hazardous. It is highly neurotoxic, carcinogenic, is a suspected endocrine disruptor and tetragen. It is banned for use and severely restricted in many countries. Although classified as moderately toxic, in 1991, 31 people died in Sudan after consuming food contaminated with Endosulfan (EJF, 2003).
Fipronil:	Fipronil is a persistent OC insecticide, however, is not volatile within the environment. It has significant bioaccumulation potential and has high neurotoxicity in rats and dogs with an LD50 of 92. Fipronil is a 'new generation' broad-spectrum insecticide, acting by disrupting normal nerve influx transmission (Hainzl et al., 1996). It is a suspected endocrine disruptor, possible carcinogen and potential ground water contaminant.
Monocrotophos:	Monocrotophos is an OPP, broad-spectrum insecticide, not specifically persistent within the environment (a short half-life between 7-14 days). Monocrotophos is a cholinesterase inhibitor, possibly carcinogenic, tetragenic and a possible endocrine disruptor. It is classified as highly hazardous due to its acute toxicity (LD50 is 14) and neurotoxic properties, is banned for use in many countries and included in PIC procedure of the Stockholm Convention.
Mehtyl Parathion:	Methyl Parathion is a commonly used insecticide in LDCs, often known by the trade name Folidol. It is a non-systemic OPP, broad-spectrum insecticide, extremely hazardous (LD50 is 3), acting by killing insects upon contact, respiratory, or digestive action (EJF, 2002). Persistence within the environment varies, ranging from 100% degradation within 2 weeks to a half-life of 175 days (EJF, 2002). It is a cholinesterase inhibitor with chronic health effects likely to be neurotoxic in nature. In humans, cumulative effects through exposure to Methyl Parathion are probable.

Source: (INCHEM, 2007 and PAN, 2007)

Hazard and Exposure

In terms of toxicity to the general population, dose is a significant factor as single exposures to residues above MRLs is unlikely to result in long-term health effects. Frequent exposure to residue concentrations exceeding MRLs and ADIs, (particularly, low ADIs with high exceedance of certain pesticides) are more likely to adversely affect human health (Low et al., 2004). MRLs are widely used in peer-review literature, national and international reports, to determine maximum concentrations of certain pesticides legally permitted within various food commodities to reflect whether regulatory standards are breached or not. Thus, those pesticide residues that occurred at levels above MRLs, being Aldrin, Cypermethrin and Maneb, are of regulatory concern. **Table 1** showshow toxicity relates to humans, outlines the principal health effects of all detected pesticides and highlights above/below MRL and ADI levels (based on mean residue concentrations across all samples)in this study.

Table 1 Pesticide Residues Detected, Toxicity Hazard, and Chronic Exposure

Detected Pesticide (f) = fungicide all others are insecticides	WHO Toxicity Hazard Class	Toxicity to Humans	Above/Below MRL	Above/Below ADI
Cypermethrin (f)	Moderate	Possible carcinogen	Above	Below
Deltamethrin (f)	Moderate	Suspected Endocrine Disruptor	Below	Below
Maneb (f)	Not Acute	Carcinogenic Tetragenic	Above	Below
Myclobutanil (f)	Slightly	Tetragenic Suspected Endocrine Disruptor	Below	Below
Pentachloroanisole (f)	No Info	Bio-accumulation Possible carcinogen	No MRL	NO ADI
Aldrin	Extremely	Carinogenic Possibly Tetragenic Suspected Endocrine Disruptor	Above	Above
Chlorpyrifos	Moderate	Possibly Tetragenic Suspected Endocrine Disruptor Cholinesterase Inhibitor	Below	Below
DDE/DDT	Moderate	Tetragenic Carcinogenic Suspected Endocrine Disruptor	Below	Below
Edifenphos	Highly	Cholinesterase Inhibitor	Below	Below
Endosulfan	Moderate	Carcinogenic Suspected Endocrine Disruptor Possibly Tetragenic	Below	Below
Fipronil	Moderate	Possible Carcinogen Possibly Tetragenic Suspected Endocrine Disruptor	Below	Below
Monocrotophos	Highly	Cholinesterase Inhibitor Possible Endocrine Disruptor Possibly Tetragenic	Below	Below
Parathion (methyl)	Extremely	Cholinesterase Inhibitor Possibly Tetragenic Suspected Endocrine Disruptor	Below	Below

Source: (PAN, 2007)

Continuous consumption of pesticides detected in this study, even at low levels can accumulate in the receptor's body, potentially causing a range of chronic health effects to the human population over the long-term. Paradoxically, mean concentrations across all samples revealed that 92% of detected pesticides with ADIs were lower than advised levels and 73% of pesticides with MRL benchmarks were lower than recommended limits.

Confounding these results is that overall average concentrations of pesticides illustrated that 1 pesticide, Aldrin, an extremely hazardous insecticide, is 2.8 times higher than the WHO/FAO MRL. This however, might well be a very isolated issue of over contamination, which is difficult to validate without return to the field. Similarly, when comparing daily intakes against overall average pesticide occurrence, Aldrin alone exceeded ADI levels but by 17.5 times, indicating that in the context of samples in this study, potentially, people consuming samples containing Aldrin over the long-term would be at higher risk of chronic exposure. Again, the issue of super exposure can only be validated by more field-work.

Conclusion

Results show 92% of detected pesticide residues occur below ADI thresholds and 73% below MRLs, possibly belying harmful implications to public health through chronic exposure due to the prevalence and variation of detected residues. If this study were wholly representative of long-term rice consumption patterns, potentially, a diverse series of adverse long-term health effects resulting from exposure through consumption would theoretically, be increased for the populace of Nepal.

Assessing potential health risks through chronic exposure using ADIs and MRLs needs to account for pesticide frequencies, type and toxicity hazard of residues, as well as their associated adverse health effects, if any. Given this premise, overall concentration levels, frequencies and prevalence of different pesticides across detected samples, give reason for concern including:

(i) Occurrence of these pesticides indicates ubiquitous use;

(ii) Proportionally, at least 61% of all detected pesticides are OCs and OPPs, some of which readily persist within the environment, bio-accumulate, easily volatilise and breakdown into a series of toxic byproducts;

(iii) Over 50% of detected pesticides are illegal to import, are heavily restricted for use, included in the PIC Procedure of the Stockholm Convention, banned in countries of origin and in many LDCs (including Nepal) via international agreements and/or are obsolete (e.g., DDT);

(iv) 69% of pesticides found, even at low levels are known to be neuro-toxic and are, at the very least, suspected endocrine disruptors;

(v) Cumulative effects of different pesticides are likely to have a diverse range of adverse health impacts dependent on the prevalence of pesticides, whether they occur individually or in a group within any one sample; and

(vi) Long-term health effects as a result of chronic exposure, through consumption, present an unnecessary risk to the general population regularly consuming contaminated commodities.

Pesticides found in this study exhibit numerous aspects outlined above, many of which have the capacity to potentially trigger catastrophic toxicological effects through chronic exposure. Should samples not be representative and only be consumed/ingested over the short term, health hazard risk and chronic exposure will be significantly reduced and unlikely to adversely affect long-term health outcomes of the general population.

Discussion

Findings of this study demonstrate that with 19 samples, it is only possible to determine the pesticide usage and chronic exposure scenario in Nepal, by contextualising results in the form of a 'snap shot' analysis of a representative, staple food type. Further research would be necessary, preferably with a larger set of around 100 samples to provide a broader and more comprehensive assessment.

Whilst recognition is given for the need to conduct futher research, acceleration of chemical use within agriculture in Nepal is beginning to mirror the previous experience of India's Green Revolution. Climate change in Nepal probably means higher temperatures at higher altitudes coupled with decreased precipitation. These factors have implications, particularly for water storage and pesticide reservoirs. Increase of extreme weather events, especially associated with flooding probably means augmented numbers of catch crops, which in turn, means an increase in the use of

pesticides and high yield seeds. Agricultural intensification and climate change leads to a decrease in species diversity, a change in pest epidemiology, and a generally uncertain agricultural future. In all probability, the use of high cost external inputs will ultimately drive changes in land use and land ownership, which could have implications for both rural and urban livelihood vulnerability.

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Dendrochronological Analsyes and Climate Change Perceptions in Langtang National Park, Central Nepal

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Introduction

Analyses of temperature and precipitation records in Nepal show that temperatures in Nepal are increasing at a higher rate than those of other mountaine regions around the world (0.060C/yr) (Shrestha et al. 1999, p. 2778). The warming seems to be consistent and continuous after the mid-1970s and more pronounced at higher altitudes. These changes cause rainfall to increase and rainy days to decrease, suggesting that rainfall events are becoming increasingly sporadic. The warming has resulted in the marked retreat of glaciers with a reduction in both area and ice volume (Agrawal et al. 2003, p. 29). These changes not only threaten the large stores of fresh water in the form of ice and glaciers situated at high altitudes of the Himalaya, but have also intensifiedthe rate and ferocity of GLOFs, flooding, landslides, erosion and sedimentation (MOPE 2004, p. 153).

Studies of climate change are urgently needed in order to better understand linkages between changing climatic patterns, the increase in natural hazards and their combined effects upon livelihoods at the local level. However, climatic records in Nepal are limited. Most meteorological stations are located at low elevations (<2000m). Therefore, time series analyses of recorded climate data for the assessment of climate change at higher altitudes is not possible. We need to identify alternative waysto study climate change. One such alternative is dendrochronology. Due to the prevalence of fur and pine tree species at higher altitudes of Nepal, dendrochronology can be used to pin-point climatic variation in the absence of climatic data. Hence, the present study was carried out with the following objectives:

- To study the growth pattern of tree ringsand develop tree ring chronological data of *Abies. spectabilis.*
- To compare responses of *A. spectabilis* ring widths with climate (temperature and precipitation).
- To ascertain perceptions of climate change from local people in the Langtang region.

Methodology

This study was undertaken from June to July, 2007 at Chandanbari (Site I) and Cholangpati (Site II) of Langtang National Park (LNP). LNP is located in the Central Himalaya of Nepal and is one of the parks nearest to Kathmandu. 60 *A. spectabilis* trees from the pure stand forest of Site I and 60 trees from Site II were cored with a Swedish increment borer and two samples from each tree were collected from a north-facing slope. After being air dried, samples were fixed on wood supports using glue with the cross section facing upwards. Samples were polished using a rotary electric belt sander to make tree rings visible with progressively finer grades of sand paper (60- to 320-grit).

An accurate machine with a precision of 0.001mm was used for measurement. Standard dendrochronological procedures(Fritts 1976; Cook et al., 1990) were followed to develop chronological data sets.A computer programmeknown as COFECHA (Holmes 1983) was then used to detect measurement and cross-dating errors and ARSTAN (Cook 1985) was used to reduce the non-climatic variations presented in series of tree-rings. Response-function analysis (program DendroClim 2002- Biondi and Waikul 2004) was utilised to assess the impact of changes in monthly mean temperatures and monthly precipitation levels from the September of previous years until October of the observed year on the annual variation of tree-ring width. Since, long-term meteorological records at high altitudes near sampling sites were not sufficient, we selected the meteorological data of Kathmandu Airport (27o42'N, 85o18'E, 1336 m), located about 50km away from sampling sites for analysis.

Household surveys and group discussions were conducted to find out perceptions of climate change within LNP communities. A total of 31 households were selected randomly and questionnaires administered to selected heads of households. Similarly, two group discussions of key informants were organised. The number of participants in the group discussion ranged 5 in Cholangpati to 6 in the Polangpati area of LNP.

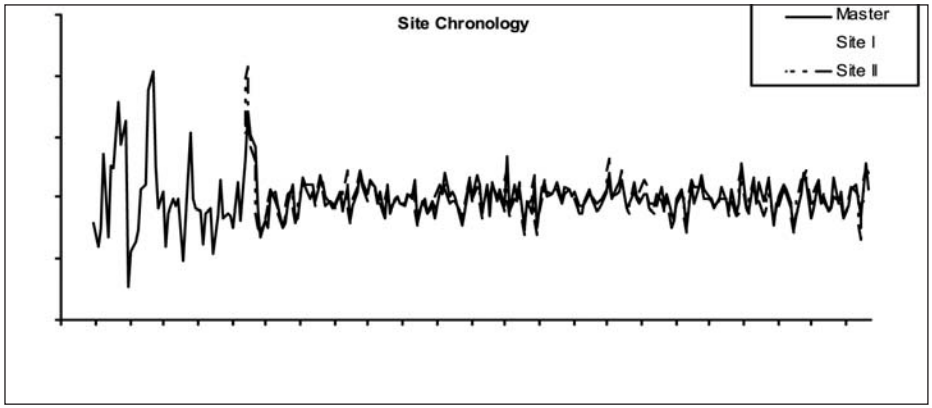

Figure 1 Master and Individual Site Chronologies of A. spectabilis

Results and Discussion

Chronology

Almost 250 years of tree ring chronological data was developedusing samples of *A. spectabilis*trees **(Figure 1)**. Tree ring chronology curves exhibited similar growth patternsfrom both sites. This means that there is no real difference in the way the sampled trees react to environmental factors. This chronological data set is comparatively short in comparison to other studies from Nepal (345 years Khanal & Rijal 2002, p.14 and 436 years of Langtang Chronology in Cook et al., 2003, p. 709). Tree ring chronologies were limited by butt rot in most of the oldest trees. Another study that focused on sites in Western Nepal by Sano et al. (2005, p. 84) revealed comparable challenges.

Analyses of increment cores from both sites revealed that trees in these stands ranged from 100-300 years old. Trees of the Chandanbari site were found to be older than Cholangpati. The mean tree ring width of Chandanbari was 2.34mm and that of Cholangpati site was 1.70mm. This showed that growth rate was highest (2.34mm/yr) in Chandanbari and lowest (1.70mm/yr) in Cholangpati. Series inter-correlation and mean sensitivity were recorded at 0.457 and 0.223 respectively for Site I, and 0.499 and 0.203 respectively for site II. The high mean sensitivity value indicated that high inter-annual variability was present in ring widths.

Additionally, chronologicalinterpretations proved valuable in illustratingyearly environmental changes and proved that the Abiestree species were indeed useful forresponse analysis.

Response Analysis

Tree growth of the Himalayan region is primarily limited by moisture availability in the pre-monsoon season (March-May) with a negative association to temperature and a positive association with precipitation (Borganokar, Panta & Rupa Kumar 1999). It was found that tree ring parameters of Site II, and master chronology positively correlated with March's total precipitation but negatively correlated with May's monthly minimum temperature. This result indicated that ring width is primarily controlled by pre-monsoon temperatures and precipitation. Similar results were found in response analyses of tree-ring parameters of A. spectabilis with climate records from Western Nepal (Sano et al., 2005, p. 83) and Central Nepal (Khanal & Rijal 2002, p. 15). The strong correlation between radial growth and March precipitation suggests that the month of March should be active in photosynthate storage that contributes to growth later in the active season. Negative correlations with May monthly minimum temperatures were attributed to water stress. This means that theAbies species from these sites are ideal for past climate reconstruction.

Past Climate Reconstruction

The value of chronology statistics and results of response analyses show that present chronologies can be used for climatic reconstruction. One of the major difficulties in undertaking thorough dendro-climatic research in Nepal relates to the dearth of long-term meteorological records for statically calibrating tree rings (Bhattacharayya, LaMarche and Huges 1992, p. 60; Cook et al., 2003, p. 710 and Sano et al., 2005, p. 85). This study was limited by factors including poor climatic data availability and sample sizes. A recent studyby Cook et al. (2003, pp. 727-729) was based on a dense network of 32 ring width chronologies across Nepal wherein two reconstructions of February–June and October–February temperatureswere analysed and presented back to AD 1546 and 1605 respectively. These were the first dendro-climatic reconstructions developed specifically for Nepal. However, only the October to February reconstruction revealed any indication of unusual late 20th century warming.

Perceptions and livelihoods

A total of 93% of respondentshad noticed abrupt climatic phenomena recentlyand believed that climate change was happening. Unusual climatic events over the last few years,such as sporadic bursts of rainfall andlower snowfall rates during winter seasons had beennoticed by 80.4% of interviewed respondents. The same respondents were unaware of global warming or reports of rapidly receding Himalayan glaciers. Most respondents believed that times are changing in the sense that rainfall and snowfall events were evidently and increasingly more erratic, variable and unpredictable. A total of 90.3% of respondents believed productivity of grassland had been decreasing and people thought that itmight be due to untimely and lower snowfall rates. Other people attributed lower grassland productivity to increased numbers of cattle and grazing pressure.

Livestock farming in Nepal is a major economic activity. For example, yaks graze above 2000m throughout the National Park. As such, communities lying within the LNP have serious concerns over declining grass production in the Himalayan grasslands. A total of 58% of respondents believed that blossoming seasons of wild flowers including rhododendrons have changed markedly over the past few years. For instance, it was highlighted that rhododendrons initially blossomed during the months of Baishak (mid April-mid May), but now they flower during the Chaitra period (mid March-mid April) too. Local people also noticed marked changes in snowfall patterns over mountains. Villagers explained that once mountains were generally covered with snow all year but that this had declined to a stage that snow coverage now occurs primarily during winter months.A total of 64.5% of respondents also noticed invasion of exotic species on grazing land and agricultural land. Species ordinarily found in lowland areas, are now becoming commonplace in highland areas too. People from the Thulo Sayfru area (situated at a height of 2500m) pointed out unknown foreign species and attributed these solely to climatic change. For instance, Cercium sp. was not commonly found in the area previously,yet this species is now prevalent within Thulo Sayfru.

Additionally, local people and senior scouts of LNP noticed a significant increase in landslides over the past decade. These have been linked witha parallel increase in permafrost melting. Productivity rates of crops including wheat, maize and potato are rapidly becoming more adversely affected due to changes in frequency and levels of

precipitation. Local people also attributed sharp increases in pest occurrences in maize(a staple food crop) directly to unusual rainfall patterns. Traditionally, apple farming was a primary economic activity in this area. However, apple productivity is also decreasing. Again, local people blamed higher than average temperatures. Much of the industrial base surrounding apple production has declined. If local peoples' perceptions and observations of climate change are accurate, continued physical changes in the environment will surely continue to adversely affect livelihood and food security. Strategies for adaptation to climate change with a range of inclusive and integrative policies are needed with an emphasis onlocal level, people-centred approaches.

Conclusion

Major international efforts are underway to reconstruct past climates at high-elevation sites to address uncertainties in predicting physical and biological responses to climate change at decadal timescales in these ecologically significant environments (Beniston 1994, p. 492). In this study we tried to explore the potential of tree-ring records from the high elevation Abies forest of Nepal for identifying major patterns of climatic variability. Results of the present study show that Abies trees can be used in dendroclimatological studies and the construction of past climate scenarios. This study illustrated that dendrochronological study isuseful in the reconstruction of monthly temperatures. Although tree ring data derived from this study is unable to singularly build a vast,chronological climatic record, the data set can easily be extended by collecting samples from older growing tree stands. Temperatures reconstructed by Cook et al., (2003, p. 728) indicated winter temperatures increased at unprecedented rates overthe last half of the 20th Century.

Communities of the Cholangpati and Chandanbari areas are already starting to feel the impacts of climate change in their day-to-day activities. Local people remain unaware of climate change and its impacts. As such, it is recommended that further research utilising dendrochronological methods and implementation of awareness programmes regarding climate change, especially for local communities in isolated mountain regions be undertaken at the earliest opportunity.

Acknowledgements

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Integrated Forest Fires Management in Spain:

Towards a More Resilient Model?

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Introduction: The Spanish Reality

Spain has traditionally been an agrarian society. Landscapes were formerly shaped with a mosaic of agricultural, pastoral and forest patches. Following Spain's democratic transition during the 1980s, and as a consequence of uneven development policies aimed to foment the importance of coastal cities; rural populationsabandoned traditional livelihoods and migrated to urban areas in search of employment opportunities. As a result, wild revegetation has invaded the understory of forests, agricultural areas and pastures. These overly dense structures of small trees with stagnated growth provideperfect conditions for the propagation of fire as they form continuous bands of particularly flammable forest fuel per square meter. In addition, this type of vegetation is increasingly prone to combustion as a result of higher temperatures, stronger winds and lower rainfall registered in Spain (IPCC, 2001). Under these conditions, any spark could easilytrigger the onset of a fire that in all probability couldbe difficult, if not impossible, to control. Thus what is of concern is how and why fires are initiated.

Only 4% of forest fires in Spain are produced by natural causes such as a lightning strike. It is estimated that 95% of fires are caused by human action: either through neglect or are intentional (WWF, 2006). Abandonment of rural areas is also tied in with the abandonment of positive feeling and affection or care that rural people have for their environment. Among those who remain near to or in forest communities, the traditional slash and burn culture to maintain pastures and agricultural land is still practised. Without knowing current risk conditions for the propagation of fire, fire when it occurs, has the potential of becoming out of control. The use of fire to establish commercial forest plantations and the conflict between different users is usually behind the origin of a considerable percentage of forest fires (TVE, 2005).

As a result, Spain is affected by an average of 20,000 forest fires every year, mainly concentrated in the three summer months (mid June, July, August and mid September). This equates to an average of 150 fires a day. Half of all forest fires in the European Union are made up of those that occur in Spain. This figure exceeds the number of fires that occur in other Mediterranean countries including Portugal, Italy, Greece and France (ISTA, 2005). This paper outlines how current Spanish forest fire fighting strategies are a result of a process of learning aimed to make Spain more resilient to this serious problem that threatens not only the environment but also the national economy and human lives.

Organisational model: Sharing of Responsibilities

Spain is divided administratively into 17 Autonomous Regions **(Figure 1)**. Each region is divided into a number of provinces. During the 1980s, the decade of democratic transition, the management of forest fires transferrd from centralised control to administrative regions. Thus, systems and frameworks of fire management are generally managed, administered and operated at the regional scale (DGB, 1997).

Individual regions haveautonomously designed regional forest fire plans and developed human and technical meanssuited to their own environmental, social and economic conditions. Therefore, there is not a common model of organisation at the national scale. In the case of regions with more than one province, Regional Coordination Centres have been created in order to facilitate and coordinate the mobility of their own means throughout its territory and to channel requests for assistance to the Ministry of Environment and other regions.

Alarge number of differing regional plans have led to the nature of forest fire fighting becoming a complex, cross-cutting administrative task, which requires a high degree of coordination between administrations. The State is ultimately responsible for the efficient functioning of the nation overall. As such, it supports and facilitates regions by providing a legislative framework, meteorological information and promoting the inter-institutional and international agreement between neighbouring countries.

In the context of the international arena, climate change which has increased the probability, verocity and number of fireshas led to greater awareness of the need to provide funding to support international programmes that focus on investigation, prevention and reduction of the effects and impacts of forest fires.

Figure 1 Administrative Division Map of Spain's Autonomous Regions (Cartomapas, 2002)

Forest Fire Fighting in Spain: A Resilience Model?

Resilience is increasingly featured in global debate in terms of reducing the impacts of disasters. There are a number of definitions for resilience. The United Nations International Strategy for Disaster Reduction (UN/ISDR) has adopted the term resilience and defines it with reference to natural hazards:

The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure is crucial. The level at which systems, communities and/or societies can build resilience is determined by the degree to which a social system is capable of organising itself to increase the capacity for learning from past disasters for

better future protection and to improve risk reduction measures (UN/ISDR, 2004, p.430).

The term resilience brings together components of the disaster cycle – response, recovery, preparedness and mitigation that essentially utilise a range of structural and non-structural approaches (O'Brien and Read, 2005). However, the current Spanish forest fire-fighting model has focused on particular areas undermining the concept of resilience.

Response

Forest fire fighting has traditionally been identified with the "response" phase in Spain. Other components of the disaster cycle are marginalised andre main focused on favouring the work of emergency services teams to detect, respond to and suppress fires. Taking into account data from the last 3 decades **(Figure 2)**, efforts in this area have achieved positive results in terms of reducingthe total area sizeof fires when they occur. On average, 63% of fires in Spain are extinguished before spreading to more than a hectare in size. Over the last three decades it has been demonstrated that there is a developing and enhanced capacity to detect firesat the early stagewith increasing capability of dealing with the area in question with sufficient enough speed in whichto extinguish fires.

Despite the fact that less than 1% of fires exceed 5000 ha (complex forest fires), the number of hectares affected by fires is of concern. In other words, only a few fires (0.18%) consume large area sizes. In terms of coordination, these large fires require assistance between regions, the government and other affected countries. The Spanish response to large-scale fires is not as effective as it could be.

