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Environmental Knowledge for Disaster Risk Management
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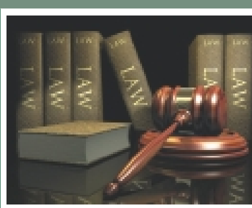
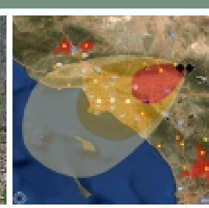
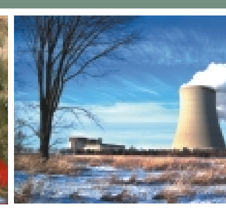
Environmental Knowledge for Disaster Risk Management



Environmental Knowledge for Disaster Risk Management

10-11 May, 2011, Vigyan Bhavan, New Delhi, India

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सत्यमेव जयते

Vice Chairman
National Disaster Management Authority
Government of India

MESSAGE

Rapid economic growth has led to accelerated environmental hazards. Climate-change, land-use changes, and natural resources degradation have resulted in new risks besides aggravating the prevailing risks of hydro-meteorological disasters like floods, drought, desertification besides complex negative impact on coastal and mountain environments.

Understanding of the environment, its processes and resources are important in the early detection of hazards, prediction of disaster risk and scenarios and in evolving mechanisms for effective mitigation and response strategies. Concerns for environmental protection have gained momentum due to their importance in livelihood security, climate-change adaptation, vulnerability reduction and post- disaster relief, recovery and reconstruction aspects of disaster management.

Environmental monitoring and assessment especially with the application of space technology and modern mapping tools of geoinformatics offers precise approach for integrating environmental information into decision support system for disaster management.

I am happy to note the recent cooperation of German Technical Cooperation & Capacity Building (GIZ) and NIDM under the aegis of Advisory Services in Environmental Management (ASBM) in India for the activities on 'Environmental Knowledge for Disaster Risk Management'. The special pre-conference volume published on the occasion of the international conference 'ekdrm2011 brings together various interdisciplinary themes of hydro-meteorological disaster management emphasizing on knowledge management and natural resource management integration.

I am sure that this publication shall serve as guiding document for making the deliberations and discussions of the conference very useful in promoting sustainable disaster risk reduction strategies.

I wish the conference a grand success!

New Delhi
06 May 2011

(M. SHASHIDHAR REDDY)

Dr. P S. Roy
Director

Indian Institute of Remote Sensing
Indian Space Research Organisation
Department of Space, Government of India
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MESSAGE

The assessment, monitoring and management of the environment and natural resources are central to sustainable development. The conflict between natural environmental systems and human activities has resulted in increased frequency and intensity of natural hazards in recent times. Climate-change, land-use change and degradation of natural resources are the major facets of environmental modifications worldwide and especially in the developing countries. Concerns for environmental protection have gained momentum due to their importance in livelihood security, climate-change adaptation, vulnerability reduction and post-disaster relief, recovery and reconstruction aspects of disaster management.

Understanding of the environment, its processes and resources are thus critical in the early detection of hazards, prediction of disaster risk and scenarios, and in evolving mechanisms for effective mitigation and response strategies. During the last few decades, continued advancements in the capabilities of Earth Observation (EO) satellites and associated geospatial, computing and communication tools and technologies have played a vital role in studying the status of Earth's natural systems and providing timely inputs in disaster management activities. The information available from high resolution satellite imagery has now empowered the public at grass root level to address the critical environmental and disaster related issues at local level and contribute in the planning process.

I am happy to note the recent cooperation between German Technical Cooperation & Capacity Building (GIZ) and National Institute of Disaster Management (NIDM) on 'Environmental Knowledge for Disaster Risk Management' under the aegis of Advisory Services in Environmental Management (ASEM) in India. The special pre-conference volume published on the occasion of the International Conference 'ekDRM-2011' brings together different facets of disaster risk management in the form of research papers by the leading scientists and professionals in the field.

I am sure that the conference shall address various issues relevant to disaster risk management, especially in the context of global change, and bring out clear recommendations for formulating strategies to reduce the impact of disasters.
I wish the conference a grand success.

6 May 2011, Dehradun **P S Roy**

एयर वाईस मार्शल (डॉ) अजित त्यागी
मौसा विज्ञान विभाग के महानिदेशक

Air Vice Marshal (Dr.) Ajit Tyagi
Director General of Meteofology &
Permanent Representative of India with W.M.O.

भारत सरकार
भारत मौसा विज्ञान विभाग
मौसा भवन, लोदी रोड.
नई दिल्ली - 110 003

Government of India
India Meteorological Department
Mausam Bhavan, Lodi Road,
New Delhi - 110 003

Foreword

Scientifically sound understanding of the environment - its structure, function, resources, is the key input for disaster risk analysis and mitigation planning. This is especially important in context of hydro-meteorological disasters - cyclones,floods, drought, desertification, extreme weather events, pest attack, forest fire, etc. Climate-change, land-use change and degradation of natural resources are the major facets of environmental modifications worldwide and especially in the developing countries. Implications of climate-change are also witnessed in the form of epidemics, social unrest and increasing conflicts.

Environmental degradation also aggravates vulnerability of people, especially of marginalized and poor, by way of jeopardizing the livelihoods, health and food resources. Environmental concerns in the disaster management is also emphasizing now on post-disaster environmental services like water & sanitation, shelter, waste management, green energy and prevention of secondary disasters. Environmental monitoring and assessment especially with the application of space technology and modern mapping tools of geoinformatics offers precise approach for integrating environmental information into decision support system for disaster management. India has made big strides in generating and managing databases on various aspects of environment. Meteorological monitoring network in India is moving towards modernization with automated facilities for weather forecast, disaster management and climate-change research studies.

I am happy to note the recent cooperation of German Technical Cooperation & Capacity Building (GIZ) and NIDM under the aegis of Advisory Services in Environmental Management (ASEM) in India for the activities on 'Environmental Knowledge for Disaster Risk Management'. The special pre-conference volume published on the occasion of the international conference 'ekdrm2011' brings together various interdisciplinary themes of hydro-meteorological disaster management emphasizing on knowledge management and natural resource management integration.

It is a matter of happiness to know the growing cooperation between National Institute of Disaster Management and GIZ-Advisory Services in Environmental Management for implementation of activities on role of environmental knowledge in climate and disaster risk management. I am sure the international conference shall bring together excellent case studies from across the nations including India and Germany, and the deliberations shall be of important contribution towards developing a path ahead in this line. I extend my greetings to the ekDRM project team and wishes for successful accomplishment. The special volume on this occasion shall be a useful document in guiding the deliberations and discussions towards an objective outcome.

New Delhi , May 5, 2011

(Ajit Tyagi)

Contents

Prologue

Hydro-meteorological disasters particularly floods, drought, desertification, cyclone, extreme weather events, pest attack, forest fire, man-animal conflict are inextricably linked with environmental systems, resources and ecosystems. Environmental challenges and their complexities have been growing with the advancement in human development and economic stewardship. Poor understanding of the environment – its structure, function, resources, especially at the level of planners and policy makers, have resulted in increasing frequency and intensity of hazards in nature.

Understanding of the environment, its processes and resources are important for the early detection of hydro-meteorological hazards, prediction of disaster risk and scenarios and in evolving mechanisms for effective mitigation and response strategies. Concerns for environmental protection have gained momentum due to their importance in livelihood security, climate-change adaptation, vulnerability reduction, and post-disaster relief, recovery and reconstruction aspects of disaster management.

The recent cooperation of the National Institute for Disaster management and the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH under the aegis of the Advisory Services in Environmental Management (ASEM) programme in India, focuses on three main aspects, viz. climate-change, natural resources and land-use changes as drivers of hydro-meteorological risks and associated vulnerabilities. The 'Environmental Knowledge for Disaster Risk Management (ekDRM)' project aims at capacity development in disaster risk management by advancing environmental knowledge, particularly the use of statistics and space technology including remote sensing & GIS for decision support systems (DSS); spatial planning for Na-tech disasters within the multi-hazard framework of disaster risk management; environmental & natural resource legislation; role of EIA in disaster mitigation and post-disaster recovery; environmental services especially shelter, water & sanitation, waste management; and natural resource management for disaster risk reduction.

The ekDRM project methodology includes promotion of training methodologies including blended learning (online plus classroom teaching), web-enabled human resource development platform (training management), research/case studies, publication of reference/awareness materials, and knowledge dissemination through online journal, newsletter and discussion forums on ekDRM themes. The international conference ekdrm2011 provides a forum for academicians, trainers, researchers, policy makers and scholars from a wide range

of disciplines and institutions, to deliberate and discuss various aspects of environmental knowledge application towards managing climate and water related disasters.

The conceptualization and commissioning of the ekDRM project owes much to Mr. P. G. Dhar Chakrabarti, former Executive Director, NIDM and Ms. Sreeja S. Nair, Assistant Professor (NIDM), Mr. Florian Bemmerlein-Lux (Ifanos c&p, Germany), Dr. Sandhya Chatterji (Ifanos c&p India), and Mr. Raghu Babu (ASEM) for their keen interest and painstaking efforts. ekDRM project of GIZ-NIDM cooperation shall be an academic furtherance to the objectives of 'Environment, Climate-change and Disasters Cell' established at National Institute of Disaster Management. Cooperation and Support of Mr. Hem Pande, Joint Secretary, Ministry of Environment & Forests, and Dr. Neeta Bhushan, Director (Deptt of Economic Affairs) have been important in facilitating project processing under ASEM.

Guidance from Mr. R. K. Srivastava, Executive Director, NIDM, and Joint Secretary (Disaster Management) Ministry of Home Affairs, and cooperation of Prof. Santosh Kumar, Prof. Chandan Ghosh, Dr. K. J. Anandha Kumar (NIDM), Dr. S K Das, Director General of Central Statistical Organization and Dr. P S Roy,, Director, Indian Institute of Remote Sensing has been invaluable for organizing this conference. Support of Maj. Gen. (Dr.) J. K. Bansal, Hon'ble Member of National Disaster Management Authority; AVM (Dr.) Ajit Tyagi, Director General of India Meteorological Department; Maj. Gen. (Dr.) Siva Kumar, Head of Natural Resource Data Management Systems at Department of Science & Technology; Dr. Akhilesh Gupta, Advisor to Minister for Science & Technology; Dr. Anil Kumar Singh, Deputy Director General (NRM), Indian Council for Agriculture Research; Prof. N. R. Madav Menon, Director, Dr. S. Radhakrishnan Chair on Parliamentary Studies; Prof. P. C., Distinguished Fellow, M.S. Swaminathan Research Foundation; Shri K.C. Gupta, Former Director General of National Safety Council; Dr. K.J. Ramesh, Advisor, Ministry of Earth Sciences; Shri, N.M. Prushty; Chairman SPHERE India; Prof. V.K. Sharma, Indian Institute of Public Administration; Dr. Luther Rangreji, Sr. Legal Advisor, MEA are deeply appreciated and acknowledged.

Dr. Dieter Mutz, Director, GIZ-ASEM
Dr. Christina Kamlage Senior Project Manager, GIZ
Dr. Anil Kumar Gupta, Associate Professor, NIDM

May 5, 2011, New Delhi

Sustainable Rural Development for Disaster Risk Reduction

P. C. Kesavan and M.S. Swaminathan

Background

The word '**disaster**' is variously defined in the literature and in this paper, it is defined as a natural or man-made event that negatively affects life, property, livelihood or employment often resulting in "**permanent or almost irreversible changes**" to human societies, ecosystems and environment. Our solar system is estimated to have been formed about 4.56 billion years ago with a violent gravitational collapse of a small part of a giant molecular cloud, which in turn was the result of an earlier explosion (13 to 20 billion years ago) of a subatomic unit. The 'Big Bang Theory' explains it. Most of the collapsing mass collected in the centre, forming the sun, while the rest flattened into a protoplanetary disc out of which the planets, moons, asteroids and other celestial bodies formed. Collisions between galactic bodies are still going on in a cycle of annihilations and creations. Earth formed from such violent events is inherently violent. Over the billions of years, after several major cataclysmic events, Earth has become substantially but *not* entirely pacific. The geophysical disasters (e.g. earthquakes, and volcanoes) and the water and weather-related (hydro-meteorological) disasters which occur at varying frequencies and intensities establish not only the violent past, but also the violent present of our planet. Even more rarely, but without doubt, astro-physical disasters (e.g. a meteorite colliding with our space ship Earth) have also occurred. One view is that dinosaurs became extinct after a meteorite impact on Earth about 60 million years ago.

The astro-physical, geo-physical and hydro-meteorological extreme events are classified as 'natural disasters', whereas major accidents such as Chernobyl nuclear reactor accident (26th April 1986), and the Bhopal gas (methyl isothiocyanate) disaster (night of 2nd and early hours of 3rd December 1984) are the man-made disasters. The March 2011 disaster in Japan is unique in the sense that a major earthquake (M~8.9) induced a powerful tsunami and the combined impact of these two caused serious structural damage to the nuclear

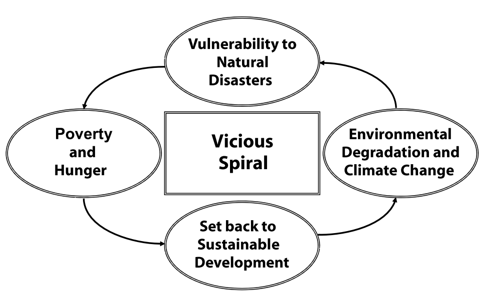
M. S. Swaminathan Research Foundation, Chennai.

power reactors in Fukushima Daiichi and consequently explosions in the nuclear reactors have led to release of radionucleides in sea water and atmosphere. As this paper is written (April 11, 2011), no effective containment of radionucleides and radiation has been achieved. This has raised serious questions on the safety of nuclear power reactors especially in the areas known to have seismic activity. Several of Indian's nuclear power reactors are required to be set up along its long coastline (~ 7500 km) where the human population density is also very high. About 30 percent people of India's population of 1.20 billion live in the coastal areas and they are highly vulnerable to hydro-meteorological (i.e. cyclones, floods, drought etc.) disasters. Hence, one of us (MSS) has written on 15 March 2011 to Shri Jairam Ramesh, Minister of State, Ministry of Environment and Forests, Government of India stating that his concern about the safety of nuclear power plants located along the coast such as Kalpakkam and Kudangulam in Tamil Nadu makes him feel that in addition to necessary technological reinforcements, the bio-shields comprising of mangrove and non-mangrove species in the coastal areas adjoining nuclear power plants should be effectively developed. There would be effective second-line defense. Besides, the risk of sea level rise on account of global warming and the melting of ice and glaciers on high mountain systems and Polar Regions is quite considerable to India and several small developing island states.

Feed-back Relationship between Social and Environmental Factors

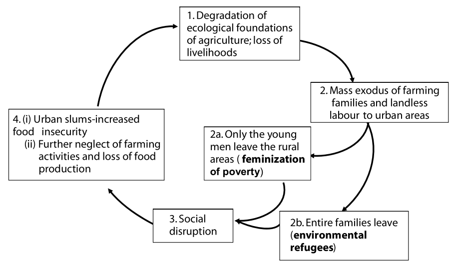
At the United Nations Conference on "**Human Environment**" in Sweden, in 1972, late Mrs. Indira Gandhi the then Prime Minister of India, who led the Indian Delegation declared that 'poverty is the greatest pollutant' and that so long as poverty persists, environmental degradation cannot be prevented. That statement led to an understanding of the vicious spiral between poverty and environmental degradation. Environmental degradation especially in the rural areas (India has about 638,400 villages) accentuate poverty and the poverty in turn results in greater degradation of the environment. The detrimental combination of these two environmental and social dimensions not only contribute to climate change and increased incidence of extreme hydro-meteorological events, but also to enhanced vulnerability to loss of lives, property and livelihood resource base. Kesavan and Swaminathan (2006) have illustrated the vicious feed back rela-

Feed-back relationships



Kesavan P.C. and M.S. Swaminathan (2006) tionships as follows:

In a subsequent paper, they (Kesavan and Swaminathan 2008) have elaborated how environmental degradation leads to social disintegration through mass exodus of rural families (i.e.'**environmental refugees'**) to eke out a living in urban areas and the burden of poverty and responsibility of feeding the household members fall on the shoulders of women, often quite young. That is the '**feminization of poverty'**.



Environmental degradation, environmental refugees- P.C. Kesavan and M.S. Swaminathan (2008)

The terms '**environmental refugees'** and '**feminization of poverty'** bring out not only the state of abject poverty but also deprivation and helplessness particularly of rural women. When a disaster strikes they are the first ones to perish without being able to offer any resistance and the survivors among them are the ones who have little resilience (i.e. coping capacity) to bounce back to normal or near normal daily life. So, the vulnerability to natural disasters has a strong social and gender dimension. Among the poor, women and children bear the brunt of a natural disaster more severely than men. An example is that in Cuddalore (a coastal town in Tamil Nadu) alone, the December 26, 2004 tsunami resulted in the loss of lives of 391 women compared with that of 146 men. A large number of children clinging to their mothers also perished. Aglionby (2005) has estimated that four times as many women died in tsunami. The rural women, many with frequent pregnancies, high level of malnourishment and lack of benefits of education, skills, economic independence and equal rights in decision-making are particularly the most vulnerable. So, social, economic and gender equities are as essential as technological empowerment of rural communities to achieve disaster risk reduction. Of course, technological development is very important. For instance, the Global Environment Outlook 3: Natural Disasters (http://www.grida.no/geo/geo3/english/448.htm) notes that the level of development is directly proportional to the severity of destruction and number of deaths to a given disaster. It is estimated that the average number of people dying per reported disaster are 22.5, 145.0 and 1052 for countries with high, medium and low level development respectively. Within India, the urban-rural divide in terms of availability of technological support, communication, transport, clean drinking water, sanitation, health care and medical facilities is very wide. Many basic amenities are still lacking in thousands of villages even after 63 years of independence.

It is therefore necessary to integrate the environmental, social and economic dimensions of rural development with disaster preparedness. After assessing the December 26, 2004 tsunami devastation of the Andaman and Nicobar islands, Kesavan and Swaminathan (2007) have emphasized on the need to integrate sustainable development with disaster preparedness for effective risk reduction.

Growing concern over Hydrometeorological Disasters

Since poverty and environmental degradation form a vicious spiral, particularly in the rural India, the primary focus must be on sustainable pathways of development to link livelihood and food security of the rural poor with ecological security of the region. A common observation is that degradation of forests directly or indirectly affect the livelihoods of forest-dependent communities and also increase the human vulnerability to natural disasters. Destruction of mangrove forests results in lack of nutrient source in the estuaries for fish, prawns, crabs etc. on the one hand and loss of an effective bio-shield to reduce the velocity of powerful cyclones and tsunami waves. Restoring degraded mangrove forests provides livelihoods for fishers and also protect them from severe hydro-meteorological disasters.

At the point, it must be mentioned here that among the natural disasters, the hydro-meteorological disasters are increasing both in their frequencies of occurrence and also in their destructive potential. The data published by the UNEP/DEWA/GRID-Europe 2004, suggest that during 1991-2004, the world distribution of disasters by geological, biological and hydro-meteorological origin were 10 percent, 14 percent and 76 percent respectively. With a long coastline of about 7,500 km and thick density of human population (~360 million) India needs to be quite prepared to deal with the risk of cyclones, floods, droughts etc. It is of interest to note that in the 1990s, more than 90 percent of those killed in natural disasters lost their lives in hydro-meteorological events (mainly droughts, floods, wind storms etc.,) while earthquakes accounted for 30 percent of the estimated risk, they caused just 9 percent of all fatalities due to natural disasters. In contrast, hunger caused by famines (due to drought) worldwide killed 42 percent of people in the affected regions (IFRC 2001).

The hydro-meteorological disasters are not only increasing in their frequencies of occurrence but their destructive potential is also increasing (Emmanuel 2005) Global warming induced climate change is implicated. Alarming scales of melting and recessions of glaciers in the Himalayas, Poles and Greenland are causing sea level rise. Several small island nations such as Kiribati, Seychelles, Maldives have more than 80 percent of land area at less than a metre above the present sea level. Such low-lying islands may have to pay a high price in terms of loss of human lies and property, if sea level rises to the extent forecast by global climate models (UNEP/GRID; A rendal 2005). India's Andaman and Nicobar archipelago and Laccadives islands also come under the threat of sea level rise.

The Himalayan glaciers are indeed melting and it is reported that there is an overall reduction from 2,077 km^2 in 1962 to 1,628 km^2 in 2007. With an eventual disappearance of Himalayan glaciers, the great rivers such as Ganges, Indus, Brahmaputra would no longer be perennial. This initial '**ecological catastrophe'** would directly result in **"agricultural catastrophe"**(Brown, 2008). A similar happening is likely in China for Yangtze and Yellow rivers fed by the Himalayan glaciers. China and India have world's largest human population and are also the two large wheat and rice producing countries (Kesavan and Swaminathan 2011). Further, data show that with even a slight rise in average night temperature of about 0.5°C, the wheat yield in the north Indian plains decreases by about 450kg/ hectare (Sinha and Swaminathan 1991). Sea level rise in the coastal areas would lead to soil erosion as well as salinization of the soil and fresh water aquifers. These in turn would have adverse implications for food production and food security of India.