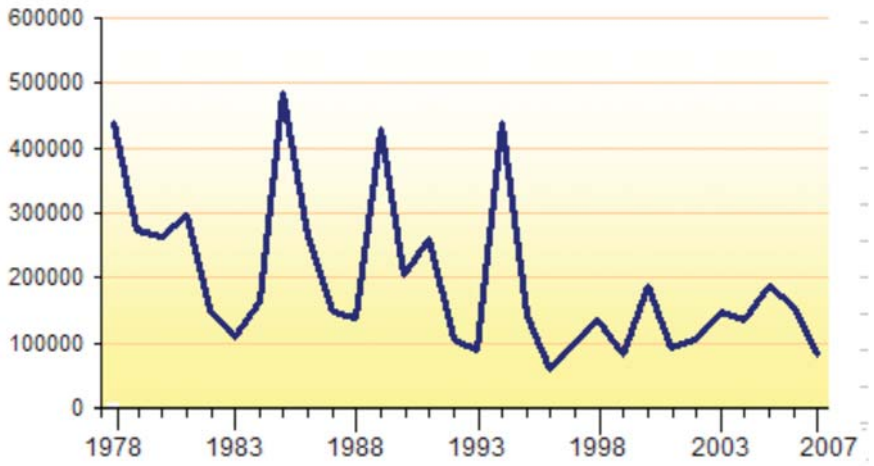

Figure 2 Total Number of Fires and Affected Areas, 1978-2007 (Ministry of Environment, 2007)

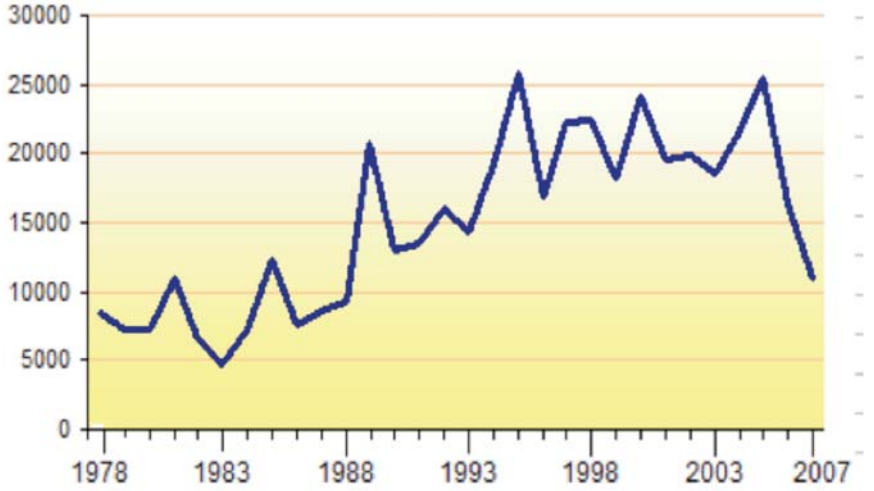

Figure 3 Total Number of Fires, 1978-2007 (Ministry of Environment, 2007)

At the same time, emergency response services are also vulnerable to waivering public support. Every year Spain has more than 20,000 people working in forest fire response. In order to reduce the high level of unemployment in rural areas, land teams recruit people from the emergency service sector. However, those dependent upon the existence of forest fires are generally those that are employed to manage them. Thus, it is not strange to find forest fire fighters as the perpetrators of fires in recent years. These cases are relatively few and far between but are difficult to prove. Consequently,the topic has become especially controversial, having triggered polemic debate in the media and society about the reliability and truthfulness of the emergency response services.

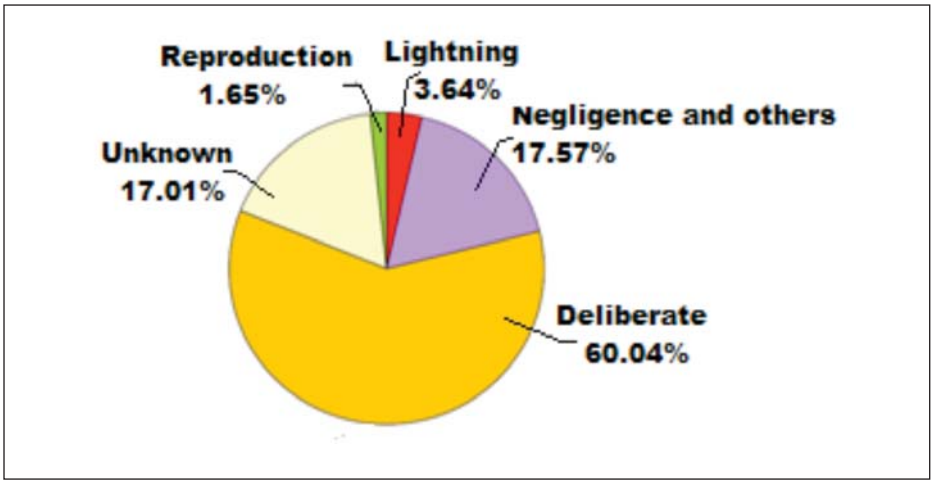

Figure 4 Causes of Forest fires – 1997-2007 (Ministry of Environment, 2007)

Prevention

According to **Figure 3**, the number of incidents continually rising each year gives cause for concern. It is clear that Spain is addressing the response to fires but is not preventing their occurrence.

It is estimated that 95 % of fires are caused by human action. 60% of fires are intentional and 17% unknown (Figure 4). Approximately 84 % of complex fires (those that produce major damage) are thought to be intentional (WWF, 2006). Despite these statistics, only 33% of the total national forest fire-fighting budget is allocated to social prevention.

Official statistics in Spain show that only 1% of forest fires in Spain involve arrest(The Guardian, 2005). This poor performance in terms of arrest of those responsible for for forest fires indicates widespread apathy in the investigation and prosecution of crimes related to forest fires (ISTAS, 2005).Meanwhile, authorities face real challenges in establishing blame and securing convictions.

Recovery

The concept of resilience was initially used in ecology to describe the ability of ecosystems to resist and recover from external negative impacts (Blaikie and Brookfield, 1985). Mediterranean vegetation has successfully adapted to fires and. However the problem arises when fires are repeated with successive frequency. At this stage, forests are unable to fully recover adequate vitality and the process of soil degradation begins. The importance of reforestation programmes is vital in terms of resilience.Without reforestation programmes, the soil, without roots or with dead roots, would be exposed to increasing soil degradation that would adversely impact upon rural peoples' livelihood security. Despite this, the number of hectares under reforestation programmes has declined in the last decade (REF).

Generally, land-ownersand/or rural people in forested regions are benefiting from agricultural insurance, which covers damage according to what was agreed in the given contract in question. The State has a subsidy programme to finance up to 50% off initial subscriptions. As well as these significant subsidies the State allocates economic support to repair or replace damaged property, compensates personal injury, andfarm damage, including commercial, livestock, industrialand tourist establishments. According to Emergency Management Australia "resilience is a measure of how quickly a system or community recovers from failures" (O'Brien and Read, 2005). However, with respect to forest fire incidents, often, decades are needed before rural communities can recover their forest-based livelihoods.

Rethinking Forest Fires in Spain

The Spanish government and regional authorities have made considerable changes to fire fighting response strategies in recent years. Forest fire planners have recognised the role of society in Spain and the importance of involving societies with the development of building resilience to forest fire events. Resilience requires capacity building of governance structures, communities and individuals to mitigate and adapt to forest fires. Therefore, new forest fire fighting approaches in the last 3 years have been given top priority in:

- **Coordination:** In order to improve the coordination in complex forest fires (>500ha), Military emergency units (UMEs) using the military's proven organisational and operational skills have been created under the responsibility of the Ministry of Defence to deal with environmental and civil protection. However, there are concerns that in times of crisis, the single chain of command and control that these structures follow could undermine civil protection and local efforts built on collaboration (Alexander, 2002).
- Cooperation between competent regional, state and international bodies is being encouraged to prevent these fires through national meetings and increased cross-border agreements. As forest fires contribute greatly to the emission of greenhouse gases (mainly CO2), agreements also form part of the national global warming policy.
- **Preventive legal framework.** The old "Ley de montes" (Countryside Act) in 1973 was changed in 2003 in order to prevent burnt land from being reclassified as suitable 'for housing' for at least 30 years after a fire event. This attempts to put a stop to many scams surrounding deliberate fires. Recent punishment measures have also been adopted to ensure the detention of perpetrators.
- **Active participation of citizens.** Focus on forest groups living in "high risk" areas via forest fire committees can share information and explore various steps that could be taken at an individual level to deal with fire. The formation of local forest fire committees is increasingly included in regional plans.
- Besides,"Specialised integral prevention teams" (EPRIF) have been created in order carry out the burnings that farm and livestock owners require to reduce accumulated fuel in their lands in a controlled way. This measure enjoys considerable popularity among rural people. These teams also educate rural people about fire and the potential risks.
- **Investigation of causes and data gathering.** "Cause investigation teams" have been created to move to affected areasfollowing fire events. Inch by inch, undertake investigations by gatheing information with the purpose of finding answers to such important questions as: "Who burns the forest, why and for what reason?". Only then, can effective measures to punish the perpetrators and solve underlying social conflicts can be proposed (WWF, 2006).
- All collected data is integrated and recorded on a national database in order to make periodical evaluations and learn from identified failures and successes. Final national yearly data is provided to the European Commission to be incorporated within the "socle commun" data, the EU data bank (DGB,1997) that enforces the identification of risk at a broader level.
- New agreements with universities have initiated to enhance existing research and promote new research projects to improve knowledge regarding the underlying causes of fires and the development of new satellite and remote sensing technologies that inform on forest fire risk identification.
- **Autocton species reforestation programmes.** Pilot projects with a mix of alocton and autocton species are being carried out in the last decade in order to support afforestation and reforestation initiatives. Supported by European projects, FEDER and FEOGAR, their implementation has resulted in effective monitoring and better rates of cooperation with farmers as these initiatives represent net incomes for farmers (UN, 1996). However, there are still concerns regarding the increasing area designated to commercial plantations to prolific and problematic species such as eucalyptus.

The Spanish Government and regional authorities are making great progress in implementing pathways to eliminating the number of forest fires to reduce disaster risk. However, despite the growing number of positive initiatives, the role of individuals is essential in the process of forest-fire reduction.

Conclusion

Traditionally, wildfire plans were focused on the phase of "response" in Spain. Only 33% of the total forest fire budget in Spain has been aimed at prevention. Studying causal factors and theintroduction of rehabilitation

programmes has declined. These approaches have not yet managed to stem the annual growth in the number of fires.In recent years, a more holistic approach to resilience is taking hold,with an evolution towards more global strategies that address the underlying causes of forest fires. Greater effort has been madeto enhance the institutional coordination of emergency response to fires. Additionally, research into the reasons behind deliberate forest fires in order to better understand, resolve and reconcile social and economic conflicts in rural areas is growing. Although it has not been the main objective of this report, it is important to highlight that the problem of forest fires in Spain is now also a global concern that requires both national and international measures to mitigate the negative range of impacts upon forests.

Recognition needs to be given to the welfare of rural populations as well as the environment upon which many rural communities rely for livelihood security and quality of life. The resilience concept has helped to identify key elements, principally, that the problem cannot be solved without social cooperation in prevention, cause investigation and crime prosecution.

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Local Government Co-operation with Climate Change Training in Turkey

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Turkey and its Hazard Profile

To better understand the relationship between the national education system, climate change training and the local government structure in Turkey, it is necessary to comprehend to a certain extent, the national profile of the country. Hence, this paper first provides information on population, government structure and geography. It then provides an overall picture of Turkey's hazard profile and explains the role of climate change.

Turkey is located in the southeast of Europe. It has a unique geographical location as its borders liewith countries in Europe, Asia and the Middle East. The political system is a Parliamentary Democracy. Although a secular country, Turkey's population is mostly Muslim. The country is subdivided into 81 provinces for administrative purposes. These provinces are grouped into 7 geographical regions with each province divided into districts.

Turkey is a member of the United Nations,NATO and OECD and is an associate member of the European Community (Central Intelligence Agency, 2008). Although Turkey's economy is growing, the gross domestic product (GDP) is one of the lowest in Europe (TurkStat, 2007). Economic growth is largely buoyed by, andprimarily dependent upon,the private sector, including principally, heavy industry and trade sectors, whereas, transport, communication and agricultural sectors lag behind in terms of overall economic input.

The demographic profile of the country shows that there are 70.5 million people in Turkey(based on statistics from 2007) and the country's population is one of the youngest in comparison to other countries in the nearby geographical region (TurkStat, 2008). 24.4% of the population is aged between 0 and 14 years old. 68.6% of the population is aged between 15 and 64 years old and only7% of the population is aged65 years and over.

School education in Turkey is compulsory. Children between 3 and 5 years old may attend pre-primary education, which isoptional. Compulsory education begins with children at the age of 6 through to 14. Secondary education follows on from primary education and as in primary education, is provided for four years. Higher education is given overtwo years. In Turkey, there are 10,870,570 students enrolled in primary education, 3,245,322 students in secondary education and 2,291,762 students at faculties of higher education as shown in **Table 1** (Ministry of National Education 2007).

Table 1 Number of Students enrolled in Primary and Secondary Schools in Turkey and Istanbul

	Primary Education		Secondary Education	
	Number of Schools	Number of Students	Number of Schools	Number of Students
Turkey	34,093	10,870,570	8,280	3,245,322
Istanbul	1,576	1,826,075	982	596,400

Turkey is a disaster prone countrywith elevated potential fora wide range of geophysical hazards (Eryılmaz et al., 2006). Earthquakes are the principal type of disaster (İskender & Erdoğan 2007).In fact, direct and indirect economic losses due to natural disasters in Turkey cost approximately 3-4% of country's GNP (Şengezer & Kansu 2001).

Statistics show that between 1940 and 2000, out of 30% of all hydro-meteorological disasters,27% were due toflood, 27% strong winds, 8% linked to snowfall,2% tothunderstorms and1% attributed to heavy fog. Other disasterswere linked to a range of other catastrophic weather related events (Ceylan 2007).Overall, Turkey's highest risk lies with the potential for severely damaging earthquakes. Lossof life and property is commonplace when earthquakes occur, particularly in urbanised areas. Between 1900 and 2000, 130 earthquakes with a magnitude equal to, or greater than 5.5 on the Richter scale were recorded. More than 110,000 people died, 250,000 people were hospitalised and 600,000 buildings badly damaged or collapsed entirely (Erdik 2006).

Climate Change and Turkey

From the mid 1990s,various studies exploring arange of possible effects that could be triggered or exacerbated by achanging climate were undertaken in Turkey. In response, the Government of Turkey formed the First National Communication on Climate Change. Based on the first set of published findings from the First National Communication on Climate Change (Ministry of Environment and Forestry 2007), precipitation was predicted to decrease along the Aegean and Mediterranean coasts and increase along the Black Sea coasts with widespread increases in summer temperatures in the near future. Most affected areas were pointed out as being those located in western and southwestern parts of Turkey. Coastal erosion, flooding and inundation along Turkish shorelines were noted aspotential hazards, particularly in the middle and eastern Black Sea region.

In Turkey, greater emphasis is often placed upon the reduction of greenhouse gases rather than the underlying causes of climate change. To address this, various legislative changes have been made. Many educational activities have recently been advocated and implemented throughout schools. The Ministry of Environment and Forestry are responsible for legal arrangements with respect to the environment at the central level, whereas other ministries have roles related to climate change in their own municipalities. At the national level, policies for the environment and climate change are produced in the form of "Five Year Development Plans", prepared by the Prime Ministry State Planning Organization. The last development plan included the setting up of an Environmental Special Expertise Commission and the recommendation of forming a national operation plan in line with the UN Climate Change Operation Plan, which focuses on pollution prevention rather than pollution control (Ministry of Environment and Forestry 2007).

The importance of mitigating climate change and provision of climate changeas an educational subject has increased since the early millennium. This is largely due to the amendment and adaptation of environmental laws in line with European Union practices. Various training schemes, workshops, seminars and other activities have been carried out to increase awareness of climate change among the community. There have also been many meetings and other types of events to reach all concerned stakeholders in Turkey. Unfortunately, the number and type of public awareness campaigns were constrained by various limitations including funding.

Nevertheless, the Ministry of National Education has undertaken the role of promoting environmental education. Environmental education has been included in the National Curriculum at various levels of the national education system. At the secondary education level,environmental education in the context of climate change has been included and at the primary education level, a compulsory one-hour a week lesson has been incorporated. Climate change has also been a subject explored and advocated via vocational training programmes. For teachers, some in-house training courses have been conducted. Additionally, some non-governmental organisations serve as stakeholders in teaching environmental issues in schools. Non-governmental organisations also work not only with the Ministry of National Education but also with local governments at the district level. They deliver training and seminars to students and teachers and distribute a range of support materials for teaching, including storybooks, painting books and games.

Conclusion

In Turkey, many progressive steps have taken place over the last few years with respect to raising awareness of climate change. However, despite positive moves forward and Turkey's increased adoption of EU standards, many challenges lie ahead. Climate change

in Turkey is a relatively modern issue that has recently gained increasing prominence, particularly, in the context of a stand-alone subject within the national educational system. Climate change is also becoming a popular issue among communities, which has its advantages and disadvantages. Principal advantages arisewhen primary stakeholders (for example, a community)become more open to participation within educational programmes that children are taught.On the other hand, various projectsimplemented without engaging primary stakeholders, have been hampered by top-down, non-participatory delivery of climate change education to students.

Animportant factor is that in certain parts of Turkey, other types of hazards are considered by communities to have greater priority than climate change. Thus, it might be difficult toinvolve and engage with some communities. Integration of climate change issues within hazard training and/or educational programmes may provide a solution in the short term. The involvement of all stakeholders, as well as the cooperation and coordination of all, is crucial in ensuring the efficacy of climate change education. As such, it should be questioned whether enough cooperation and coordination exists among all stakeholders within the realm of climate change education.

Another challenge is the level of consistency in terms of what students are taught and whether learning is consolidated at home, supported or abandoned. For instance, students generally learn about a host of preventative actions and fundamental measures that can be applied to mitigate climate change. However, at home students may be discouraged in the application of newly acquired knowledge,as parents, for instance, may not have the same level of awareness as children.

To conclude, it can be said that although many steps have been taken to standardise and improve the delivery of climate change education for students, it remains a new topic and still has room for improvement. Established, effective and well-delivered subjects, particularly earthquake education,can be used as models of good practice for improving the design and delivery of climate change programmes.

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Two Approaches to Disaster Education

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Introduction

This paper outlines two distinct approaches to disaster education, namely independent and holistic. Ituses examples of disaster education in Japan and the United Kingdom. Based on these examples and in light of the likely increase in the risk of hazard events associated with climate change, the paper explores how two very different approaches might be applied to pre-disaster planning and the mitigation of disasters.

The Challenge of Climate Change

Numerous internal and external factors drive climate change. Global warming, in the context of 'natural', ongoing environmental change, independent of human activity is considered as an internal factor. In contrast, accelerated global warming resulting from, for instance,industrialisation that leads toincreased levels of greenhouse gases emissions (GHGs),is considered as an external contributory factor. Relationships between internal and external factors are not always transparent, especially at thelocal scale. It also remains difficult to project impacts resulting from climate change, although recently, the Fourth Assessment Report of the IPCC suggests that an increase in severe climatic events around the world, especially, the frequency of heavy precipitation events is likely.

There are significant differences between the causal mechanisms of climate change and natural hazards. Anthropogenic mechanisms triggering accelerated global warming can arguably be mitigated. Conversely, many natural hazards cannot be easily mitigated, nor is an increase in natural disasters necessarily attributable to peoples' activities. In the global sense, climate change is more open to effective pre-disaster planning than other environmental hazard risks.

Two Approaches to Disaster Education

As mentioned above, there are two distinctively different approachesto disaster education, one being independent and the other, holistic. The independent approachfocuses onan individual hazard risk, which is taught separately. This is particularly common in Japan and the United States where, for example, dangers of hurricanes and typhoonsare generally taught as separate subject matters. Earthquake training is also delivered separately.

The holistic approach, in contrast, is when the issue of risk is presented as arange of issues that people may face. In doing so, this approach aims to bring together a range of aspects that may affect livelihood security in any given disaster situation, within a broad and inclusive framework. Consequently, the spotlightis placed upon vulnerability of socio-economic systemsin that consideration is

given to the rate of exposure to, and the risk of, a wide range of hazards. Thus, risk can be viewed as a consequence of natural and/or technological hazards. For example, an every day risk such as a traffic accident,though considered a technological hazard, when considered within a holistic framework, is considered in parallel to a range of factors. This is because an accident may be exacerbated by either a singular factor, or any numberof factors including perhaps,road conditions to road type. The contextualisation of risk as a holistic problem is organic in that it develops over time, being both pre-emptive and responsive. Pre-disaster planning that includes the role of emergency services(also known as Blue Light Services) is common when using the holistic approach. This kind of pre-disaster planning is operational in the United Kingdom and generally includes awareness training,is integrated within educational programmes as well as business continuity planning.

In Japan, most schools have an independent approach to risk that emphasises risk in the form of singular events. For instance,disaster training is often provided in the form of evacuation drills. Some schools are trying to adopt a more holistic approach as exemplified by the "Ozone Rescue Troop".

Ozone Rescue Troup, Japan

What is the "Ozone Rescue Troop"? Ozone is a local name given to the city of Nagoya. Nagoya is currently under threat of a large earthquake, widely predicted to strike in the near future. The Ozone Rescue Troop delivers disaster educational programmes to junior high schools in Ozone/Nagoya on earthquake dynamics. However, lectures differ from traditional training programmes in that counter-measures in pre-disaster planning, discussion of post disaster relief, rehabilitation and reconstruction are thoroughly explored. Lessons involve a series of learning tasks, whichare undertaken in participation with the local community. Educational practice using the Ozone approach includes mapping household vulnerability, disaster reduction mapping, demonstration of rescue procedures, and briefing on resources,where evacuation centres are, as well as when and how to use them.

Household vulnerability mapping entails conducting safety assessments of houses and providing recommendations to reduce any identified risk/s. Household resources including water, food and portable lighting are also assessed with a view to finding the best possible way to preserve essential resources and access in the case of an emergency. Self-help is advocated. For instance, the practice of building 'safety-hoods' on homes that protect people from falling masonry is actively encouraged. Additionally, disaster reduction mapping (which involves identifying and quantifying levels of risk)looks at entire communities rather than relying solelyon individual households.

Training delivered to rescue groups has a great emphasis on life saving intervention. Aside from training given to save lives, training is also provided in terms of operational logistics, how services are provided in hospitals and other emergency institutions. Students are thus exposed to a range of scenarios and trained in aspects including:conducting patient logs,first aid, reducing trauma levels of individuals and communities, through to wide scale, community epidemiology.Students are given the opportunity to familiarise themselves with the layout and provisions available at existing evacuation centres.Students in each local authority also survey and conduct appraisals of evacuation centres available to residents.

The Holistic Approach – A UK Case Study

The holistic approach to disaster education was explored in a series of seminars held in Edinburgh, Newcastle and London in 2007. It was shown that in the United Kingdom, generally, a cohesive and generic approach had been adopted by both teachers and external representatives of the Blue Light Services, particularly, the Fire Service in the delivery of risk-training programmes.

A case study of St David's Primary School, Edinburgh,revealed that courses were designed to meet specific learning outcomes for different age groups. The main themes, learning objectives and outcomes of educational programmes delivered to students of St David's are detailed below.

For P1/ P2 (5/6 years old) a range of issues were raised including:

- What causes fire?
- How can matches be dangerous?
- What should we do if our clothes go on fire?
- What action should be taken in the event of a fire?

For P3/P4 (7/8 years old)a different set of questions were raised which implied that children at this age were better equipped to comprehend and follow through a range of actions that should be taken in the event of a fire. Questions included:

- Where should we go if fire strikes?
- What can help us get out of a building?
- How can we detect smoke quickly?

For P5/P6 (9/10 years old) discussion moved from a focus on fire in school to outside, including the home. The aim of exploring incidents that could occur outside the school environment was to better equip students to deal with and think of a range of alternative evacuation procedures. At this level, exploration of a range of options is undertaken with a typical question being:

- What would we do in the event of a fire in our home?

Plate 1 A Firefighter Addressing School Children

Plate 1 shows P5/P6 children exploring a range of hazards that couldpotentially generate significant fire risks.

At P7 (11 years old) focus is on learning by doing. By visiting the Risk Factory, students learn about both general risk and evacuation procedures but also about specific hazards related to individual commercial activities. The range of scenarios investigated includes: Police, Home, Water, Electricity, Building Site, Farmyard, Fire, Railway, Transport, Road and Internet.

Plate 2 The Risk Factory Building

Plate 3 Road Safety Instruction

Plate 4 Demonstration of High Risk Wiring

Plates 2 to 4 show the Risk Factory visited by P7 students.

How Can weReduce Impacts of Climate Change through Disaster Education?

It has been demonstrated that a holistic approach to disaster education may involve exploring vulnerability by location demographic profile assessments and appraisal of the socio-economic status of an area in question,using both adaptation and mitigation measures. In developed countries, retrofitted technologies can be used in disaster education programmes to illustrate how the impact of climate change can be reduced.

Although the Kyoto Agreement focuses on techno-centric approaches in dealing with environmental risk, considering the increasing likelihood of disasters as a result of anthropogenic climate change, the need to raise awareness of adaptation processes, including coping mechanisms at the local level,is as essential as mitigating hazard risks at local and national levels. As mitigation, generally requires technological input, which is typically out of the reach of developing countries reliant on knowledge transfer from the North, there is an urgent need to explore adaptation planning within a structuralist framework of disaster education.

Spatial Assessment of Risk of River Flood in Dhaka City, Bangladesh

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Introduction

Bangladesh is one of the most seriously affected developing countries in the world in terms of flooding. Frequency of floodingis likely to rise and become increasingly hazardous with the onset of climate change. Until recently, many assumed that floods could be prevented by building higher and stronger embankments. In the past, flood inundation maps were used as a basis upon which safety levels were defined. A methodology based on the recurrence periods of floods resulted in the creation of flood maps. Presently, water management begins by lookingat where flooding occurs and uses this informaiton as a foundation for predicting where and to what extent flooding may occur in the future.

Providing complete protection against flooding in Bangladesh is not socially justifiable (as it would involve the resettlment of thousands of poeple), and due to the low-lying nature of land, itis not technically or economically viable.Investments in water policy are still necessary but water management is no longer limited to flood prevention at anycost.

Modern water management approaches aim to limit damage by ascertaining risk. Dhaka, the capital city of Bangladesh is surrounded by a network of rivers, which makes the city vulnerable to flooding. After the 1988 flood, the western part of Dhaka City was protected from river flooding by new embankments and raised roads (JICA, 1991; Khan, 2006). However, despite protective measures for Dhaka West, catastrophic floods in 1988 and 2004 affected both the protected western area and the unprotected eastern part of the city. The situation continues to deteriorate. In designing flood control measures reliant solely on old flood inundation maps, the absence of flood risk maps for reference and information provision generally constrains theefficacy and design of existing flood control systems.

To address the need to close theidentified gap, thisstudy aims at assessing flood risk caused by the Balu-Tongikhal river system in the eastern part of Dhaka City, which is

unprotected from river flooding. We present an approach combining flood frequency analysis, hydrodynamic modelling and GIS to assess the risk of flooding in the study area. Finally, damage risk costs of the study area for different return period floods have been calculated and outlined in this paper.

The Study Area

The focus of this study is the Balu-Tongi khal river system of the eastern part of Dhaka City. See **Figure 1**. The area of the basin stands 124 km2 within the study area and is bordered by Old Demra Road to the south, Progati Sarani-Airport road to the west, Tongi to the north and Purbachal to the east. Land elevation ranges between 0.5m and 7m (Public Works Datum).

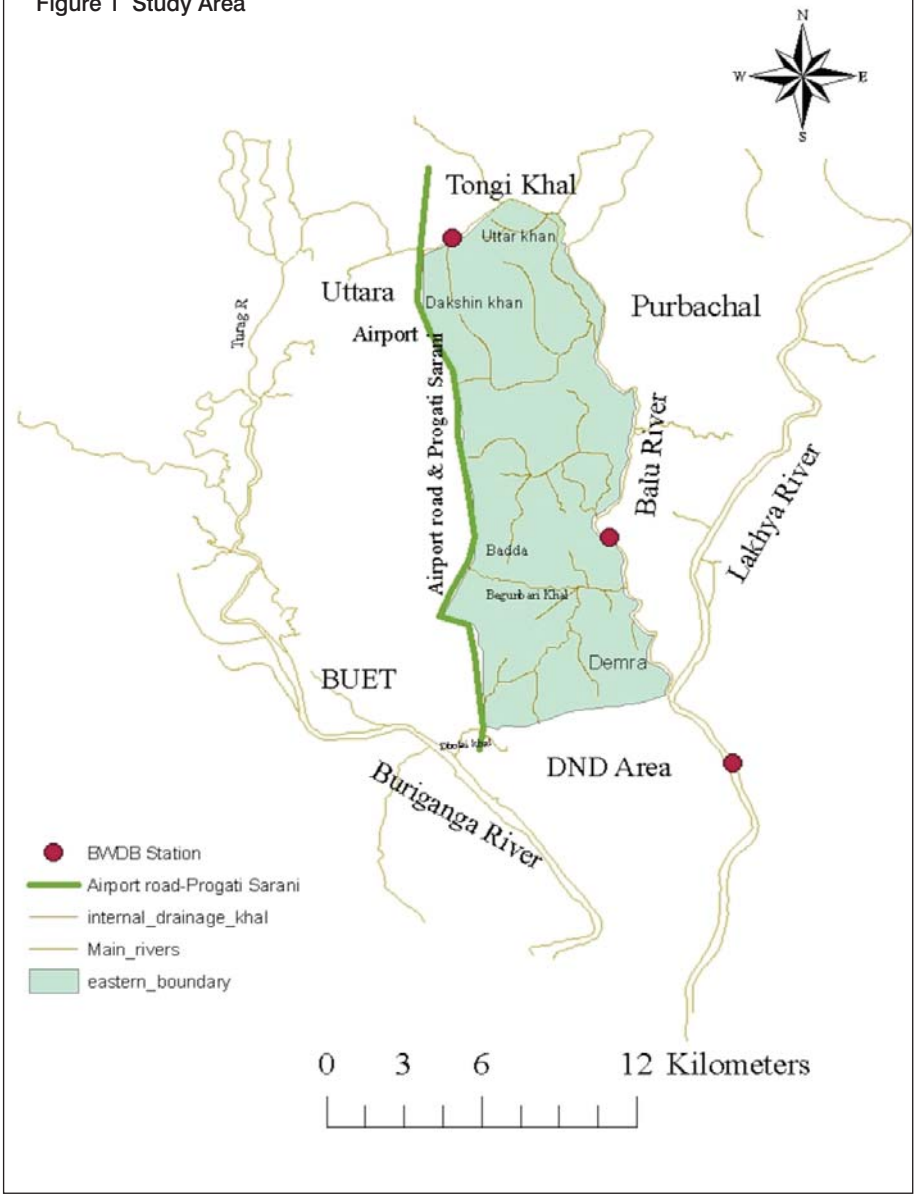
Methodology

The method was developed based on the use of hydrodynamic modelling (HEC-RAS) and Geographic Information Systems (GIS). It involves several steps: (1) flood inundation mapping using geo-informatics tools; and (2) the estimation of expected damage and risk in order to map flood events using GIS.

Data collection and pre-processing

Sources of information used for this study include water level and discharge records, topographic and land use maps, indicators of vulnerabilityand wealth(in the form of formulas) and given monetary valuation figuresfor land and property. Water level and discharge data was collected from three gauging stations managed by the Bangladesh Water Development Board

Figure 1 Study Area



(BWDB). Spatial topographic data was obtained from a wide variety of sources. A Triangulated Irregular Network (TIN) was developed using topographic data. By utilising bathymetric surveys, river cross sections of several locations were also digitised and used in the development of TIN. Ascertaining vulnerability via a formulaic function used by JICA (1991) which happened to be specifically applicable to and appropriate for the study area,was developed andincorporated into the study. The monetary value of specific land and property was collected from secondary sources. A primary survey was also conducted to collect data on the economic value of property.

Flood Inundation Mapping

All inundation mapping was accomplished using hydrodynamic model HEC-RAS, Geographic Information Systems and HEC-GeoRAS. In the study, HEC-GeoRAS created an import file from TIN, referred to herein as the RAS GIS Import File, containing river, reach and station identifiers; cross-sectional outlines; downstream reach lengths for the left overbank, main channel, and right overbank. After importing the GIS processed file into HEC-RAS, water surface profile calculations for unsteady flow were carried out. Standard hydrographs at upstream boundaries for various return period floods that were generated by means of non-dimensional or normalised hydrographs in combination with cluster analysis (Apel et al., 2006). In the unsteady flow calculation, these hydrographs were provided as an upstream boundary. In the downstream boundary, the rating curve was provided. For the subcritical flow with a small change in cross-section coefficients of contraction and expansion, assumed as 0.1 and 0.3 respectively. An initial flow value has been given at the upstream boundary of the channel Balu River and Tongi Khal.

The focus of this study is the calibration of Manning's roughness coefficients. Starting with roughness value estimates given in Chow (1959), flood data of 1988 was used for calibration of Manning's n. After several trials the best-fit between simulated and observed water levels was achieved using Manning's values of 0.040 for the left bank, 0.036 for the main channel and 0.041 for the right bank.

Using the calibrated roughness, HEC-RAS was run for thirty days with computational time intervals of 30minutes and detailed output intervals of one hour. The flood water levels obtained by the HEC-RAS model for various return periods were exported and overlain onto each cross-section of TIN for the study area. By using HEC-GeoRAS, extension of ArcGIS, raster based flood inundation maps of various return periods was possible via a cell size of 20m. The flood inundation map of 100-yr flood is shown in **Figure 2**.

Estimation of Expected Damage of Designed Flood Event

In the final step of risk assessment, the expected damage rate of inundated land types based on land use was estimated using **Equation 1.**

$$D = \frac{1}{T} \times Vul \times P \times A$$

Where *D* is the total direct property damage per cell of raster map, T is the return period of a flood event, Vul is the vulnerability value per cell which is function of Depth *(DP)* in metres and Duration *(DR)* in days of inundated land use categories, *A* is the area of each cell in m^2 and P is the property value in monetary terms of each cell. For the vulnerability function,*Vul*, is the depth-duration-damage function of the study area developed by JICA (1991) which was incorporated into the study. The function is shown in **Equation 2.**

$$Vul = \frac{a + b_1 \times DP + b_2 \times DR}{100}$$

Where a, b_1, and b_2 occur, these are the regression coefficients of the JICA (1991) study. Land use and property value, P was collected from respective Government and Non-Government authorities for the study area. For validating property value, a quick survey was conducted in the study area and finally land useP was selected. For area *A*, $400m^2$ was given as every grid size being 20m. For each coefficient of the function, grid-based raster map was produced in the extent of flood inundation map. Then using the vulnerability function in raster calculator of ArcGIS, a vulnerability map for designed flood was produced. Using Equation 1, raster-based expected damage map or risk map was also prepared with the help of the raster calculator of GIS. For a risk map, see Figure 3. Finally, expected annual damage cost was found by taking the product of the probability that an event of magnitude will occur in any given year, and the damage that would result from that event, and integrating both for the design level. Then, damage risk costs for different design return floods were calculated and shown in **Figure 4.**

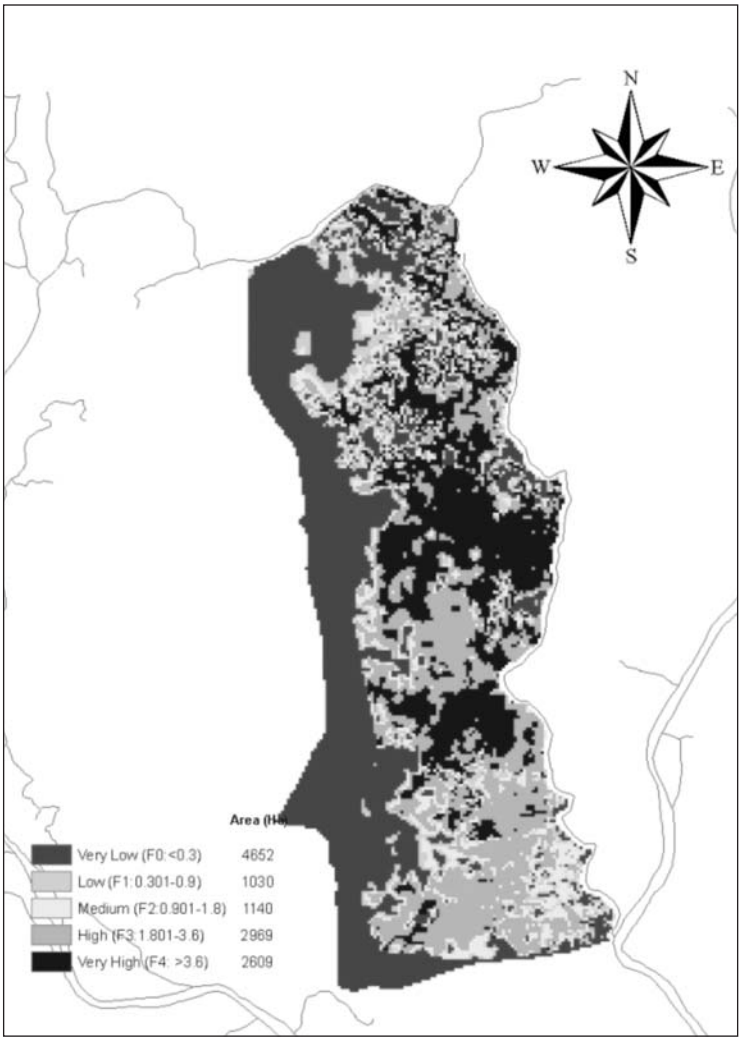


Figure 2 Flood Inundation Map of 100-yr Return Period

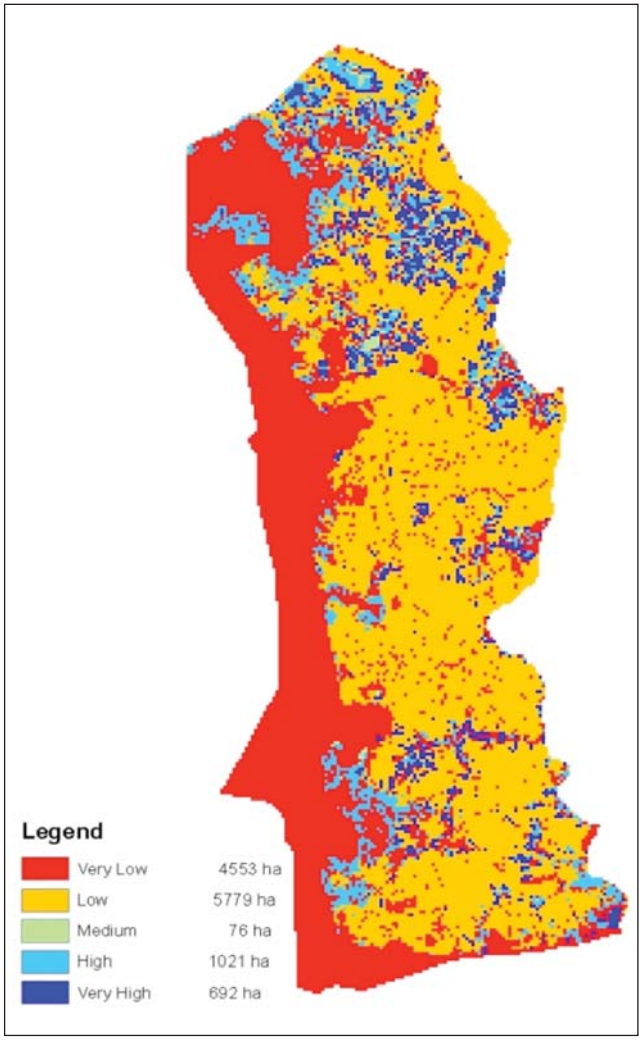


Figure 3 Expected Damage Map of 100-yr Return Period Flood

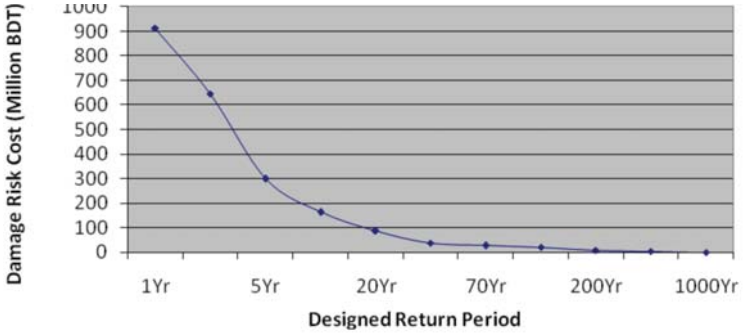


Figure 4 Damage Risk Costs for Different Return Period Floods

Table 1 Area Occupied by Various Risk Classes

Expected damage class or risk class	Expected damage value (BDT/cell)	Area covered (ha)
Very Low	< 19.50	4553
Low	19.50 – 20.00	5779
Medium	20.00 – 100.00	76
High	100.00 – 350.00	1021
Very High	> 350.00	692

Discussion

In the expected damage map **(Figure 3)**, expected damage value (BDT/cell) is classified into five defined classes, which indicate levels of risk of the study area. These are detailed in **Table 1**. The area occupied by different risk classes is also shown in **Table 1**. From **Figure 3**, it is evident that the risk class of 'Low' covers most of the study area. The land use category defined as agriculture, fell under the risk class that is very much susceptible to damage. Yet, this zone falls under the lowest expected damage value because economic value of agricultural goods is very much lower when compared to the value of other land use classes. Risk class 'Very Low' presents the lowest expected damage value because the area is occupied mostly by open water or open space. Conversely, 'Very High' risk zones indicate where land is categorised as having the greatest economic value but recognised as themost vulnerable area in terms of possiblefiscal damage (these high risk zones cover 692 ha of land). **Figure 4** illustrates that with the increase of designed return period damage risk costs are reducing.

Conclusion

In comparison to classical inundation maps, flood risk maps generate more information about flooding events because they account fora range of potential effects of flooding(for example, risk maps may facilitate economic loss projections in target areas). Planners and decision makers may find results of this study useful for framing an appropriate flood risk management plan in the eastern side of Dhaka City.

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An Emerging Geospatial Database for Biodiversity and Climate Change Studies – Indian Preparedness

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Introduction

India's richness in biological resources and related indigenous knowledge is well recognised. In India, formal policies and programmes for conservation and sustainable utilisation of natural resources date back several decades. Concepts of environmental protection are enshrined in Articles 48a and 51a(g) of the Indian Constitution. Conservation and sustainable use of biological resources based on local knowledge, systems and practices are also ingrained within Indian culture. Despite knowledge of biodiversity richness at the local scale, little is known at the national scale, as large information gaps exist. To date, approximately 65 percent of the total geographical area of India has been taxonomically surveyed. Over 46,000 species of plants and 81,000 species of animals wereclassified by the Botanical Survey of India (BSI) (established in 1890 and the Zoological Survey of India (ZSI), established in 1916 respectively). The Forest Survey of India, established in 1981, assessed forest cover, with a view to develop an accurate database for planning and monitoring purposes. According to an estimate, (BSI 1983) about 30 percent of all identified plant species are endemic to India. The mountainous region of the Eastern Ghats has also been identified as being particularly rich in endemic species (MacKinnon and MacKinnon 1986). AProject on Study, Survey and Conservation of Endangered Plants (POSSCEP) estimated 3000-4000 plant species as being under varying degrees of threat. Additionally, the red data book of the International Union for the Conservation of Nature and Natural Resources (IUCN)lists and categorises many plants and animals occurring in various parts of India (Nayar and Shastri 1987).

In India, the Ministry of Environment and Forests has recently launched a project to document the country's rate of biodiversity with the aim of developing an action plan to protect India's biodiversity, known as the National Biodiversity Action Plan. In other recent attempts, biogeographical regions of India have been mapped into ten zones. The Wildlife Institute of India has detailed these regions on the Survey of India (SOI) digital database. An established method of biodiversity conservation is the protected area concept, which lacks many integral components. Most cases of biodiversity loss in India have been attributed to habitat loss, over exploitation, the introduction of invasive species and lack of any national land use policy. Accordingly, it isimperative that a concerted effort is made to ascertain India's biodiversity,spatially and temporally.

Emerging geospatial databases

The climatic control of forest vegetation is well documented (Mueller-Dombois and Ellenberg 1974). Physiography, topography, climatic variation and human intervention largely influence the distribution of vegetation and biodiversity. Developments in remote sensing, GPS, GIS and communication tools enable the integration of spatial and non-spatial information for defining habitats and improving vegetation type descriptions in space and time. A review of GIS and databases for vegetation mapping and monitoring outlined by Skole etal. (1993). It is also possible to develop geospatial models using multi criterionto map disturbance regimes and landscape diversity. Landscape ecology has evolved in line with geospatial modelling techniques. The advantage of having increased access to information, modelling, and visualisation tools at the finger tips of a user aids the advancement of science, accelerates the discovery process, and enhances the quality of science and education. Steps used in Geoinformatics for creating Biodiversity Information Systems are shown in **Figure 1.**

Geospatial Databases for Biodiversity and Climate Change Studies – Indian Preparedness

Vegetation Characterisation

Spatial information provides definitions of vegetation patches, which are related to phenological types, gregarious formations and communities occurring in each unique environmental setup. The temporal representation helps in monitoring landscape processes (Delcourt and Delcourt, 1988).

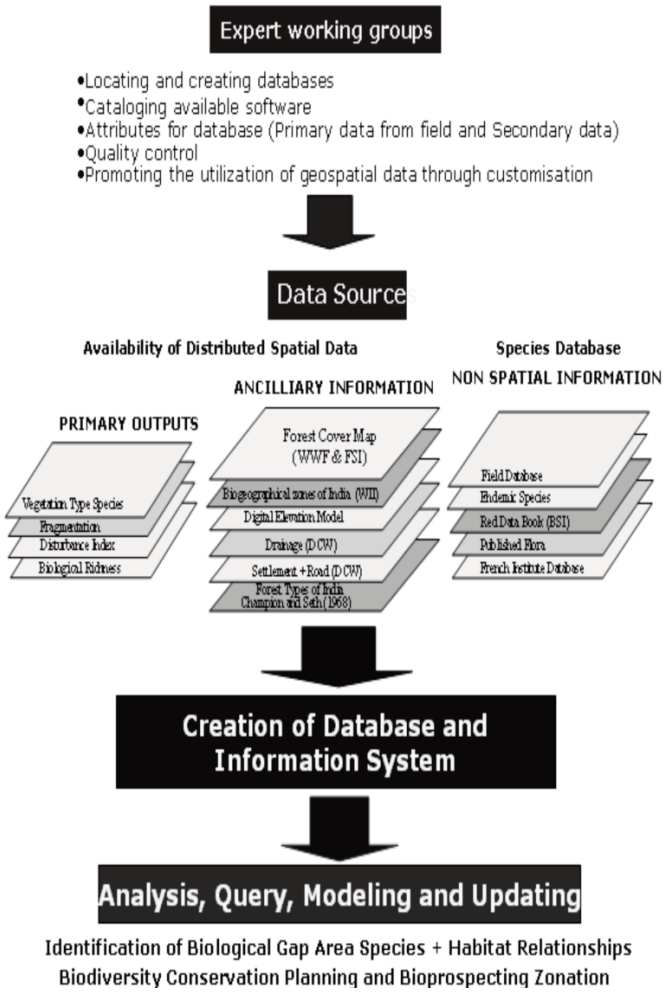

Figure 1 Geoinformatics for biodiversity information system – Indian context

Recent improvements in spatial resolution of the spatial arrangement of land cover and vegetation type aids clarification (Chuvieco, 1999). Biophysical spectral modelling techniques enable stratification of vegetation types based on canopy closure (Roy et al., 1996). Such approaches allow monitoring of forest conditions and degradation processes. Temporal SPOT Vegetation and Maximum Value Composite (MVC) of Normalised Difference Vegetation Index (NDVI) have been explored to prepare land cover maps (Stibig et al., 2007). Classifications are based on the Food Aid Organistion's Land Cover Classification System (FAO LCCS). In a similar attempt, monthly IRS WiFS data has been explored to prepare a vegetation type cover map of India (Joshi et al., 2006). These initiatives have been undertaken independently of the national forest cover assessment exercise. During 1983, assessment of the forest cover of the country, based on satellite data interpretation was one of the most important initiatives of the National Remote Sensing Agency (www.nrsa.gov.in). In India, the country's total forest cover assessment was first undertaken using Landsat - MSS false color data sets (from 1972-75 and 1980-1983 periods) to categorise forest cover into different density classes on a 1:1 million scale. From 1987, the Forest Survey of India (FSI) took over the task of providing biennial assessments (www.fsi.nic.in).

Landscape dynamics

In a study of Meghalaya (a state in north eastern India), satellite remote sensing using sources derived from vegetation and land use maps of years 1980, 1989 and 2000 were used to characterise land dynamics. A hierarchical geospatial model attempted to map the status of land dynamics over two decades (Talukdar 2004). Another initiative by Lele (2007) assessed forest cover maps over three decades for the entire northeastern region of India, in order to understand landscape dynamics and impacts of soil erosion processes. These characterisations provide valuable input to conservation, as the region is one of the largest biodiversity hotspots. The region is also facing severe human induced disturbances due to inappropriate and intensive agricultural practices, limestone quarries and timber extraction.