Paradigm shift in Disaster Risk Reduction

From the foregoing, it is obvious that resource-poor, poverty-stricken, food insecure, largely illiterate and unskilled rural women and men cannot reduce their vulnerability unless their living conditions improve and they are able to stand on their own feet. It has already been discussed earlier that the famine of rural livelihoods is a major cause of environmental degradation. Rural livelihoods for hundreds of millions of rural women and men cannot be solved by establishing factories, promoting mining activities etc., with a major thrust largely on jobless economic growth. Such activities are invariably akin to "mass production" and "jobless economic growth". In order to link the livelihood security of over 500 million rural people with ecological security of their regions, there is need for development eco-friendly market oriented rural enterprises by harnessing ecotechnologies. The ecotechnologies have pro-nature, pro-poor and pro-women orientation resulting from blending of frontier technologies with traditional knowledge and ecological prudence of the rural and tribal communities. The goal is to enable them to manage their local resources in a sustainable manner and develop ecoenterprises using ecotechnologies. As has been described by Kesavan and Swaminathan (2006), knowledge and ecotechnological empowerment of the rural women and men is the first step in improving the present helpless state of affairs. Sustainable management of local resources and creation of sustainable livelihoods through technological and knowledge empowerment provide not only means of income generation and food security but also dignity and self-confidence. The largely "subsistence agriculture" should be transformed into dynamic eco-agriculture combining crops, (cereal grains, pulses, oilseeds, millets, vegetables, fruits etc.), farm animals for milk and meat and biodiversity. In the coastal villages, culture fisheries, especially ornamental fisheries should be included. In the coastal areas, conservation and enhancement of mangroves enriches harvest of edible marine organisms and also protects lives and livelihoods of the coastal communities against severe cyclonic storms, tsunami etc. Illiteracy or inadequate literacy and lack of skill do not handicap the rural women and men in mastering various ecotechnologies for ecoenterprises and making use of modern ICT for tele-conferencing, tele-commerce and for early warning and disaster management purposes. Nearly four decades ago, Swaminathan (1972) had emphasized that rural women and men could master the use of technologies through a pedagogic method of *'learning by doing'* and he coined the term '*technilracy*' to describe it. So, the experience at the M.S. Swaminathan Research Foundation is that rural people in the Village Knowledge Centres (VKCs) master computer operations in very short time, say a week, and take to useful ecotechnologies like fish to water. Eco-agriculture together with eco-enterprises fight both the famines of food and rural livelihoods. Livelihoods for income generation, agriculture for food production, technological and knowledge empowerment for disaster preparedness and sustainable rural development bring about a "paradigm shift" in the pathway to disaster risk reduction. This 'paradigm shift' initiated by the MSSRF in the 1990s revealed its immense usefulness in (a) forewarning the arrival of tsunami in the fisher village Veerampattinam, in Puducherry on the 26th December 2004 and alterting people to move away from shoreline to higher and safer grounds and (b) in organizing the relief and rehabilitation in a disciplined and organized manner to avoid chaos and to ensure that women, children and old and infirm people received food, water and medical aid.

The two dimensions of "paradigm shift" are the following:

- a shift from "**post-disaster management**" to "**pre-disaster preparedness**" through technological and knowledge empowerment of the vulnerable rural women and men. Ecotechnological empowerment and knowledge empowerment through establishing people-owned, people-managed, Village Knowledge Centres (VKCs) with modern ICT have played a role in the "paradigm shift". The second aspect of the "paradigm shift" is that in the VKCs established by the MSSRF, the development of ecoenterprises for livelihood, conservation and enhancement of coastal bio-shield, initiatives for setting up VKCs and disaster preparedness are "bottom-up" and participatory in approach.
- After the Indian Ocean tsunami of 26th December 2004 by which time MSSRF had set up several VKCs and also Village Resource Centres (VRCs) with up-and down satellite link in cooperation with the Indian Space Research Organisation (ISRO), the Government of India enacted the Disaster Management Act 2005. It has much in common with the MSSRF's model and its focus is on a paradigm shift from '**post-disaster relief and rehabilitation to improving the pre-disaster preparedness, initiating disaster** mitigation projects and strengthening emergency response capacities. It has also established **National Disaster Management Authority** (NDMA) as the apex body for disaster management in

the country. The State Disaster Management Authorities (SDMAs) Chaired by respective Chief Ministers at the state level, and District Disaster Management Authorities (DDMAs) Chaired by the respective District Collectors and Co-Chaired by the elected representative of the "Zilla Parishad" in the respective districts have also been set up. During the last five years of its existence, the NDMA has developed a number of disaster management guidelines for dealing with extreme natural events such as floods, drought, cyclone, earthquake, infectitious and other biological disasters, nuclear and radiological emergencies, chemical disasters and disasters caused by terrorist activities, landslides and snow avalanches. It has also developed guidelines for revamping of civil defence, medical preparedness and mass casuality management. It also addresses the technological, social and management dimensions. However, these approaches need to be integrated with basic elements of sustainable rural development, restoration and conservation of ecosystems, as well s ecotechnological and knowledge empowerment of resource-poor, small and marginal farming, fishing and landless rural families. These would usher in the much-needed "bottom-up" approach necessary for an effective disaster risk reduction in the rural areas, especially in the remote villages located in disaster-prone regions. Modern ICT tools, particularly the cell phones can play an important role in reaching the last mile and last person. These would greatly help in developing a **"bottom-up and participatory**" rather than a '**top-down**" system of preparedness. These will also enhance the 'resilience' or the "coping capacity" of the disaster-affected people to restore normalcy within a short time. It may be recalled that despite best efforts, the civil societies and the government could not repair extensive damage to boats, fishing nets etc. after December 2004 tsunami and consequently, the fisher families in Tamil Nadu suffered without livelihood and food security for quite a long time. MSSRF facilitated alternate livelihood (poultry, oyster mushroom) for the fisher women in one of the worst-affected coastal village, 'Sadraskuppam', a village near the Kalpakkam nuclear power plants. These equip the rural communities to stand on their feet to face the disaster whenever it could strike all of a sudden. Appropriate protective response would be instantly needed. Hence, the vulnerable people themselves need to be trained, equipped and psychologically prepared.

Social, Environmental, Economic and Technological Factors at the Grassroot Level

In as much vulnerability has social, environmental, economic and technological dimensions, approaches to achieving disaster risk reduction must also address all of these in an integrated manner. These essentially sum up what one of us (M.S.S) had emphasized in an article, "**Beyond tsunami: An agenda for action**", in 'The Hindu', (Monday, January 17, 2005). In that article three following initiatives are proposed all along the coast viz., (i) strengthening the ecological foundations of sustainable human security (ii) rehabilitating livelihoods and fostering sustainable livelihood security, and (iii) putting in place knowledge centres in vulnerable coastal villages. Also, these are implemented necessarily in a 'bottom-up', participatory manner. Operationally, a cluster of ecoenterprises based on appropriate ecotechnologies (which result when frontier technologies are blended with traditional knowledge and ecological prudence) each with pro-nature, pro-poor, pro-nature and pro-employment is undertaken in a village, it becomes a 'biovillage' (bios= living). This is indeed transforming a village with conventional subsistence farming and sedentary lifestyle to a more vibrant agribusiness unit with a number of ecoenterprises run by enthusiastic self-help groups. Sustainable management of environmental resources for sustainable livelihoods links livelihood security with ecological security. Technological and skill empowerment are through 'techniracy' (i.e. a pedagogic method of learning by doing). Knowledge is power today. Locale- and time-specific, demand-driven information is needed by the resource-poor, rural women and men to overcome the problems encountered in crop and animal husbandry, fisheries, marketing, health care, communication, transport, education etc., and also for awareness of welfare schemes of the state and central governments; when young rural women who have passed 7th or the 8th standard are trained in computer operations, they become the managers of the VKCs. With young women as the Heads of Knowledge Centres, many tangible and intangible benefits occur. Income generation and enhancement of social esteem are clearly tangible. Women connected with VKCs and VRCs gain self-confidence and participate in decision-making processes at home and at grassroots' Panchayat level. Enlightenment of women leads to family planning and better education and better management of food and nutrition security at the household level. And in case of any emergency caused by accidents, or natural disasters, they are no longer helpless and incapable of appropriately dealing with the situation. They also master the use of cell phones for contacting police, hospitals, fire service, weather centres etc. These represent preparedness at the grassroot level. Women in particular are known for conservation of forest trees, water bodies and biodiversity.

In nutshell, the biovillages together VKCs help in integrating sustainable rural development with **pre-disaster** preparedness. The five Es Viz., economics, environment, (ecology included), equity (gender and social), energy and employment are essential components of pre-disaster preparedness.

New Dimensions of Disasters

It is a fallacy that technological innovations effectively thwart Malthusian scourge. Every technology exerts a negative impact too. The green revolution of the 1960s and 1970s degenerated into greed revolution and resulted in serious environmental degradation and loss of biodiversity. The modern satellite and computer linked technologies have created electronic pollutants in the space and land. So, the real situation is that both humanity and planet Earth are crossroads. The "**ecological footprint**" has far exceeded the **"biocapacity"** of Earth (Wackernagel *et al,* 2002). The Copenhagen Accord (2009) does not provide a concrete action plant to contain the emission levels at or below 44 Gt CO_2- eq. The national emissions reduction pledges are insufficient to meet the objective of keeping the global warming to below 2°C. An analysis by Rogelj *et al* (2010) suggests that the global warming could exceed 3°C by 2020. This means a catastrophe resulting from crossing over the "**tipping point"**. The '**tipping point'** with reference to climate change is a point when global climate changes from one stable state to another stable state. Transition to a new state occurs. And the tipping event could be irreversible. Rockstrom *et al* (2009) show that the planetary boundaries have already been transgressed in a number of parameters viz., concentration of CO_2 in the atmosphere, rate of biodiversity loss, nitrogen cycle, ocean acidification etc. So, tipping point with regard to hydrological cycle will be highly catastrophic.

Notwithstanding controversies whether climate change is natural or man-made, the fact of a climate change is well-established (Climate Change Reconsidered, The Heartland Institute, Chicago, 2010). Predominantly agricultural, densely populated, and very long coastline countries such as India will need to be well-prepared to avert famine of food, drying up of rivers and loss of biodiversity.

India's action plan on climate change is to protect the poor and vulnerable sections of the society through an inclusive and sustainable development strategy, that is sensitive to climate change. The Prime Minister's council on climate change has put emphasis on promoting basic understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. Eight National Missions Viz., (i) National Solar Mission (ii) National Mission for Enhanced Energy Efficiency (iii) National Mission on Sustainable Habitat, (iv) National Water Mission (v) National Mission for Sustainable Himalayan Ecosystem (vi) National Mission for a Green India (vii) National Mission for Sustainable Agriculture and (viii) National Mission on Strategic Knowledge for Climate Change with major goals of mitigation, adaptation, and risk management have been identified.

These eight missions have much of their basic tenets and pathways based on the concept of "evergreen revolution" proposed by Swaminathan (1996a;b;1999;2000;2002;2005). It is particularly suitable to achieve productivity in perpetuity without accompanying ecological harm in millions of resource-poor, small and marginal farms with nearly 2/3 of them located in the rain-fed regions of farming. The National Commission on Farmers (NCF) under the Chairmanship of Professor M.S. Swaminathan submitted its final report in October 2006.

It has included a draft National Policy for Farmers incorporating its major recommendations. These include technological, economic, environmental, social and gender aspects which would greatly enhance resilience of Indian agriculture in an era of climate change with increased incidence of hydro-meteorological disasters. There is no indication as yet that these are under implementation now. It would seem that acute and sudden disasters are now receiving some attention, but not the slow and chronic ones especially in the agricultural front. We should remember that drought-related famines have killed far more number of people, than the most serious earthquakes. So, the disaster risk reduction must have appropriate strategies to overcome the impact of a bad monsoon, as well as hydro-meteorological disasters.

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Flood Warning in Bavaria, Germany

Alfons Vogelbacher

Introduction

Timely warning of flood hazard is an essential part of precautious flood protection. Prolongation of the forecast lead time enables more substantial protection measures like the building up of mobile walls. The effectiveness of the warnings mainly depends on the awareness and preparedness of the recipients. Today the enhancement in information media i.e. the internet has lead to a much better reach ability of flood information and warning for everyone.

In Germany, the responsibility for a flood information service is assigned to the federal states. Until 2000, the flood information service in Bavaria primarily served as a reporting service that collected water gauge records and forwarded these – supplied with a trend comment – to those concerned. The amount of quantitative flood forecasts was limited. Simple methods were used, e.g. regression functions for gauges.

In the last 12 years, Bavaria has suffered under a series of extreme floods. There was a large flood at the Whitsuntide in the year 1999 in Southern Bavaria and the Alps. The centres of damage have been located at the Danube River and the southern tributaries Iller, Lech and Isar. Three years later the heavy rainfalls in August 2002 caused extreme floods of the Danube River and its northern tributary Regen in East Bavaria. In January 2003, the northern parts of Bavaria, especially the Basin of the River Fränkische Saale, a tributary to the Main in the Rhine Basin, suffered a large flood. Recently, the flood in August 2005 hit the same region as 1999. Partly the flood peaks even surpassed the peaks of 1999.

Because of the increasing damage and the increasing number of floods - in particularly the Whitsuntide Flood in 1999 - the Bavarian State government established an Action Program for sustainable flood protection led by a long term flood prevention and protection strategy until 2020. The Action Program is part of the Integrated River Basin Management. Actions have been taken at the same time in the fields of natural retention, structural flood

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measures and flood precaution including new challenges like Climate Change. According to the resolution of the Bavarian State Government in May 2001 there will be an investment of 2.3 billion Euros until 2020 in the fields of improvement of natural detention, improvement and construction of structural flood measures and flood precaution.

Part of this program was the development of flood forecast models as well as the implementation of an automatic online rain gauge network and an optimisation of the existing river gauge network. The dissemination of flood information based on means of modern communication and its reliability was improved.

Today, hydrological forecasts have become an important part of the flood information service in Bavaria, since hydrological models cover almost the total area of Bavaria (70 000 km^2). The hydrological forecasts are calculated daily on business days and more frequently during flooding periods in five regional flood forecast centres. The decision-makers within the Bavarian Water Management Authority can access the results, i.e. forecasts for around 600 gauge stations over whole of Bavaria. Additionally, the forecasts of about 100 selected gauging stations are published in the web site (http://www.hnd.bayern.de) for a horizon of 6–24 h depending on the catchment area.

Organisation of Flood Warning in Bavaria

Flood warning systems in river basins and on lakes are the responsibility of the German federal states. For this purpose, Bavaria has set up a Flood Warning Service that collects data on water levels, run-off and precipitation, analyses this information, draws up flood alert plans and warns people affected. Connected to the Flood Warning Service are the state offices for water management, the county district offices, towns and communities. The coordinating unit is the Flood Warning Centre in the Bavarian Environment Agency (Fig. 1). Five regional Flood Forecast Centres are responsible for calculating and preparing flood predictions for the basins of the rivers Main, Danube, Isar, Iller/Lech and Inn respectively.

The respective centres are put into action as soon as rivers or lakes rise above defined threshold values. The water levels at the gauging stations are then read on an hourly basis and flood predictions are updated continuously. The state offices for water management put out regional alerts, while the Flood Warning Centre issues a flood status report for all Bavaria.

Alert plans make sure that this information is passed on through the county district offices to the affected towns and communities. Towns and communities are the last link in the alert channel and play a particularly important role. The alert plans specify who is to be warned, when and how, and what measures are to be taken at which gauge levels.

For this case, the local authorities have plans of endangered areas or buildings and plans for the organisation of flood defence systems.

The flood warnings have to be actively transmitted to the concerned recipients. Once warned, the recipient has the responsibility to inform himself about the threatening flood. For this purpose, the state offices for water management, the regional flood forecast centres and the flood information centre provide updated data, forecasts and flood reports via the website as well as flood news via a telephone service to the public and authorities. Actual water levels of all gauging stations are provided via TV-text and telephone service.

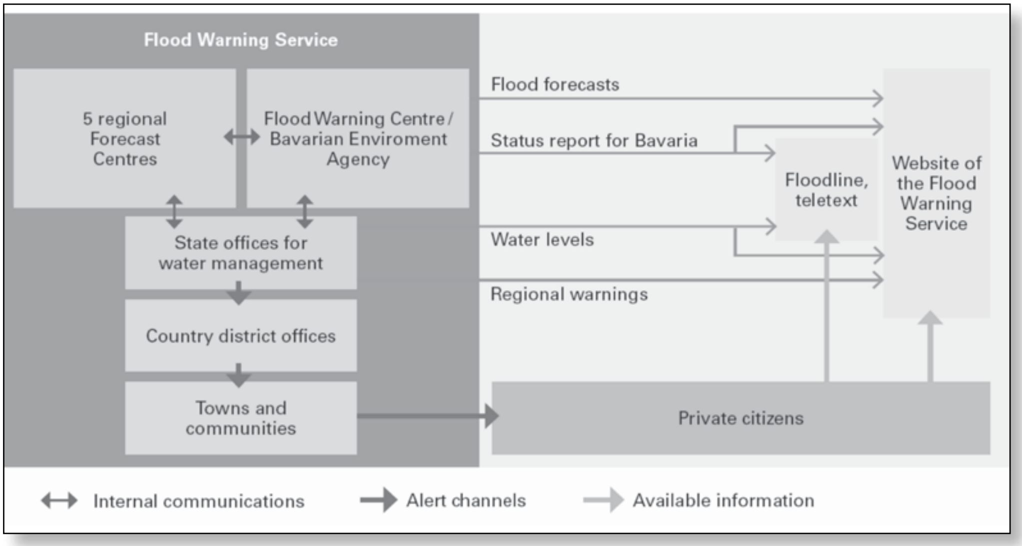

Figure. 1 Reporting and information scheme of the Bavarian flood information service

Role and Operation of the Flood Forecast Centres

In Bavaria there are five flood forecast centres corresponding to the main river catchments (Danube, Inn and Main) and Danube tributary catchments where large reservoirs have to be operated (Iller-Lech and Isar). They are responsible for operational flood forecast. The decentralised and river catchment-related organisation of the flood forecast allows the use of experiences with local knowledge and the operation of large reservoirs in-situ. The model-based flood forecast service supports the services of the regional water authorities and the flood information centre. In the case of the flood forecast centres Iller-Lech and Isar, respectively, the flood forecast service additionally assists in the management of reservoirs.

The state offices for water management are responsible for local flood forecasts and the dissemination of flood information in the regional flood information service, the application of models for reservoir operation and for the data service (collecting and providing data of the river gauge network).

The regional flood forecast centre informs the main reporting offices within the forecast area and the flood information centre, if due to the flood forecast a lasting overrun of the warning limits has to be expected. After receiving this information, the main reporting offices have to provide the river gauge data on an hourly basis.

In case of a flood event the flood forecasts are calculated three or four times per day at defined points of time. If necessary, the flood forecasts are updated every hour.

The forecast centres calculate forecasts for all river gauges implemented in the flood forecast models. The complete flood forecast simulation results are made available for the regional water authorities, regional governments and ministries by a Java-Client application within the data network of the Bavarian water management administration. In the intranet and internet, only forecasts of selected river gauges and for reduced forecast horizons are published. The regional water authorities have access to the flood forecasts for all river gauges and can use these results for their own forecasts.

Water level and flood risk

The basic Information in flood warning is the water level at the gauge site – measured or forecasted. For interpretation in respect to the flood risk and to protective measures more information is needed. First, there are 4 alert levels that deliver plain and simple information

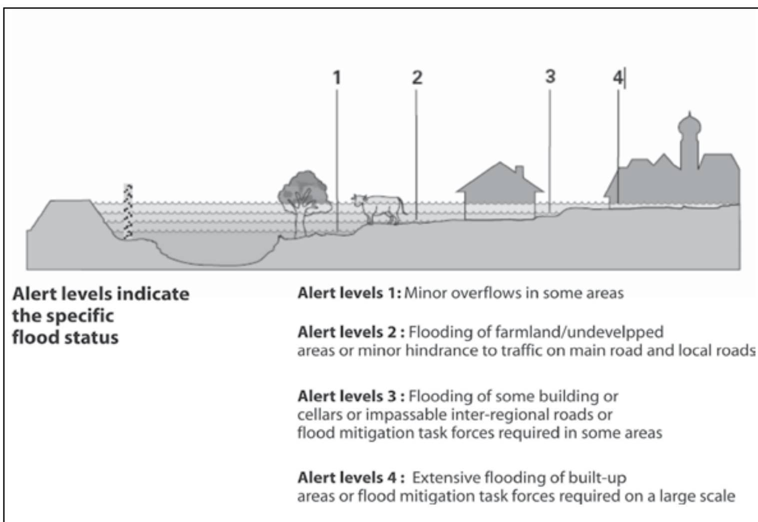

Fig. 2: Flood Alert Levels

on the extent of flooding. At each individual gauging station it is determined which water levels correspond to the respective flood alert levels (s. Fig. 2). Second, there are tables for each gauging station connecting water level to a description of the flood extent, protective measures and flood hazard (Tab. 1). The communities are responsible for the maintenance of plans linking water level to flood risk and protective response. They keep plans of endangered areas or buildings and plans for the organisation of flood defence systems. Protective responses in Bavaria are: manageable flood polders, major storage dams in headwater, flood protection walls, mobile closures, superstructures, sandbags and evacuation.

Table 1 *: Flood hazards and protective measures in relation to the water level at gauging Station Passau Donau (cut version)*

W cm	Place	Type of measure or hazard
630	Passau	Advance warning to the police by the regulatory agency
720	Passau	Flooding of the upper Zollände in Passau and the harbour area Racklau.
720	Passau	Flooding of the Fritz-Schäffer-Promenade at the tavern -Tiroler-, removal of the motor vehicles.
740	Passau	Flooding of the Fritz-Schäffer-Promenade, traffic stoppage.
750	Passau	Evacuation of the parking lots at Schanzl.
750	Passau	Traffic blocking at the upper Donaulände
770	Passau	Flooding of the high road ST 2132 at Löwmühle
770	Passau	Evacuation of garages and souvenir shops at the lower Donaulände. flooding of the harbour area Racklau
780	Passau	Highest water lever for water navigation (HSW).
790	Passau	Flooding of the approach to the Nagelschmied- and Höllgasse
800	Passau	Flooding of the posterior Donaulände downstream of the Schanzl bridge.
800	Passau	Warning by loudspeaker for the upper Donaulände, Regensburgerstreet, Rindermarkt and Ort.
810	Passau	'Ort' partly flooded.

More information about flood risk, vulnerability and hazard

Online Maps (www.iug.bayern.de)

Via Internet, online maps of the designated flood areas and preliminary assured flood areas can be reached by the public. The Information Service Flood Affected Areas (IÜG) gives an overview of the status of the investigation and determination of flood risk in Bavaria. Flooded areas for frequent, medium and rare flood events and water-sensitive areas are displayed. Where available, also the water depths in flooded areas and observed floods are shown.

The EU Directive on the assessment and management of flood risks

The EU Floods Directive on the assessment and management of flood risks went into force in 2007. This Directive now requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. This Directive also reinforces the rights of the public to access this information and to have a right of codetermination in the planning process.

The Directive's aim is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to first carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding. For such zones they have to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015 (http://ec.europa.eu/environment/water/flood_risk/index.htm).

Website of the Flood Information Service

The website of the Flood Warning Service (Fig. 3) gives access to detailed background information and to the latest water level readings and recorded measurements. Maps and Charts give a quick overview of the current status 24 hours a day. These sites give access to water level and run-off data from river and lake monitoring stations as well as to measurements provided by precipitation and snow depth monitoring stations.

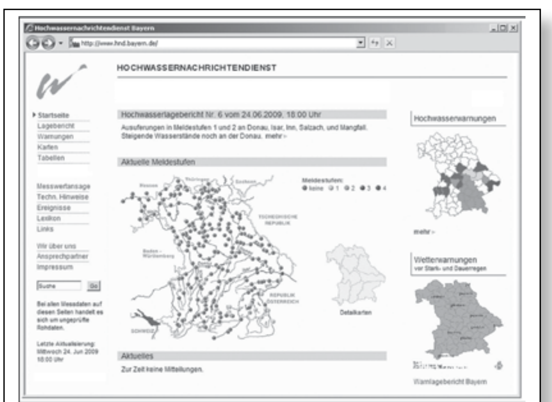

Fig. 3: Website of the Flood Information Service

In a flood event the Flood Bulletin (status report) gives an overview of the flood situation and a forecast of the expected further development. The bulletin is updated several times a day. In their Warnings the state offices for water management provide a detailed description of current and predicted flooding for each one of their county districts that are threatened. In addition reports on past flood Events as well as Links, addresses and phone numbers of other contact partners can be found on the website (www.hnd.bayern.de).

Real-Time Data Collection

The flood warning system uses all reachable data of the different measurement networks in hydrology and meteorology, weather radar products and numerical weather forecasts from the weather services and data of the hydro power plants.

- Transmission of the data is done by:
- Polled Systems (sampling of data via telephone landline, digital mobile as GSM (GPRS))
- Push Systems (active transmission from station to server via ISDN or GSM)
- NFS file transfer in the computer network
- Ftp transfer and http-request between computer in different networks and from neighbouring countries

Water Level and Discharge Data

The river gauge network in Bavaria consists of about 600 stations, 560 of which are equipped with telemetric data transmission. 320 river gauges are so-called "report river gauges" for the flood information service. The extreme flood events in the Danube river catchment in May 1999 and August 2002 as well as in January 2003 in the Main river catchment revealed that equipment and data transfer were not sufficient. Failures and breakdowns of the measurement installation and data supply occurred. To ensure the data supply, most of the river gauges have been equipped with redundant measurement devices and telecommunica-

Gauging Station at the river Isar in flood stage tion channels. For telemetric data transfer, the conventional telephone network or mobile telephone systems GPRS are used. The remaining river gauges in the flood information service have at least redundant measurement devices. Furthermore, there were numerous river gauges where the extreme floodwater stages could not be assessed. Constructional measures will be taken within the next years.

For the flood forecast models, discharge is the observation, and thus reliable stage-discharge-relationships are needed. However, often discharge is not measured during flood situations and additionally it is associated with large uncertainties. To check and improve the rating curves especially in the high-flow extrapolation range, a project has been started at the Bavarian Environment Agency where hydraulic simulations for about half of the Bavarian river gauges shall be conducted.

There are also water level data available from the Hydrographical Services of Austria, from the adjacent Federal States of Baden-Wuerttemberg, Thuringia, Hesse as well as from the Federal Waterway and Navigation Administration for the national waterways. For the flood forecast models, discharge data at the power stations are required. These data are obtained in a data exchange with different operators of hydro power stations. The data of most of the external partners are imported per ftp or http-request via the internet into the main database of the flood information service.

Hydromet Inputs

Most of the precipitation data are provided by a joint automatic monitoring network, operated by the German Weather Service and the Bavarian Environment Agency with about 285 stations. Additionally, data from the monitoring networks of the private company Meteomedia, the Bavarian Agency of Agriculture and the Bavarian Avalanche Warning Service are used. Because of transboundary tributaries, also precipitation data of the Central Institute of Meteorology and Geodynamics, Vienna, and the Austrian hydrographical services as well as of the federal states of Baden-Wuerttemberg and Hesse are collected. Overall, precipitation data of 700 stations are available online.

Besides precipitation, snow height, snow water equivalent, air temperature, wind speed and radiation are the most important meteorological observations for snow melt calculation. However, these quantities are measured in a lower spatial resolution. The snow measurement network has been considerably increased within the last years. At present, the snow water equivalent is measured at approx. 120 stations.

The spatial assessment of precipitation can be improved by using weather radar measurements. The adjustment of radar signals to the measurement data of the ground precipitation network allows a spatially high-resolution assessment of rainfall events. The operational products of the German Weather Service project RADOLAN (radar online-adjustment) are available since 2005. The composite data of the radar echoes and the products adjusted to the ground monitoring network are received each hour via FTP from the German Weather Service. Since 2008, the RADOLAN-data can be used directly as input data for the operational flood forecasts.

Numerical Weather Prediction (NWP)

Several weather forecasts are available for operational flood forecasting in Bavaria. Usually, the results of the numerical weather forecast models of the German Weather service are used. COSMO-EU is the main product of the German Weather service for the forecast horizon of 3 days (www.cosmo-model.org). The most recent product is COSMO-DE, which has been used for operational flood forecasting in Bavaria since 2008. The high horizontal resolution of 2.8 km allows direct simulation of thunderstorm cells of the size of only a few kilometres. Forecast runs are started every 3 h. Within the model runs, updated radar measurements are integrated.

For Southern Bavaria, the results of the ALADIN-Austria model operated by the Central Institute of Meteorology and Geodynamics in Vienna are available additionally (Vogelbacher 2007). For the purpose of comparison, forecast products such as the American GFS (Global Forecast System) model or the ECWMF (European Centre for Medium-Range Weather Forecasts) model are used at times.

Since December 2007, the model output of COSMO-LEPS (Consortium for Small-Scale Modelling – Limited-area Ensemble Prediction System) of 16 ensemble members is available and used in flood forecasts.

To spatially assess the water release from snowmelt and rainfall, simulation results of the snowmelt model SNOW4 of the German Weather Service are used. Water yield and water equivalent of the snow cover are given in a spatial resolution of 1×1 km in an hourly time step.

Weather and storm warnings of the German Weather Service are sent via FAX, e-mail or are made available via the internet. Further information can be obtained by telephone contact with the meteorologist in charge at the regional office of the German Weather Service in Munich. For defined geographical regions in Bavaria, the meteorologist gives an evaluation for areal precipitation amounts.

On-Line Data Base

All of the data are continuously fed into a set of MySQL relational data base tables to form the online master data base. The master data base is replicated continuously on up to 15 other web servers with a Linux-Apache-MySQL system. These servers are located at 3 regional flood forecast centres and in the computing centre of the state of Bavaria for internet access. If the master data base fails the other servers can take over the function of a master. The automated import procedures can be run on each of the servers in the network.

The data base contains the following data (number of stations in parenthesis):

- Metadata for gauging-stations, meteo-stations, precipitation-stations, data transfer, statistics, level-discharge curves, flood stages, warning levels, flood-risk plans etc.
- Alert and dissemination plan with 3991 addresses and 1425 messages
- reports, like the flood bulletins and warnings,
- water level & Discharge (1077) with Forecasts (184)
- precipitation (919)
- Snowfall level (627)
- Water Equivalent (377)
- Atmospheric pressure (71)
- Global Radiation (191)
- relative Air Humidity(406)
- Sunshine Duration (92)
- Air Temperature (511)
- Dew Point Temperature (148)
- Wind Velocity (365)
- Snowmelt and Rain from SNOW4-model 1kmx1km grid-data
- Water Equivalent of the Snow Cover from SNOW4-model 1km x 1km grid-data

Flood Forecast Model System

Forecast models completely cover the area of Bavaria (Fig. 4). The rainfall–runoff model predominantly used is LARSIM (Ludwig et al. 2006). Because of its robust and relative simple components, the model is suitable for operational forecast (Gerlinger et al. 2000). LARSIM can be applied as an event-based flood model as well as a water balance model for continuous simulations. For the time being, the operational LARSIM flood forecast models are implemented in event-based mode. The water balance model mode is currently being introduced. For the Iller catchment the water balance mode of LARSIM has been implemented, and is now in an operational pilot phase.

The rainfall–runoff models used are deterministic models, which calculate discharge rates as response to precipitation input. In the simplest case, the effective precipitation is determined with a runoff-coefficient depending on the antecedent moisture content of the area. According to non-linear relations between precipitation and resulting discharge, the runoff-producing precipitation is adjusted by superposition calculations.

The catchment parameters can be subdivided either in gridded or irregular sub-catch-

Description (No.)*
(1) Danube upstream of Lech
(2) Lech
(3) Altmuehl
(4) Naab
(5) Regen
(6) Danube incl. Paar
(7) Isar
(8) Chiemsee
(9) Traun
(10) Mangfall
(11) Rott
(12) Inn
(13) Danube downstream Regensburg
(14) Upper Main
(15) Regnitz
(16) Fraenk. Saale

Fig. 4: Overview of the hydrodynamic and rainfall-runoff models used for operational flood forecast in Bavaria

ments. Each sub-catchment is characterised by coordinates, elevation, length of watercourses and schematic river cross-section with roughness coefficients. On a grid or sub-catchment basis, the relevant runoff processes are calculated using specific hydrological methods (Laurent et al. 2010).

Snow accumulation and snowmelt can be considered as well as artificial influences (e.g. storage basins, diversions, water transfer between different catchments). The model calculations are based on hourly data of precipitation, discharge, precipitation forecasts, as well as on snowmelt calculations and forecasts. The forecasts for the tributaries based on rainfall–runoff models are linked to hydrodynamic models.

The basis for the flood routing model at the Main river is the hydrodynamic model WAVOS of the German Federal Institute of Hydrology. The hydrodynamic model FLORIS 2000 (Reichel 2001) is run for the Danube, the Lech and for the Inn River. The standard operating regulations of the hydropower stations are included in these models.

The operational flood forecast model system works in a so-called served operation. First, the rainfall–runoff models have to be run to the connecting gauge for the hydrodynamic model. Besides forecasts of the rainfall–runoff models for the Bavarian region, external flood forecasts for tributaries are needed and implemented in the system.

For example, the Danube forecasts upstream of the Iller tributary are produced by the Federal State of Baden-Wuerttemberg. For the Inn catchment, flood forecasts are needed for the Inn upstream of Kufstein which are supplied by the federal state of Tyrol (Austria) and for the Inn tributary Salzach, supplied by the federal state of Salzburg (Austria). The Salzach River is within the responsibility of the federal government of Salzburg where they use HYDRIS (Hydrological information system for flood forecast).

Using rainfall–runoff models, the forecast period is limited by the precipitation forecast. To adjust to the COSMO-EU model of the German Weather Service, 72 h forecasts are produced by default. However, forecasts for shorter periods are published on the internet. At present, the hydrodynamic models are run for 48 h forecasts (Vogelbacher 2007). Since December 2007, ensemble precipitation forecasts have been used operationally for the catchments of the Rivers Regen, Fraenkische Saale, Upper Main, Regnitz and Mangfall and are currently being evaluated.

Uncertainty of Forecast

Experiences with published forecasts during former flood events have shown the need for communicating the uncertainty associated with hydrological forecasts to the public and the responsible persons in civil protection. Expectations on the reliability of flood forecasts are high. Publishing only one forecast as a quasideterministic forecast with one value at a given time even raises these expectations by pretending to be exact. Therefore, one aim of computing uncertainty is to publish it along with the corresponding forecast. The resulting illustration should make the numeric forecast less absolute for the average user and communicate the probability of a certain water level to be reached.

The uncertainty in the flood forecast is the result of uncertainties in input data, in model simplifications, in the estimation of the model parameters and in operational practice of forecast generation. Each of these components bears a particular uncertainty, which affects the uncertainty of the simulation output. In many cases, especially in headwaters, meteorological forecasts are the most dominant source of input data uncertainty. Often there are large differences in rainfall amounts between forecasts originating from different meteorological models and between the different model runs of the same model. Not only the amount, but also the spatial and temporal distribution of precipitation can vary between different forecasts and the measured precipitation affecting the output of the hydrological model, especially in smaller catchments. Therefore, ensemble forecasts should be included in the calculation of total output uncertainty to account for the dynamic uncertainty of the meteorological forecast. If the forecast horizon lies within the travel time of a flood wave observed upstream, the runoff forecast is expected to be more accurate as it only involves the single process of flood routing.

The relative influence of the different sources of uncertainty depends on different factors like forecast horizon, meteorological conditions and up- or downstream location of the catchment. With increasing forecast horizon, the influence of the uncertainty of the meteorological forecast increases (Fig. 5).

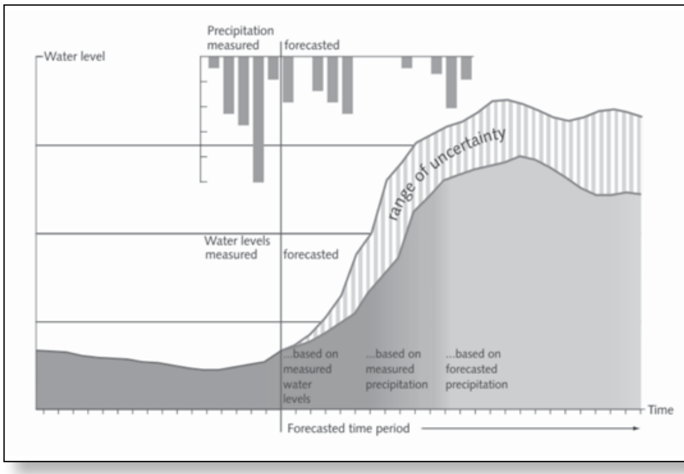

Fig. 5: Uncertainty increases with the lead time

Considering all the sources of uncertainty, the optimal approach would be to do multiple forecast realisations by randomly varying all of the sources of uncertainty within their range (Monte Carlo simulation). Because of operational constraints, a relatively straightforward approach for the calculation of forecast uncertainty has been applied in Bavaria. Long time series of former, archived flood forecasts have been compared to gauge observations calculating the relative error for each time step within the forecast horizon. From the error distribution obtained for each gauge, the relative error on the 10 and 90% exceedance probability level is used to illustrate the uncertainty on each new forecast (Fig. 6). In addition to these "static" uncertainties the results of ensemble predictions (Fig. 7) are analysed and a combination of the "static" uncertainty with the "dynamic" uncertainty is calculated. Especially in headwaters, where the precipitation forecast is the dominating source of uncertainty, this is seen as an advisable procedure. The procedure is explained in detail in LAURENT et. al. (2010).

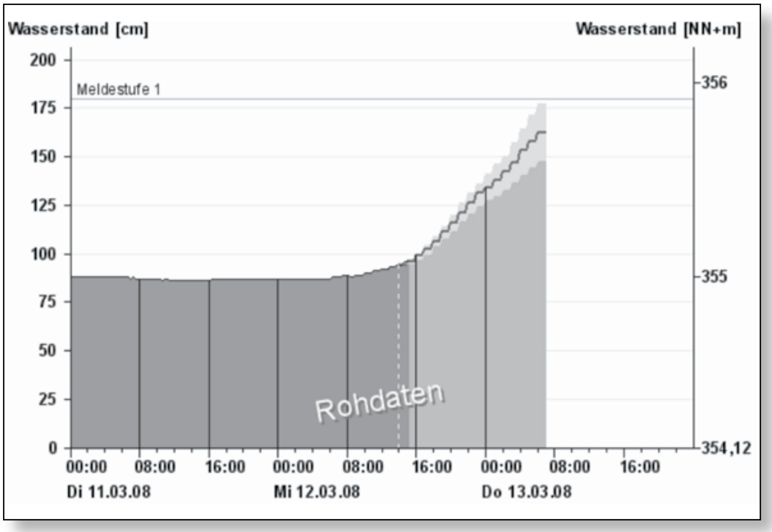

Fig. 6 : Deterministic lead forecast surrounded by an uncertainty range

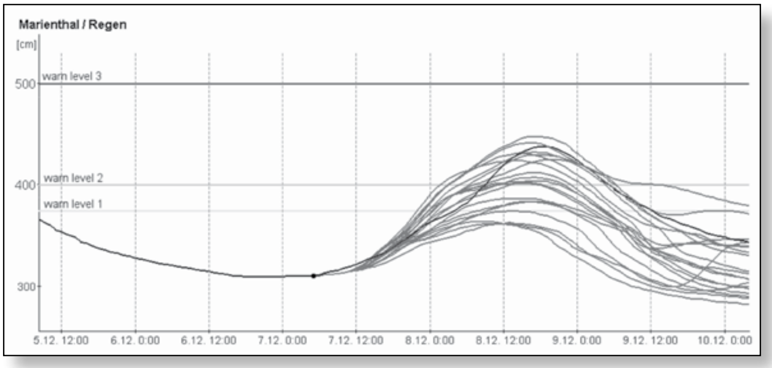

Fig. 7: Using all available meteorological forecasts as input into a rainfall–runoff model for a medium-sized catchment in the Bavarian Forest shows the broad variety in the resulting forecasts of water level (green lines). The observed water level is marked blue

Communicating uncertainty to the users of the hydrological forecast is a very important task. As dealing with probabilistic numbers is not common to most users, descriptions and explanations should also be understandable to all. Adequate illustrations and descriptions should be evaluated in relation to the normal and advanced user. Additionally, experiences gained during future flood events might help in further adaptation of methods of communication.

For advanced users such as decision-makers in the water management authority, the published uncertainty should furthermore serve as a tool for better risk assessment. For example, the person in charge of operating a flood control basin can then base his decisions on probabilistic numbers in addition to the deterministic forecast instead of only on the latter. By judging, what probability threshold value should be taken into account the responsibility for operators increases. Therefore, it is very important to teach users how to interpret the published forecasts, especially the probabilistic part. Understanding the sources of uncertainty and their meaning also helps improving the correct usage of published prognostic data. This task is especially important since, compared to the normal weather forecasts; flood forecasts rarely gain the same every-day importance for the average user. Therefore, users are mostly lacking personal experience in evaluating the reliability of hydrological forecasts.

Overall, analysis and experiences with forecasts over the last years show that the accuracy achieved so far could be improved upon in many cases. Hence, calculating and communicating uncertainty is one goal. A major goal, though, remains reducing the existing uncertainty in the data, the model and its operation. Appropriate operations and projects remain a permanent task.

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Epidemiological Disasters: Role of Environmental Knowledge

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Disasters have been as old as the human civilization but their impact on the human lives and the environment is being on the rise world over for recent times. Population explosion, rapid urbanization and industrialization across the world has led to people living in habitats that are hazardous and vulnerable to natural disasters, and on the other hand, they have led to unsustainable pressures on resources causing the erosion of natural ecological balance, both of which have intensified the frequency of occurrence as well as damage caused by natural disasters.[1] Considering rampant increase in occurrence of disasters, it has become a concern of national and international importance. Epidemiological principles would be useful to undestand the health impact of disasters and usefulness of intervention applied in a cost effective manner. As the resources are scarce judicious and scientific methods in their utlization required.

What is a disaster?

Disaster is defined as any occurrence that causes damage, ecological disruption, loss of human life, deterioration of health and health services, on a scale sufficient to warrant extraordinary response from outside the affected community or area (WHO). A 'Hazard' is the dangerous condition or event, that threat or have the potential for causing injury to life or damage to property or environment and 'Vulnerability' is the extent to which a community, structure, services or a geographic area is likely to be damaged/disrupted by the impact of a particular hazard on account of their nature, proximity to hazardous terrain, or a disaster prone area. The probability that a particular population will be affected by the hazards is known as 'Risk'. Therefore, Risk=Vulnerability X Hazard.

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Disasters are of two types: Natural Disasters (e.g. Earthquakes, floods, volcanoes etc.) and manmade disasters (e.g. famine, epidemics, fire, microbial warfare, etc.). Irrespective of the nature of hazard, all disasters exert "7D effect":

- Death
- Disability
- Disease
- Distress
- Damage to health services
- Damage to the economy of the country
- Damage to the environment

Epidemiology of disasters in India

India's unique geo-climatic conditions together with dense population make for an interesting mix of vulnerability and resilience. India has a vast coastline, out of which, approximately 5700 km is prone to cyclones and Tsunamis. 59% of the land is prone to seismic hazard, 5% of the total geographical area is prone to floods, while 70% of the total cultivable area is vulnerable to droughts.[2] The super-cyclone of Orissa (1999), the Gujarat earthquake (2001), the Tsunami (2004), Bihar Floods (2008) and more recent radiation exposure in Delhi (2010) clearly highlights the fact that disasters are not bound by political boundaries or socio-economic considerations. Thus, each part of the country is susceptible to some or the other form of disasters. The increased susceptibility of Indian landmasses to disasters can be adjudged by the fact that according to EM-DAT 2005, India was ranked among top ten in the incidence of Natural hazards.