Biodiversity characterisation at the landscape level

Biodiversity characterisation at the landscape level was attempted in three phases. Phase I surveyed the northeastern region of India, the western Himalayan region, Western Ghats and the Andaman Nicobar Islands. Phase II looked at central India and the eastern coast of India. Phase III was executed in northwestern India and remaining parts of the country. The study is scientifically significant as large, diverse landscapes have been analysed spatially and results on fragmentation, disturbance regimes and biological richness were observed. Findings revealed that highly fragmented forests have fewer plant species, reduced evidence of human activity and newer community types than medium and low fragmented forests. This research concludes by highlighting that findings indicate that slow fragmentation produces a decreasing trend in plant species diversity. The landscape perspective is fundamental to understanding the role of disturbance. Disturbance regimes vary across landscapes as a function of topography and substrate. The study also looks at species niche modelling and habitat assessment of selected species.

Biodiversity Information System (BIS)

The Department of Biotechnology (DBT) and Department of Space (DOS) have collaboratively studied biodiversity characterisation. Main objectives of this project were to identify bio-rich areas, evaluate forest types for their value (in terms of biodiversity richness) and to provide location information of economically important species for bio-prospecting. The primary outcome of this project was to provide useful information to forest managers, decision makers and national institutes involved in genetic diversity and bio-prospecting. The Biodiversity Information System aims to provide user level information regarding biodiversity hotspots. It was agreed that in addition to biodiversity characterisation, information should be made available and accessible to aid decision-making, monitoring and management of various resources. It is for this reason that the Biodiversity Information System was conceptualised as a 5-component unit, namely: (i) BioSPATIAL (Biodiversity characterization at Landscape Level); (ii) BIOSPEC (Bio-prospecting and Molecular Taxonomy Programme); (iii) FRIS (Forest Resource Information System); (iv) PhytoSIS (Species Information System); and (v) Biocon SDSS (Spatial Decision Support System for Biodiversity Conservation Prioritization).

GAP analysis for conservation prioritisation

One of the most important components of biodiversity conservation in light of anthropogenic pressure and climate change is to maintain continuity of natural landscapes,

vital corridors and natural plant community settings. This approach will provide habitats to associated life forms - a basic requirement for in-situ conservation. Visualisation of the natural landscape model helps to simulate the association. Satellite imagesprovide vital information for spatio-temporal scenarios and help in simulating natural settings. Conserving diversity requires specific efforts to restore gaps created by natural or anthropogenic process. Overlaying habitat maps, biological richness data and existing protected area network information could show where gaps exist in landscape conservation. Such information is vital to policy makers and planners in developing networks of protected areas that represent all habitats.

Gap Analysis in forest stands - Spatial forest gap analysis allows spatial correlation between various sizes of canopy and indicates gaps in species richness. These canopy gaps are created due to natural processes of trees, disease damage or clearing of a single tree or group of trees. High resolution satellite imageryis of immense value in providing information on varying gap sizes, community structures and ascertaining whether alteration of forests have occurred as a result of natural or man made events. In-depth information in the context of identified gaps is thus likely to be of immense value, particulary, for instance,in programmes of reforestation.

Discussion

Ecological approaches in setting priorities for biodiversity conservation generally seek to protect most species within conservation areas that are representative of a region's natural habitat. Ecosystem approaches in identifying conservation priorities involve the use of numerous criteria such as species richness, endemism, abundance, uniqueness and representativeness. It also considers the physical environment, ecological processes and disturbance regimes that help to define ecosystems (Roy and Tomar, 2000). The conservation priority setting varies considerably due to the complexity of biodiversity and the number of ways of valuing it. Among the biological criteria are: richness (the numberof species or ecosystems in given area), rarity, threat (degree of harm or danger), distinctiveness (how much a species differs from its nearest relative), representativeness (how closely an area represents a defined ecosystem) and function (the degree to which a species or ecosystem affects the ability of other species or ecosystems to persist). Some priority setting approaches use social, policy and institutional criteria. Utility, the most common non-biological criteria, points to biodiversity elements of known or of potential use to humankind. Feasibility is often considered paramount in deciding how to allocate conservation resources. Geospatial tools can suggest actions that are most likely to succeed when taking into account social, political and institutional frameworks.

Goals and scales of inventory and monitoring programmes may change with time. Hence, the baseline data at landscape levels should be sufficiently robust to accommodate changes. It should be based on samples enabling calibration for future rapid biodiversity assessment. Landscapes contain all levels of the biological hierarchy, ranging from whole ecosystems to species and genes that are targeted for biodiversity inventories and conservation. This effort to characterise vegetation cover, fragmentation, disturbance and biological richness across landscapes is a unique initiative at the national level. The database is also organised in the form of a BIS. BIS enables the identification of gaps, species/habitat relationship and aids biodiversity conservation planning by setting priority areas. Such a database coupled with detailed site-specific field inventories provides valuable information on bio-prospecting.

Baseline information generated in the DOS-DBT project has relevance to the international programme on biodiversity conservation and management. DIVERSITA's (an international initiative on biodiversity assessment) issues focused on by DIVERSITA's core project on Global Invasive Species programmes (GISP) and the Global Mountain Biodiversity Assessment (GMBA) coincide with Indian initiatives, addressed by the Department of Space/Department of Biotechnology project (DOS-DBT). Biological diversity is considered essential for fully functioning ecosystems and this dependency is likely to increase as environmental conditions change. Changing environments, especially in mountains,combined with ever increasing changes and pressures on land use havecaused ecosystems in mountainsto rank among the most endangered landscapes, worldwide.

Finally, the emerging geospatial database provides a platform upon which to record these changes in space and time. Varied satellite systems allow the creation of an information base that can be applied at global, regional and local levels. The Indian Space Programme has developed indigenous, state of the art platforms, which ensure the continuity of data products. Landscape ecological concepts and tools for geospatial analyses, principally, GIS, have helped us to understand biodiversity distribution in regions across various spatial and temporal scales.

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A Changing Climate: Developing Community Resilience in the UK

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Introduction

In 2003 the UK government commissioned the Foresight Report (FR). The FR examined how the risk of flooding might increase. The report concluded that climate change could affect rainfall patterns, with a predicted 2 to 4 fold increase in the risk of flooding across the country over the next 100 years (Office of Science and Technology, 2004). The Stern Review, which examined the economics of climate change, suggested that the cost of flood events to the UK economy could rise from the current estimate of £1 billion to £27 billion by the end of the century. This could be reduced only with heavy financial investment (Stern Review, 2007).

Three major flooding events have defined the escalation of environmental impacts over the last decade, being the city of York in 2000, Carlisle in 2005 and UK wide flooding in 2007. The York flood event was considered to be large scale during its occurrence in September of 2000, affecting approximately 40 households (City of York Council, 2004).

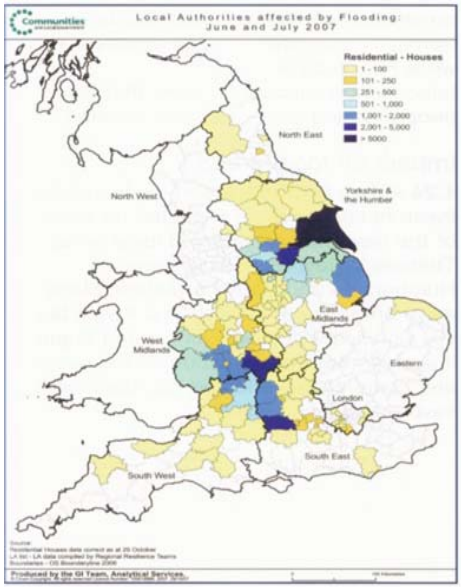

Figure 1 (The Pitt Riview, 2007)

The Carlisle flood five years later would redefine the thresholds for response requirements. The event resulted in 3 deaths, 1,925 flooded properties and the evacuation of 3,000 people. 1 year later, only 50% of people had returned to their homes. The financial cost was estimated at £6.7millon, but the cost of restoration is estimated to have reached £250 million (Cumbria Resilience, 2005).

The trend of larger scale flooding events and subsequent impacts escalated during the summer of 2007. The months of May, June and July were the wettest ever recorded with 111mm of rain falling over a period of 24hrs, at a rate 5.8 times higher than average for the month (The Pitt Riview, 2007). Flooding damaged approximately 55,000 properties. Emergency agencies responded but were overwhelmed by the scale and duration of support required. Figure 1 is taken from the Pitt Review 2007 and illustrates the main areas affected by the flooding.

In the northeast of the country, the city of Hull was submerged. Not only homes were affected. Of the city's 99 schools, only 8 where left undamaged. In central England the severity of the event resulted in significant damage to infrastructure, leaving 48,000 homes without power and potable water for periods of up to 17 days.(Severn Trent Water, 2007). 40 million bottles of water were distributed over an area of 3,150km^2 (Gloucestershire County Council, 2007).

In addition to flash flooding, temperature levels in the UK have been steadily increasing since records began in 1772. Temperatures have increased since 1980 by 1^o Celsius over each decade (**Figure 2** Parker & Horton, 2005). During August 2003, Europe experienced the hottest summer temperatures for an estimated 500 years (Met Office, 2008). Throughout June and August of 2003, temperatures were 20% to 30% above normal with a maximum of 38.1^o C. High temperatures caused extensive loss of life across Europe with an estimated total of over 30,000 fatalities. One of the worst effected countries was France with deaths in excess of 14,000. The elderly and vulnerable were at the most risk due to limited access to warnings and lack of suitable facilities (UNEP, 2003). Heatwave conditions also exacerbated forest fires and caused disruption to infrastructure, the melting of road networks and damage to power stations. The estimated cost from the high death toll and infrastructure damage is estimated to be in the region of €13 bn (UNEP, 2003). The UK experienced a 17% rise in the number of recorded deaths of elderly people. 2,091 of these deaths were attributed to complications directly related to heat wave conditions (Jonson, 2005).

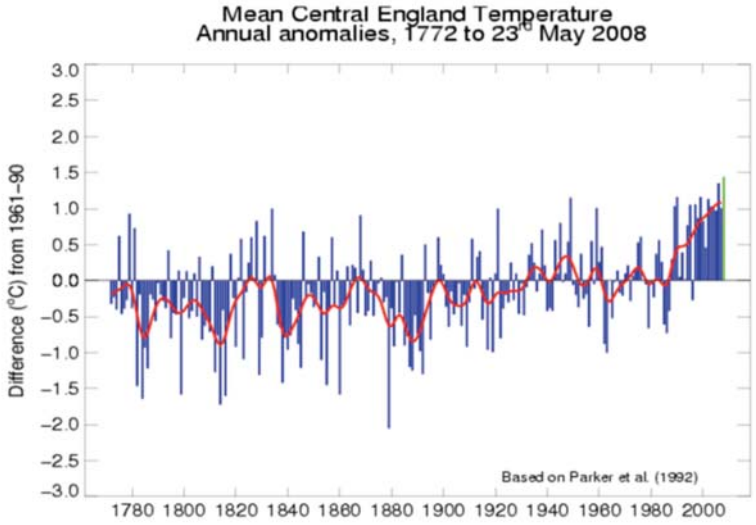

Figure 2 (Parker & Horton, 2005)

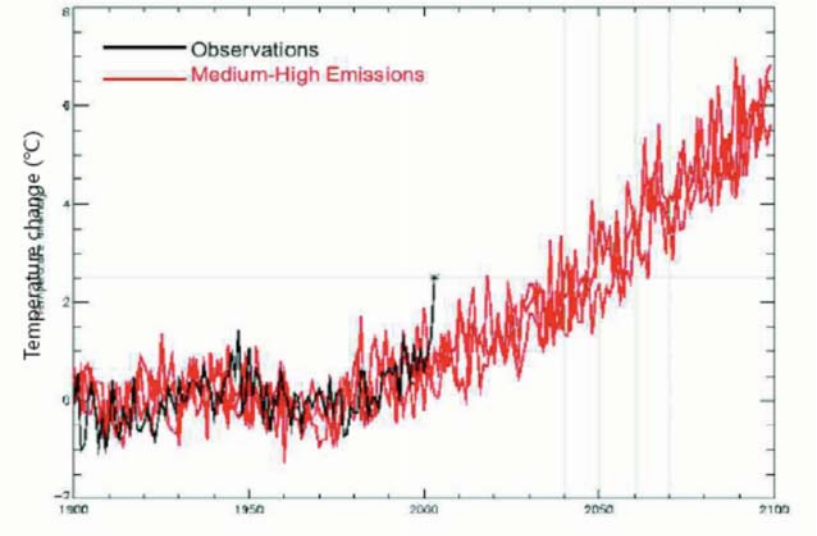

Figure 3 (The Hadley Centre , 2005)

A Changing Climate

In 2003, heat mainly affected vulnerable members of the population. Should temperature levels continue to rise, heatwave conditions will become more common. Figure 3 is taken from the research carried out by the UK Met Office Climate research centre (The Hadley Centre, 2005).

The changing climate introduces another potential risk to the UK. Increasing temperatures could lead to changes in ecosystem dynamics that are more favourable to non-indigenous species, which could change pest epidemiology (Walther, Post, & Menzel, 2002). This is a key concern for the risk of diseases that are transmitted by insects. For instance, gradual temperature increases have led to an increase in mosquitoes. This increases the possibility of emerging public health issues from viruses and parasites transmitted by mosquitoes and ticks (McMichael & Campbell-Lendrum, 2003). This could see the emergence of malaria and lyme disease. Suspected cases of each have already been found in Europe. Confirmation of an increase in the likelihood of infestation and subsequent disease are expected.

Climatologists are attempting to predict environmental conditions for the medium and long-term. Current predictions suggest that climate change will increase the frequency, intensity and duration of environmental effects. These changes have the potential to reduce early warning, overwhelm responder capabilities and reduce the time available for recovery. The UK has already witnessed the change from rapid onset to immediate onset events. For example, the village of Boscastle was destroyed during the 2003 floods. The same area was affected during the 2007 flooding, as restoration activities were underway and subsequently destroyed. (Environment Agency 2004).

Emergency Response

Emergency preparedness measures in the UK are based upon risk assessment. Legislation requires emergency responders to work together to identify localised risks. This process is undertaken by compiling risk registers. Identifying the impacts and likelihood of potential hazards drives mitigation activities in a given area. Through risk assessment at national and local levels, UK response agencies have also been able to determine planning requirements. However, the process of risk assessment captures current hazards and does not incorporate forecasting for longer-term risks. As risk assessment relates to a specific point in time and its supporting data is based on historical evidence of events in the area, the process remains reflective. Assessments also include those hazards, which are generic, or are not tied to any geographic area, for example, major storms,human pandemic or major fires. The process is considered to be incomplete in its aim to determine preparedness requirements for the area.

With any large scale disaster or emergency the identification of those who are particularly vulnerable before, during and after the incident is critical. Those categorised as being more vulnerable are considered to be at greater risk. A key characteristic of vulnerability is the level of dependency of an individual or family. Those that rely on local government, voluntary agencies and extended family support on a day-to-day basis are more likely to require additional support during and after an emergency or disaster. Community preparedness in the UK as a whole is significantly under developed. This is compounded by the false assumption that emergency responders have the capacity to manage all impacts of an event. Public opinion places sole responsibility for disaster mitigation upon the responding agencies, and little to none on individuals, families and communities. Informal support mechanisms are only tested in the event of an incident and are often insufficient in their capacity to assist.

Hazard and Vulnerability in Communities

As there is limited experience of large-scale events in the UK, many of the population are complacent about their level of vulnerability. For communities to be more resilient, greater awareness of hazards and details of how to be prepared for their effects is required. To be effective, groups must be targeted to make information appropriate and relevant. In Hounslow, studies have been undertaken to identify indicators of vulnerability within a given area, as current risk based planning does not incorporate characteristics of vulnerability.

A vulnerability assessment includes those elements of an area that relate to the status of the community in question. These elements are categorised and divided into health, social, economic and environmental indicators to adequately illustrate the degree of vulnerability in a given area. **Table 1 (page 62)** outlines categorised vulnerability indicators.

Table 1 – Vulnerability indicators by category

Social vulnerability	**Definition**
High proportion of those who do not speak the local language	Inability to understand early warnings, mix with other groups and communicate
High proportion of transient/internal migrant population mechanisms in the area	Unaware of local hazards, unlikely to have family or support
Extremes of population density	Extremes of population. Either areas of high density or low density
Lack of education	Effects peoples ability to understand impacts and access information
Low number of voluntary organizations	Lack of social support
Lack of access to transport services	Inability to move freely, for example to find work and access support
Environmental vulnerability	
High proportion of the area is developed	Increased likelihood of surface water flooding
Large number of manufacturing sites	
Low proportion of exposed ground increasing likelihood of doubt.	Less ground available to retain moisture in the soil. Thus
Economic vulnerability	
Large proportion of the local population employed in one industry/organization	If the business is disrupted a large proportion of people may become unemployed
Lack of access to funds (credit, savings, employment)	Poor means of financial support following a large incident
High number of independent businesses/sole traders	Loss of customer base and supply disruption forcing closure
Large proportion of the local population employed in the local area	Local unemployment
Health vulnerability	
High proportion of people living with a long-term illness	Greater support required
High proportion of disabled people	People may be at increase risk because of their disability
Low proportion of health facilities	People unable to easily access medical support
High proportion of elderly/infirm	Large at risk group

Many diverse communities populate the London Borough of Hounslow. The estimated population is approximately 220,000. Of this number, 29.2% were born outside of the UK. Statistics show that the population is mainly white British comprising64.9%, which is significantly lower than the national average of 91.3%. The second largest ethnic group is from the Indian sub continent, being 29.6%. The four main religious groups are Christians, Muslims, Sikhs and Hindus. Areas in Hounslow differ too. Some areas are considered affluent and others deprived.

Often these two groups live very close to one another. In order to better understand where key areas of vulnerability are located, different factors were mapped. For example, multiple deprivation indicators (which combinesocio-economic data to provide an indicator of poverty) were used. Darker areas indicate higher levels of deprivation. See **Figure 4**.

Maps were prepared taking into account a number of factors that could represent vulnerablity in its different forms. The

current version of the vulnerablity map contains 5 indicators: (i) those with a limiting long-term illness; (ii) those seeking employment;(iii) indices of multiple deprivation; (iv) population density; and (v) age. Age data includes children under the age of 5 and adults over 70.

Each vulnerability indicator was ranked. Darker colours occur where a number of different indicators rank highly in that area. Maps only indicate areas of increased vulnerability but greatly assist targeted planning. The method can also be used for mapping vulnerability to a particular hazard. For example, mapped areasshowing concentrations of elderly and the very young could be useful for emergency response

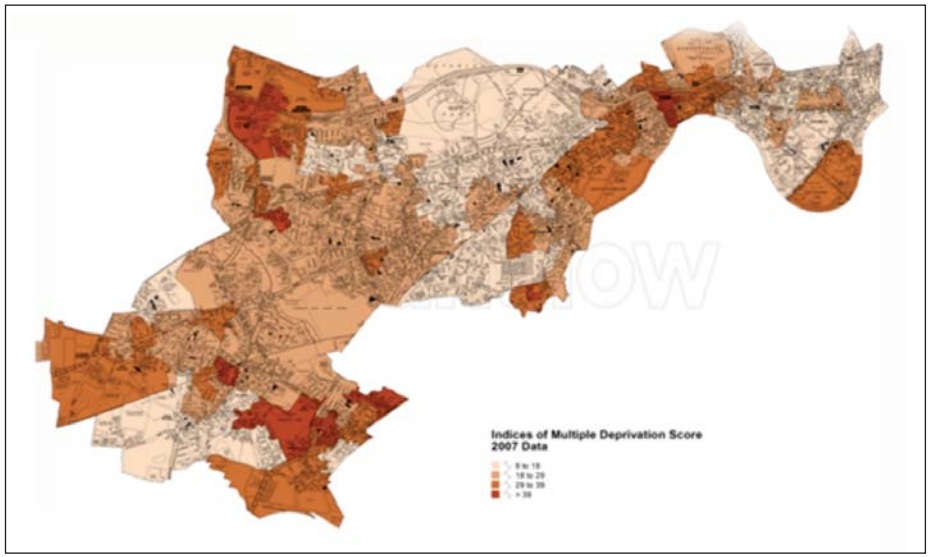

Figure 4 Incides of Multiple Deprivation 2007

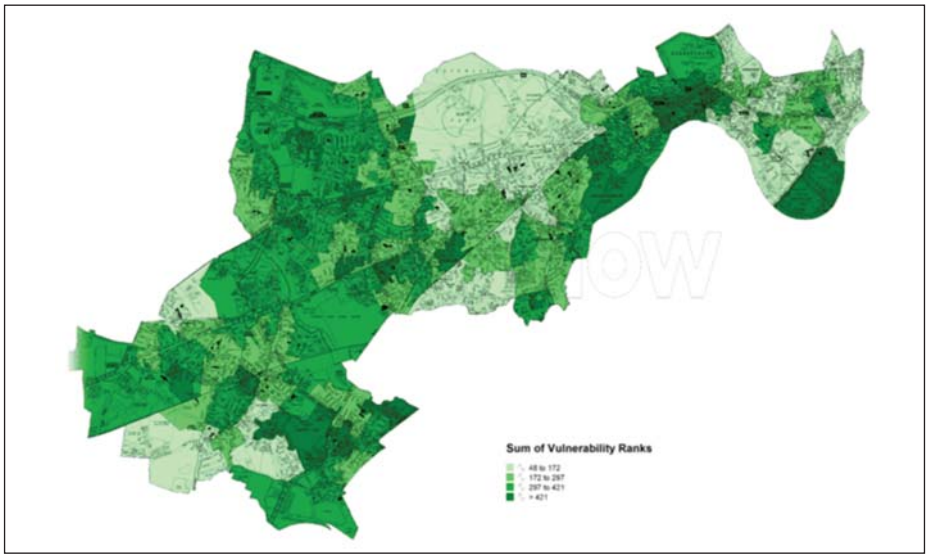

Figure 5 Emergency Planning Vulnerability Map

during severe weather events and useful for pre-disaster planning and training.Once areas have been identified as being more vulnerable they can be targeted, with different methods for raising awareness. This could be in the form of a media campaign, or by visiting community groups and schools in a given area.

The process of hazard mapping is well established throughout the disaster management discipline. Maps have been successfully used to engage at-risk populations in preparedness activities. Using the same process in identifying the degree of vulnerability for a given area, we applied a rank system of grading local geographic risks. **See Figure 5.**

Populations are more likely to prepare for one type of hazard if given a map indicating singular hazards and/or riskswithin given areas. Whilst beneficial, this is not the aim of the process as raising resilience to all hazard types is the primary and long-term goal. Information on hazards needs to be accessible to all regardless of education or cultural backgrounds.

Providing an image of combined multiple hazards allows populations to relate to dangers in the vicinity of their home and workplace. Types of hazard in Hounslow include floodplains, flash flooding, large industrial sites, high-pressure pipelines and potential aircraft accident risks (all of Hounslow is under the flight path of Heathrow airport). These were rated according to probability and mapped over the area. **Figure 6** shows the Hounslow hazard map. Where hazard areas overlap the colour is darker.

The vulnerability and multiple hazard maps were combined to produce a risk and vulnerability map. As with the previous maps, the darkest areas are where there is highest vulnerability but this is combined with highest risk levels. This type of information allows target planning of the most at-risk groups. The combination map is not meant for public use but as a tool to aid planning. However, local knowledge shows that the map has enough accuracy to be used as a planning guide. This exercise could also be carried out post disaster, with data collected from a community impact assessment. This data can be used to produce dynamic vulnerability mapping, allowing for better allocation of resources to the most at risk groups/areas.