Disasters have the potential to cause mass casualty and loss of property. According to International Disaster Database: EM-DAT, there have been 431 events in India from 1980-2010 which have killed 1,43,039 people and affected 1,521,726,127 lives. This has incurred 1,550,446 US$ of damage per year to the country during the same period.[3] Further, it has been estimated that the losses to the Gross National product due to disasters can be twenty times greater in developing countries than developed countries.[4] According to World Bank estimates, direct losses of public and private infrastructure in India have amounted to approximately $30 billion over the past 35 years.[5]

Thus, it will be empirical to say that the disasters result in large number of deaths, both of human and animals, in short span of time that place overwhelming stress on individuals, society and the administration. Also, the country is faced with an uncommon challenge of handling large numbers of survivors seeking medical attention due to the effects of the hazard. Hence, in this context the preparedness of health sector and its response can play a major role for limiting the damage caused by the disaster.

Current status of disaster management in India

The ferocity and impact of catastrophic events have increased for the recent times in the country. Traditionally, disasters have been looked upon as aberrations or interruption in normal day to day activity of the society to be responded primarily with relief. But, there was growing realization that development cannot be sustained unless all the phases of Disaster Management Cycle continuum are comprehensively addressed considering the large number of casualties and economic losses which the country has experienced in the recent past.[6] The Government of India thereupon adopted a more pro-active multidisciplinary and holistic approach for prevention, mitigation and preparedness. This paradigm shift in the national approach to disaster management led to enactment of Disaster Management Act, on 23rd Dec, 2005, which envisaged the creation of an apex body National Disaster Management Authority with Prime Minister as a chairperson and likewise constitution of State Disaster Management Authorities (SDMA) and District Disaster Management Authorities (DDMA).[7,8]

With the backdrop that the common denominator of all disasters is human suffering, there is a need of concerted actions from SDMA/DDMA and medical fraternity for prevention and management of mass casualty inflicted due to disasters.

Environment and disaster risk

The connection between environment, development and disasters is rarely disputable. While it is often recognized that ecosystems are affected by disasters, it is forgotten that protecting ecosystem services can both save lives and protect livelihoods. Several pathways link environment management to disaster risk reduction.

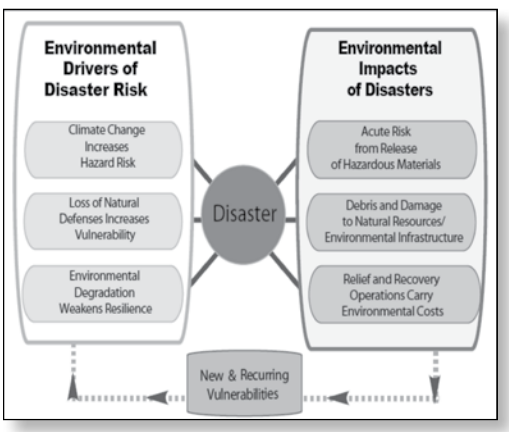

Fig1: Environment causes and consequences

Natural hazards are physical processes that are directly affected by the environmental interventions. Human endeavors have triggered global warming and thereby affected the frequency and intensity of extreme climate events. On a local scale, deforestation and desertification have had demonstrable effects on local rainfall patterns and are complicit with the occurrence of drought. Thus, many of the impacts associated with climate change have exacerbated or altered existing hydro-meteorological hazards such as droughts, floods etc. The UN Millennium Ecosystem Assessment recognizes that Ecological conditions not only modify the frequency and magnitude of hazard events, but also affect natural barriers that can moderate the impacts of a disaster and protect communities. Wetland ecosystems function as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and floodwaters. Deforestation is often blamed for worsening the effects of flooding while mangroves, dunes and reefs create physical barriers between communities and coastal hazards.[9]

It has also been seen that pre-existing degraded environment reduce the community resilience when a disaster strikes. Though the environment is able to recover from disaster events, environmental impacts can result in serious risk to life and livelihoods if not addressed. Unplanned recovery processes that fail to take the state of ecosystems and ecosystem services into account: recovery is a period of immediate development, and without proper consideration of the environment, pre-existing vulnerabilities may be re-created or exacerbated.

Environment impact assessment utilization of local knowledge in disaster management

Identifying, evaluating and responding to critical environmental issues during a disaster are key to effective disaster relief and recovery operations. Mapping hazard risk is often a core function of the environmental management. The Hyogo Framework defines "reducing the underlying risk factors" as a Priority for Action and specifically recommends environmental and natural resource management that encourage the sustainable use and management of ecosystems and promote the integration of risk reduction associated with existing climate variability and future climate change.

Environmental conservation and disaster management are critical to the livelihoods of indigenous people who often live in hazard-prone areas. They have built up, through thousands of years of experience and intimate contact with the environment, a vast body of knowledge on hazards and the environment events. This knowledge is a precious resource that continues to contribute to environmental conservation and disaster management in these regions. Indigenous knowledge should be considered as a complement to scientific knowledge in the development of community based disaster risk management plans and programmes. Also, The proliferation of new technologies and processes for managing natural resources, including new knowledge of the ecological, social and cultural dimensions of resource management, presents many opportunities for reducing disaster risk. Communities around the world are protected from floods and storms by engineered structural defences. Multi-sectoral development-oriented zoning enables governments and other stakeholders to assess possible land-use options for different areas and to choose the best options on the basis of possibilities, limitations and values.[9]

Health impact assessment of disasters

Though each disaster is distinct in the areas it affect with differing vulnerability with divergent social, economic and health conditions, yet there are definite similarities between them. Also, there is a relationship between the type of disaster and its effect on health. For instance, earthquakes cause more injuries relative to that caused by floods and tidal waves. The actual and potential health risks after a disaster do not all occur at the same time. Instead, they tend to arise at different times and to vary in importance within a disaster-affected area. Thus, casualties occur mainly at the time and place of impact and require immediate medical care, while the risks of increased disease transmission take longer to develop and are greatest where there is overcrowding and standards of sanitation have declined.[10] Thus, to initiate appropriate pre-disaster measures and provide timely, adequate and apt response, health impact of potential emergencies need to be anticipated in advance.

Epidemiological methods are required to study the health effect of disasters. A disaster health outcome assessment is a systematic assessment of the current and potential health problems in a population affected by a disaster. Different methods can be used to examine the health problems and health needs of the affected population,[11] such as:

- Rapid assessment of health needs;
- (Longitudinal) epidemiological studies using questionnaires;
- Continuous surveillance of health problems using existing registration systems;
- Assessment of the use and distribution of health services; and
- Research into the etiology of the health effects of disasters.

Disaster health outcome assessment is a useful activity as it provides insight into the health problems of individual survivors, and their possible relationship to disasters. Different health problems occur at different times after the precipitating event and surveillance for the health effects is essential for providing an effective public health response over a prolonged period of time. For instance, peak psychological problems such as PTSD occur within one year after the disaster or birth defects that occurred after a long time after Bhopal disaster. A disaster health outcome assessment also is very useful to identify groups of survivors that are at increased risk for chronic health problems. The effects of management interventions can also be evaluated by means of a disaster health outcome assessment. Besides providing information for policy-makers, a disaster health outcome assessment can contribute to the knowledge and evidence base of disaster health outcomes. Besides authorities may build or strengthen a pro-active, caring, and transparent reputation by performing a disaster health outcome assessment about the distributions of risks.

Despite the importance of a disaster health outcome assessment, it is not advocated that a disaster health outcome assessment be conducted after each disaster. A disaster health outcome assessment only should be performed if appropriate help and support can be offered.

Public health effects of the disaster

The public health consequences of natural disasters are complex. These ramifications can be best reduced by appropriate application of public health interventions. Before exploring into those interventions it is important realize the common problems faced during almost all disasters. They are as follows:

- Injuries and death
- Social reactions
- Communicable diseases
- Other acute illnesses
- Chronic illnesses
- Mental diseases
- Population displacements
- Climatic changes
- Food and nutrition problems
- Water supply and sanitation problems
- Damage to health infrastructure

Injuries and death

Different types of disasters cause different patterns of injuries, which in turn produce variable levels of morbidity and mortality. Earthquakes, tornadoes, flash floods are often associated with severe injuries requiring intensive care and maximum fatalities.[11] But, the number of injuries and subsequent fatalities associated with each disaster varies tremendously from event to event. It also depends on the multitude of factors such as its magnitude, proximity to a populated, the soil type, time of the day, population characteristics and behaviors. Secondary disasters may also follow such as fire outbreak following an earthquake or the more recent Tsunami and Fukishima nuclear reactor meltdown following a massive earthquake in Japan. These may, only compounds the problems and increase the casualties.

Social reactions

After any major natural disaster, the general behavior of the affected population is of generalized panic or stunned waiting. It usually takes minutes to hours for the individuals to adapt themselves for an organized action. Sometimes, the person's conflicting roles as the head of the family and health official may result in delayed reporting of the personnel to the relief duty until their families and property is safe.[10] Usually, there are many informal means of communication and rumors particularly about epidemics, following the disasters which may divert the attention of the concerned authorities towards prevention and control of such events without sound medical justification and thus, deprive the affected people off the actual care they required during that hour.

Communicable diseases

Often the risk of an outbreak or an epidemic following the disaster is theoretically apparent but not much reported.[12] In one of the review studies[13] where more than 600 geophysical disasters records were scrutinized, it was found that there were only 3 outbreaks related to those disasters: 1 of measles after the eruption of Pinatubo in Philippines, 1 of coccidioidomycosis after an earthquake in California, and 1 of *Plasmodium vivax* malaria in Costa Rica related to an earthquake and heavy rainfall. That lower risk of outbreaks could be due to availability of prompt humanitarian response in those areas. However, natural disasters may not result in massive outbreaks of infectious diseases, but in some situations they do increase the potential for disease transmission. The disruption of pre-existing sanitary conditions such as food, water and sewage disposal may aggravate the risk of occurrence of an outbreak in the immediate post disaster phase.[12] Additionally, in the longer run there is increase in the vector borne diseases because of the disruption of vector control methods particularly following heavy rains and floods. It has been seen in the past that those areas where there is overcrowding, malnutrition and lack of basic sanitation services, massive outbreaks of gastro-enteritis, cholera, typhoid etc. have occurred. Thus, it will be more appropriate to conclude that the more accurate reflection of how well a community can withstand the adverse health effects of a disaster would be found in the strength of public health system in place prior to the occurrence of disaster.

Some of the communicable diseases and other illnesses during the post disaster phases:

Phase	***Days***	***Likely health problem***
I	0-3 days	Disposal of dead bodies, injuries, drowning, snakebites,

II	4-10 days	Cholera, Bacterial dysentery,
III	11 days-3wk	Pneumonia, hepatitis, meningitis, polio, measles, Skin and Eye infections,
IV	3-6 wk	Malaria, dengue, JE, plague, rehabilitation of injuries,
V	> 6 wk	Psychological Problems, Malnutrition, HIV and STDs

Other acute illnesses

In contrast to causing infectious diseases, disasters do have the potential to cause short term impact on the health of the affected population. Earthquake, for example, can cause release of soil containing spores such as coccidioides immitis, causing clinical coccidioidomycosis. Other natural hazards such as volcanoes cause both respiratory and ocular problems as a result of ash, smoke and toxic gases.

Chronic illnesses

Anecdotal accounts of disasters reveal an increased number of acute coronary events such as heart attacks following the disasters such as earthquake. It may be untrue to say that disasters are responsible for the fatalities caused due to these acute coronary events, they do appear to result in greater morbidity from chronic conditions such as diabetes, hypertension and heart disease. Researchers in Japan found that the glycemic control was impaired in diabetics following the Kobe earthquake.[14] Similarly, following Hurricane Iniki on the Island of Kuai in Hawaii, the mortality rate from diabetes doubled compared to prior to Hurricane.[15] Therefore, the conditions for which stress is a risk factor and for which ongoing healthcare is eminent appear to be affected by the disasters.

Mental diseases

The health effects of disasters extend beyond the physical symptoms and also include the psychological or emotional stress. Anxiety, neuroses and mild depression are some of the acute mental problems encountered immediately in the post disaster phase. Again there are number of factors responsible for variation in the presentation of psychological symptoms. Generally, the mild emotional distress is self-limiting in nature. But, some proportion of the affected population also seems to experience severe form of distress, depending upon their prior psychological state and impact of disaster on them and their families. Another group at risk to suffer from mental distress is the humanitarian volunteers or relief workers. Post Traumatic Stress Disorder (PTSD) or are the most frequent and debilitating psychological disorder that occurs after traumatic events and disasters[16,17] and can be handled by professionals. But such mental professional are usually not available.

Medically Unexplained Physical Symptoms (MUPS) is another common problem affects large number of disaster victims in long run.

Population displacements

As discussed previously, disasters mount heavy economic losses due to damage to life as well as property. Most of the disasters render large chunk of population homeless. Due to this, large, spontaneous and organized population displacements occur which the public health services of the area may not be able to cope and thus, result in increased mortality and morbidity.

Climatic changes

Extreme weather conditions during the disaster double the potential for adverse health effects on the affected population. For instance, an earthquake during summer months of a tropical country can expose the individuals who are shelter less, to extreme heat waves that may secondarily cause heat stroke and compound the morbidity and burden the health services. However, as long as the population is dry, reasonably well clothed, and able to find windbreaks, death from exposure does not appear to be a major risk.

Food and nutrition problems

Food shortages in the immediate aftermath are very common. Food stock destruction within the disaster area may reduce the absolute amount of food available, or disruption of distribution systems may curtail access to food, even if there is no absolute shortage. Flooding and sea surges often damage household food stocks and crops, disrupt distribution, and cause major local shortages. But, generalized food shortages severe enough to cause nutritional problems do not occur.

Water supply and sanitation problem

Drinking water supply and sewerage systems are particularly vulnerable to natural hazards and the disruptions that occur in them pose a serious health risk. Deficiencies in established amounts and quality of potable water and difficulties in the disposal of excreta and other wastes result in the deterioration of sanitation, contributing to conditions favorable to the spread of enteric and other diseases. For example, immediately after the devastating earthquake in Turkey in August 1999, an infectious disease surveillance system mainly focused on diarrheal diseases analyzed 1,468 stool cultures and found main cause of diarrheal outbreak was Shigella species. This study has emphasized the necessity to set up infectious disease surveillance systems after such events.[18]

Damage to health infrastructure:

Health systems are also among the most vulnerable to natural disasters. For example, after the 2004 Indian Ocean tsunami, a large number of health institutions were damaged. These included hospitals, drug stores, cold rooms, preventive health care offices, health staff accommodation facilities and district health offices. In addition, a large number of vehicles (ambulances, vans, motorbikes) and most of the medical equipment and office equipment in the affected areas were totally destroyed. The loss of health personnel included medical officers, nurses, midwives and support staff. Furthermore, a large number of health staff were injured, traumatized or displaced by the event, hence were unable to assist the affected.[19]

Therefore, health care physical infrastructure and personnel are affected by the disasters as any other individual in the affected area. This damage occurs at the most in opportune time, just when the need for provision of emergency care is the most. Besides, non-structural damage also alters the ability of a health care system to provide adequate care at the time of catastrophe. The destruction of equipment and supplies, especially the loss of laboratory functions and pharmaceuticals places an additional burden on a health care agency trying to provide services to increased number of patients.[12]Beside this, natural disasters may seriously inflict damage on the services considered vital for smooth functioning of a health care system such as electricity, water supply, transportation etc. Transportation and tele-communications may seriously be jeopardized during a catastrophic event which may impede public health sector's ability to respond to disaster.

***Table 1**: Health (related) effects of natural hazards*

Health (related) effects	Earthquake	Floods	Land-slides	Epidemics	Conflict situation
Deaths/ Severe injuries	Many	Few	Many	Many	Many
Requiring extensive treatment	Many	Few	Few	Few	Many
Increased risk of epidemics	Yes	Yes	Yes	------	Yes
Damage to water systems	Severe	Light	Severe (but localized)	None	Limited (depends on the factions fighting)

Health (related) effects	Earthquake	Floods	Land-slides	Epidemics	Conflict situation
Damage to health facilities	Severe (structural & equipment)	Severe (equipment usually)	Severe (but localized)	None	Limited (depends on the factions fighting)
Damage to health services	High	High	Low	Moderate	High
Food shortage	Possible (due to distribution problems)	Common	Common (but localized)	None	Common (in prolonged conflicts)
Major population movements	Common (generally limited)	Common	Common (generally limited)	Rare	Common (generally limited)

Other effects: There may be other social effects such as increase in orphans, disabilities, decline of local spending, unemployment, disruption of normal lifestyles and increase in the food prices which in turn impact the overall health status of the affected population. There may increase in theft, molestation, sexual abuse, kidnapping of small children communal disharmony etc. leading to social unrest in the affected area and indirectly affecting the health of the people. The potential health risks of different disasters[20] can be summarized as shown in table 1. This is evident that health risk is always there in almost all disasters.

Medical preparedness of Disasters in India

The pro-active approach adopted by GOI and NDMA culminated into formulation of the National Guidelines on Medical Preparedness and Mass Casualty Management.[21] These guidelines encompasses medical management in four phases, that is, initially at the Incident site by the Medical First Responders within the 'golden hour' preferably a critical period between injury and life/limb saving surgery that decides the patient's outcome; then evacuation in the ambulances fitted with critical care equipment; followed by prompt treatment in the hospitals and sequelae of resultant disease/disability; and lastly, prevention of epidemics, management of chronic health effects and provisioning psychosocial care (medical preparedness). Environmental knowledge plays a significant role planning, implementation and evaluation of health intervention in disasters.

Some of the initiatives taken in this regard are:[6]

- From various studies it is found that immediate onsite medical care can save lives. Full fledged containerized mobile hospitals enabling quick deployment at the time of disasters to treat large number of casualties on the site are in the process of being acquired and attached with hospitals in the strategic locations.
- Disease surveillance can predict outbreaks and epidemic in the community after disaster. For that fully furnished laboratorties are required. Bio-safety laboratories with few BSL-3 and BSL-4 are being established at designated nodal institutions. Integrated Disease Surveillance Project along with upgraded laboratories have proved very useful in the management of H1N1 pandemic.
- Most of the deaths due to sock can be prevented by intravenous fluid infusion and blood transfusion. Licensed blood banks critical for management of shock have been networked to cater for surge requirement during disasters.
- Burn and trauma centers are specialized in handling critical cases. Burn Centres are being expanded to 30 beds each in all medical colleges, tertiary care hospitals, and districts having more than 10 Major Accident Hazard (MAH) units with burn risks.
- Trauma Centres of varying bed capacities are being established that range from State Apex Trauma Centre to Zonal Trauma Centre (25 beds), Regional Trauma Centre (10-15 beds) and District Trauma Centre (10 beds). AIIMS has established state of the art JPN Apex Trauma Centre.
- Transportation for casualty evacuation by the Integrated Ambulance Network having basic medical equipment for resuscitation, essential drugs, and two way communication vis-à-vis the hitherto before Ambulances which functioned only ferried patients. Of late, casualty evacuations by air, especially by helicopters ambulances, have greatly improved patient care management capabilities.
- Additional thrust is on telemedicine which entails putting diagnostic equipment and Information Communication Technology for connectivity between the disaster site and advanced medical institutes where such linkup have been installed.
- Training in First Aid of the community to improve their response to disaster.
- Recognizing the psychological problems in the survivors' resultant of disaster's effects, the Psychosocial Support and Mental Health Services in the aftermath of disasters was considered to be addressed in detail. Consequently, its National Guidelines have been released on 20th January, 2010 by Hon'ble Health Minister whereby its framework has been institutionalized for all stakeholders to ensure it as an integral part of their role in disaster management.
- Capacity building ventures are being conducted under the aegis of NDMA such as Basic Life Support (BLS) and Advanced Trauma Life Support Courses are being conducted in

collaboration of MoHFW, training capsules on emergency response to CBRN casualties and mock exercises.

India celebrated World Health Day 2009 with the official slogan "Save lives. Make hospitals safe in emergencies."[19] that focused on the safety of health facilities and the readiness of the health workers who treat those affected by emergencies. Health centres and staff are critical lifelines for vulnerable people in disasters - treating injuries, preventing illnesses and caring for people's health needs. Often, already fragile health systems are unable to keep functioning through a disaster, with immediate and future public health consequences. Now, construction of new hospitals are conforming international rules are regulations for disaster resistance. However, at the local state level such norms need to be understood and followed.

These and many more initiatives notwithstanding, India still remains one of the most severely and seriously affected countries in the world due to natural and manmade disasters. It is imperative for the administration and governing authorities to provide for setting up of a comprehensive and effective catastrophe (disaster) management apparatus. Willingness to channelize substantial financial resources and ability to learn from the experiences of the past natural events (disasters) is very important in current scenario. People are the one who are going to face the catastrophe and they should be the ones to be empowered by correct knowledge so that fear or hopelessness is not created. Besides, a strong and fool proof public health system is the mandate for reducing the morbidity and mortality during a disaster. A public health sector which conducts routine surveillance, has good immunization coverage, maintained water and sanitation services etc, is better equip to handle increased burden of health care needs during the catastrophic events. Concerted efforts by all the stakeholders to follow all the national guidelines for appropriate disaster management would pave the way for 'safer and disaster resilient India'.

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The Role of Land-use Planning in Chemical Disaster Risk Management

Christian Jochum

Safety Distances as a Key Issue in Chemical Disaster Risk Management

Chemical risk management always starts in the plant itself, where primarily loss of containment has to be prevented by technical and organisational safeguards. In addition (and as the second layer in the "onion skin" model) any reasonable effort has to be undertaken to mitigate possible releases of hazardous chemicals. However, a number of sad experiences demonstrate that safety and mitigation measures may fail. Toxic clouds may travel far outside the facility as in the Bhopal tragedy, inflammable vapours may ignite beyond the facility´s border as in Buncefield/GB and Mexico City or an explosion on site may cause a shockwave killing people in the neighbourhood of the plant as in Toulouse/France or Enschede/NL.

All those events have one commonality: the bigger the distance to the source of the hazardous chemical the smaller are the effects. Safety distances therefore are essential safety measures. They are also a key issue for disaster risk management. The farer away people are from the place of a disaster, the less casualties will occur. The fewer people live around a major hazard facility the easier will be an evacuation.

Initially most chemical sites have been built far away from other developments. Although pollution was the driving force for that, also safety distances have been kept. This common-sense approach was rapidly undermined in most cases. Workers wanted to live close to the facility, other businesses appreciated the vicinity of chemical facilities for different reasons, traffic lines had to be built anyway, etc. Especially in densely populated areas as e.g. in Germany and other countries of the European Union space became so valuable that eventually most major chemical sites became closely surrounded by residential areas, schools, hospitals, railway stations, highways, etc., creating a serious potential for disasters.

Chairman, German Commission on Process Safety & Director, European Process Safety Centre

European Regulation on Land-use Planning around Major-hazard Sites

Process safety and emergency response experts always had been aware of this intrinsic risk. However, even in the European Union, which traditionally tends to be risk adverse, it was not before 1996 that land use planning around major hazard sites became regulated in the so called Seveso II Directive ():

Article 12 (Land-use planning)

- Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land-use policies and/or other relevant policies.
  They shall pursue those objectives through controls on:
  - (a) the siting of new establishments,
  - (b) modifications to existing establishments covered by Article 10,
  - (c) new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, buildings and areas of public use, major transport routes as far as possible, recreational areas and areas of particular natural sensitivity or interest and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.

- The Commission is invited by 31 December 2006, in close cooperation with the Member States, to draw up guidelines defining a technical database including risk data and risk scenarios, to be used for assessing the compatibility between the establishments covered by this Directive and the areas described in paragraph 1. The definition of this database shall as far as possible take account of the evaluations made by the competent authorities, the information obtained from operators and all other relevant information such as the socioeconomic benefits of development and the mitigating effects of emergency plans.

- Member States shall ensure that all competent authorities and planning authorities responsible for decisions in this area set up appropriate consultation procedures to facilitate implementation of the policies established under paragraph 1. The procedures shall be designed to ensure that technical advice on the risks arising from the establishment is available, either on a case-by-case or on a generic basis, when decisions are taken.

German Guidance on Land-use Planning

As in most EU countries different authorities are responsible for spatial planning and for the Seveso Directive implementation was slow. It needed the explosion of a fertilizer storage at Toulouse/France in 2001 with more than 10 fatalities outside the site that this regulation started to become effective. In Germany the Commission on Process Safety, which advises the German Federal Government, issued in 2005 a guidance on land-use planning. It covers the planning of industrial zones, for which the concrete usage is not yet known (greenfield developments), as well (and even more important in Germany) developments in the neighbourhood of existing major-hazard sites. The guidance has recently been updated, taking into account the experience of the first years of implementation. The new version (KAS-18) is available at www.kas-bmu.de. A short version of it in English will be published soon on the same website. A short version of the first issue in English is still available there (SFK/TAA-GS-1 short version).

Separation distance recommendations for land-use planning without detail knowledge

The guidance first deals with the setting out of new industrial and trading areas, for which the concrete usage is not yet known, which are however designated by the local administration as a planning law basis for the permissible siting of establishments under the German Federal Immission Control Act. This "land-use Planning without detail knowledge" would be applicable for instance if a city which is responsible for spatial planning decides to develop a new industrial area. In this case the distance to existing or also planned sensitive areas, e.g. residential areas, is known. The guidance now defines precautionary "separation distances" for the possible use of certain hazardous substances in the planned industrial area. At that point of time typically no detailed information exists about the chemical plants which may be built there. This tool should help in the decision which substances could be used in major-hazard installation in that area and which not. Eventually this information can be included in the legally binding land-use plan, restricting the future use of this area to minimize the consequences of industrial disasters.

For explosives and ammonium nitrate specific German regulations, which already set safety distances, are to be applied. In recommending separation distances for all other hazardous substances it was decided to use a precautionary deterministic approach, in line with the major hazards legislation as practiced in Germany. Long term operating experience and the registered major accidents in the last 15 years in Germany have been reviewed. As a result of these studies, as basis for a consequence assessment as source term for a release a leakage of 490 mm² was adopted (equivalent to the cross-sectional area of a DN 25 pipe). For highly hazardous substances as phosgene a DN 15 leakage was chosen, as the above mentioned reviews demonstrated that this comes closer to reality, where such substances are handled with extreme care. It has to be noted that a number of other European states use a probabilistic approach to land-use planning instead of this deterministic approach.

As scenarios were chosen fire, vapour cloud explosion with immediate ignition and release of toxic substances. As permissible thresholds were used for thermal radiation 1.6 kW/m², for explosions 0.1 bar and for toxic substances the concentration guidance value ERPG-2. The dispersion model used was the VDI Guideline 3783. The dispersion conditions chosen for the hazardous substances were average meteorology (including a wind speed of 3 m/s) in a typical industrial topology (uniform buildings).

There is no simple relationship between toxicity, thermal radiation or explosion pressure wave and the recommended separation distance s. Substance characteristics (e.g. vapour pressure) and typical operating conditions lead to differing release rates, which had to be taken into account. However, consequence modelling of these scenarios cannot be con-

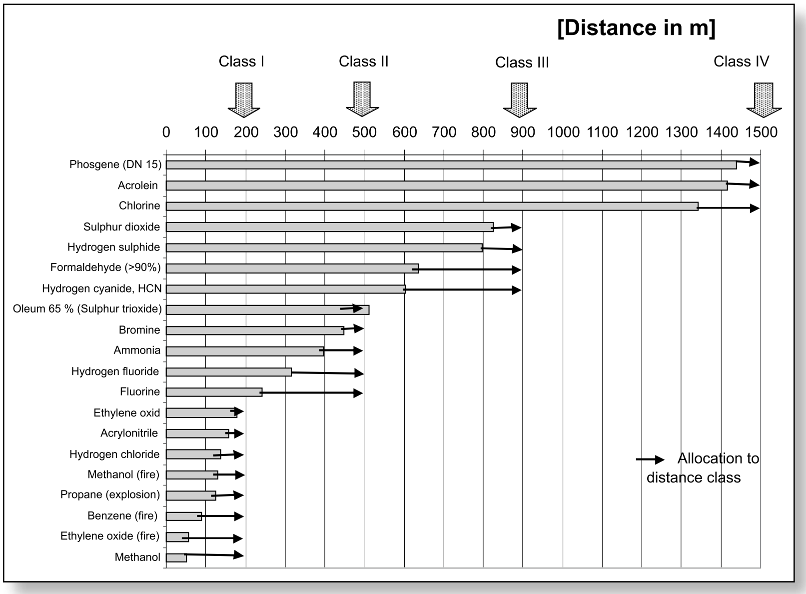

Figure 1: Recommended separation distances for land-use planning without detailed knowledge (for an updated version see KAS-18 at www.kas-bmu.de)

sidered as completely realistic, but as a typification. Taking this into account, the substances have been clustered into distance classes to make the application easier. The guidance had to be limited to the most prominent substances (see picture 1). However, it sets out a procedure which would allow the development of such separation distances for other substances, too. It has to be noted that the separation distance recommendations are only related to people as the subject to be protected. For sensitive environment, e.g. natural reserves, no guidance exists up to now.

Separation distance recommendations for land-use planning with detailed knowledge

Unfortunately (speaking economically) greenfield development of industrial sites occurs rather seldom in Germany nowadays. Much more relevance has development coming closer to industrial and especially chemical sites. Consumer markets would like to make use of the good traffic connections near industrial sites, new roads or railway stations may be planned, etc. Quite frequently other industrial sites near major-hazard facilities may have had to close down and their land is a valuable asset which attracts investors. Here the guidance gives "separation distance recommendations for land-use planning with detailed knowledge".

For existing major-hazard facilities the substances, their licensed quantities and the technical installations in which they are handled are already known. In this case a specific individual case study with a systematic hazard analysis is possible. For the determination of separation distances the following recommendations are made in the guidance:

- If the distance to sensitive areas is less than the separation distance recommendation for land-use planning without detail knowledge (see picture 1), then an individual case study is necessary.
- If other legal requirements prescribe a minimum distance for the type of installation (e.g. Explosives Law, Technical Regulations) then these are to be respected.
- For the individual case study the following recommendations are made with regard to the scenarios which are to be considered:
    - The loss of the complete inventory, the loss of the largest contiguous volume, bursting of a vessel and the shearing of a very large pipe are not to be considered for land-use planning, as they are too improbable when the state of the art technology is adhered to.
    - For storage in barrels and drums, and storage in gas bottles the release of the contents of a barrel/drum or bottle is to be considered.
    - For process installations and in storage facilities it is to be assumed that leaks from pipe-work, vessels, safety equipment, etc. can occur.

- In general the starting point is the consideration of a leak area of 490 mm² (equivalent to DN 25).
- In the individual case study the leak area is determined according to the technical systems actually in place.
- As a minimum assumption it is recommended that a leak of no less than 80 mm² (equivalent to DN 10) is chosen. (This corresponds to the flange leakage of larger pipe-work, the shearing of a small line, the leakage due to corrosion damage, etc.)
- Measures to limit the effects of a release are to be considered in so far as they are not damaged by the events in the scenario considered.
- It is explicitly noted that these recommendations cannot replace the consideration of the particular situation in the individual case study.

In a nutshell: whenever the (precautionary) "separation distances for land-use planning without detailed knowledge" cannot be met, the necessary separation distance between the existing major-hazard facility and new sensitive developments have to assessed individually, following similar criteria as developed for greenfields. As all safety measures within the facility have to be taken into account, the individual separation distance may be considerably smaller as in the greenfield case.

Theoretically the separation distance could be zero, if the assessment of the installation´s inner layers of protection (inherently safe processes, high integrity of equipment, very efficient mitigation measures) lead to the conclusion, that there is no major hazard outside the fence. However, the precautionary approach will usually lead to a separation distance. Also other planning rules prevent the direct neighbourhood between industrial sites causing hazards, pollution or noise, and e.g. residential areas.

Other Planning Scenarios

A third quite common case both in Europe as in India are "mixed situations" of major-hazard facilities and sensitive neighbourhood, grown more or less unplanned over many years. Here the directive of the European Union is only setting the long term goal to maintain appropriate separation distances and, on a case by case decision, the request for additional technical measures. Those cases are legally very complex, as operators have been granted licenses to operate as they do. The rather schematic and strictly precautionary approach of the above mentioned separation distances can here only serve as a very first approach. Eventually the interests and rights of all stakeholders have to be balanced in light of the history of these developments, and this will frequently end at the court. Relocation either of hazardous installations or sensitive neighbourhood is rarely possible, so that here the focus is on improved safety measures and emergency preparedness.

The fourth case is the planning of a new major-hazard facility close to existing developments. Here the authority has to make an individual assessment, if such a facility does not pose an unacceptable risk to its neighbourhood before they grant a license. Although the procedure for "separation distance recommendations for land-use planning with detailed knowledge" is not legally applicable here, it may serve as a reference.

Separation Distances and Emergency Planning

On reaching or exceeding the recommended separation distances, it may be generally assumed that the effects of a major accident within an establishment, based on the assumptions made, will not lead to a serious hazard for the population. The "intermediate zone" resulting from the separation distance recommendation should not be understood as an area free of buildings. Within these distances less sensitive usage may be planned. This could be e.g. other industries or office buildings with a clearly defined population which may be included in the major-hazard facility´s alarm system and trained how to act in emergency situations.

Outside the separation distances emergency planning still is a must. Although the consequences for people are minimised by proper land-use planning, the underlying assumptions are "credible worst case scenarios" only. As Bhopal and recently Fukushima have demonstrated it could come worse. Even if the probability of such catastrophes is very low, emergency responders have to take that into account. Also reaching e.g. the ERPG-2 value for toxic substances, which is one of the definitions of the separation distances, has to trigger emergency procedures.

As a result, 3 different zones have to be assumed (see picture 2). Looking from inside the facility, its fence forms the first zone and the area of the on-site emergency plan. Then comes a zone characterised by the separation distances with limited use, followed by the outer zone without limitations of use, but also subject to the off-site emergency planning.

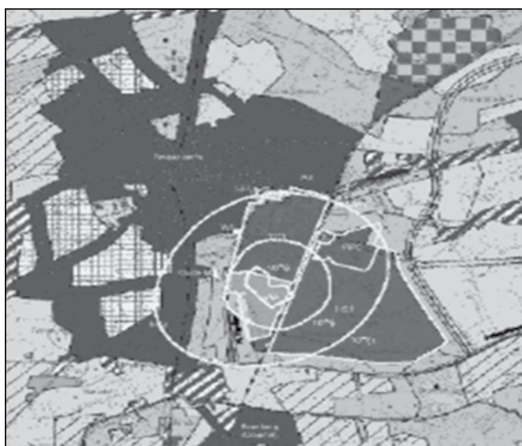

Figure 2: Zoning around major-hazard facilities

Implementation of the Guidance on Land-use Planning

Land-use planning always is a trade-off between different justified interests: safety and health, ecology, economy, culture and people. For all these interests different authorities may be responsible. This makes implementation of land-use regulations difficult. In Germany for instance, land-use planning is in the responsibility of the municipalities. The EU Seveso II Directive forces them now to consult the authorities competent for major-hazard installations. However, a local mayor may be more interested in major investments as in major hazards and therefore may not take the obligatory consultation serious enough. Although the co-operation between the different authorities improved in the recent years, a growing number of cases ended up at court. The guidance of the German Commission on Process Safety, although legally not binding, has been widely accepted by all parties as well as the courts as a reference. One typical case is pending at the European High Court and a fundamental judgement can be expected. Anyhow experience in Germany shows that a critical precondition for effective land-use planning is a good cooperation between the different authorities responsible for spatial planning and environmental safety.

Disasters due to Unplanned Urbanisation

T. V. Ramachandra

Introduction

Urbanisation is a form of metropolitan growth that is a response to often bewildering sets of economic, social, and political forces and to the physical geography of an area. It is the increase in the population of cities in proportion to the region's rural population. The 20th century is witnessing "the rapid urbanisation of the world's population", as the global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005 and is projected to rise to 60% (4.9 billion) by 2030 (World Urbanization Prospects, 2005). Urban ecosystems are the consequence of the intrinsic nature of humans as social beings to live together (Sudhira *et al*., 2003; Ramachandra and Uttam Kumar, 2008). The process of urbanisation contributed by infrastructure initiatives, consequent population growth and migration results in the growth of villages into towns, towns into cities and cities into metros. Urbanisation and urban sprawl have posed serious challenges to the decision makers in the city planning and management process involving plethora of issues like infrastructure development, traffic congestion, and basic amenities (electricity, water, and sanitation), etc. (Kulkarni and Ramachandra, 2006). Apart from this, major implications of urbanisation are:

- **Loss of wetlands:** Urbanisation has telling influences on the natural resources such as decline in number of wetlands and / or depleting groundwater table.
- **Floods:** Common consequences of urban development are increased peak discharge and frequency of floods as land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Conversion of water bodies to residential layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving

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the construction of high rise buildings, removal of vegetative cover, reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000.

- **Decline in groundwater table:** Studies reveal the removal of waterbodies has led to the decline in water table. Water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of lake with its catchment for commercial activities. Also, groundwater table in intensely urbanized area such as whitefield, etc. has now dropped to 400 to 500m.
- **Loss of tree cover**: Drastic reduction in cover is observed due to the removal of lane tress and conversion of plantations to layouts, etc.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water pervious surfaces, which reduce surface temperature through evapotranspiration.
- **Increased carbon footprint**: Due to the adoption of inappropriate building architecture, the consumption of electricity has increased in certain corporation wards drastically. The building design conducive to tropical climate would have reduced the dependence on electricity. Higher energy consumption, enhanced pollution levels due to the increase of private vehicles, traffic bottlenecks have contributed to carbon emissions significantly. Apart from these, mismanagement of solid and liquid wastes has aggravated the situation.

Unplanned urbanisation has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface runoff. Drainage systems are unable to cope with the increased volume of water and are often encountered with the blockage due to indiscriminate disposal of solid wastes. Encroachment of wetlands, floodplains, etc. obstructs floodways causing loss of natural flood storage. Damages from urban flooding could be categorized as: direct damage – typically material damage caused by water or flowing water, and indirect damage – e.g. traffic disruptions, administrative and labour costs, production losses, spreading of diseases, etc.

Studies on the phenomenon of Urban Heat Island (UHI) using satellite derived land surface temperature (LST) measurements have been conducted using various satellite data products acquired in thermal region of the electromagnetic spectrum. Currently available satellite thermal infrared sensors provide different spatial resolution and temporal coverage data that can be used to estimate LST. The Geostationary Operational Environmental Satellite (GOES) has a 4-km resolution in the thermal infrared, while the NOAA-Advanced Very High Resolution Radiometer (AVHRR) and the Terra and Aqua-MODIS have 1-km spatial resolutions. Significantly high resolution data come from the Terra-Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) which has a 90-m pixel resolution, the Landsat-5 Thematic Mapper (TM) which has a 120-m resolution, and Landsat-7 Enhanced Thematic Mapper (ETM) which has a 60-m resolution. However, these instruments have a repeat cycle of 16 days (Li *et. al.,* 2004; Ramachandra and Uttam Kumar, 2009). Weng (2001, 2003) examined LST pattern and its relationship with land cover (LC) in Guangzhou and in the urban clusters in the Zhujiang Delta, China. Nikolakopopulos *et al*., (2003) have used Landsat-5 TM and Landsat-7 ETM+ data for creating the temperature profile of Alfios River Basin. Stathopoulou and Cartalis (2007) have used Landsat ETM+ data to identify daytime urban heat island using Corine LC data for major cities in Greece. Using a Landsat ETM+ imagery of City of Indianapolis, IN, USA, Weng *et al.,* (2004) examined the surface temperature UHI in the city. They derived LST and analysed their spatial variations using Landsat ETM+ thermal measurements with the urban vegetation abundance and investigated their relationship. UHI studies have traditionally been conducted for isolated locations and with in situ measurements of air temperatures. The advent of satellite remote sensing technology has made it possible to study UHI both remotely and on continental or global scales (Streutker, 2002). In this work, Landsat data of 1973 (of 79 m spatial resolution), 1992 and 2000 (30 m), IRS LISS-III data of 1999 and 2006 (23.5 m) and MODIS data of 2002 and 2007 (with 250 m to 500 m spatial resolution) are used with supervised pattern classifiers based on maximum likelihood (ML) estimation. Also, an attempt is made to map land surface temperatures across various LC types to understand heat island effect.

Study Area

Greater Bangalore (77°37'19.54" E and 12°59'09.76" N) is the principal administrative, cultural, commercial, industrial, and knowledge capital of the state of Karnataka with an area of 741 sq. km. Bangalore city administrative jurisdiction was widened in 2006 by merging the existing area of Bangalore city spatial limits with 8 neighbouring Urban Local Bodies (ULBs) and 111 Villages of Bangalore Urban District (Ramachandra and Uttam Kumar, 2008; Sudhira *et al.*, 2007). Thus, Bangalore has grown spatially more than ten times since 1949 (69 square kilometers) and is a part of both the Bangalore urban and rural districts (figure 1). Now, Bangalore is the fifth largest metropolis in India currently with a population of about 7 million (figure 2). The mean annual total rainfall is about 880 mm with about 60 rainy days a year over the last ten years. The summer temperature ranges from 18° C – 38° C, while the winter temperature ranges from 12° C – 25° C. Thus, Bangalore enjoys a salubrious climate all round the year. Bangalore is located at an altitude of 920 meters above mean sea level, delineating four watersheds, viz. Hebbal, Koramangala, Challaghatta and Vrishabhavathi watersheds. The undulating terrain in the region has facilitated creation of a large number of tanks providing for the traditional uses of irrigation, drinking, fishing and washing. This led to Bangalore having hundreds of such water bodies through the centuries. Even in early second half of 20th century, in 1961, the number of lakes and tanks in the city stood at 262 (and spatial extent of Bangalore was 112 sq km). However, number of lakes and tanks in 1985 was 81 (and spatial extent of Bangalore was 161 sq km).

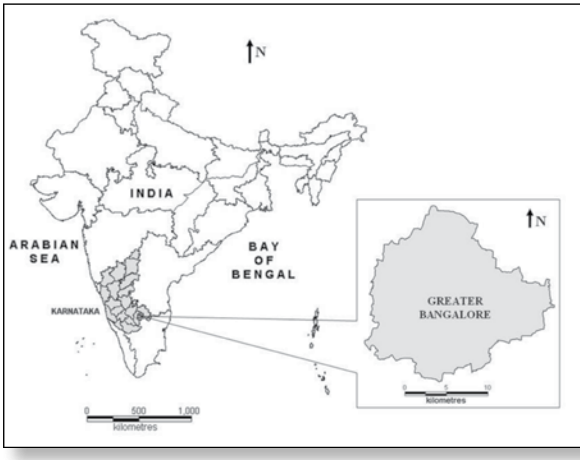


Figure 1: Study area – Greater Bangalore.