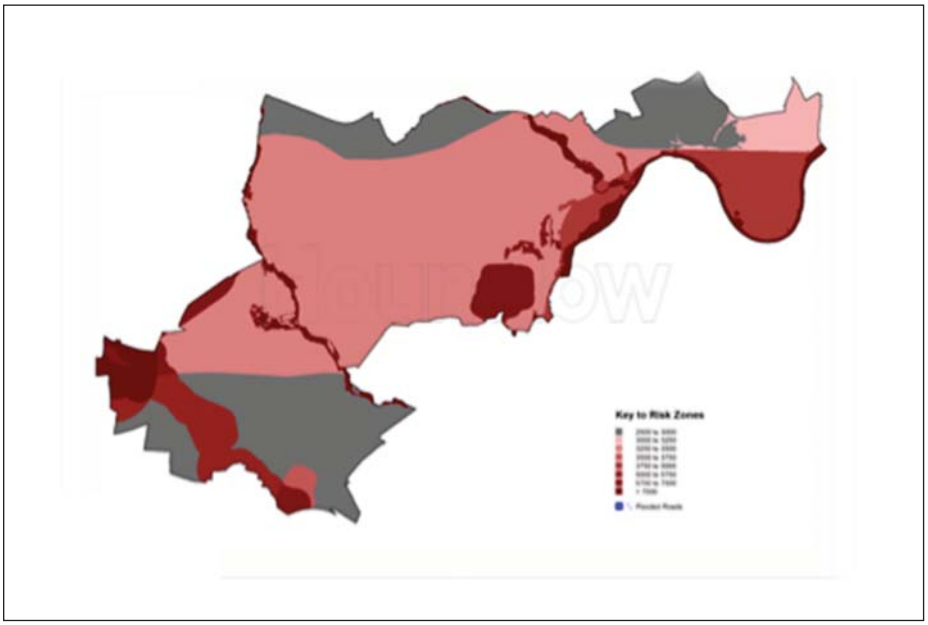

Figure 6 Hazard and Vulnerability Map 2008

Conclusion

People are made more vulnerable not only by their ability to cope with a large incident, but also the means by which they have to recover from it. Individual, family and community characteristics of vulnerability do not change significantly when based on the hazard type. If you are poor, you are vulnerable to any natural hazard event occurring in your area. If you are disabled, your ability to take necessary action following an early warning will be limited. The level of vulnerability (post incident) will be determined by the severity of the event in question. By identifying the characteristics and levels of vulnerability pre-event, our

ability to reach and maintain a consistent level of resilience is improved.

To build a resilient community, an indicator of resilience is required. To achieve this, a combination of different factorsis required in order toevaluate the state of a community's reslience. The UK's Place Survey assesses perceptions and the understanding of response and resilience measures across the country. Although useful, additional measurements are essential for identifying levels of preparedness. For example, the number of people from a given area that have signed up to volunteer schemes, the number of and attendance at community meetings, subscription to early warning systems and so forth.

Through enhancing the provision of emergency management materials to schools, both short and long-term resilience is improved. By ensuring that educational material applies to all school children and making the content specific to the local area, the information is more likely to be retained and applied within the home environment.The insurance and financial services sectors can also play integral role with respect to individual and familial resilience. Business services can act as a regulator for resilience measures by, for instance, requiring risk reduction measures to be implemented before home loans or insurance certificates are awarded.

New approaches in the UK focus on incorporating emergency response and communications networks into all voluntary and community groups at the local level. For emergency management to be effective within communities it must become a regular occurrence, for information to be retained and to maintain accurate, up to date skills, a level of familiarity with procedures needs to be refreshed at frequent intervals. Conversely, a community group dedicated solely to emergency management would encompass limited areas of the community and could be inactive for long periods of time, leading to reduced interest and commitment. The purpose of any group and its contribution to the community should be assessed focusing on what are the positive and negative consequences of resilience building within a community and how normal activities may be affected. This should lead to an impact assessment of the potential areas of influence of a group or committee. At regular intervals emergency management should be discussed highlighting predicted hazards, changes to community structure or procedures and seasonal differences.

Subsides and grants to local voluntary groups and committees should be issued with conditions which enhance resilience. Community engagement incentives can be offered to individuals who promote an understanding of the hazards and vulnerability of the area in question.

A changing climate presents the UK with an increased risk of extreme events. These events will have a long-term effect on people and communities. There is little that can be done to reduce the probability, severity and extent of environmental hazards occurring. Efforts are better placed in ensuring that all communities have an adequate level of resilience. Changes in social patterns have traditionally moved at a faster rate than changes to environmental conditions. Social characteristics are also easier and more cost effective to assess than environmental conditions. Planners can do little to change the environmental conditions that are expected. However, there is the opportunity to change social conditions through enhancing resilience measures. Our ability to change social patterns is better than our ability to anticipate and mitigate the effects of climate change. Reducing vulnerability and improving the resilience of individuals and families through their communities provides long-term benefits both for disaster management and social cohesion. Resilience provides the ability to adapt in a challenging climate and maintain a functional community through adversity. The long-term aim is to bring all levels of the community to a maximum standard of resilience.

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Investigación Sobre Enos en América Latina: Reflexiones, Aprendizajes Y Desafíos

Alonso Brenes

LA RED

La creación de foros y espacios de intercambio, vistos como herramientas y puentes de entendimiento acerca de la identidad y la realidad de América Latina y el Caribe, es parte de una larga trayectoria entre actores e instituciones. Esta práctica se identifica en múltiples ámbitos del quehacer humano en la región, y el desarrollo científico no es una excepción; todo lo contrario, es uno de los terrenos más fértiles para la transmisión de experiencias, conocimiento y la implementación de estrategias de desarrollo. La tradición en investigación, acuñada desde tiempos anteriores a la Colonia, ha propiciado que Latinoamérica se coloque a la vanguardia en múltiples temas que hoy son trascendentales por su importancia regional y global.

La indiscutible diversidad como que cuenta la región es uno de los principales catalizadores del desarrollo científico latinoamericano. Lo dinámico y lo variado, conjugado con lo estático y particular, marcan el universo dentro del cual los investigadores deben abordar sus objetos y sujetos de interés. De ahí la importancia que han cobrado en las últimas décadas los estudios comparados, que permiten a diversos actores compartir y entender conocimientos y realidades particulares, además de hacernos ver el potencial que existe en los esfuerzos conjuntos de investigación.

La investigación vinculada a El Niño – Oscilación Sur (ENOS) es una clara muestra de ello. Dicho proceso se ha caracterizado por ser particularmente didáctico, más allá del conocimiento general sobre el tema, sobre las formas innovadoras de generar nuevos mecanismos, técnicas y enfoques en investigación aplicada. Nos ha recordado constantemente nuestras limitaciones pero también nuestras múltiples alternativas. Nos ha empujando a imaginar y compartir y, algo sumamente rescatable, nos dejó claro que la generación del conocimiento no es un proceso lineal. Por el contrario, nos hizo borrar y devolvernos a empezar de nuevo, corregir, solicitar ayudas, debatir en nuevos foros y humanizar significativamente nuestros esfuerzos y proyectos académicos.

Desarrollo y avances de la investigación en torno a ENOS

El proyecto ENSO en América Latina fue un reflejo de lo antedicho. Recogió parte de un arduo proceso de aprendizaje y cooperación que, para fortuna del desarrollo científico, se consolida cada vez más en la región. Presentó mezcladas las experiencias y aproximaciones a un tema común desde distintas disciplinas. Abrió espacio para el trabajo de consolidados científicos lo mismo que para jóvenes investigadores que recientemente se incorporan a trabajar en la temática. Muestra también un balance de sólido desarrollo teórico y conceptual con investigación aplicada, atendiendo a uno de los ejes de mayor interés dentro del proyecto: generar bienestar humano a través de la diversidad de los aportes científicos.

Los avances en el estudio de ENOS son significativos y nos han acercado más a la meta de comprender, de modo integral, cómo se comporta la oscilación y cómo las sociedades debemos percibirlo. Las lecciones aprendidas trascienden el ámbito científico y técnico; y empiezan a calar entre

los actores políticos, tomadores de decisiones y la sociedad civil en general.

Ahora parece lejana la idea que privó por años al hablar de El Niño: una manifestación casi mística, de misteriosa recurrencia y de alcances marcadamente específicos en el territorio. En tal sentido, los aportes de este proyecto regional contribuyen a entender cómo ENOS se manifiesta y es entendido a nivel hemisférico, y cómo sus efectos son asimilados –o no– por las comunidades americanas. Nos deja claro también que los componentes de cambio espacial y temporal son dos aspectos que condicionan significativamente las manifestaciones y sus efectos derivados, lo que se suma a un dinamismo social y ambiental que es proverbial en la región.

ENOS en América Latina

La idea del cambio nos permite señalar elementos que se vienen manifestando desde décadas atrás. Los mismos tienen un efecto claro, tanto en el modo en que percibimos las amenazas como las formas en que ENOS puede estar variando dentro de una dinámica planetaria mayor. Dichos elementos pueden agruparse en torno a dos ejes: uno que articula un mosaico regional entre diversas formas en que el fenómeno se desarrolla en países y regiones; y otro que agrupa procesos de cambio que atraviesa ENOS y que han sido identificados a partir de los últimos eventos registrados.

Tanto al hablar de ENOS como de Latinoamérica es preciso una ubicación en escalas espaciales macro regionales, distintas a las de referencia cotidiana. Sin embargo, al mismo tiempo, la temática se filtra a través de escalas y dinámicas más puntuales, generando múltiples realidades e involucrando a un amplio espectro social; matizando sus efectos inmediatos en diferentes territorios.

A nivel de los países que comparten el área podemos ver cómo la oscilación presenta similitudes y diferencias en su manifestación. Es reconocida como una de las fuentes de variabilidad climática de corto plazo a escala estacional e interanual en los trópicos y en buena parte de las latitudes medias, lo que genera alteraciones en los procesos de acoplamiento océano / atmósfera.

Transformaciones epistemológicas y desafíos institucionales

El ambiente de cambio que respecto a ENOS se ha tratado de esbozar es, efectivamente, un rasgo que identifica otros procesos que se dan globalmente y que se manifiestan con claridad a nivel latinoamericano. En la gran escala espacial están ocurriendo procesos de transformación (también interpretados como signos de colapso) que reestructurarán muchas de las dinámicas sobre las que se basa nuestro mundo tal y como lo conocemos. Más allá del tema ambiental, estamos presenciando transformaciones en el plano económico y la consolidación de nuevos mercados; vivimos un periodo de revisión y reinvención de la figura del Estado y sus instituciones; estamos ante una etapa de reacomodo de los principales centros de poder global en el sentido más amplio de la expresión. En suma, somos testigos de una etapa de transición mundial muy particular, cuyos efectos nos presentan nuevos retos, para este caso, retos en el campo de la generación de conocimiento.

Este contexto no es, pese a los aires de novedad que se le atribuya, una manifestación súbita de cambios estructurales. Por el contrario, es visto como la culminación o punto de inflexión de la interacción entre prácticas, actores, instituciones y tendencias dentro de la evolución cultural de los últimos dos siglos. Para el caso concreto de la investigación científica, gran parte de periodo transcurrió mediado por dos procesos.

En uno se dio una separación, en la práctica ficticia, entre las ciencias exactas y las humanidades. Esto lo retrató C. P. Snow con su idea de las “dos culturas”; posteriormente se acuñó el término de la “guerra de las ciencias” para describir el contexto posterior a esta ruptura. Consiste en un diálogo maniqueo y de sordos en el que las humanidades y las ciencias naturales se restan importancia, se achacan defectos y reclaman calidades de garantes de la verdad y la belleza. Este conflicto epistemológico ha significado un notable obstáculo a la hora de establecer puentes de comunicación entre las disciplinas y temas comunes de interés para diferentes actores. Los efectos puntuales, vistos tanto en la región como en otras partes del mundo, retrasan el desarrollo de las investigaciones y vulneran la calidad de vida de cientos de comunidades que dependen del impacto y los adelantos en investigación.

El segundo proceso tiene que ver con el cambio en torno a las figuras tradicionales en donde se genera el conocimiento científico. Esta tarea, históricamente atribuida a las universidades, empieza a compartirse con otras figuras como institutos especializados, compañías con sus propios programas, organismos no gubernamentales o entes estatales. Nuevamente, los impactos para la región son de consideración. La política de desarrollo de muchas

universidades se ha tenido que flexibilizar o modificar, y en ocasiones su capacidad de funcionamiento ha tendido a disminuir. La participación de nuevos actores en el proceso de generación de saberes pone en relieve el tema de la injerencia particular y política de intereses concretos sobre la investigación, la divulgación, el impacto y transferencia y las reglas y condiciones de financiamiento. Así, al final de este periodo, otra lección aprendida fue que la idea de "neutralidad valorativa" se tambalea al quedar en evidencia la relación directa entre temas morales, desarrollo científico y el ámbito (e injerencia) de lo político; aquí de nuevo el aislamiento y el mutismo entre actores y sectores debe evitarse a toda costa.

En el desarrollo del proyecto ENOS en América Latina se pudo transmitir y experimentar directamente el alcance de ambos procesos, De igual manera, se logró asumir con modestia al menos tres de los retos que, al respecto, mantienen una vigencia innegable. Más allá de seguir cosechando rencillas entre disciplinas claustros académicos, se procuró construir diálogo y sano debate entre todos los que están vinculados a la temática de ENOS, cuya diversidad es tan grande como compleja. Igualmente, las actividades apuntaron a establecer prácticas de interacción entre distintos organismos e instituciones de investigación regionales; esto es un esfuerzo necesario dentro del nuevo proceso de transformación estructural que ya está en marcha. Finalmente, se reconoció la naturaleza diversa y conjuntamente activa de quienes realizan investigación: se reconoció en los aportes la cuestión tripartita del científico no sólo como tal, sino también como un ser moral y como un ser político.

ENOS, lo mismo que otros fenómenos y procesos que despierten la inquietud científica, tiene implicaciones sociales claras que deben ser analizadas con la seriedad y rigurosidad del caso. Pero también precisan una traducción de resultados en el ámbito intelectual, moral y político, lo que garantice un sentido integral a un esfuerzo global que se sigue desarrollando en estos momentos.

Improving Resilience: Coping with Global Climate Change Locally

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Introduction

Due to its fragile geophysical characteristics, Nepal is vulnerable to changes in climate. Within the relatively short distance of 200 km, the landscape rises from a few metres above sea level to the highest altitudes in the world, the Himalayan mountain chain. The climate in Nepal is influenced by altitude with different climatic conditions in different altitudinal zones. The formation of the mountains and valleys has created many fragile microclimates, which are susceptible to even minor changes in temperature, precipitation and wind circulation. Contained in these microclimates are weak eco-systems that are unable to resist the changing climatic conditions of recent years.

This study concentrates on identifying how climate change affects peoples' livelihoods and tries to identify effective adaptation strategies for communities affected by floods and droughts. The paper highlights the importance of integrated approaches to vulnerability reduction and resilience building as well as measures to cope with adverse impacts of climate change. The study was undertaken in theJugedi stream watershed in the Chitwan District where Practical Action has implemented a three-year pilot project with vulnerable communities. The project sought to strengthen the capacity of communities to cope with floods and droughts exacerbated by climate change.

The study utilised participatory vulnerability assessment tools (Actionaid, 2005) to analyse prevailing hazards and their impacts upon affected communities. 187 families were consulted via individual and group discussions. Secondary data from both published and unpublished sources, relevant to the scope of the study, was referred to,serve to provide additional information and to verify primary field data.

The study area is subtropical. Precipitation ranges from 2,000 to 2,500mm annually, of which 80% is received in the three months between mid-June to early September. Over the past few decades, hotter summers and warmer winters have been experienced. 98% of the people consulted reported that climatic conditions in the area were changing. The changes most commonly identified were increasing frequency and severity of drought coupled with changing patterns of rainfall and rising temperatures. These perceptions were based on experience, an understanding of the nature of clouds and wind flows, and historical trends in rainfall records. Data from the meteorological station situated 20 km south-east from the Jugedi streamsupport these perceptions (Shrestha et al, 2007).

Respondents perceived that the frequency of rainstorms have decreased while their intensity has increased. The pattern of rainfall distribution is unusual both in timing and location. When rain falls, it is intense, of short duration and interspersed with long dry periods.

Findings

Impacts and Vulnerabilities

The study identified landslides, flash floods, unusual rainfall patterns, seasonal storms (dry winds, hail and thunder) and drought as the major adversities, which have increased in severity over the past few years. Prolonged winter fog (cold wave) is increasingly common, though previously not experienced in the area. Both day and nighttime temperatures have increased, particularly during the summer. Hotter days shorten the time farmers are able to work in the fields. Increasingly erratic and unpredictable rainfall prevents the timely sowing of seeds, affects harvesting and generally reduces productivity and yield. Poor rural people are highly vulnerable to the impacts of climate change. Being heavily reliant on natural resources (most are subsistence farmers), lacking assets and access to resources and with very weak institutional support, traditional coping strategies are being overwhelmed by the pace and scale of the changes in weather patterns. Over the last decade, major water-induced hazards such as floods and landslides have increased in frequency, exacerbated by erratic rainfall patterns. Socio-economic activities such as deforestation, shifting cultivation and over-grazing, which weaken ecosystem resilience have combined to increase the magnitude and frequency of these events.

Erratic rainfall patterns have multiple adverse effects. Heavier downpours within a short time prevent the adequate recharging of watersheds and available precipitation is lost through run-off and overland flow. This creates landslides and flash floods, erodes fertile soil, decreasing productivity, degrading and ultimately destroying livelihood assets. As available rainfall flows away instead of recharging ground water reserves, less water is available later in the year in the form of springs and stream flows. Much stream flow water percolates through debris deposited by floods and flows underground, leading to lack of water for dry season irrigation. This contributes to a seasonal shortage of irrigation water during the non-monsoon season. Untimely rainfall coupled with long gaps between successive rainfall events (even during the wet season), combine to increase the frequency and extent of droughts. Erratic rainfall prevents timely planting, care and harvesting of crops, and decreases food production. Farmers traditionally maintain a calendar of cropping and harvesting based on the rainfall and seasons. This calendar no longer fits. The increased intensity of rainfall is itself hazardous for crops, for working in fields, for infrastructure and mobility.

Seasonal storms, often associated with erratic rainfall, affect communities in many ways. Dry windstorms, which often destroy roofs of houses and cattle sheds damage crops and injure people. These storms used to occur during the pre-monsoon period between March and June. Now their incidence is unpredictable. They increase the incidence of fires that, until now, have only affected forests. Hailstorms have become a normal occurrence in recent years with increasing ferocity and damage to crops, roofs, killing wild birds and destroying their nests and eggs (box 1). As the number of birds decrease, insect pests multiply, destroying crops in the absence of predators. Thunderstorms with lightning have increased in frequency. In the past, lightning was rarely observed during July and August but now it is more common. Until recently, little physical damage has occurred due to lightning strikes but thunder creates fear among children, particularly when outside or coming home from school.

Box 1 Large Hailstones

Hukum Singh Gurung (58), a resident of Khetbari village had managed his vegetable farm with drip irrigation system to cope with the limiting water resources available. In April 2007, there was huge hailstorm in the village. His drip irrigation pipe was broken at all along with damages to his zinc plate roof. "I had never seen such big and damaging hail stones in my life" he exclaimed with sadness at his face. Apart from pipe, which cost about $ 31, he lost his whole crops of vegetable that would give him about $ 300 – his family budget for more than six months! The story repeats to all farmers in the area. "It's of no use how favourable other factors are on other days; single event is enough to cause a great loss within a short time", says Janga Sarki (45). In the earlier week there was a dry windstorm, which uprooted hundreds of trees in their community forest. There were only two rainfall events between October 2007 and February 2008; one in January and other in February. Both brought hailstones and damaged winter vegetables tremendously. "I had never seen such big heap of hailstones in this area" says Sher Bahadur Tamang (50) of Bhotedhap village.

Over the past few years, people have suffered the effects of drought. The imbalance between recharge and discharge of aquifers results in a lack of water for irrigation. Farmers reported that despite using more fertilisers, taking extra care in reading and using improved seeds and varieties, their yields of cereals are less than in the past. The duration of winter fog has increased in the valleys, causing wilt in winter crops such as potatoes and mustard oil. This is assumed to be an extension of the cold wave from the Southern Plains. All of these climatic effects impact upon production and food security.

Existing adaptation practices

People have responded to the changing climate and its impacts in different ways. Flood victims have tried to renovate their land, shifted houses or constructed new ones in other nearby sites. More than 70% of families were found to have intensified their traditional alternative occupations, such as liquor production, firewood collection and sale and goat rearing. Often these options are not sufficient, forcing people to invade new land or expand shifting cultivation. In recent years, remittances from workers who have left the rural areas have become a significant source of income. Ultimately, this outward migration of wealthier families intensifies rural poverty. Analysis shows that adopting new strategies is dependent on levels of awareness, skills and capacity. The success of alternative livelihood options is heavily dependent on the availability of resources and access to markets. Communities build strategies based on what they have and what they know. Many of these adaptations are based on the exploitation of natural resources. Ecosystems are weakened through deforestation and degradation ultimately reduces community resilience (UNISDR, 2007). Poor adaptation strategies and socio-economic activities can exacerbate the impacts of climate change, bringing more adverse conditions.

Consequences of climate variability and change are potentially more significant for the poor in developing countries than for those living in more prosperous nations. Poor people with subsistence livelihoods are most at risk because they depend uponagriculture and forestry, which are both sensitive to climate and local weather conditions to generate income for food and livelihood security. Changes in meteorological conditions impact directly on productivity levels, diminishing livelihood returns (USAID, 2007). Poor socio-economic conditions together with a lack of awareness, skills and alternative options have led communities to adopt inappropriate landuse practices, which in turn, have increased levels of vulnerability.

More than 90% of the population is dependent on subsistence agriculture. This reinforces the urgency and importance of adapting to climate change. The lack of options and flexibility in livelihood strategies of the poor constrains their ability to make positive livelihood choices and reduces their ability to withstand or adapt to shocks and stresses such as droughts, floods and other hazards. Scientific analyses on a global level support the findings that those with the least resources have the least capacity to adapt and are consequently the most vulnerable (IPCC, 2007).

Agricultural land, potentially able to grow vegetables, used to remain fallow during winter. People were found to be interested in adopting new crops, if skills and initial inputs were provided. The nearby national highway provides easy access to markets. Informal self-help groups existing in the community were formalised and linked to networks of service providers. The community eagerly grasped opportunities to intensify and use available land with short rotational cash crops in addition to the traditional cereal crops. This has improved their income.

Project inputs on adaptation

The Practical Action project utilised existing experience and ideas drawn from literature to devise field approaches. It is difficult to separate climate change impacts from environmental consequences of human activities because they are inexorably interconnected. The project provided experience on understanding the local impact of climate change in the context of existing livelihood strategies and their impact upon local natural resources. A broad approach to adaptation, which reduces vulnerability, identifies locally appropriate and affordable risk reduction measures, and develops adaptive capacities through skill and technology enhancement are necessary where problems of ecosystem degradation and climate change interact. The project adopted an integrated approach and implemented a range of activities including:

- Awareness raising
- Management of water resources
- Short-rotation varieties and cash cropping
- Improved land management
- Forest conservation
- Livestock improvement

- Disaster preparedness
- Institution and network development and strengthening

Many measures taken by families in response to problems they faced were leading to undesirable consequences. They were in fact, mal-adaptations. Raising awareness of the impacts of their activities and the importance of making sustainable choices was stressed. Project staff shared information on current scientific thinking on climate change trends, future projections and potential impacts with school children, students, teachers and farmers through audiovisual presentations, discussions and exposure visits. The project helped farmers to repair irrigation channels and adopt irrigation techniques appropriate to the increasing water deficit. Farmers were encouraged to grow vegetables in both winter and summer, providing more income from a small area. This helped them to recover from the lost production of maize and rice due to untimely rainfall and storms. Drip and spring irrigation were introduced as alternatives to traditional flood irrigation for dry season crops, reducing water requirement.

Farmers were given the option to choose species and the timing of crops planted, based on their ability and confidence. The project aimed to increase diversity and availability of crop species, and improve timing knowledge (regarding seasonality of certain crops) that simultaneously increases resilience to adversity (for instance, flood or drought events). During the first year, an agricultural graduate provided the necessary technical inputs and skills through weekly field orientations. During the second year, farmers led the process and acted as local resource personnel on production. Marketing vegetables provided an employment opportunity for youths, while releasing farmers from this task to allow them to focus on cultivation.

Sloping agriculture land technologies (SALT) were introduced to control soil erosion on the cultivated hill slopes. Three forest user-groups were established and institutionalised with their own rules, regulations and norms. These have been registered with the District Forest Office as required by the Nepalese Government's rules. Grazing has been regulated and improved breeds of livestock and stall-feeding have been introduced through training, exposure visits and input support. Providing seeds and seedlings have encouraged tree planting and fodder grass cultivation. Both vegetative and gabion check dams have been constructed along stream banks and micro-catchments to protect agricultural land and settlements from erosion and flooding.

Sustainability of these adaptation measures has been ensured by the formation of community-based organisations (CBOs). These have been registered with the District Administration, each with a constitution as required under the current National Act. Every household is a member of the CBO. This provides communities with a legal basis for requesting external support and enables communities to coordinate with other stakeholders, both within and outside the District. Linkages have been established with the Local and District Government, NGOs and other line agencies such as Agriculture and Forestry Departments. Currently, CBOs are members of a district level disaster preparedness network, which enables them to share experiences and learn from one another. Based on project experiences, the communities have prepared a long-term integrated watershed management plan, implementation of which is being supported by theLocal Government.