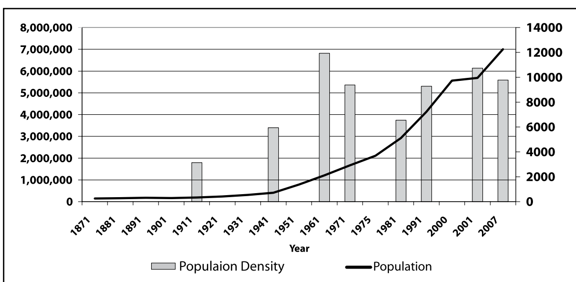


Figure 2: Population growth and population density.

Materials and Methods

Survey of India (SOI) toposheets of 1:50000 and 1:250000 scales were used to generate base layers. Field data were collected with a handheld GPS. Remote sensing data used for the study are: Landsat MSS (1973), Landsat TM (1992), Landsat ETM+ (2000 and 2009) [Landsat data downloaded from http://glcf.umiacs.umd.edu/data/], IRS (Indian Remote Sensing) LISS (Linear Imaging Self Scanner)-III of (1999 and 2006), MODIS (Moderate Resolution Imaging Spectroradiometer) Surface Reflectance 7 bands product [downloaded from http://edcdaac.usgs.gov/main.asp] of 2002, MODIS Land Surface Temperature/Emissivity 8-Day L3 Global and Daily L3 Global (V004 product) [http://lpdaac.usgs.gov/modis/dataproducts.asp#mod11]. Google Earth data (http://earth.google.com) served in pre and post classification process and validation of the results. The methods adopted in the analysis involved:

- Georeferencing of acquired remote sensing data to latitude-longitude coordinate system with Evrst 56 datum: Landsat bands, IRS LISS-III MSS bands, MODIS bands 1 and 2 (spatial resolution 250 m) and bands 3 to 7 (spatial resolution 500 m) were geo-corrected with the known ground control points (GCP's) and projected to Polyconic with Evrst 1956 as the datum, followed by masking and cropping of the study area.
  - Band 1, 2, 3 and 4 of Landsat 1973 data to 79 m.
  - Band 1, 2, 3 and 4 of Landsat TM of 1992 to 30 m.
  - Band 1, 2, 3, 4, 5 and 7 of Lansat ETM+ to 30 m.
  - MODIS bands 1 to 7 to 250 m.
  - IRS LISS-III band 1, 2 and 3 to 23.5 m.
  - Thermal band of TM (resampled to 120m), ETM+ (to 60m) and MODIS (to 1 km) and Panchromatic bands of ETM+ (resampled to 15 m).
- Supervised Classification using Bayesian Classifier: In supervised classification, the pixel categorisation process is done by specifying the numerical descriptors of the various LC types present in a scene. It involves (i) training, (ii) classification and (iii) output.
- Accuracy assessment: Accuracy assessments were done with field knowledge, visual interpretation and also referring Google Earth (http://earth.google.com).
- Computation of Normalised Difference Vegetation Index (NDVI): It separates green vegetation from its background soil brightness and retains the ability to minimize topographic effects while producing a measurement scale ranging from –1 to +1 with NDVI-values < 0 representing no vegetation.

Derivation of Land Surface Temperature (LST)

LST from Landsat TM: The TIR band 6 of Landsat-5 TM was used to calculate the surface temperature of the area. The digital number (DN) was first converted into radiance L_{TM} using

$$L_{TM} = 0.124 + 0.00563 * DN \quad \text{(Equation 1)}$$

The radiance was converted to equivalent blackbody temperature $T_{TMSurface}$ at the satellite using

$T_{TMSurface} = K_2/(K_1 - \ln L_{TM}) - 273$ (Equation 2)

The coefficients K_1 and K_2 depend on the range of blackbody temperatures. In the blackbody temperature range 260-300K the default values (Singh, S. M., 1988) for Landsat TM are K_1 = 4.127 and K_2 = 1274.7. Brightness temperature is the temperature that a blackbody would obtain in order to produce the same radiance at the same wavelength (λ = 11.5 μm). Therefore, additional correction for spectral emissivity (ε) is required to account for the non-uniform emissivity of the land surface. Spectral emissivity for all objects are very close to 1, yet for more accurate temperature derivation emissivity of each LC class is considered separately. Emissivity correction is carried out using surface emissivities for the specified LC (table 1) derived from the methodology described in Snyder *et al.*, (1998) and Stathopoulou *et al.* (2006).

Table 1: *Surface emissivity values by LC type*

LC type	Emissivity
Densely urban	0.946
Mixed urban (Medium Built)	0.964
Vegetation	0.985
Water body	0.990
Others	0.950

The procedure involves combining surface emissivity maps obtained from the Normalized Difference Vegetation Index Thresholds Method ($NDVI^{THM}$) (Sobrino and Raissouni, 2000) with LC information. The emmissivity corrected land surface temperature (Ts) were finally computed as follows (Artis and Carnhan, 1982)

$$T_s = \frac{T_B}{1 + (\lambda \times T_B / \rho) \ln \varepsilon}$$ (Equation 3)

where, λ is the wavelength of emitted radiance for which the peak response and the average of the limiting wavelengths (λ = 11.5 μm) were used, $\rho = h \times c/\sigma$ (1.438×10^{-2} mK), σ = Stefan Bolzmann's constant (5.67×10^{-8} $Wm^{-2}K^{-4}$ = 1.38×10^{-23} J/K), h = Planck's constant (6.626×10^{-34} Jsec), c = velocity of light (2.998×10^{8} m/sec), and ε is spectral emissivity.

LST from Landsat ETM+: The TIR image (band 6) was converted to a surface temperature map according to the following procedure (Weng *et al.*, 2004). The DN of Landsat ETM+

was first converted into spectral radiance L_{ETM} using equation 4, and then converted to at-satellite brightness temperature (i.e., black body temperature, $T_{ETMSurface}$), under the assumption of uniform emissivity ($\varepsilon \approx 1$) using equation 5 (Landsat Project Science Office, 2002):

$$L_{ETM} = 0.0370588 \text{ x } DN + 3.2 \qquad \text{(Equation 4)}$$

$$T_{ETMSurface} = K2/\ln (K_1 / L_{ETM} + 1) \qquad \text{(Equation 5)}$$

where, $T_{ETMSurface}$ is the effective at-satellite temperature in Kelvin, L_{ETM} is spectral radiance in watts/(meters squared x ster x μm); and K_2 and K_2 are pre-launch calibration constants. For Landsat-7 ETM+, K_2 = 1282.71 K and K_1 = 666.09 $mWcm^{-2}sr\text{-}1\mu m^{-1}$ were used (http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_htmls/chapter11/chapter11.html). The emissivity corrected land surface temperatures Ts were finally computed by equation 3.

Results and Discussion

The supervised classified images of 1973, 1992, 1999, 2000, 2002, 2006 and 2009 with an overall accuracy of 72%, 75%, 71%, 77%, 60%, 73% and 86% were obtained using the open source programs (i.gensig, i.class and i.maxlik) of Geographic Resources Analysis Support System (http://wgbis.ces.iisc.ernet.in/ grass) as displayed in figure 3. The class statistics is given in table 2. The implementation of the classifier on Landsat, IRS and MODIS image helped in the digital data exploratory analysis as were also verified from field visits in July, 2007 and Google Earth image. From the classified raster maps, urban class was extracted and converted to vector representation for computation of precise area in hectares. There has been a 632% increase in built up area from 1973 to 2009 leading to a sharp decline of 79% area in water bodies in Greater Bangalore mostly attributing to intense urbanisation process. Figure 4 shows Greater Bangalore with 265 water bodies (in 1972). The rapid development of urban sprawl has many potentially detrimental effects including the loss of valuable agricultural and eco-sensitive (e.g. wetlands, forests) lands, enhanced energy consumption and greenhouse gas emissions from increasing private vehicle use (Ramachandra and Shwetmala, 2009). Vegetation has decreased by 32% from 1973 to 1992, by 38% from 1992 to 2002 and by 63% from 2002 to 2009. Disappearance of water bodies or sharp decline in the number of waterbodies in Bangalore is mainly due to intense urbanisation and urban sprawl. Many lakes (54%) were unauthorised encroached for illegal buildings. Field survey (during July-August 2007) shows that nearly 66% of lakes are sewage fed, 14% surrounded by slums and 72% showed loss of catchment area. Also, lake catchments were used as dumping yards for either municipal solid waste or building debris. The surrounding of these lakes have illegal constructions of buildings and most of the times, slum dwellers occupy the adjoining areas. At many sites, water is used for washing and household activities and even fishing was observed at one of these sites. Multi-storied buildings have come up on some lake beds that have totally intervene the natural catchment flow leading to sharp decline and deteriorating quality of waterbodies. This is correlated with the increase in built up area from the concentrated growth model focusing on Bangalore, adopted by the state machinery, affecting severely open spaces and in particular waterbodies. Some of the lakes have been restored by the city corporation and the concerned authorities in recent times.

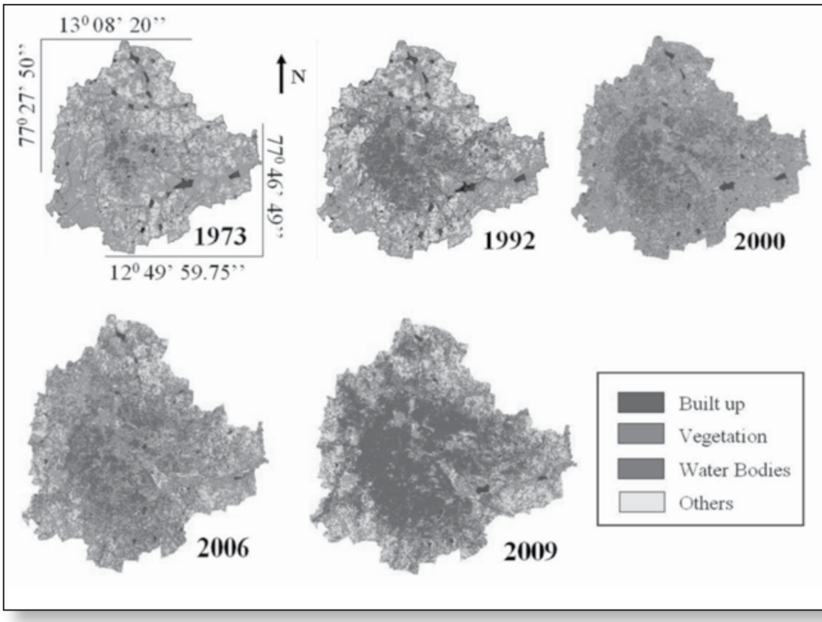


Figure 3: Greater Bangalore in 1973, 1992, 1999, 2000 and 2009.

***Table 2**: Greater Bangalore LC statistics*

Class Year		Built up	Vegetation	Water Bodies	Others
1973	Ha	5448	46639	2324	13903
	%	7.97	68.27	3.40	20.35
1992	Ha	18650	31579	1790	16303
	%	27.30	46.22	2.60	23.86

Class / Year		Built up	Vegetation	Water Bodies	Others
1999	Ha	23532	31421	1574	11794
	%	34.44	45.99	2.30	17.26
2000	Ha	24163	31272	1542	11346
	%	35.37	45.77	2.26	16.61
2002	Ha	26992	28959	1218	11153
	%	39.51	42.39	1.80	16.32
2006	Ha	29535	19696	1073	18017
	%	43.23	28.83	1.57	26.37
2009	Ha	39910	11153	489	16785
	%	58.40	16.32	0.72	24.56

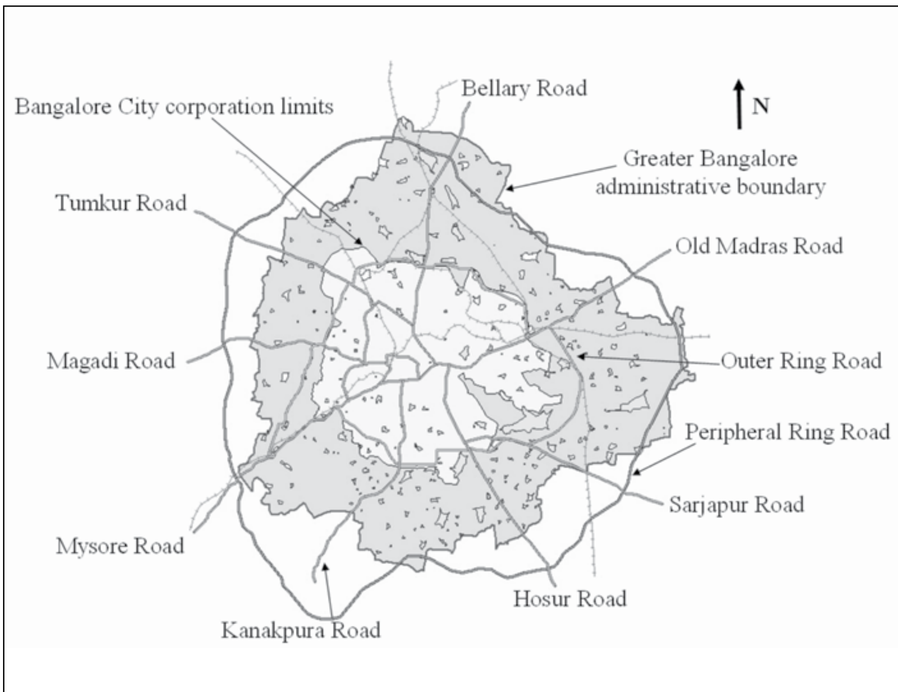


Figure 4: Greater Bangalore with 265 water bodies.

LST were computed from Landsat TM and ETM thermal bands. The minimum and maximum temperature from Landsat TM data of 1992 was 12 and 21 with a mean of 16.5±2.5 while for ETM+ data was 13.49 and 26.32 with a mean of 21.75±2.3. MODIS Land Surface Temperature/Emissivity (LST/E) data with 1 km spatial resolution with a data type of 16-bit unsigned integer were multiplied by a scale factor of 0.02 (http://lpdaac.usgs.gov/modis/dataproducts.asp#mod11). The corresponding temperatures for all data were converted to degree Celsius. Figure 5 shows the LST map and NDVI of Greater Bangalore in 1992, 2000 and 2007. The minimum (min) and maximum (max) temperatures were computed as 20.23, 28.29 and 23.79, 34.29 with a mean of 23.71±1.26, 28.86± 1.60 for 2000 and 2007 respectively. Data were calibrated with in-situ measurements. NDVI was computed to study its relationship with LST. The Landsat TM NDVI had a mean of 0.04±0.4543, ETM+ data had a mean of 0.0252±0.5369 and MODIS had a mean of -0.0917±0.5131.

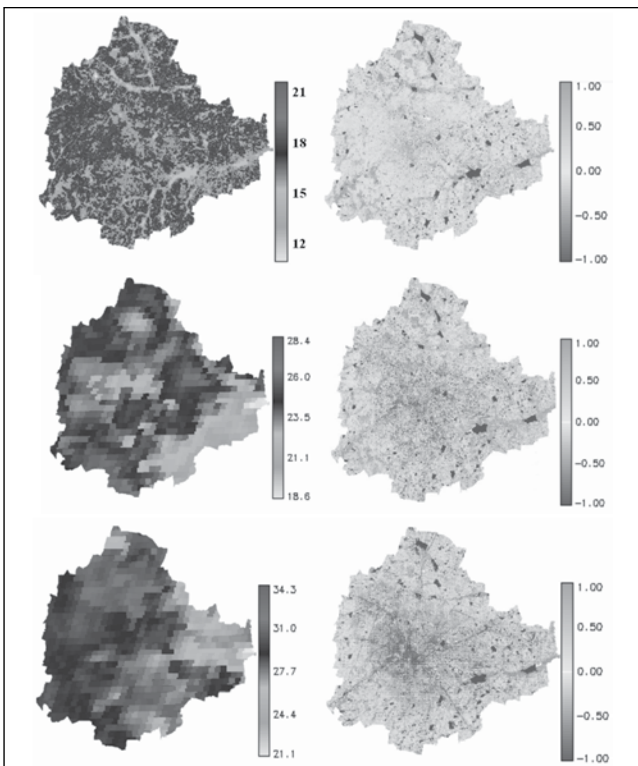


Figure 5: LST and NDVI from Landsat TM (1992), MODIS (2002 and 2007).
(Note: pixelisation of MODIS 2002 and 2007 is mainly due to coarse spatial resolution ~ 1 Km)

The correlation between NDVI and temperature of 1992 TM data was 0.88, 0.72 for MODIS 2000 and 0.65 for MODIS 2007 data respectively, suggesting that the extent of LC with vegetation plays a significant role in the regional LST. Respective NDVI and LST for different land uses is given in table 3 and further analysis was carried out to understand the role of respective land uses in the regional LST's.

***Table 3**: LST (°C) and NDVI for various land uses.*

Land use	1992 (TM)		2000 (MODIS)		2007 (MODIS)	
	LST ± SD	NDVI ±SD	LST ± SD	NDVI ±SD	LST ± SD	NDVI ±SD
Builtup	19.03	-0.162	26.57	-0.614	31.24	-0.607
	±1.47	±0.096	±1.25	±0.359	±2.21	±0.261
Vegetation	15.51	0.467	22.21	0.626	25.79	0.348
	±1.05	±0.201	±1.49	±0.27	±0.44	±0.42
Water bodies	12.82	-0.954	21.27	-0.881	24.20	-0. 81
	±0.62	±0.055	±1.03	±0.045	±0.27	±0.27
Open ground	17.66	-0.106	24.73	-0.016	28.85	-0.097
	±2.46	±0.281	±1.56	±0.283	±1.54	±0.18

It is clear that urban areas that include commercial, industrial and residential land exhibited the highest temperature followed by open ground. The lowest temperature was observed in water bodies across all years and vegetation. Spatial variation of NDVI is not only subject to the influence of vegetation amount, but also to topography, slope, solar radiation availability, and other factors (Walsh *et al*., 1997). The relationship between LST and NDVI was investigated for each LC type through the Pearson's correlation coefficient at a pixel level and are listed in table 4. The significance of each correlation coefficient was determined using a one-tail Student's t-test. It is apparent that values tend to negatively correlate with NDVI for all LC types. NDVI values for built up ranges from -0.05 to -0.6. Temporal increase in temperature with the increase in the number of urban pixels during 1992 to 2009 (113%) is confirmed with the increase in 'r' values for the respective years. The NDVI for vegetation ranges from 0.15 to 0.6. Temporal analyses of the vegetation show a decline of 65%, with a consequent increase in the temperature.

A closer look at the values of NDVI by LULC category (table 3) indicates that the relationship between LST and NDVI may not be linear. Clearly, it is necessary to further examine the

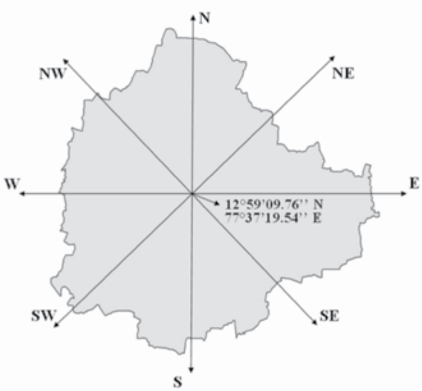
***Table 4**: Correlation coefficients between LST and NDVI by LC type (p=0.05)*

Land use	1992	2000	2007
Built up	-0.7188	-0.7745	-0.7900
Vegetation	-0.8720	-0.6211	-0.6071
Open ground	-0.6817	-0.5837	-0.6004
Water bodies	-0.4152	-0.4182	-0.4999

existing LST and vegetation abundance relationship using fraction as an indicator. The abundance images using linear unmixing from ETM+ bands were further analysed to see their contribution to the UHI by separating the pixels that contains 0-20%, 20-40%, 40-60%, 60-80% and 80-100% of urban pixels. Table 5 gives the average LST for various land use classes.

***Table 5**: Mean LST for various land use classes for different abundances*

Class → / Abundance ↓	Mean Temperature± SD of dense urban	Mean Temperature± SD of mixed urban	Mean Temperature± SD of vegetation
0-20%	21.99±2.37	21.57±2.36	17.91±2.19
20-40%	22.06±2.15	21.58±2.36	17.39±1.37
40-60%	22.27±2.00	21.67±2.41	17.22±0.89
60-80%	22.33 ±2.22	22.28±2.02	17.13±0.85
80-100%	22.47±1.96	22.37±2.17	17.12±0.91



Direction	Mean LST±SD
N	21.30±2.39
NE	22.15±2.22
E	21.01±2.47
SE	21.34±2.30
S	21.71±2.07
SW	22.19±1.92
W	22.97±1.72
NW	22.07±2.25

Figure 6: Transect lines superimposed on Greater Bangalore boundary along with LST in various directions.

8 transacts were laid across the city in different directions (north [N], north-east [NE], east [E], south-east [SE], south [S], south-west [SW], west [W] and north-west [NW]) and LST was analysed as shown in figure 6, to understand the temperature dynamics.

The temperature profile was analysed by overlaying the LST map on the Baye's classified map to visualise the effect of vegetation, builtup, water bodies and open ground. The temperature profile plot fell below the mean when a vegetation patch or water body was encountered on the transact beginning from the center of the city and moving outwards along the transact. The corresponding graphs are shown in figure 7. The major natural green area and water bodies responsible for temperature decline are marked with circle. The spatial location of these green areas and water bodies are shown in figure 8.