Discussion

Environmental degradation is a hazard in itself (UNISDR, 2007) and has significantly contributed to increasing the occurrence of landslides and floods. Climate change is seen to enhance the magnitude and frequency of stresses and shocks. If local practices are not environmentally friendly, both climate change and socio-economic activities will act together to increase the impact of hazards. If natural systems are maintained or strengthened they provide greater resilience to adverse environmental consequences in addition to increasing the range and robustness of livelihood resources. The exploitation of natural resources is most often uneven, the exploiters benefiting at the expense of the poorest. Those with the least coping capacity are most adversely affected. It is important to understand who is most affected by the impacts of climate change and how and why they are affected. Participatory vulnerability analysis provides insights into these issues. The project has clearly established linkages between resource degradation, land use, increased precipitation and the resultant increase in frequency and intensity of disasters. This creates a spiral with further negative impacts upon available water, soil productivity, human well-being and health.

The IPCC (2007) concludes that the impacts of climate change are unequivocal. The end results are multi-dimensional, multi-faceted and interconnected. Generally, one impact leads to another. For example, if land is damaged by flood, families are displaced

and respond by moving or cultivating a new parcel of land, putting pressure upon a new location. This weakens the ability of land to withstand effects of changes in climate, increasing its vulnerability to future disasters. Logical in-depth analysis is necessary to understand the complexities and inter-relationships of the possible impacts of climate change on the livelihoods of poor people.

This study demonstrates that great care needs to be taken to devise appropriate coping strategies that are not mal-adaptations to existing and future climate change. The study has provided examples of how resilience can be increased by diversifying livelihood options and improving ecosystem health. There is still uncertainty as to how these strategies will operate in the future in the face of changing environmental and socio-economic pressures. Mandatory policies to support and promote adaptation will be needed. It is suggested that these experiences and good practices can be replicated and scaled up in communities living with similar constraints. Interventions need, however, to be context specific. There is no "one size fits all" solution. Most importantly, linkages between impacts of climate change, the prevailing socio-economic conditions and their implications for natural resource management must be recognised. The rural poor depend on their natural resources. Unpicking the impact of climate change from the impacts of social processes such as deforestation, faulty and unsustainable agricultural practices and inefficient livelihood strategies remains a major challenge.

Conclusion

In depth analysis of climate induced hazards and social processes help to identify resultant impacts of climate change in a particular locality and can provide insights into how climate change impacts affect different livelihood assets. Many impacts of climate change, especially precipitation, extend throughout a watershed. Adaptation measures adopted at different locations may not necessarily be unique but context specific. They are dependent on the forms and extent of impacts, adaptive capacity and livelihood options for people vulnerable to a particular impact.

Better management of natural resources strengthens ecosystem health and increases resilience. This most frequently requires changes in individual and social attitudes and practices. Identification and adoption of new options for earning a living that are flexible and resilient to changing climatic conditions are central to community-based adaptation strategies. Inputs to reduce vulnerability thus need to simultaneously increase the capacity of individuals to cope with changing climateand improve ecosystem functioning at the local scale.

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Indigenous Knowledge and Modern Science Provide Environmentally Friendly Shelter Solutions in Flood Affected Desert Regions of India

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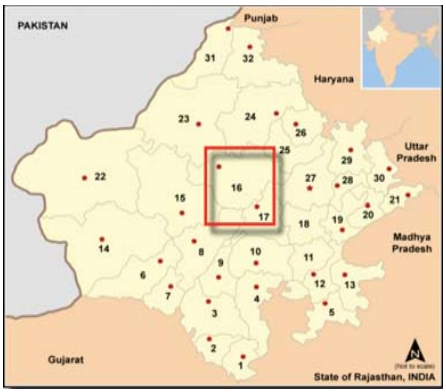


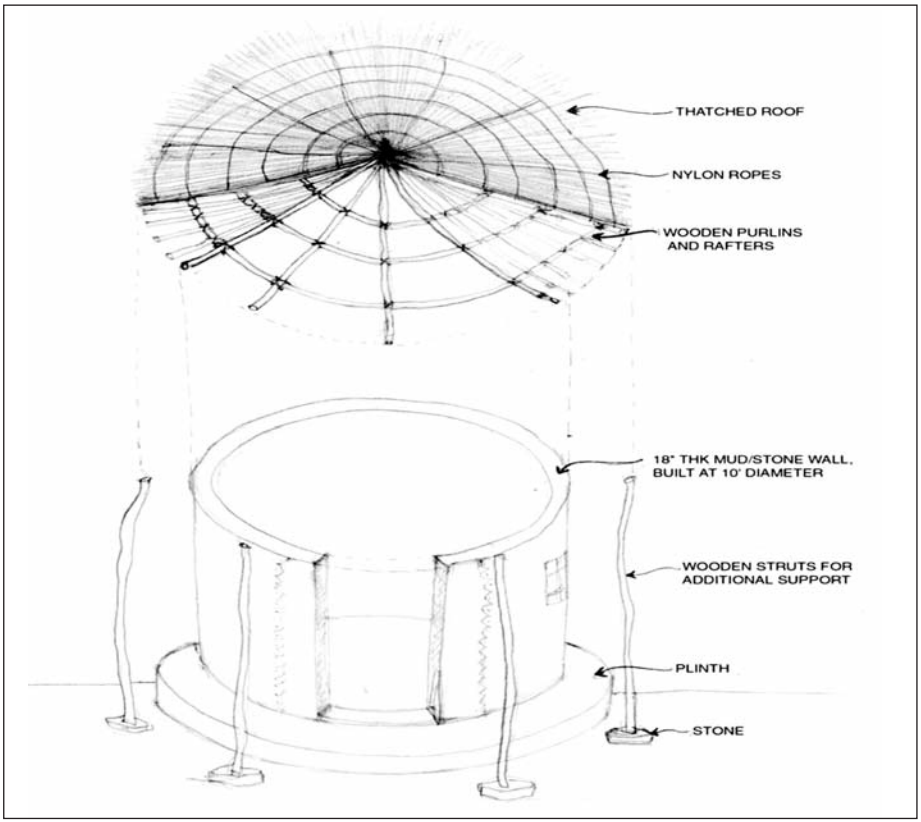
Location

The district of Barmer lays in the western most part of the state of Rajasthan, India. This district is the western-most district of India. Located along the border of India and Pakistan, this district falls completely under the Thar Desert region. SEEDS worked in Sheo block of Barmer district where 300 shelters were constructed for the worst of the flood-affected families, specially targeting those from socially excluded groups who had no capacity to rebuild their houses on their own.

Unique characteristics of the local community

The local community is characterised by sparsely and widelyscattered settlments. There are four to five circular structures in one cluster bound by a low boundary wall, which forms a family's abode and is called a Dhani in the local language. Each structure is used for a different activity such as sleeping, storage, cooking and daily activities. A cluster of Dhanis constitutes a village. These communities are live in very harsh climatic

The design of an emergency shelter



Souce: Adapted from Safer World Communications

conditions and make judicious use of the sparse resources available within their surroundings for their day-to-day requirements, and also for construction of houses. The population density of the Barmer District is among the lowest in India. Water is a major problem in this area. Village women walk long distances with headloads of pots to fetch drinking water, sometimes making more than one trip per day. Life in this region is full of hardships. Means of livelihoods are severely limited.

Indigenous Knowledge for Shelter Comfort and Sustainability

Communities living in rural Rajasthan haveconstructed houses with local materials and indigenous technology for many generations. For construction of houses, all members of the family play a major role and have allocated responsibilities. While the men of the family collect soil of good quality from nearby places, the womenfolk gather cow dung, which they mix with the mud to prepare their basic construction material. The women of the family do the plasterwork for the new house, as well as for regular maintenance of the walls and floor. Tying and weaving dried stalks and use of by-products of the local Jowar crop make the roof. The house is oriented in such a way that the wind direction and sun path ensure good ventilation and thermal comfort, which is very critical since summer temperatures in this region reach about 50o C. Normally the size of openings is very small as it reduces heat gain, and also gives less exposure to sand storms, which are a common local threat.

The people generally go for houses that are circular in plan and opt for lower heights. This is basically due to the location in the High Wind Velocity Zone due to which they face heavy winds especially during the summers. The circular plan helps to streamline the airflow with least resistance.

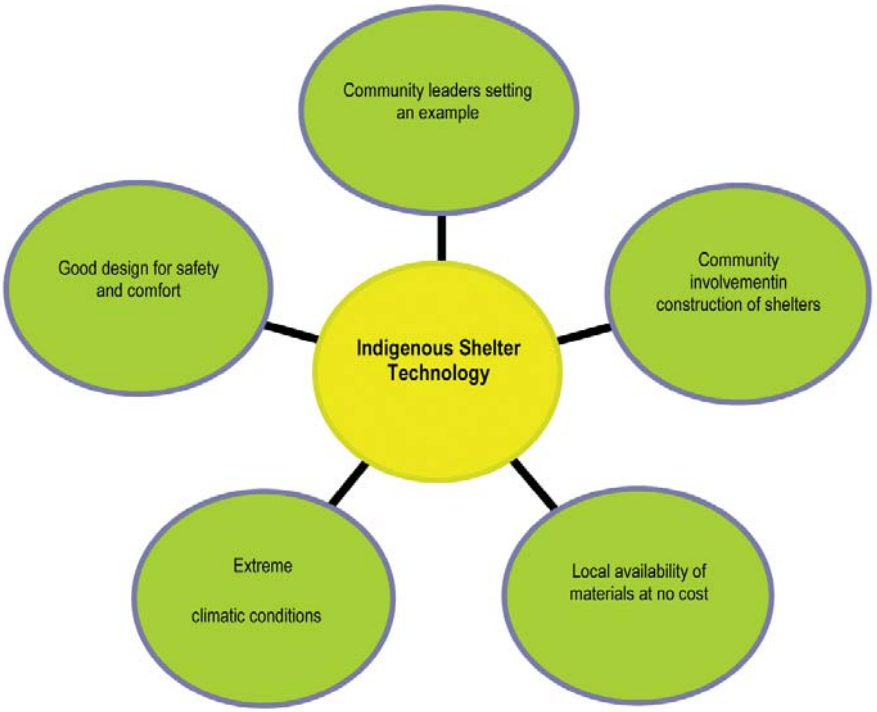
As this area also falls under moderate the high seismic zone based on the Earthquake Vulnerability Map of India , the circular shape can also give good lateral resisting strength to house. During the 2001 earthquake in Kutch, Gujarat, which is close to Barmer, significantly less damage was observed in houses with a similar design .

Survival and Propagation of Indigenous Construction Knowledge

The indigenous technology for constructing shelters is being widely used in the area, and the community members are themselves the messengers for transferring this technology to their next generation. As all the members of the family are part of the construction activity, they have a sense of ownership of the shelter, and an understanding of the

materials and processes.

There are five main factors behind why this technology of shelter construction is still surviving in the remote desert areas and how information was disseminated among other communities in the larger region. These are illustrated in the accompanying figure and in the points right:



Community Leaders; Setting an Example by using this Technology

One of the typical traditions followed in any rural community in India is that whenrespected people are living in a particular area, others like to aspire to and follow their way of life. This is very common and an important aspect of community. In villages within Barmer,it wasgenerally found that respected people in the community lived in these kinds of Dhanis. Seeing this, other community members were also encouraged to follow suit.

Community Involvement in Shelter Construction

All community and family members are involved in various activities of shelter construction. Involvement of family members as well relatives eases the burden of construction, and also strengthens community spirit. This is also one of the reasons why this technology is surviving in this still rural and tradition centric area.

Extreme Climatic Conditions

Barmer witnesses summer temperature as high as 50^{o} C, while during winters the night temperature is near the freezing point. In order to survive in these extreme situations an appropriate house is required. Cement concrete houses become ovens in the heat, and chillers in the cold. There is no electricity and fuel is very scarce and unaffordable for thermal control. Though some people have started opting for modern materials, they are not feeling as comfortable in these modern houses as they did in the traditional ones.

Local Availability of Materials at No Cost

Local availability of materials, which is free of cost and of transportation is a major attraction for a community already impoverished by the harsh climate and having very few and weakened livelihood options.

Good Design, Safety and Comfort

The traditional circular shape is appropriate forresisting wind pressure created by sand storms, and wave pressure created by earthquakes. The walls are also of insulating quality and are thick, giving good thermal comfort insidehouses in both temperature extremes. Roofing is also properly connected

with the walling system, giving higher structural safety to the shelter as a unit. The combination of safety and comfort has resulted in a time tested shelter technology that is respected locally for its immediate andlong-term benefits.

Desert Rain, a Sign of Climate Change: the Shock

By midnight on 21 August 2006, Barmer had received 577 mm of rainfall in three days, 300 mm more than annual average rainfall of 277 mm. About a hundred villages were affected in the district. Some of the worst affected villages were Kavas, Malua, Bhadkha and Shiv. The water level reached close to thirty feet above the ground level. It is officially reported that 103 people died. About 95 percent of families in these affected villages were rendered homeless. Even where parts of their houses were standing, these were madeuninhabitable. Since the structures were mostly made of mud, they were badly damaged and mostly destroyed by the flood. As the local people had never experienced this kind of a situation before, they were shocked and were not able to understand how to handle this disaster. Some local people thought that this was an act of displeased gods, while those linked to the scientific world pointed fingers at climate change.

Shelter Response: Build Back Better, Faster and More Resilient

SEEDS and partners intervened in construction of shelter after the unusual floods in the desert area. As the original houses had used mud as the basic material for construction of Dhanis, many families had lost their houses as they were washed away in the fast flowing floodwater or severely damaged due to sustained submergence. After carefully studying the local natural environment, availability of materials, prevalence of traditional practices, and availability of skills, SEEDS decided to construct shelters with the same kind of traditional technology but by enhancing disaster resistance through introduction of Stabilised Compressed Interlocking Earth Blocks. The construction of three hundred such shelters was taken up with community participation under the *Barmer Ashray Yojana (Barmer Shelter Programme).*

Main objectives of the reconstruction programme were:

- Assistance to the worst affected and socio-economically weakest families for rebuilding their homes
- Promotion of sustainable and disaster resistant construction technology
- Community participation in all the phases of reconstruction program
- Generation of livelihood for the flood affected population
- Skill upgrading of local masons and artisans
- Involvement and engagement of all stakeholders, including local governments and civil society actors

Indigenous Knowledge and the Support of Science

SEEDS visited the affected areas immediately after the floods and carried out a damage assessment along with a study of the local natural and built environment. The team assessed and documented traditional construction practices in the area. This was very environmentally friendly as materials have low ecological and carbon footprints; houses were conducive to and thermally comfortable for extreme weather conditions traditionally prevalent in the area. The circular design protected structures from strong winds and earthquakes;construction processes were simple and suited to the local skill levels.

Research was carried out on appropriate technologies for supporting the traditional construction system, and it led to Stabilised Compressed Interlocking Earth Block technology, wherein local mud was stabilised with five percent cement, and compressed into blocks that had high structural strength and water resistant capability.

In partnership with Christian Aid, and with support from ECHO, three hundred shelters were built using this appropriate technology, which was a mix of indigenous knowledge, and limited scientific inputs to make it further resilient in the face of new threats. Village Development Committees (VDCs) were formed in each village to take decisions and to guide and monitor the construction process. The VDCs comprised men, women, local leaders;schoolteachers, NGO representatives and project team personnel, and interacted closely with the local government officials. The traditional circular designs were retained, and so were the `breathing' thatch roofs. An efficient system was established to mass-produce the SCEBs very quickly to provide housing to the affected families in a short time span of six months. The house-owner families mainly did the construction with limited support from the project team. The knowledge and skills were left with local construction workers so that they can be replicated and scaled up in

the region. Upon completion, local families preferred these traditional structures far more than the modern cement concrete technology based houses being provided by other sources, which turned into ovens under the scorching desert sun.

Lessons Learnt

The project intervention, and documentation of this case study led to many lessons being learnt. These are related to construction technologies, material sciences, as well as social systems and processes. Main lessons learnt are summarised as follows:

1. Post disaster shelter programmes must capitalise on existing traditional wisdom of construction materials and technologies, since it has been tested over generations and is best suited to the local environment and culture.
2. Technology should be introduced where necessary, but in minimalistic ways, so as to add value to traditional systems and make them more resilient in the face of new threats such as those posed by climate change
3. Materials used for construction should be eco-friendly and local to the extent possible. This keeps the cost low, and also minimies the carbon footprint of the intervention.
4. Participation of the beneficiaries in decision-making regarding the siting, design and construction details is critical to gain their involvement and ownership of the process.
5. Participation of house-owner families in the construction process is very useful for cutting costs, enhancing the sense of ownership, and keeping the design and construction process flexible enough for each family to customise small things to suit its preferences and convenience.
6. Transfer of technology to the local construction workers is very useful for ensuring the sustainability of the construction approach, its replication and scaling up in the area.
7. Linkages with local stakeholders including governments, academia and the private sector is useful for the smooth completion of such projects, and also for creating a local buy-in for the approach, which will help its sustainability in the long-term.
8. Linkage with other sectors such as water, sanitation, livelihoods and education helps create a more comprehensive package around shelter, habitat and lifestyles, and provides value added benefits to the local community.

Social and Environmental Vulnerabilities in the Face of Climate Change for the Semi-arid Area of Bahia – Brazil

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Introduction

Global climate change is largely attributed toglobal warming and the greater frequency and intensity of extreme weather phenomena. Average temperatures of the planet have steadily been increasing since the Industrial Revolutionof the mid twentieth century. The scientific community largely has no doubt that the expansion of the greenhouse effect is caused by increases in the concentration of greenhouse gases in the Earth's atmosphere.

The Fourth Report of the Intergovernmental Panel on Climate Change (IPCC) shows that global climate change results from human activities and it is believed that recent regional changes in temperature have had impacts in many physical and biological systems.

Climatic changes tend to contribute towards an increase in temperatures, ultimately leading toevapouration, whichwill result in the probable reduction of water availability (water deficit), which in turn will impact adversely upon agriculture, and, most likely,the quality of life of the population of semi-arid areas such as Bahia. Long term drought and desertification, have together, caused changes in the hydro regime. These changes have led toagricultural loss, threatened biodiversity and have had adverse social, economic and environmental consequences in the semi-arid area of northeast Brazil, already aparticularly vulnerable region, socially, economically and environmentally.

Knowledge of the level of vulnerability of regions will contribute in the identification of the most potentially affected areas in the context of climate change. This knowledge base will contribute towards thedevelopment and implementation of policies and measures for adaptation and mitigation of climate change impacts.

The Semi-arid of Bahia is a region known for its climatic and social environmental fragilities. At the same time, this is an economically significant region in terms of its agro-economic potential for Brazil. Thereforeresearch is needed to identify the possible impacts of climate change in this region, particularly with respect to the level of exposure to vulnerability.

The general purpose of this research was to identify and evaluate the social and environmental vulnerabilities in the semi-arid districts of Bahia against the projected changes and impact of climate in the region.Specific aims were:

1. To analyse the scenarios and the climatic projections in the semi-arid regions of Brazil;
2. To discuss possible impacts of climate change on agriculture in Bahia - Brazil;
3. To identify years of extreme event occurrence (such as droughts) and evaluate the possible impacts in semi-arid of Bahia; and
4. To create an indicator for measuring the socio vulnerability of municipalities in the semi-arid region of Bahia.

The studybegan with a theoretical review on the subject of climate change, vulnerabilities, impacts and adaptation to climate change. Later abibliographical review about the Northeast and the Semi-arid of Bahia was undertaken with a view toidentifying relevant information on socio-economic and environmental indicators.

The employed methodology was based on a selection of cities, taking into consideration the criteria established by the Author. Cities chosen were located in the semi-arid region of Bahia, with aclimatic typology varying from sub-humid to dry or semi-arid and, which had recordedclimatic data from 1961 to 1990.

At the second stage, research was developed to illustrate droughtand lack of rain patterns in semi-arid regions over the years sated above via a climatic socio-environmental and economic data collection for the six studied sites. The Climate Scenarios of the Intergovernmental Panel on Climate Change (IPCC) and the weather forecasts of the National Institute for Space Research – INPE were also evaluated.

Firstly, some climatic and socio-economic indicators had been selected to identify the existing socio environmental vulnerabilities. According to the survey, it was observed that the studied cities present a high water deficit.

The systematisation of the data was carried through and the following indicators were selected to build the Socio Environmental Vulnerability Index (IVSA): Index of aridity (calculated from the Water Deficit), IDH-M, IDEB, and PIB Municipal Agricultural Sector, for all the six cities of the semi-arid of Bahia. The Socio Environmental Vulnerability Index was developed using the formula:

IVSA = IA x PIB Agro./ IDH-M x IDEB x 10

Where: IVSA = Socio Environmental Vulnerability Index

IA = Index of Aridity

PIB Agro. = PIB Municipal Agricultural Sector

IDH-M = Municipal Human Development Index

IDEB = Development of the Basic Education Index

As a result, it was possible to identify which cities show higher socio-environmental vulnerability against climatic changesprojected for the semi-arid area of Bahia.

Development

With continued global warming, it is estimated that an increase in frequency and intensity of extreme events such as droughts, floods, sea level rise and greater frequency of heat waves is on the horizon. Rising temperature promotes greater evapotranspiration, thereby increasing the ability of air to retain water vapour, causing greater hydro deficits.

Increasedsocio-economic costs related to regional variations in climate suggest an increase to vulnerability to climate change. According to IPCC (2007), some social and economic systems have been affected by recent increases in droughts and floods, with increased economic losses from extreme weather events.

The Fourth Assessment of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) provide a complete analysis of climate change observed and its relationship to recent changes observed in the natural environment and humans.

In Brazil, climatic change andexisting vulnerabilities of semi arid areasmean an increase in thefrequency of droughts and floods. These consequences include disastrous impacts on agriculture and biodiversity, changes in the hydrological system, particularly coastal areas,especially with respect to sea levelrise, which is likely toheavily affect large coastal metropolitan regions.

Knowing what, how and whyregions are vulnerablewillserve to identify those areasmost likely to be affected by climate change. Houghton (2004) states the need for intensive research aimed at improving confidence in scientific predictions.

It is thus the responsibility of all stakeholders within Brazil to propose and implement solutions that have a core aim of reducing CO2 emissions to ensure minimal socio-economic and environmental impacts, via

mitigative and adaptative measures.

All scenarios presented in the Special Report of the Emissions Scenarios from the IPCC, project an increase in average global temperature and sea level. In the context of scenarios of climate change for northeast Brazil, weather classifications made by Salati et al. (2007) highlight that the water balance data achieved average values inHadCM3, GFDL, CCCma, SCIRO and NIES models, for the two analysed scenarios(A2 - High emission and B2 - Low emission). These indicate that there will be a decrease in excess water in the region of up to 100% for the period 2011 to 2100.The area studied by the IPCC goes beyond the northeast semi-arid region of this report. Consequently it is difficult to predict, specifically, scenarios of climate change for Bahia.

Severe impacts to water resources are expected in Bahia. A strong tendency for aridityof the semi-arid region of the northeast by the end of the twenty-first century may be observed due to a higher hydro deficit in the region, characterising vulnerability in agriculture. Regarding the population, those with fewer resources and less ability to adapt, are the most vulnerable. The study developed by the Nucleus of Strategic Subjects of the Presidency of the Republic in 2005 (NAE 2005, b) suggests that the Bahiaregion is the most vulnerable to climate change.

In fact, the northeastern region could, due to lack of precipitation become an arid, barren area, catastrophically affect subsistence agricultureal regimes, the availability of water and health, in turn, forcing urban migration to cities ill equipped to cater to large influxes of people.

IPCC evaluations repeatedly indicate that developing countries are among the most vulnerable to climate change. This observation is increasingly noticeable in Brazil especially when consideration is given to studies highlighting the likelihood of adverse impacts on society resulting from climatic variability such as droughts and rain shortage.

Based on the Fourth Assessment Report of the IPCC - AR4, the semi-arid and arid areas of northeaster Brazilwill suffer significant decrease in the availability of water due to climate change. In general, there will be a negative impact on freshwater systems. In tropical regions, even slight increases in temperature will result in a fall income from crops.

Changes in the occurrence and severity of extreme events affect food production systems and cause food insecurity in the poorest countries, highlighting:

- Water shortage;
- Reduced potential for hydroelectricity;
- Potential migration of the population;
- Heightened adverse impacts on subsistence agriculture.

The Northeastern region occupies 18% of Brazilian territory, with a fragile fauna, irregular distribution of rainfall, coupled with the possibility of large time intervalsrelated to the intermittent character of many rivers. In the northeast there is a high-range of climatic variability. Insemi-arid areas of the north east, climate can vary from less than 500 mm per year of precipitation, to the most rainy climate, (normally recorded around the eastern coast), with the annual accumulated precipitation exceeding 1500 mm (KOUSKY & CHU, 1978).

Oyama & Noble (2004), in a study on the climatic consequences of large-scale desertification in northeastern Brazil, identified that desertification is a consequence of the reduction of precipitation, an increase of evapotranspiration which consequently converted part of Caatingainto semi-desert.

The Brazilian northeast is an example of a vulnerable semi- arid region, characterised by water shortage and the vulnerability of natural resources, which in turn are exacerbated by climatic variability and adversely affect social structures. The state of Bahia, with its large open expanse of land, is divided into fifteen eonomic regions, which were established by the government to improve administration and to encourage joint solutions for these cities, based on similar cultural, social and economic characteristics.

Based on the methodology used, 6 cities had been identified, all of them lying within the semi-arid region of Bahia, with climatological typologies that vary from sub-humid to dry and semi-arid, according to registers of climatological data from the Normal Climatologic (1961 to 1990).

The "Normal Climatologic" was obtained by calculating the average of meteorological parameters, according to criteria recommended by the World Meteorological Organization (WMO). These averages are for standardized periods of 30 (thirty) years, successively, from 1901 to 1930; from 1931 to 1960 and from 1961 to 1990.

According to climatic classification of Thornthwaite (1955), the climate of cities in this study, vary from sub humid to dry and semi-arid. They generally follow the following criteria: Minimum temperature, average

temperature, maximum, Potential, Real Evapotranspiration Hydro Deficiency, Hydro Excess, Dryness Index and Hydro Index (SEI, 1997).

The Dryness Index was calculated from Normal Climatologic data (average from 1961 to 1990). To select the indicators, it was considered that the higher the dryness of cities, the higher the socio environmental vulnerability. As these cities depend heavily on agricultural activity for economic development, vulnerability in the face of climate changes were projected to inrease. Thus, the PIB Municipal Agricultural Sector, was chosen as an indicator in the evaluation of the economic dependence of a city in the context of agricultural production, specifically cattle raising. A period from 2002 to 2005 was selected.

According to IBGE, cattle raising activity appears in the 2005 GDP research of cities as the sector with better distribution of the PIB (GDP, in English) among Brazilian cities. As previously mentioned, climate change impacts may adversely affectagricultural activities, due to reduction inprecipitation, increase of temperature, with consequent increases in evapotranspiration.

The Human Development Index was originally created to measure the level of human development in countries from indicators of education (literacy and school registration tax), longevity (life expectancy at birth) and income (GDP per capita). The index ranges from 0 (no human development) to 1 (total human development).

The goal of the Human Development Index is to offer a counterpoint to another widely used indicator, PIB or Gross Domestic Product (GDP) per capita, which considers only the economic dimension of development. For the

Figure 1 New Deliniation of Brazilian Semi-Arid Region According to the Ministry of National Integration Source: (MI, 2005)

Table 1 - indicators of vulnerability for the 6 cities studied

VULNERABILITY INDEXES					
Municipalities	Index of Aridity (IA)	IDH-M	IDEB	PIB Agropec.	IVSA (Socio Environmental of Vulnerability Index)
Barra	0.57	0.536	0.853	0.100	0.12
Bom Jesus da Lapa	0.42	0.606	0.882	0.260	0.20
Irecê	0.43	0.631	1.000	0.040	0.03
Itaberaba	0.42	0.583	0.882	0.120	0.10
Jacobina	0.30	0.596	0.853	0.100	0.06
Senhor do Bonfim	0.29	0.626	0.794	0.033	0.02

HDI-M indicator were used data from 1991 and 2001. As the HDI-M only considers quantitative indicators of education it was decided to include the IDEB as an indicator of the quality of education offered in the municipalities. The IDEB was calculated from the data from the years of 2005 and 2007. Due to the difficulty of data indicators for the same years, it was made normalisation and an average of available data in the search for an approximation of the real situation of each studied municipality.

Table 1 presents indicators of vulnerability for the six municipalities studied in the semi-arid region of Bahia. A Socio Environmental of Vulnerability Index (IVSA) was built for each municipality.

According to the result of the calculation of the Socio environmental Vulnerability Index, it can be concluded that the cities of Barra and Itaberaba are the most vulnerable ones in relation to other municipalities studied, occupying the first position, with an IVSA equal to 0.34.

The city of Jacobina appears as the second most vulnerable, with IVSA of 0.23, followed by the city of Irecê, occupying the third position, with the IVSA of 0.11. The cities of Senhor do Bonfim and Bom Jesus da Lapa appear in the fourth and fifth place respectively with IVSA of 0.07 and 0.03.

Conclusion and Recommendations

The projections from The National Institute for Space Research (INPE), (regarded as an approximation of the characteristics of the future climate in Brazil), indicate that for the Brazilian northeast, reduction of rain as a consequence of global warming is expected. Average temperatures could rise by 4ºc in a pessimistic scenario, and from 2º to 3ºC in the most optimistic scenario. All climate scenarios generally predict an increase in temperature, with a consequent increase in evapouration.

Subsistence agriculture would be most affected by climatic change. High temperatures and low rainfall index, followed by drier air, can favour a high rate of evapouration and scarcity of rainfall. Some climatic models also project desertification processes. For instance, the semi-arid area of Sertão could, under the scenario in question, become a desert or a semi-desert.

Though droughts are frequent and natural phenomena in areas of semi-arid northeastern Brazil, droughts usually result in serious consequences for resident communities. Prolonged droughts and desertification cause changes in the hydro regime, losses in agriculture, threaten biodiversity and generate social, economic and environmental impacts.

Asurvey was undertaken in 6 municipalities of

the semi-arid region of Bahia, Barra, Bom Jesus da Lapa, Irecê, Itaberaba, Jacobina and Senhor do Bonfim. They were chosen because all of them present climate typologies varying from sub-humid to dry and/or semi-arid, and for having reliable climate data sourced from the national Normal Climatologic database (for years 1961 to 1990).

The percentage of poor people, according to data from the Institute of Applied Economic Research (IPEA), ranged from 52.05 to 79.29% in 2000. The Index of Development of Basic Education (IDEB) ranged from 2.6 to 3.4 in 2005 and 2007, below the Brazilian average. Agricultural activity is the most significant economic activity of the 6 cities. However, according to the Superintendence of Economic and Social Studies (IES), there was a decrease of 7% in agricultural production from 1996 to 2006. In 2006, negative resultswere reported for practically all grain yields. Climatic change was blamed for this drastic reduction.

It appears that the occurrence of years of drought led to decreased outputs in thecommercial agricultural sector of dry land, mainly, production of beans and maize. With the persistence of global warming, events of droughts could become more frequent. As such,pre-disaster planning and government programmes directed towards adaptation measures to deal with climate change and mitigate adverse effects of drought are of paramount importance.According to the intensity and extent of the occurrence of climatic phenomena, adverse climatic events can destroy entire crop fields. For instance, severe droughts in 1998, led to substantial losses in the production of beans and maize in the Bahia region.

In the search to assess municipalities according to existing socio environmental vulnerabilities, 4 indicators of vulnerability were selected to construct the Socio Environmental Vulnerability Index (IVSA): Index of dryness, IDEB, HDI-M and GDP Municipal Agricultural Sector.Due to difficulty of data collection for equal periods, all indicators of vulnerability were assessed using an average from the available data, to achieve an approximation of the real situation in each municipality. As a result, from the calculation of IVSA it was possible to identify among the 6 cities studied, those most vulnerable to climate change impacts. For example, the city of Barra and Itaberaba present grater socio-environmental vulnerability in comparison to the others.

This work, along with the development of the Socio environmental Vulnerability Index, is expected to contribute to future research, so that governments can consider the issue of vulnerability in the planning and management of municipal, states, and federal regions. Greater knowedge of vulnerability will enable better adaptation measures to be developed, which are fundamental in areas where high socio-economic and environmental vulnerability exists as exemplified in the semi-arid region of Bahia.

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Climate Change and Education: Issues Arising

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Introduction

Changes in climate have occurred throughout the history. Climate change is not new. What is alarming is the increased rate of change over a relatively short period of time. Governments and organisations over the last few years have increasingly insisted that climate change is an issue that requires urgent attention. Global temperatures are on the rise as the natural rate of change is compounded by human activity (UNFCCC, 2007). Melting ice caps and retreating glaciers have caused further eustatic efffects and at the current rate of change, there is risk of permanent inundation across many low lying areas, particularly, those defined as small island developing states. Consequences of climate change coupled with increased global temperatures are likely to have a greater adverse impact on the poorerest nations. Lack of awareness, poor technology capability and transfer from Northern countries and vulnerability resulting from poverty and exposure to disasters are just some of the contributory factors that put least developed countries (LDCs) at risk an make them more vulnerable. One seemingly indirect but important factor that makes populations in LDCs vulnerable is the lack of education, particularly, in the context of issues arising as a direct and/or indirect consequenceof climate change. This paper highlights the importance of equitable, accessible and relevant education within developing countriesas it is argued that education is a fundamental and essential component in dealing with anthropogenically influenced climate change, from local to global scales.

Human Contributions to Climate Change and Risks

Temperatures are likely to continue to rise exponentially,causing a rise in the number of severe weather events. Societies ill prepared or equipped to cope, adapt and/or mitigate disaster will be most adversely affected by climatic change at local, regional, national and global levels. One may argue that the lopsided nature of climate change, being the principal result ofrapid industrialisation by Northern nations (in the pursuit of further development post World War II). Ability, capacity and capability to mitigate and adapt to climate change is skewed in favour of Northern nations. **Plate 1** shows the exposure to flooding of countries around the world. Most at risk are the low lying and poorer countries.

Plate 1 Risk from floods *(source: World Resource Institute)*

Effects of Climate Change in Developing Countries

Because of the population and socio economic dynamics of developing countries, climate change can heighten vulnerability in a multitude of ways. Poverty and high-density populations are major contributory factors. In the case of Bangladesh the fact that it is low lying, deltaic and already susceptible to natural disasters makes the situation worse. Cyclones and floods not only cause huge loss of property and resources but act as deterrents to development activities. Other than increased incidences and intensities of natural disasters the country faces risk of permanent inundation, salinity intrusion, loss of livelihoods, crop damage and failure, disease and out migration (GoB, UNDP. DFID, CDMP. EC, DoE, Report. 2008).

Consequences of climate change are a serious threat to development activities. Hotter summers, more rainfall in short periods, increased incidences of floods and cyclones are already noticeable in Bangladesh.

Mitigation Approaches

At present, approaches to combating the effects of climate change seem to have more of a resistant or precautionary approach, particularly in the cases of incidences of cyclones and floods. Structural interventions such as building cyclone shelters and stronger house construction are increasingly advocated. These are important since such natural phenomenon can happen at almost anytime. Approaches that will save lives in the cases of cyclones and preserve life in the case of flood seem appropriate. Also addressed are issues of livelihood and health.

However, long-term approaches to mitigate effects of a sustained climate change regime are yet to be addressed. Issues related to climate change and their projected effects on Bangladesh require planning now, despite the fact that adverse effects may not be immediately apparent.

If, as forecasted by some, a fourth of Bangladesh will be inundated by 2050, strategies should be adapted now, to either, not let that happen or if it were, to ensure steps be taken to minimise damage. Salinity intrusions, signs of which are already commonly witnessed, require strategies for alternate cropping patterns and new breeds of crops. This necessitates planning and research well in advance.

Plate 2 (above) Cyclone shelters and strengthening of houses: Resistant and precautionary *(source: Post Graduate programs in Disaster Management, BRAC University)*

Of serious concern is migration. Because of phenomena related to climate change, it is likely that a considerable migration of people from affected areas to less affected areas is likely. In the case of developing countries such as Bangladesh,urban in-migration is most likely to take place. As such, cities in these situations that are already overcrowded are likely to grow even bigger, faster. A long-term strategy to tackle this problem is also of urgent importance.

Approaches to mitigate many effects of climate change need to be looked at within the overall perspective of development. Strategies that project well ahead should therefore be formulated.

Long-term Approach: Education

Apart from the need to make the climate change issue cross cut all aspects of future planning in developing countries, inclusion at the policy level is also relevant and necessary. Lack of education is one the reasons for poverty and underdevelopment. Education is not only about gaining knowledge it is also about raising awareness. Awareness about climate change, its causes and consequences are imperative to enable societies to develop skills and build capacity for innovation in tackling climate change impacts.

In developing countries a significant proportion of the population is young. In Bangladesh 33% of the population is under the age of 14 (Bangladesh Bureau of Statistics: 2007). In 20 years, this young population is likely to be heavily impacted by the effects of climate change. This population will, in 20 years, be making or contributing to important policy decisions. It is therefore important that knowledge and awareness of climate change issues are conveyed to younger genrations in order to equip them to make informed decisions. For this, a holistic view of climate change is required. Concern should extend beyond the consequences of climate change to its causes.

While there is the need for prioritising education as a part of the development agenda, education on climate change issues needs to be highlighted within curriculums ofschools, colleges and universities. Below are some suggestions as to how climate change can be incorporated within the education system of Bangladesh.

Primary education can increase concern for the environment and climate change in terms of answering questions regarding “what climate change is” and “ how to simply mitigate/adapt to climate changes”.

Secondary education is probably the most important as it is the foundation for future education and also because a lot of students discontinue after this level. Here, apart from introducing the scientific aspects of climate change emphasis should be made on its socio-economic effects. Most importantly, students should have a clear insight about the causes of climate change. It is important for the students to know that the causes of climate change were predominantly initiated by rapid industrialisation of Northern countries in the twentieth century. Justice issues with respect to development would therefore evolve to take clear shape in future education.

Tertiary education is not accessible to a large portion of the population. The few that have access to it should be made to develop an enquiring attitude to climate change. Since disciplines are separated quite early on in the current system, each one should incorporate an element of climate change education. Cross cutting issues relating to development, increased awareness, and knowledge dissemination need to be prioritised. Also important here is the backflow of information to lower levels through future educators.

Research on climate change has so far been primarily concentrated in developing countries, particularly scientific research. In developing countries research can be more people centric and action oriented. It is important to create an environment where scientific research of developing countries is viewed in terms of practical consequences. There is an urgent need to exchange ideas and information amongst the developing countries facing similar situations.

Informal Education is effective where there is limited access to formal education. There are success stories of informal educationgetting simple messages across to large portions of the population. Popular means of information dissemination need to made use of. For example, media is a useful platformvia television, billboards and theatre.

The role of religious teaching can be utilised to great value. Whether educated or not, people attend religious gatherings. Religious teachers and clergymen can effectively communicate climate change issues. Of importance here is the role of tertiary education to make this possible, i.e. transferring the knowledge of formal education into a form easily understood by the transmitters and transmitees of informal education.

Conclusions

In the case of climate change, education must not be equated to learning only, but also geared towards awareness and capacity for innovation. Local approaches to mitigation require knowledge-base capacity for innovation. The transmission of knowledge from all sources has to be interfaced with the ability to generate solutions, which in turn adds to the knowledge base. This knowledge base has to be people centric and geared towards evolving solutions that address: (i) the problems not only the consequences; and (ii) also question the causes.

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Additional Earthquake Risk from Climate Change and Preparation in Nepal

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Introduction

Nepal is a Himalayan country and its range covers 800kms with numerous glacial lakes. Glaciers are major attractions of the Himalaya and add to the energy water tower of Asia that covers about an area of 33,000kms, square (Dyurgerov et al., 1997). This is the largest glacial coverage outside the polar ice cap regions. These Himalayan glaciers are reservoir of ice, and the source of fresh water for billions of people in the Indian sub-continent and China. Seven great rivers of the Asia; the Ganga, Indus, Brahmaputra, Salween, Mekong, Yangtze and Huang Ho are feed up on these glaciers. The Himalaya of Nepal consists of 3252 glaciers with an area 5322 Km2 and reserved about 481 Km3 ice above 3500 mean sea level (Bajracharya et al., 2002), discharge water regularly to the First Category Nepalese River i.e. rivers originated from above the snow line. The increases of temperature melt more ice glaciers, which is linked to climate change: that could induce tectonic activity, according to scientists.

Nepal lies in the high seismic zone of the world and many destructive earthquakes fill its history. The last major earthquake to strike the country was the 1934 Bihar-Nepal Earthquake that destroyed half of the buildings killing about two percent of Kathmandu Valley population.

Despite the knowledge on historical seismicity and the underlying earthquake risk, public awareness on earthquake hazard and risk was minimal until a few years back. An urgent need for defining a coherent and comprehensive approach towards earthquake mitigation and preparedness was felt by all quarters in Nepal, only after the massive destruction and a loss of 721 human lives due to the earthquake in 1988. Since then, several innovative initiatives on ERM have been implemented. The National Society successfully implemented many initiatives for Earthquake Technology – Nepal (NSET) in cooperation with other institutions.

This paper tries to aware additional potential risk of earthquake from climate change and presents successful initiatives on earthquake risk reduction and preparedness in Nepal.

Relation of Climate Change with Earthquake

Climate change is the most challenging environmental crisis of the 21st century. A number of geologists say glacial melting due to climate change will unleash pent-up pressures in the Earth's crust, causing extreme geological events such as earthquakes, tsunamis and volcanic eruptions. As ice melts and waters runs off, tremendous amounts of weight are lifted off of Earth's crust. As the newly freed crust settles back to its original, pre-glacier shape, it can cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. It shouldn't come as a surprise that the loading and unloading of the

Earth's crust by ice or water could trigger seismic and volcanic activity and even landslides. Dumping the weight of a kilometre-thick ice sheet onto a continent or removing a deep column of water from the ocean floor will inevitably affect the stresses and strains on the underlying rock. While not every volcanic eruption and earthquake in the years to come will have a climate-change link, as the century progresses we should not be surprised by a hike in the number of geological disasters as a direct and indirect result of dramatic changes to our environment.

Sharon Begley of *The Wall Street Journal* recently wrote about the subject in her "Science Journal" column, noting that new research suggests that when ice sheets retreated some 10,000 years ago, volcanoes in the Mediterranean, Antarctica and California became more active. Begley spoke with Allen Glazner of the University of North Carolina, Chapel Hill, a geoscientist who has studied the phenomenon. Analysing an 800,000-year record of volcanic activity in eastern California, Glazner found that "the peaks of volcanic activity occurred when ice was retreating globally. With Earth's glaciers and ice gaps melting at increasing rates due to climate change, it is conceivable that we could see further impact from "isostatic rebound" in the Earth's crust. Begley cites work by Patrick Wu, a professor of geophysics of the University of Calgary, which suggests that past disappearance of ice "may still be contributing to quakes in eastern Canada." (http://news.mongabay.com)

The Himalayan Glaciers have been declining over at least the past 150 years (Wake, 2000) and increased in temperature i.e. 1 degree Celsius over the past two decades (Hasnain, 2000) in the Himalayan region, is accelerating the rate of glaciers melting significantly. There are several evidences of the glaciers melting, for instance the Khumbu Glacier has receded over 5 km since the first climb of Mt. Everest in 1953 (WWF-N, 2005). The Himalaya region is experiencing the global warming and so is the impact. According to the Department of Hydrology and Meteorology, Nepal (DHM, 1997) the temperature in the Himalayas of Nepal is increasing at the rate of 0.12 degree Celsius annually, while it is 0.03 degree and 0.06 degree Celsius for the mid-hills and the Terai region, respectively. Hence, the Himalayan region, which stored the freshwater in the form of glaciers and ice caps, will react the warming more than other region. The Himalaya, geologically Young and Active Mountain with fragile rock and steep topography will face more geological problem. It is anticipated that glaciers and ice caps will continue their widespread retreat during the 21st century (IPCC, 2001). The rate of the Himalayan Glaciers receding is accelerating very fast. Intergovernmental Panel on Climate Change (IPCC) in 1996 had predicted that up to a quarter of the present mountain glacier mass could disappear by 2050 due to global warming. Many tiny glacier lakes are forming and existing lakes are resizing as a result of climate alteration. If this process continued, there may chance to merge those newly formed small lakes and formation of larger one, which may exacerbate the threats. About 20 glacial lakes are potentially dangerous, including 17 that appear not to have experienced a prior GLOF (Mool et. al. 2001) and their spreading may have chance to burst in future. Both increasing rate of melting and decreasing rate of ice formation will reduce the amount of snow drastically, which will have feedback effect on global warming that may increase the magnitude and frequency of earthquake occurrence in our region.

Essential infrastructure such as dams and reservoirs are rarely designed considering potential earthquakes or GLOFs. GLOFs are commonly triggered following earthquakes and landslides as a secondary hazard. The pre-planning and assessment of such crucial infrastructure is crucial in the reduction of probable and uncertain risk.

Conversely, it is possible that climatic variances occur after the devastative earthquakes due to the change in topography such as changes in river course flow. These changes result in ecosystem and environment changes, which govern many complex interchanges including levels of precipitation and evatranspiration rates, which eventually, can influence changes in climate. Likewise, earthquakes severely damage buildings and essential infrastructure resulting in the heavy loss of life, livelihoods and homes. Loss of livelihood and food security generally forces people to rely on unsustainable livelihood practices.

Earthquake Risk Management in Nepal

The need and value of seismological studies and monitoring started being realised in Nepal after the 1934 the Bihar-Nepal Earthquake. The Department of Mines and Geology has been monitoring the seismicity and interpreting the seismic characteristics of the country by its system of seismic stations spread all over the country. Nepal National Building Code Development Project (BCDP) prepared a consolidated earthquake catalog that covers the period from 1255 to 1992 in 1994. This is the most widely used catalog; however, consolidation of pertinent events

since 1992 is yet to be done.

The National Society for Earthquake Technology-Nepal (NSET) used findings of seismological research and studies, to understand earthquake risk and promote earthquake awareness, mitigation, and preparedness. Assessment of earthquake hazard and risks forms the basis of planning and implementation of these earthquake risk management initiatives. Successes of these initiatives were largely due to a wider understanding of hazard and risk, by stakeholders: communities, private sector and the municipalities. For example, the Municipal Earthquake Risk Management (MERMP) that focuses on developing Action Plans for municipalities and the School Earthquake Safety Program (SESP) that focuses on earthquake preparedness in school has benefited a great deal from training courses that have been developed and implemented for masons, technicians, contractors, and engineers with joint efforts of many organisations including community representatives. The training programmes include modules on seismology and the results of seismic interpretation. Similarly, vulnerability assessment of hospitals of Nepal and identification of mitigation and intervention options are based on the understanding of hazard and risk. Several Community Based Disaster Management (CBDM) programmes are being carried out in earthquake risk management. Likewise, the formal sectors are involved in implementing the Program for Enhancement of Emergence Response (PEER), which includes enhancing the capabilities and institutionalisation of Medical First Response (MFR), Collapsed Structure Search and Rescue (CSSR) and the Hospital Preparedness for Emergencies (HOPE). All these programs, implemented by NSET in partnership with local institutions have significantly contributed to raise earthquake awareness, enhance local capacities and prepare the communities to cope with earthquake emergencies. An understanding of seismicity was always the prerequisite.

Thus, NSET has been translating the complex seismological concepts into simple terms that could be understood by communities. At the same time, we found that simple risk assessment tools such as the Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters (RADIUS) was very useful for developing earthquake scenarios for municipalities. Such scenarios are very effective for planning and awareness raising purposes.

Our experience tells us that effective earthquake mitigation can be achieved on a sustained basis even in developing countries, and that dialogue and communication among seismologists, engineers and disaster risk manager enhances the process significantly. The National Society for earthquake Technology (NSET) is working to bridge the knowledge gap between academia and research stations, and the stakeholders for enhancing earthquake mitigation and preparedness.

Improvements in Environmental Policy

A High Level Meeting (HLM) organised by the local enthusiasts- members of the World Seismic Safety Initiative (WSSI) in Kathmandu in 1994 was the first milestone towards influencing the policy-makers on aspects of earthquake risk management in Nepal. Subsequently, several policy improvement initiatives have been formulated and implemented in the country. These policies were created to be conducive to the environment for implementing disaster risk reduction initiatives and achieving emergency response capabilities in the country. Some efforts and achievements in these areas are described below.

Creation of the Nepal Forum for Earthquake Safety (NFES):

NFES has been established as one of the technical committees of the Nepal Bureau of Standards and Metrology, which is a government institution for defining and maintaining Nepal Standards. NFES draws membership from a wide variety of institutions: government, private consultants, contractors, builders, their associations as well as the representatives from engineering institutes, professional societies, material producers and traders, municipal authorities etc. It is a forum dedicated to the task of improving seismic performance of new construction by encouraging compliance of Nepal standards in terms of quality control of materials and construction processes including observing all stipulations of the earthquake codes.

Mandatory implementation of national building code:

The Bureau of Standards and Metrology has initiated a process for defining the draft Building Code as Nepal Standards. Several of the 22 documents that was prepared, as the National Building Code, which is focused on seismic safety, has been accepted as Nepal Standards.