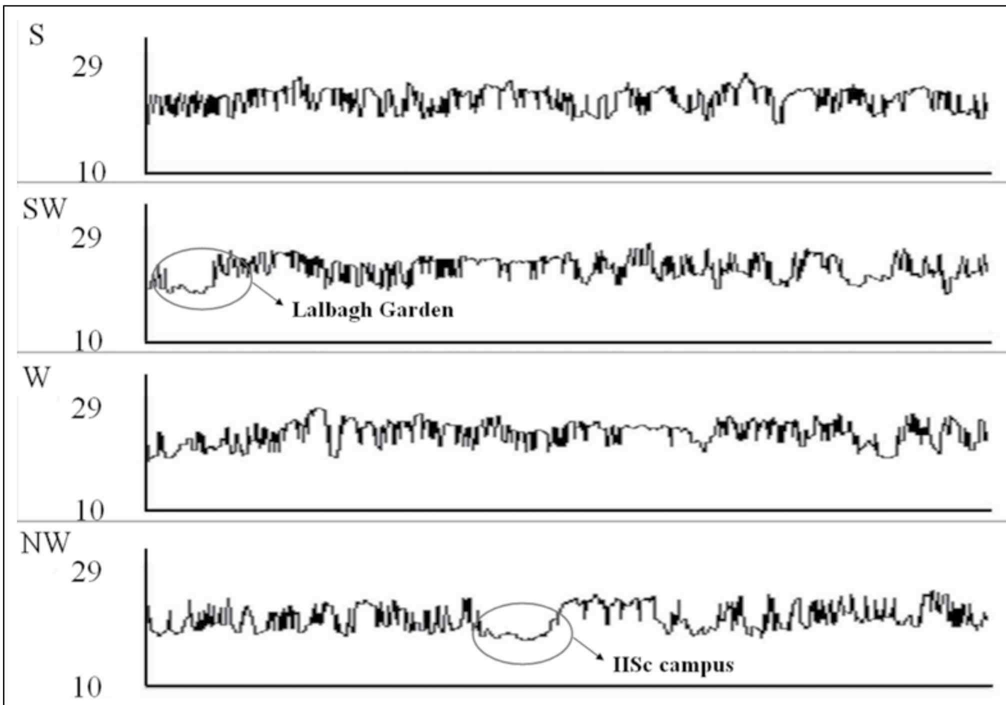


Figure 7: Temperature profile in various directions. X axis – Movement along the transacts from the city centre, Y axis - Temperature (°C).

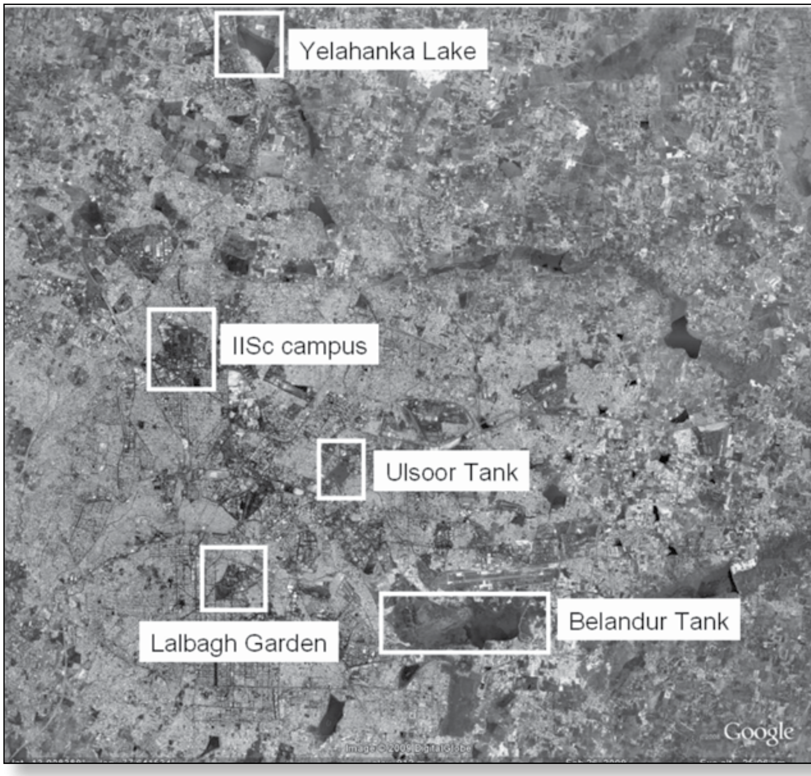


Figure 8: Google Earth image showing the low temperature areas (refer figure 7).
[Source: http://earth.google.com/]

Conclusion

Urbanisation and the consequent loss of lakes has led to decrease in catchment yield, water storage capacity, wetland area, number of migratory birds, flora and fauna diversity and ground water table. As land is converted, it loses its ability to absorb rainfall. The relationship between LST and NDVI investigated through the Pearson's correlation coefficient at a pixel level and the significance tested through one-tail Student's t-test, confirms the relationship for all LC types. Also, increased urbanisation has resulted in higher population densities in certain wards, which incidentally have higher LST due to high level of anthropogenic activities. The growth poles are towards N, NE, S and SE of the city indicating the intense urbanization process due to growth agents like setting up of IT corridors, industrial units, etc. Newly builtup areas in these regions consisted of maximum number of small-scale industries, IT companies, multistoried building and private houses that came up in the last one decade.

The growth in northern direction can be attributed to the new International Airport, encouraging other commercial and residential hubs. The southern part of the city is experiencing new residential and commercial layouts and the north-western part of the city outgrowth corresponds to the Peenya industrial belt along with the Bangalore-Pune National Highway

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Natural Resource Management Policy Implications on Disaster Risk Management Practices: Insights from North-East Cambodia

Kathlyn Kissy H. Sumaylo[1]

Overview of selected NRM policies in Cambodia

Located in the fertile Mekong River Basin, Cambodia is one of the most disaster-prone areas in South-East Asia (IOM, 2010; NCDM PDNA, 2010). The kingdom, considered a Least Developing Country, has very high vulnerability levels in terms of human development indices (NCDM and WFP, 2003a; MoP and WFP, 2003b) and low adaptive capacity of institutions, livelihoods, communities, and ecosystems to natural disasters and climate change (Helmers and Jegillos, 2004; Yusuf and Francisco, 2009).

Cambodia suffered from deep social and cultural intergenerational trauma, economic stagnation, large population displacements into the Thai borders and movements outside of the country, and institutional fragmentation as a result of nearly twenty years of civil war from 1975 to 1991. Following the signing of the Paris Peace Accords in October 1991, which gave then State of Cambodia its first comprehensive political settlement, the United Nations Transitional Authority in Cambodia (UNTAC), was formed under UN Security Resolution No. 745 to "lead peace restoration efforts, to hold free and fair elections leading to a new constitution and to spearhead the rehabilitation of the country" (UN website). The holding of Cambodia's first democratic elections under the auspices of the UNTAC in 1993 also paved the way for the foundations of decentralized governance. With the completion of the post-conflict repatriation of displaced Cambodians, the multi-donor integrated development project

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[1] *The author was Project Manager of IOM Cambodia's Building Resilience to Natural Hazards in North-East Cambodia project. Insights presented in the paper were drawn from the findings of IOM's vulnerability assessments to natural hazards in Ratanakiri, Mondulkiri and Stung provinces in 2009 and 2010, sumaylo.kathlynkissy@gmail.com*

phases, Cambodia Area Rehabilitation and Regeneration Project (CARERE) 1 and 2 and the Partnerships for Local Governance, shifted their focus from emergency post-war recovery and rehabilitation to a developmental approach. This new approach addresses Cambodia's long-term challenges and needs for institutional governance, planning systems, infrastructure and capacities delivered under the government program SEILA[2]. Natural resource management was a key output under the program's objective on poverty alleviation, alongside delivery of rural infrastructures and de-mining. Community-based natural resource management was the centrepiece of the SEILA/CARERE's NRM program in Ratanakiri Province to address communal lands, forests and water resources management (UNDP CARERE website). The program, which was piloted in Ratanakiri Province in the north-eastern region and in two north-western provinces, produced trained Department of Environment staff in forest protection; 12 community forest pilots; formation of two Provincial Land Use Planning committees; and issuance of 7,600 land titles. At the height of the SEILA program implementation, the first policy stipulation for disaster risk management- the National Committee for Disaster Management Policy Paper- was also released in 1995.

From 2000, national administrative and legal bases for environmental and natural resource management began to take shape. Alongside, decentralization experiments in national administrative and local development planning were posting development gains. From 2001 onward, significant NRM and environmental policies and frameworks were put in place on four areas: land tenure and management; forestry protection; protected areas and wildlife conservation; and water resources management. These policies intersect with national and local policy developments on disaster risk reduction and management (DRRM) within a decentralized governance system, which is broadly described below as they impact on the DRRM and NRM local policies and practices in North-East Cambodia.

Land tenure and management

The Land Law of 2001 forms the basis of Cambodia's present land use, tenure and management, setting the legal regime for the ownership of immovable properties in the country as determined by nature, by purpose and by law[3] (Articles 1 and 2, Land Law, 2001). Legally-

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[2]*Seila means foundation in Khmer.*

[3]*Article 10 of Land Law of 2001 defines immovable property by nature as all natural grounds such as forest land, cleared land, land that is cultivated, fallow or uncultivated, land submerged by stagnant or running waters and constructions or improvements firmly affixed to a specific place created by man and not likely to be moved whole, while immovable property by purpose are those fixed to the ground or incorporated into the constructions and which cannot be separated there from without damaging them or altering them, such as trees.*

recognized properties in Cambodia are distinguished into three types: State Public Property, State Private Property and Private Property The distinction is significant for natural resource management and environmental conservation as it determines the mode of land tenure, use and management. For instance, state public properties, having public interest as its primary purpose "may not be sold or transferred to other legal entities, though subject to occupancy and use rights that are strictly temporary in nature, such as logging concession in the forest reserve" (Land Law, 2001; Oberndorf, 2006, p.3). Meanwhile, state private property, or lands owned by the State and public legal entities that are idle or excess, "may be sold or transferred to other legal entities, such as to land recipients under the Social Land Concession framework" (Obendorf, 2006, p.4). Article 14 on state private property strongly stipulates that that no transformation of a land concession, unless in response to social purposes determined by the State, can be converted into a right of ownership (Land Law, 2001, p.8).

The same law also provides for land concessions, bestowed as a legal right to qualified persons or entities for economic or social reasons. Economic land concessions (ELCs)[4] in Cambodia are characterized by large scale plantations such as rubber, and for agro-industry such as corn, cashew nuts and soybeans, for a maximum period of 99 years (Sub-Decree No. 146, 2005). This land use arrangement is a particularly contentious form of natural resource exploitation because of its associated socio-economic and political implications on land access and tenure especially on traditionally held agricultural lands, and environmental damages brought about by excessive land clearing and related activities. While an environmental impact assessment is required before an approval of a concession activity, many reported ELC commence their operations before the EIA approval and beyond the land area limit set by law. Social land concessions on the other hand are a land allocation mechanism that may be granted to repatriated persons, poor homeless households for farming or residential purpose, demobilized soldiers; to those displaced by natural disasters or by infrastructure development and needing resettlement; and to workers of land for ELCs (Sub-Decree No. 19 on Social Land Concessions, 2003).

Forestry protection and management

The Forestry Law (2002) defines the framework for the sustainable management, harvesting, use and development of forests in the Cambodia. The permanent forest re-

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[4] Sub-decree No. 146 on Economic Land Concession was issued in 27 December 2005, in compliance with the provision of the Land Law of 2001. The SD defines ELC as a mechanism to grant private state land through a specific economic land concession contract to a concessionaire to use for agricultural and industrial-agricultural exploitation.

serves of the country consist of production forests, protection forests, and conversion forestland. Production and protection forest sub-classification are particularly significant for indigenous people and local communities who have traditionally used the forest and harvested its by-products. It also provides for the establishment of community forests as a mechanism to balance traditional use of forest areas for livelihoods, residence and practice of customary beliefs in the Permanent Forest Reserves with preserving natural balance. The authority to allocate such forest areas for traditional user rights rests with the Ministry of Agriculture, Forestry and Fisheries. The arrangement is enforced through a Community Forest Agreement (CFA) between the local community and the Forestry Administration cantonment for a maximum period of 15 years. The implementing guidelines are laid out on the Sub-decree on Community Forestry Management[5] issued in 2003, which includes the formation of community forestry management committees and the crafting of a forest management plan, scope of use and harvesting within the designated area, and the roles and responsibilities of the implementing institutions (Forestry Administration and the Department of Agriculture, as well as local communities).

Wildlife conservation is another important contribution of the law, which reiterates stipulations in past sub-decrees and policies on the designation of protected areas in the country, a number of which are located in the north-eastern provinces of Cambodia. However, the law also prohibits certain forest activities that may lead to pollution, damage, overharvesting, excessive natural resource exploitation. Shifting cultivation and harvesting of high-value forest products such as resin or rare species for instance are not allowed within the permanent forest reserves (Protected Areas Law, 2008).

An equally significant dimension of the law with regard to forest management is the forest concession management[6] in production forest not under use, which could be entered by the Royal Government with any investors or legal entity. Forest concessions must be entered through a bidding process and shall have an Environmental and Social Impact Assessment (ESIA) in their Forest Management Plan. They must also ensure that concession operations do not interfere with customary practices on registered land property held by indigenous peoples, as mandated by the Land Law of 2001, and customary access and user rights within and close to the concession areas (Forestry Law, 2002).

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[5]The sub-decree defines community forest is a forest planted under the state's public property, the rights of which are given to a local community living in or near the forest to manage and utilize it in a sustainable manner.

[6]See Chapter 5 of the Forestry Law of 2002

Protected Areas and Wildlife Conservation

The mandate on protected areas is governed by the Protected Area (PA) Law (2008) which establishes and modifies the scope of protected areas into eight classifications from the four as provided in the Royal Decree on the Protection of Natural Areas in 1993[7] . The PA Law identifies four management zones for each of the eight protected areas: 1) Core zone, or areas of high conservation values containing threatened and critically endangered species and access to the zone is allowed only for researchers and officials of the Nature Conservation and Protection Administration for scientific studies and observation for conservation and protection of biological resources; 2) Conservation zone, also of high conservation value, consists of natural resources, ecosystems, watershed areas and natural landscape which are adjacent to the core zone. Limited access to and strict control of the zone is allowed for small scale community uses of non-timber forest products to support local ethnic livelihoods; 3) Sustainable use zone are areas allocated for national and local development, and conservation of protected areas for local communities and indigenous ethnic minorities. These include areas for national cultural heritage, eco-tourism, wildlife, preservation and recreation, and infrastructure development (irrigation, reservoir, hydro-power), mining and sustainable resin exploitation; and 4) Community zones, which are reserved for the socio-economic development of local communities and ethnic minorities as well as areas with existing residences, paddy fields and upland fields[8]. Criteria for zoning shall be based on area management objectives, potential values of the area, socio-economic implications, and geographical location. The law encourages the participation of local communities in the management of the area.

Water Resources Management

Cambodia sits in the Mekong River Basin which spans six countries in Asia, including Thailand, Lao PDR, Viet Nam, China and Myanmar. The Agreement on the Cooperation for the Sustainable Development of the Mekong Basin signed in 1995 forms the basis of the river basin management trans-boundary cooperation framework by the four countries in the Lower

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[7]The royal decree identified 23 natural areas under four classifications: natural parks, wildlife preserves, protected scenic view areas and multi-purpose areas. The eight classifications under the Protected Areas Law of 2008 are natural parks, protected landscape, wildlife sanctuary, multiple use site, ramsar site, Tonle Sap Biosphere Reserve, natural heritage site, Marine Park, wetland, protected areas, coastal areas for management and conservation, and Provincial/Municipal protected area.

[8]Article 11, Chapter IV on Zoning, Protected Areas Law; See related discussions in Chapter 2, IOM (2009). Mapping Vulnerability to Natural Hazards in Mondulkiri.

Mekong Basin (Lao PDR, Cambodia, Thailand and Viet Nam)[9] , while China and Myanmar sit as Dialogue Partners (MRC website). The Agreement aims to "optimize the multiple use and multiple benefits" of water resources and to "minimize the harmful effects that might result from natural occurrences and man-made activities." To further operationalize the plan, the governments of Cambodia and Viet Nam have further signed a Memorandum of Understanding (MoU) and Action Plan to promote cooperation on cross-border water resource management (IOM, 2010, p. 29)

The country has been noted for its unique hydrological system wherein the Mekong River and the Great Tonle Sap Lake are joined by the Tonle Sap River, which reverses its flow twice a year.[10]

Interface of DRRM and NRM: Insights from North-East Cambodia

Cambodia has suffered from the devastating effects of flood and drought, as well as from storms and storm surges and strong winds. Between 1987 and 2007, 12 floods killed 1,125 people and caused approximately $300 million in damages (SNAP, 2008). In 2009, Cambodia was among the countries in Southeast Asia heavily hit by Typhoon Ketsana, which swept through 14 of its 24 provinces and severely affected 50,000 families. The Ketsana Comprehensive Post Disaster Needs Assessment report (2010) led by the National Committee for Disaster Management reported that agriculture and fisheries were among those severely affected, which cover 80 per cent of the country's still largely rural population that are heavily dependent on climate-sensitive livelihoods and natural resources. [11]

Cambodia's institutional mechanism for disaster risk management was first laid out in a policy paper in 1995 creating the National Committee for Disaster Management to be the lead agency in coordinating disaster management activities in the country. As an inter-ministerial body, the NCDM is composed of 22 ministries, representatives of the Cambodian Armed Forces, Cambodian Red Cross, and Civil Aviation Authority. Royal Decree No. 0202/040 of 2002 mandated the NCDM to play a leading role in facilitation and coordination, including the exercise of a comprehensive approach to disaster man-

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[9]The Lower Mekong Basin is home to 60 million people. Its rivers and wetlands provide sources of food, livelihoods, power, transport and trade to many communities and industries, The entire river basin has one of the most productive inland fisheries in the world. Source: http://www.mrcmekong.org/about_mekong/water_work.htm

[10]Water profile of Cambodia indicates that in early November, when the level of the Mekong decreases, the Tonle Sap River reverses its flow, and water flows from Lake Tonle Sap to the Mekong River and thence to the Mekong Delta. http://www.eoearth.org/article/Water_profile_of_Cambodia

[11]See Chapter 3 in IOM. (2010). Mapping Vulnerability to Natural Hazards in Stung Treng. Phnom Penh: IOM.

agement; the analysis of existing and potential hazards and taking measures to mitigate against hazards; and provide and formulate effective disaster preparedness and response plans.

Structures at the sub-national level are present at the provincial, district, commune and village levels, in line with the decentralization policy of the government. Since the creation of the NCDM, major policy developments on DRR have been accomplished nationally and internationally. International policies and declarations that have translated to national action plans include the Hyogo Framework of Action which led to the signing and crafting of the Strategic National Action Plan (SNAP) 2008-2013 on six key areas: institution-building; local and community based disaster risk management, early warning; IEC and knowledge management to promote culture of safety and resilience; mainstreaming of DRR and disaster preparedness at all levels. Another important development was the crafting of the National Adaptation Programme of Action to Climate Change (2006) in compliance with Cambodia's commitment to the United Nations Framework Convention on Climate Change (UNFCCC). Decentralized mechanisms have been the main channels through which DRRM and NRM policies are synergized, and harmony is established between sectoral agendas. The Decentralization and Deconcentration (D&D) Strategic Framework (2005) emphasizes the adherence of governmental strategies and programs to the pillars of representation, participation, accountability, effectiveness, and poverty reduction: all rooted in bringing services and decision-making processes closer to citizens. The new law on the administrative management of the Provincial, Capital, District, and Khan councils (2009), also called the Organic Law, spells out the roles and responsibilities of sub-national councils, including tasks in agriculture, forestry, natural resource management and environment, land use, electricity production and distribution, and water management. [12] Emphasis is placed on allocating the use of resources within the framework of a larger poverty reduction scheme that considers the needs of vulnerable groups; the law also recognizes the need for a disaster management plan along with the mandated Local Development and Investment plans. Guidelines on Provincial/Capital Development Plan are being drafted and contain sections on natural resource, environment and disaster risk analysis for natural disasters and climate change.

The interface of DRRM and NRM in the north-eastern region of Cambodia is multi-fold and complex. The region, which comprises of the provinces of Ratanakiri, Mondulkiri and Stung Treng, has for many decades remained isolated from mainstream Cambodian politics and

[12] *Articles 39, 49, and 215 of the Organic Law passed and signed in 2009.*

economy. The region is home to more than 50 per cent of the country's indigenous peoples and to some of the most regionally important biodiversity and natural resources (Stephens and Brown, 2006), natural parks, protected landscapes, and wildlife sanctuaries. A network of tributaries called the 3-S Rivers (Sesan, Sre Pok and Sekong rivers) flows through the three provinces from the bordering countries of Viet Nam and Lao PDR before they empty into the Mekong River. In the last ten years, the region has opened up to economic development, inviting economic boom from land development and natural resource extraction as well as cross-border trade and in-migration. Just as the region is endowed with natural resources, it is also subject to intense natural resource exploitation and environmental degradation. The three provinces also have very high poverty rates estimated from 41 to 100 per cent according to a recent poverty survey for the Cambodian Millennium Development Goals (MoP and RGC, 2009, p.6). IOM vulnerability assessments in Ratanakiri, Mondulkiri (2009) and Stung Treng (2010) identified the region as having high disaster risk levels to flood, drought and insect infestation, although they were not included in the priority areas under the Strategic National Action Plan (SNAP) for Disaster Risk Reduction 2008-2015 (SNAP, 2008). These provinces are seasonally exposed to slow onset and flash floods caused by a combination of above average precipitation during the monsoon, overflow of rivers and streams, and water releases from the upstream hydropower dams; and to agricultural and hydrological droughts resulting in greater water stress for competing local uses, lower agricultural production, and insecure clean water sources. Other hazards affecting local populations include insect infestation, animal diseases, emerging and recurrent human diseases, in combination with the environmental hazard risks from deforestation, rapid changes in hydrological regime of the Mekong tributaries with contributions from water pollution and upstream hydropower dams, which further raise the risk levels of communities to extreme weather events.