Incorporation of disaster mitigation policy in tenth 5-year national plan:

For the first time in Nepal, the document on the tenth 5-year National Development Plan (NDP) incorporates natural disaster management as one of the objectives of the government in order to contribute towards "making the (infrastructure) Construction and development projects of the country durable, sustainable and capable of providing the intended service". Thus the development concept now encourages prevention and mitigation as important efforts for disaster prevention.

Local Self Governance Act and Kathmandu Metropolitan City Act:

The recently promulgated Local Self Governance Act 1999 (LSGA, 1999) gives a fresh momentum to the process of decentralization and devolution of authority. It empowers the local governments to undertake disaster management activities. Techno-legal aspects of mitigation actions are now considered within the jurisdiction of local governments. A separate act, notably, Kathmandu Metropolitan City Act, is being formulated in order to provide a comprehensive legal and policy framework for an effective governance of the capital.

Important Achievements

Following are some of the important achievements of NSET and many other institutions in earthquake risk management in Nepal:

- There has been a remarkable change in terms of policies, especially in the area of building code development and implementation
- The level of earthquake awareness in the population is remarkably enhanced in areas where people and agencies were active in the past decade. It indicates towards a very high potential of bringing in change in other parts of the country also.
- The demand for earthquake-resistant construction is growing; house-owners are influencing the municipal authorities to include seismic safety in the building permit process. The importance of such change in peoples' attitude towards earthquake safety becomes obvious when one considers that it is taking place at a time when there has been no significant devastating earthquake in Kathmandu in the past several decades.
- More and more institutions are implementing earthquake risk management actions as their regular agenda

While these changes are positive, they are just the start. There is still much to be done, and several challenges to be met remain. Now, we have to widen our earthquake risk consideration in all heavy infrastructure in addition to buildings comprehensively. The motto should be to safeguard people from earthquakes whatever the source of earthquake.

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Landscape, Livelihoods and Risk: A Study of Community Vulnerability to Landslide Events in Central Nepal

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Introduction

Landslides are one of the most destructive geological processes, often resulting in major loss of life and economic damage. Global data show an overall increase in the number of landslides and associated fatalities over time, a trend largely ascribed to human and social factors, rather than to changes in physical processes (Alexander 2005). Similar patterns of landslide occurrence have been observed in Nepal where Petley *et al*. (2007) examined trends in fatal landslide activity between 1978 and 2005. Their findings show a high level of variability in the occurrence of landslides from year to year, but with an overall upward trend. Further analysis of these data suggests there is cyclicity in the occurrence of landslide fatalities in Nepal that strongly mirrors the cyclicity of the southwest summer monsoon in South Asia. However, Petley et al., (2007) go on to note that the number of landslide fatalities have, in recent years, increased dramatically over and above the effects of the monsoon cycle. This trend has been variously attributed to the effects of population growth and urbanisation (Alexander 2005); land-use change resulting from intensive deforestation, unsafe irrigation practices and quarrying (Gerrard and Gardner, 2000); infrastructure development beyond the capacity of the slopes (Sidle et al., 2006); and the effects of (anthropogenic) climate change, which may be changing rainfall patterns and intensities. In the Nepalese context specifically, increasing vulnerabilities may also be attributed to the decade-long civil war, which has exacerbated poverty levels, and led to the migration of people from the Maoist controlled rural areas into government controlled population centres. However, there is little quantitative evidence to support these postulated causes and, indeed, there is very little research into the nature of vulnerability to landslides in the Nepalese context.

Thus, this paper seeks to examine and, where necessary, challenge a series of assumptions made in the context of landslide vulnerability in Nepal with a view to developing a better understanding of social vulnerability and its underlying causes. Specifically, the research seeks to address the following questions:

1. Who is vulnerable to landslide hazards?
2. Why do people occupy landslide prone areas?
3. How are the physical risks perceived and understood?
4. How do people respond to landslide hazard and risk?

Conceptual and theoretical frameworks

The vulnerability paradigm evolved out of the social sciences and was introduced as a response to the purely hazard-orientated approach that dominated disaster thinking in the 1970s (Hewitt and Burton 1971; O'Keefe et al. 1976). Viewed as the 'internal side of risk', vulnerability is an intrinsic characteristic of a system (Birkmann and Wisner 2006). Cutter (2006) identified three distinct themes in vulnerability research:

1. **Vulnerability as a pre-existing human condition**

   The focus here is on the distribution of landslide hazard, the settlement within the hazardous zone and the degree of loss associated with a particular event or series of events.

2. **Vulnerability as a social response**

   This perspective highlights the social construction of vulnerability and its root causes, here focusing upon what makes individuals, households and communities vulnerable to landslides. Consideration is also given to the coping capacity and resilience of the exposed population.

3. **Vulnerability as hazard of place**

   Here, vulnerability is conceived as both a physical risk from landslide activity as well as a social response within a specific geographic domain.

The aim of this study is to move beyond a simple exposure assessment in an attempt to develop understanding of the causal linkages associated with landslide vulnerability in the Nepal Himalaya. As noted by Alexander (2005) much is now known about the physics of landslide hazards, but landslide vulnerability remains a more elusive concept, dependent upon seemingly nebulous patterns of decision-making, response and behaviour. With this in mind, Cutter's (2006) 'hazards of place model' of vulnerability provides the conceptual framework for this study.

Study sites

The research has been conducted in the Upper Bhote Koshi Valley, Sindhulpalchok District, in the Central Development Region of Nepal **(Plate 1)**. The catchment is drained by the Upper Sunkoshi River and its main tributary, the Bhote Koshi River. The Upper Bhote Koshi Valley forms the route of the Arniko Highway to Tibet and is characterised by a complex tectonic sequence of steeply dipping quartzite, phyllite and schist formations. These are overlaid with highly weathered colluvial and alluvial deposits. Large, often creeping, deep seated translational and rotational slides are common, in addition to extensive gully erosion both above and below the road. During the monsoon, river bank undercutting is common, with notable glacial lake outburst flood (GLOF) deposits within the river channel. In addition, the main central thrust (MCT) zone, marking the boundary between the Lesser and Higher Himalaya, traverses the valley at the settlement of Tatopani. This broad zone of disturbance and deformation is characterised by highly fractured material, with high susceptibility to rock falls and slides.

Plate 1 The Upper Bhote Koshi Valley, Sindhupalchok District, Central Nepal

Anecdotal evidence suggests there has been an increase in the number of landslides in the Upper Bhote Koshi Valley in recent decades. However, there has been only limited documentation of these events and their place within the overall physiographic

evolution of the area is poorly constrained (Adhikari and Koshimizu 2005). The study focuses on a 10 km stretch of highway where a number of landslide prone settlements have been identified. These include the three case study settlements of Chaku, Larcha and Kodari **(Plate 1).**

Chaku

Chaku is at risk from imminent, catastrophic slope failure from an active translational slide **(Plate 2a).** Five houses were destroyed here following a landslide in 2001. The remaining four brick houses at the foot of the slope and a single house on the crown remain occupied despite evidence of continued movement. This is a complex slide, with successive failures retrogressing up the slope, putting a wider area and more houses at risk. In addition, two large colluvial fans are located at the southern end of the settlement. Here remobilised rock fall debris destroyed paddy fields and adjacent farmland five years ago blocking the highway for approximately 10 days.

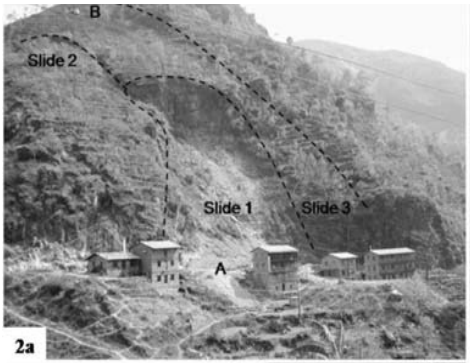

Plate 2 Study sites

2a The active translational slide in Chaku. (A) marks the location of the houses destroyed by the 2001 landslide (slide 1). (B) indicates a house located above the main scarp of the landslide.

2b The Bhairab Kunda Stream (B) joining the Bhote Koshi River (C) below Larcha bridge (A). The inset shows the settlement of Larcha at the confluence of the Bhairab Kunda Stream and the Bhote Koshi River.

2c The roadside settlement of Larcha. The inclining trees and marked changes in the level of the road can be clearly seen.

Larcha

The settlement of Larcha is located at the confluence of the Bhairab Kunda Stream and the Bhote Koshi River, in the base of a steep sided gorge, characterised by steeply dipping phyllite rock walls **(Plate 2b).** Larcha is at risk from landslide dam-break flood events and debris flow hazards. On 22ndJuly 1996 a channelised debris flow killed 54 people and destroyed 16 houses, 150 m of highway, including a highway bridge and surrounding agricultural land. A combination of intense rainfall, runoff concentration and stream down-cutting triggered the slope failure around 500 m upstream and upslope of the settlement. The landslide debris dammed the channel of the Bhairab Kunda Stream and was subsequently breached, inundating the village.

Kodari

The settlement of Kodari was destroyed approximately 60 years ago by a landslide and has subsequently been rebuilt. The 500 m slope on which the settlement sits failed catastrophically again in 1981 following a flood and incision by the Bhote Koshi River, destroying 15 houses, a post office and farmland. The houses and farmland were subsequently abandoned and the displaced population resettled by the government onto adjacent public land. Construction on the slope began approximately five years ago **(Plate 2c).** However, continuous undercutting by the Bhote Koshi sustains the gradual movement of the slope, with the newly constructed houses already showing signs of movement.

Methodology

In the research presented here, a livelihoods approach is adopted which focuses on the social aspects of vulnerability. To investigate the vulnerability of rural communities to landslides it is necessary to gather data on landslide occurrence and susceptibility, exposure, response capabilities and mitigation strategies. The field research began with a geomorphological assessment of landslides along the highway, and focused within the selected case study villages. Baseline surveys were conducted in each village to determine who occupies the landslide prone areas and a 'snowball sampling' method adopted to select information-rich cases for more in-depth analysis. Household surveys were conducted with the aim of gaining an appreciation of the underlying dynamics of the household. In order to address the issues of risk perception and response, a participatory-based approach was adopted involving qualitative engagement with communities. This involved in-depth semi-structured interviews; oral histories; and participatory mapping sessions.

Table 2 The caste and ethnic groupings of sample households in Chaku, Larcha and Kodari.

		Settlement			
Caste/ethnic group	**Sub-group**	**Chaku**	**Larcha**	**Kodari**	**Total**
Upper/high	Brahmin	1			1
	Chhetri	6		1	9
	Newari	5	2	6	11
Low/ occupational	Biswakarma	1		4	5
Hill tribes	Gurung	1			1
	Rai	1			1
	Sherpa	13	7	1	21
	Tamang	7	3	2	12
	Lama	1	2		3
Terai caste	Bahun-Chhetri			1	1
	Total no. hh	36	14	14	65

Research outcomes

Who is vulnerable to landslides?

In order to determine who occupies the landslide prone areas and why, it is necessary to take a historical approach and explore land use change and settlement patterns over time. Research suggests that the Tamangs were amongst the early settlers in Sindhupalchok District. The government's forest clearing policy in the 1920s encouraged the migration of the Chhetris and Newars from the Kathmandu Valley, who claimed and then cleared the land and settled in Sindhupalchok.

This historical account offers an insight into current settlement patterns in the Upper Bhote Koshi Valley. Tamang and Sherpa (hill tribe) groups interspersed with high caste Chhetris and Newars **(Table 1)** predominantly occupy the settlements of Chaku, Larcha and Kodari. The "exposed" households in these locations are both relatively rich and relatively poor. However, and perhaps surprisingly, there appears to be no strong correlation between poverty level and caste/ethnic grouping. These findings suggest that the "most-marginalised" groups i.e. the destitute, low caste households do not always occupy landslide prone areas, as anecdotal evidence would suggest.

Why do people occupy landslide prone areas?

Traditionally, people living in mountain regions have recognised environmental hazards and have made provision for them in terms of settlement layout and design. In rural Nepal, people have traditionally inhabited the more stable ridges lines cultivating the more productive land on the flat valley floor. However, the building of

roads in the valley bottom is leading to outmigration from the hill areas and the resettlement of populations by the road. Such migration has been observed within the Upper Bhote Koshi Valley following the construction of the Arniko Highway in the 1960s.

The landslide problem in the high hills can be described as chronic. Landslides frequently occur but these are characteristically large, slow but constantly moving failures, which progressively damage property and farmland, usually without human loss. By comparison, landslide hazard in the valley bottom is acute. The events which occur are characterised by high velocities and long run-out distances from a distal source, which are commonly not witnessed, and hence are often catastrophic. In this context, migration can be viewed as an exacerbating force with regards to landslide hazards with an increasing population density occupying highly vulnerable locales (Hunter 2005).

Households were seen to occupy landslide prone areas through lack of choice, whereby their assets tie them to a particular place; to take advantage of a roadside location, in which the economic/livelihood advantages outweigh the risks associated with the local landslide activity; and in some cases, because the inhabitants are unaware of the potential threat of mass movement. This will be explored through the following case studies:

Limited choice

Case Study: A relatively poor Tamang household in Chaku

The family house is located above an active translational slide. The head of the household was born in the village and inherited land. They own their house but their farmland was swept away by a landslide approximately five years ago. The husband and wife sharecrop another villager's land and keep half of the crops grown. Their only direct source of cash income is from the husband's day wage labour in the nearby stone quarry. There is clear evidence of slope movement with cracks appearing in the house and the surrounding terraced farmland moving down slope. However, while they are aware of the risk of landslide activity they cannot afford to move. The house is their only asset and it ties them to their location.

This, to a large extent, is what we expected to find: relatively poor marginalised groups living in highly vulnerable locations with no choice but to occupy the site. However, as noted by Wisner (2006) it is important to look beyond the simplified taxonomic approach whereby all poor, ethnic minority households are classified as vulnerable. Instead, by taking a more situational/case study based approach we uncovered a range of further processes, which cause households to occupy landslide prone areas.

The advantages of a roadside location outweigh the risks associated with landslide activity

Case Study: A middle income Sherpa household in Larcha.

The household migrated to the roadside to take advantage of the business opportunities. They purchased the land in Larcha just before the 1996 debris flow disaster and constructed their house approximately one month after the event. While the head of the household is concerned that a debris flow may reoccur, the land is now worth very little due to the risk of debris flow activity. The family could return to their hill village but the livelihood and economic opportunities are better at the roadside.

These findings suggest that risks do not map onto each other. Instead, new opportunities tied to roads cause traditional settlement patterns and their logics to be re-organised leading to increased risk in one sense (that from landslides) but growing opportunities and reduced risk in other respects (for example, through the access to services and the opportunity to generate a steady income for a more secure livelihood).

Unaware of the risks associated with landslide activity

Case Study: A high-caste household in Kodari.

The household migrated from their remote hill village approximately two years ago in search of employment opportunities. Their main income sources are from lorry driving and carrying goods across the nearby Nepal/China border. The family rent a house on the landslide prone slope in Kodari, which failed in the 1980s. Despite evidence of movement, including changes in the level of the road, cracks in buildings and inclining trees, the household believe the land to be stable and much safer than alternative areas.

Knowledge of the physical environment is passed on through generations and people draw on this knowledge and on past experience to make assessments (Dekens 2007). The sample households in Kodari have limited, and in most cases no knowledge of past landslide activity and are essentially exposed to a new and unfamiliar risk environment.

Risk perception

Two overarching themes have emerged with regard to indigenous people's perceptions of risks from landslides: a natural/scientific and a supra-natural understanding of landslide hazard and risk. These findings are similar to those of Bjonness (1986) who undertook research into the perception and risk-avoiding strategies among the Sherpas of Khumbu Himal, Nepal. Local people are aware that they live in a landslide prone environment and make clear links between steep slopes, heavy monsoon rainfall and resulting landslide activity. Links were also made between soil characteristics; deforestation; the quarrying of slate; river undercutting and incision; and in some cases, road construction and mass movement. These findings are likely to reflect the strong social-environmental interaction inherent in mountain communities.

Supra-natural explanations based on Hindu and Buddhist mythology were also given. In this context, landslides were viewed as the work of the deities or gods who reside in the mountains and trigger landslides when angered by the sinful acts of the community and their disrespect of the natural environment. Examples include the dumping of rubbish and the killing of a sacred cow. Popular Hindu beliefs link the gods with giant snakes or nags, which live below the ground. When the gods are made angry, the giant snakes move, triggering slope failure. Few households have, what Pigg (1996) terms, 'blind faith'. Supra-natural understanding does not go unquestioned by the sample households but equally the ideas are not totally dismissed. This reflects everyday life in Nepal, which is traditionally interwoven with religion. Supra-natural explanations were seen to emerge when there was no obvious physical trigger for a landslide or when the events are deemed beyond the control of the community.

Landslide risk in the context of the everyday risk environment

The sample households were seen to attach only minimal importance to severe landslide risk. Instead they were found to have more pressing everyday livelihood concerns, which were viewed as far more immediate threats than relatively infrequent landslide and debris flow events. Hall (1999) describes these pressing everyday concerns as 'felt needs'. Frequently, cited examples include a good, reliable income; education for the children; and access to medical treatment. Researchers involved in the International Karakorum Project (an interdisciplinary study relating to geological hazards in the Karakorum Mountains of Pakistan) in the early 1980s, came to a similar conclusion: local communities seemed to attach minimal importance to the sever threats they faced from their physical environment (Hall 1999).

Many of the case study communities in the Upper Bhote Koshi Valley were found to have a very astute view of risk. What at first appeared to be "risky actions", for example, constructing a house on government land at the bottom of a steep, unstable slope prone to failure, were in fact well thought out actions with clear underlying reasonings. In general, the sample households adopted 'risk-averse strategies'but these were undertaken in the context of the everyday risks they face (Blaikie et al. 2002) rather than in the context of geological hazards. As summarised by Hall (1999) '*in effect they* (the case study communities) *accepted the risk from an infrequent hazard event in order to reduce the risk to their everyday economic needs'* (p.3).

However, not all the example households were 'strategising' and making considered decisions to settle in landslide prone areas. Some households were seen to have limited choice. In this context, individuals and households were seen to 'react' rather than 'strategise'.

Responses

Both the psychometric and constructivist approaches to the epistemology of risk have recognised that people's attitudes towards risk partly reflect their feelings of power, or lack thereof, in relation to the sources of risk (Jasanoff 1998). Accepting something as beyond their control may therefore be viewed as a coping strategy. Both Bjonness (1986) and Pilgrim (1999) discuss this in the context of landslide hazard and risk in the Himalaya and make a clear distinction between events about which something can be done (i.e. decisions made and actions taken) and events which are beyond the mitigating capabilities of the household or community, for example large or rapid landslides. The responses at individual and household level were therefore seen to fit Burton et al's (1993) behaviour patterns:

- Do nothing
  Risk denial/rejection ("it will never happen")
  Passive acceptance of risk ("it doesn't matter what I do")
- Take action
- Action to reduce further losses ("I must be ready")

- Drastic changes in livelihoods or land use considered ("I will not let it happen again")

Do nothing

For those who do nothing, this may reflect a lack of awareness regarding the hazard for example, the community living on the landslide prone slope in Kodari. The new and recent migrants that live on this slope did not experience the landslide 20 years ago. Although the slope continues to move today, to the residents it does not pose an immediate or potentially catastrophic threat. Alternatively, the household or community may be aware of the hazard but may reject the risk and do nothing. The settlement of Larcha was destroyed by the 1996 debris flow event and has since been rebuilt.

Many of the new migrants believe they are safe because *'the big event has already happened'* (male villager, Larcha, fieldwork 2006). Households and communities may also passively accept the risks they face. Examples include some of the residents in Chaku who view landslides as *'uncontrollable', 'acts of god'* and ask the question *'what can we do?'* (male and female villagers, Chaku, fieldwork 2006).

For some people therefore, 'do nothing' is driven by ignorance, for others it is indicative of powerlessness; while for others it is a positive decision to 'do nothing' having considered the alternatives. It is therefore important to note that we cannot determine from a decision (i.e. to move or not to move) the context in which the decision has been made.

Take action to reduce loss

A limited number of households within the case study communities were seen to take action to reduce loss and these were the households with the capacity to do so. Examples include a relatively rich Sherpa household in Chaku who live at the bottom of the landslide prone slope. A roadside location is important for their trade business but they are aware of the risk of landslide activity. In response they have constructed gabion walls at the front of the house and they migrate to the relative safety of their second house in Kathmandu during the monsoon months. However, no drastic changes in livelihood or land use were observed to accommodate landslide risk.

Sims and Bauman (1972)reported that individuals who believe they control what happens to them are more likely to undertake protective actions in response to hazard warnings. By comparison, those who don't, (those who adopt what is often described as a fatalistic attitude) believe it is not possible to achieve protection. The case study communities in the Upper Bhote Koshi Valley largely consider landslides to be beyond their control: *'we do not have the skills to stop the landslides'* (male villagers, Chaku, fieldwork 2006). They do, however, believe the government could provide external control and do something to lessen the impact. Frequently cited examples of such mitigation include the construction of gabion walls and check dams.

Discussion

The research briefly summarised here highlights the impact of road construction on landslide vulnerability in Central Nepal. Undoubtedly, roads influence livelihood trajectories and bring about social change. When roads are constructed and access is given, the process of outmigration and roadside resettlement is inevitable. This reflects agency (voluntary but constrained choice), contingency and the broader processes associated with the political economy (Blaikie *et al.,* 2002). The Government of Nepal states clearly in the country's Tenth Development Plan (National Planning Commission 2002) that temporary and permanent settlements around major highways are illegal. However, while this legislation has not been enforced along the Arniko Highway, the government or the multi- and bilateral agencies funding road construction projects to increase resilience of exposed populations are doing little. While road construction may be enhancing certain livelihood elements, leaving people vulnerable to landslide hazards can be seen to undermine development objectives. With many communities still isolated, the main objective of the Tenth Plan (National Planning Commission 2002) is to further expand the road network through the construction of national and regional highways and major roads at local level. It is therefore a logical step for future road design to take into account migration and roadside settlements.

Understanding what makes people vulnerable to landslides and how exposed communities and households perceive the risks they face are first steps towards effective disaster risk reduction. To achieve this we must consider the role of human agency and recognise alternative framings of risk. For the exposed communities themselves these risks are largely concerned with human security, everyday needs and wellbeing. However, from the context of an 'outside researcher' what may appear to be 'risky actions' are often, in fact, 'risk-averse'

strategies. This does not mean that we should negate the management of landslides but rather that we should look towards devising interventions which reduce landslide risk whilst meeting the basic needs of the exposed populations.

For landslides, structural mitigation strategies are highly developed and non-structural measures are also emerging. However, the focus of such advancements tends to be developed countries. Possible risk reduction strategies for resource poor rural areas include improvements in risk communication; hazard zoning the road corridor to encourage settlements to develop in lower risk areas; the construction of feeder roads in 'safer' areas which enable communities to benefit from access to the road without being at risk from complete annihilation. However, these suggestions raise a series of questions regarding the targeting of already scarce resources and the governance of disaster risk reduction. Nepal has, after all, recently emerged from a decade long civil conflict characterised by political instability and poor governance.

Conclusion

Whilst landslide activity is strongly controlled by monsoon intensity, in recent years the number of fatalities has increased dramatically over and above what might be expected from the climatic conditions. A number of explanations have been postulated, including population growth, land use change and the development of transport infrastructure. However, with little evidence to support these causes a bottom-up approach has been undertaken to better understand social vulnerability in the Nepalese context.

Within the case study area of the Upper Bhote Koshi Valley, a clear transition has been seen over time in the settlement pattern, rural livelihoods and thus the occupation of landslide prone areas. Households were seen to occupy landslide prone sites through lack of choice as their fixed assets tied them to a particular location; to take advantage of a roadside location; or through a lack of awareness of the risk associated with slope failure. There was both natural and supra-natural reasoning attributed as causes of landslide activity, with responses reflecting Burton et al's (1993) behaviour patterns.

Building upon these findings, we now need to turn our attention towards policy and practice with a view to increasing the resilience of communities to landslide activity. This is a particularly salient point given the future uncertainty associated with climate change and the unknown impact this will have on monsoon intensity. In addition, with the continued investment into the expansion of the road network in Nepal, it is hoped that this research will help to target resources and improve the identification of areas and individuals at risk from the effects of landslides. In order to do this successfully we need to recognise alternative framings of risk and devise interventions, which not only reduce landslide risk but also meet the basic needs of vulnerable populations. This will require the engagement of all stakeholders as set out in Nepal's National Strategy for Disaster Risk Management (UNDP Nepal 2008). Only then will we begin to address the vulnerability of rural communities to landslides in Central Nepal.

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