More than 70 per cent of the communities in all surveyed villages were found to have medium to high disaster risk levels to flood and drought, with secondary hazard impacts such as animal disease outbreaks and recurring and emerging human diseases. Climate-induced hazards are emerging hazards that is increasingly being faced by the region. Among the manifestations of rapid climactic changes include longer duration and intensity of droughts, highly irregular precipitation levels, increase in average temperatures, and smaller cycles and frequency of floods which disrupt traditional agricultural farming practices and contribute to worsening existing health, socio-economic, environmental and material vulnerabilities of the communities studied (IOM, 2009a, 2009b, 2010).

The vulnerability assessments further indicate that the key features of social/organizational vulnerability in the North-East are the 1) lack of vertical linkages between national and sub-national committees for disaster management, and sub-national authorities and local communities on disaster preparedness and response; 2) the absence of coordination mechanisms for timely receipt and dissemination of reliable early warning information to affected populations; and 3) the low priority given to disaster risk reduction as a development issue, with PCDM and its line departments convening only during the onset of disaster events

Based on IOM's field assessments, the interactions between environment and natural resource management policy and program implementation and DRRM in the context of the north-east region of Cambodia can be summarized in the following key points below:

- The need to build on local and indigenous practices and knowledge of their natural environments for effective disaster preparedness, response to and recovery from seasonal natural and environmental hazards.

Traditional knowledge and warning signals are present and considered to be reliable means for predicting the onset and behaviour of hazards. Rootedness to land and natural resources as central part of the local identity may serve as an impetus for basic but sustained community disaster risk management initiatives. However, the increasing unpredictability of seasonal and climactic patterns, and prolonged and more frequent periods of drought, renders this knowledge unreliable to changing conditions (IOM, 2009b, p. 3). Traditional knowledge needs to be complemented by access to safe areas and facilities, timely receipt and actions based on early warning signs both traditional and modern, and alternative livelihood strategies. A broader environment and natural resource management campaign for local communities is important in raising awareness on the linkage between disaster risk management and natural resource management.

- Changes to livelihood, food, and social securities driven by environmental degradation may increase the impact of natural disasters and further exacerbate the vulnerabilities of affected communities.

Food insecurity and insecure access to water are central features of vulnerability to natural disasters in the region. While the region is abundant in water sources, the lack of appropriate technology and storage to tap and deliver water to households and paddy fields is a challenge. Availability of new crop fields is decreasing due to restrictions placed by conservation policies, economic land concessions as well as increasing demand from growing population in the assessed villages. For instance, in Ratanakiri Province, some of the assessed villages expressed concern over changes in access to natural resources following the passage of the Protected Area Law. Efforts are underway to ensure community participation in the co-development of a community protected areas (CPA) management plan. While management zones are provided by law, there are yet no defined boundaries between protected area zones. Some areas already identified as community protected areas cover resin and malva nuts which are harvested by indigenous communities and old crop fields, but prohibit the clearing of new areas (IOM, 2009b, p. 26). In Stung Treng Province, land conversion for agriculture, cash crops and resettlement expansion in response to population growth and migration, and infrastructure development are identified as main threats to management of the ramsar site. Conservation for international bird areas (IBA) in the same province is threatened by extreme exploitation of riverine birds for commercial and local uses, and habit loss due to flash floods and forest clearance for agriculture and logging. In Mondulkiri Province, two wildlife sanctuaries face management challenges such as unmonitored timber poaching, harvesting of wood for fuel, charcoal production and wildlife hunting and trading, and habit changes due to forest land conversion for settlement and agro-industries. Across the three provinces, forest areas that were affected include communal forests that are under the traditional use of indigenous people for resin tapping, grazing lands, wild game, and for spiritual purposes (IOM, 2010, p. 25).

- Linkages between environmental protection, disaster preparedness, and population stabilization:

One potentially significant consequence of their high vulnerability to natural disasters and climate-induced hazards and environmental degradation is on local community's mobility patterns. Although no large movements have been reported in the North-East, both temporary and permanent movements that had been documented in the last ten years (IOM 2009a, 2009b, 2010; 3SPN, 2007) which indicate movements as part of local coping strategies to environmental and natural hazards, including flood and drought, and to socio-economic factors such as search of new lands for cultivation and settlement. Indigenous communities, having a tradition of moving within village boundaries, have noted the difficulty of moving their rice fields or houses in response to these hazards or in the practice of their traditional beliefs. Even when temporary movements serve as a coping strategy, there are no water and sanitation facilities and shelters available in safe areas identified by communities. Migration to safer areas is also limited by the lack of financial resources, the lack of available lands within the village, and the limitations posed by conservation policies in forest and protected areas. There is a need to understand how migration can be maximized as a coping strategy and as part of community-based preparedness and response to floods and drought (i.e., identification of safe areas and safe area management, and inclusion of migration/population displacements in pre and post disaster risk assessment).

As road and border access to the region improves, local economies experience growth as well as population growth that stems from seasonal labour migration, permanent in-migration, and cross-border trade. The combination of these factors makes unplanned population movements unsustainable. The survey and development of land use plans down to the commune level is still at its early stage, and when finalized these plans can better inform local officials and communities in their local land use. The experience of Mondulkiri Province demonstrates the importance of government, NGO and community cooperation in natural management that is crucial for CBDRM wherein the Forestry Administration led the participatory land use planning (PLUP) in partnership with NGOs like the Wildlife Conservation Society for the Seima Biodiversity Conservation Area. Communities were engaged in identifying different land uses through a participatory approach resulting in a PLUP agreement with the community. Under the agreement, each family will be allocated five hectares to use for their residence and farming activities (IOM, 2009a, p. 23). In Ratanakiri, the Forestry Administration in cooperation with local NGOs and indigenous communities has identified 31 areas to be allocated for community forestry. In Stung Treng, local community projects have been set up by NGOs in three districts, but have yet to be officially endorsed by the Forestry Administration (IOM, 2010, p.25).

In line with the mandate of the Land Law of 2001 as well as the Sub-Decree on Procedures of Registration of Land of Indigenous Communities, communally held lands by indigenous communities can be recognized subject to the establishment of their legal identity as a community and subsequent legal registration as defined by the Ministry of Interior. In Ratanakiri Province, two legal identities and in Mondulkiri and one legal identity for a Phnong indigenous village have been registered (IOM, 2009a, p. 23; IOM, 2009b, p.24).

- Institutional capacities for convergence of DRRM and NRM are crucial in effective development planning and rationalized resource mobilization and community engagement and in addressing the emerging impacts of climate-induced hazards.

Among local communities surveyed particularly in areas where chronic poverty is high, disaster preparedness was limited to household-level preparations—such as preparing food stock and evacuating livestock to safety during floods or storage of water during drought—and some village-based mechanisms such as sharing of boats and identification of safe areas during evacuation. These disaster preparedness activities proved sufficient in the past during small scale floods and drought; however, recent trends indicate unpredictable flooding and precipitation patterns that have increased in intensity, duration and scale are rendering these mechanisms insufficient. Overall disaster response capacity is also very limited owing to the lack of technical and human resource capacity, as well as financial and material resources to undertake emergency response, relief and recovery. Often, Provincial Committee for Disaster Management (PCDM) officials meet only during onsets of disasters to mobilize resources from different line departments and from other funding sources, indicating a very high dependence on external assistance. At the district, commune and village levels, there are no dedicated technical and material resources to first lines of response at the onset of disasters nor are there trained local human resources that can be tapped to undertake systematic disaster response and evacuation, and assessment of damages and displacements and assistance to be given to affected populations.

Institutional capacities by the Provincial Committee for Disaster Management (PCDM) are limited by both technical and financial resources as well as low levels of appreciation of disaster risk reduction beyond emergency response. Past disaster management efforts had focused on remedial measures for drought and emergency response during and after floods and there is very low inter-departmental and administrative coordination on disaster management. DRR is not identified in the provincial development plan as prioritized development issue and has yet to be fully mainstreamed into natural resource management, environment and health programs in the provinces. Hence, there is no human, technical and financial resources tied to DRR-related activities. Awareness on climate change is at its earliest stage at the institutional and community-levels through the Provincial Department of Environment and some local non-governmental organizations.

The low level of awareness on climate change makes it challenging for the interaction of DRR and climate change at field level. Both concepts are new and their application in local development planning is limited as yet. IOM assessments had shown that inter-sectoral departmental coordination by key provincial departments such as the Agriculture, Forestry and Fisheries, Water Resources and Meteorology, and Environment, for DRR, NRM and climate change has not yet taken place due to the lack of guidance for the operationalization of these mandates. The lack of coordination and convergence of sectoral planning and focus at lower levels of government more importantly reflects the difficulty of such convergence at the national level, where each responsible ministry under the Strategic National Action Plan (SNAP) for DRR has defined responsibilities. The shift to a developmental focus of DRR is gradually taking place but this eventual shift has yet to be supported by national and provincial wide capacity building and administrative reform process. Clear definition of roles and responsibilities and budgetary allocation at provincial, sectoral department levels, and other sub-national levels must be reinforced. Field experience from piloting of the Village Disaster Management Teams (VDMT) in two provinces had shown that community-based disaster risk management could only be effective when informal social mechanisms are linked to formal mechanisms such as through the commune investment and development planning mechanisms. It has also demonstrated how the impacts of climate change and environmental degradation need to be considered in community action planning and risk assessment. Present mechanisms have not yet been fully maximized to allow for this convergence at the local level. For instance, natural resource management priorities supported under the DANIDA CB-NRM funding stream could be channelled as a major DRR measure in the annual Commune Investment Planning but this has yet to be done. Ongoing administrative streamlining following the newly passed National Program on Sub-National Democratic Development for 2010–2019 provides for a set of planning guidelines currently on draft at sub-national levels that include DRR and climate change in the risk assessment and planning priorities.

Concluding Statement

Policy developments in the last two decades in Cambodia have placed environment and natural resource management as pillars to its development strategy and long-term poverty reduction targets. The increasing complexity of Cambodia's socio-economic development challenges calls for more integrated policy and institutional convergence and solutions on key issues such as environmental degradation, impacts of natural disasters and climate change on food security and human vulnerability, and natural resource exploitation. Decentralized mechanisms had shown promising gains in bringing these convergences and mandates to sub-national government and local communities.

Historically exposed and devastated by floods and drought and in recent years, by extreme weather events such as the Typhoon Ketsana in 2009, Cambodia has low adaptive capacity to both natural and climate hazard risks. Two of three north-eastern provinces, Ratanakiri and Mondulkiri, rank high in vulnerability levels and low in adaptive capacity in a recent study on climate vulnerability in Asia (Yusuf and Francisco, 2009).

Research assessments from the provinces of Ratanakiri, Mondulkiri and Stung Treng in North-East Cambodia confirm the high vulnerability levels of local and indigenous communities as well as ecosystems and institutions to the compounding risks from natural hazards, environmental degradation driven by such factors as natural resource exploitation, rapid economic development and in-migration, and climate induced hazards. Institutional capacities for disaster management are low and synergies between environment and natural resource managements are weak. Despite these challenges, pockets of optimism abound for the contribution of natural resource management and environmental preservation to disaster risk reduction and management practices in the region. Field experiences demonstrate the clear benefits of community-based disaster risk management (CBDRM) and community-based natural resource management (CBNRM) as complementary approaches to help address local vulnerabilities to natural hazards. Recent policy approval on decentralization and poverty reduction recognizes the development linkages between address vulnerability reduction to natural disasters, increasing ecosystem and human resilience, and poverty reduction. The development of local institutional, technical and human resource capacities for NRM and DRRM is crucial in developing adaptive capacity of local communities and ecosystems to recurrent risks of natural hazard and extreme weather events, environment hazards as well as climate-induced hazards.

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Role of Legislations and Policies in Reducing Disasters and their Impact

Indrani Chandrasekharan[1] and Anil K. Gupta[2]

Introduction

India is vulnerable to both natural and Man-made disasters. About 58.6% of India's landmass is susceptible to earth quakes of moderate to very high intensity, 68% of cultivable area is susceptible to drought, over 12% is prone to floods and river erosion , 5700 kilometers of the mainland coast line is prone to cyclones and tsunamis and hilly areas are at risk from landslides and avalanches1. There are 1894 Major Accident Hazard (MAH) chemical units in the country and these are classified as probable sites of major chemical accidents. Emergencies due to Chemical, Biological, Radiological and Nuclear (CBRN) accidents also exists. Disasters entail huge economic losses leading to developmental setbacks and therefore efforts to mainstreaming disaster risk reduction, i.e., inclusion in policies, legislation and the process of development planning at all levels is thought essential.

Disaster management

Disaster management in India has evolved from an activity-based setup to an institutionalized structure; from single faculty domain to a multi-stakeholder setup; and from a relief-based to a 'multi-dimensional approach for reducing risk'. The beginning of an institutional structure for disaster management came during British period following the famines of 1900, 1905, 1907 & 1943, and the Bihar-Nepal Earthquake of 1937. Over the past century, the structure for managing disasters in India has undergone substantive changes in its composition, nature and policy.

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Policies and Legal regime for Natural and Chemical disasters

A Strategy for total risk management, comprise; prevention, preparedness, response and restoration, Risk reduction and mitigation, streamlining institutional arrangements for disaster response, communications and data links and resources. All the components of the strategy need to be explicitly laid down in policies and legislations to ensure compliance.

Legislation is critical to ensure institutional systems, planning and coordination, local participation and policy implementation. Legislations set standards and boundaries for action, i.e., define building codes, training requirements and basic responsibilities of key stakeholders in risk management.

Legislation on its own cannot induce people to follow the rules hence Monitoring and Enforcement are needed. In high-risk locations, monitoring and enforcement — and knowledge — of legislation in the short- to medium-term is lacking for want of financial and human resources .

Natural disasters

Post independence, the task for managing disasters rested with the Relief Commissioners in states, who functioned under the Central Relief Commissioner, with their role limited to delegation of relief material and money in the affected area. Frequent occurrence of floods and droughts in the country further limited the scope of disaster issues in India to the two hazards. Since both floods and droughts had a direct impact on the agriculture sector, disaster management in India came to be associated with agriculture and related issues. Every five-year plan addressed flood disasters under "Irrigation, Command Area Development and Flood Control". A permanent system and institutional setup began in the 1990s. The disaster management cell was established under the Ministry of Agriculture, following the declaration of the decade of 1990 as the 'International Decade for Natural Disaster Reduction' (IDNDR) by the UN General Assembly.

Natural disasters were dealt with under a Central Sector Scheme of Natural Disaster management. During 1993-94 the Programmes were implemented by the Department of Agriculture and Co-operation with the objective of disaster preparedness and emphasis on mitigation and preparedness for enhancing capability to reduce the adverse impact of disasters. A National Centre for Disaster Management (NCDM) at the Indian Institute of Public Administration was also created for training in the eighth plan. Natural Disaster management was always considered as a state subject.

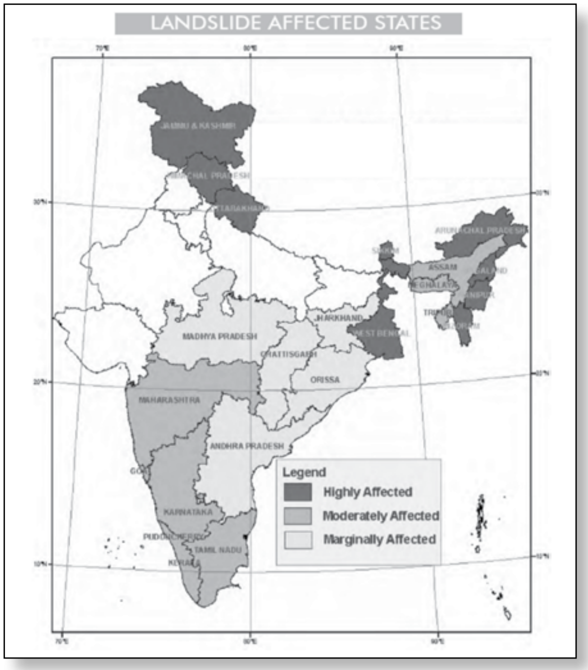
In the tenth Plan , the States were asked to convert the existing State Department of Relief and Rehabilitation into Department of Disaster Management with the responsibility of looking at the whole cycle of disaster management- prevention, mitigation, preparedness, response, relief and rehabilitation. The Department of Disaster Management was also asked to coordinate the steps taken by the different Departments of the Government. Considering that mitigation, preparedness and response are multi-disciplinary activities involving a number of Departments, the State Governments were requested to consider setting up a State Disaster Management Authority under the Chairmanship of the Chief Secretary with the Secretaries of Departments of Water Resources, Health, Agriculture, Animal Husbandry, Roads, Communications, Rural Development, Public Works, Public Health Engineering, Finance and Home as Members. The Secretary of the Department of Disaster Management was the member-Secretary and this authority was to ensure coordination of activities towards mitigation and preparedness as also coordinated response when a disaster strikes. Each State was also asked to consider setting up specialised search and rescue teams of one coy of the State Armed Police trained and equipped to carry out specialised search and rescue; one mobile engineering unit with necessary equipment and one medical assistance team. Guidance/advise required with reference to training and equipment was to be provided by the Disaster Management Division of the Ministry of Home Affairs, Government of India.

Map 2
FLOOD ZONES IN INDIA

Source: BMTPC Vulnerability Atlas

Map 3
WIND AND CYCLONE ZONES IN INDIA

Source: BMTPC Vulnerability Atlas



Maps 1-4

Policy for Natural Disaster management

The Policy for Natural Disaster Management was drafted by the National Disaster Management Authority (NDMA) in 2009 indicating vulnerable zones on the map of India to various types of disaster (Map-1-4). The DM policy notified is based on the following 5 themes:

- Community based DM, including last mile integration of the policy, plans and execution.
- Capacity development in all spheres.
- Consolidation of past initiatives and best practices.
- Cooperation with agencies at National and International levels.
- Multi-sectoral synergy.

The objectives as stated in the National Policy on Disaster Management are as under:

- Promoting a culture of prevention, preparedness and resilience at all levels through knowledge, innovation and education.
- Encouraging mitigation measure based on technology, traditional wisdom and environmental sustainability.
- Mainstreaming disaster management into the developmental planning process.

- Establishing institutional and technological frameworks to create an enabling regulatory environment and a compliance regime.
- Ensuring efficient mechanism for identification, assessment and monitoring of disaster risks.
- Developing contemporary forecasting and early warning systems backed by responsive and fail-safe communication with information technology support.
- Ensuring efficient response and relief with a caring approach towards the needs of the vulnerable sections of the society.
- Undertaking reconstruction as an opportunity to build disaster resilient structures and habitat for ensuring safer living.
- Promoting a productive and proactive partnership with the media for disaster management.

Chemical disasters

In the Pre-Bhopal phase , legislations in force such as ; Explosives Act, 1884 , The Petroleum Act, 1934 , Factories Act, 1948 and Rules made there under , The Insecticide Act, 1968 , Static & Mobile Pressure Vessels Rule, 1981 , Motor Vehicles Act, 1988 focused on on-site safety of workers. No legal system to regulate, Off-site emergency system, Safe storage and safe transportation of hazardous substances were in place.

Post Bhopal a Legal Regime consisting of the following Acts and rules were enacted, including Amendments to the Factories Act, 1948 and Motor Vehicles Act., 1988.

- Environment (Protection) Act, 1986
  - Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 amended, 2000
  - Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
- Public Liability Insurance Act, 1991 and rules there under

Policy for Chemical Disaster management

The National Environment Policy of 2006 aims to mainstream environmental concerns in all development activities. It describes the key environmental challenges both current and prospective for the country and in addition to others , stresses on the strategic themes for intervention and broad indications of the legislative and institutional development. The dominant theme of the policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods from the fact of conserva -tion , than from degradation of the resource.

One of the principles of the policy is prevention of environmental damage from occurring, rather than attempting to restore degraded environmental resources.

One of the actions proposed is strengthening of the legal arrangements and response measures for addressing emergencies arising out of transportation, handling, and disposal of hazardous wastes, as part of the chemical accidents regime.

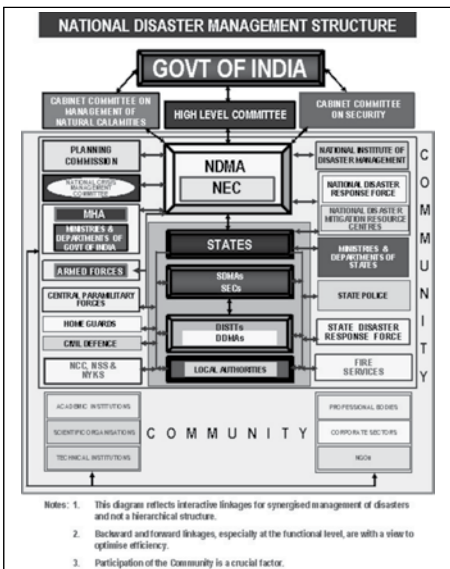
Reducing Disasters and their Impact through legislations

Disaster Management Act, 2005

The Disaster Management Act, was enacted in 2005 for establishing requisite institutional mechanisms (Fig-1) for drawing up and monitoring the implementation of disaster management plans, ensuring measures by various wings (Fig-2) of the government for prevention and mitigating the effects of disasters, and for undertaking a holistic, coordinated, and prompt response to any disaster situation.

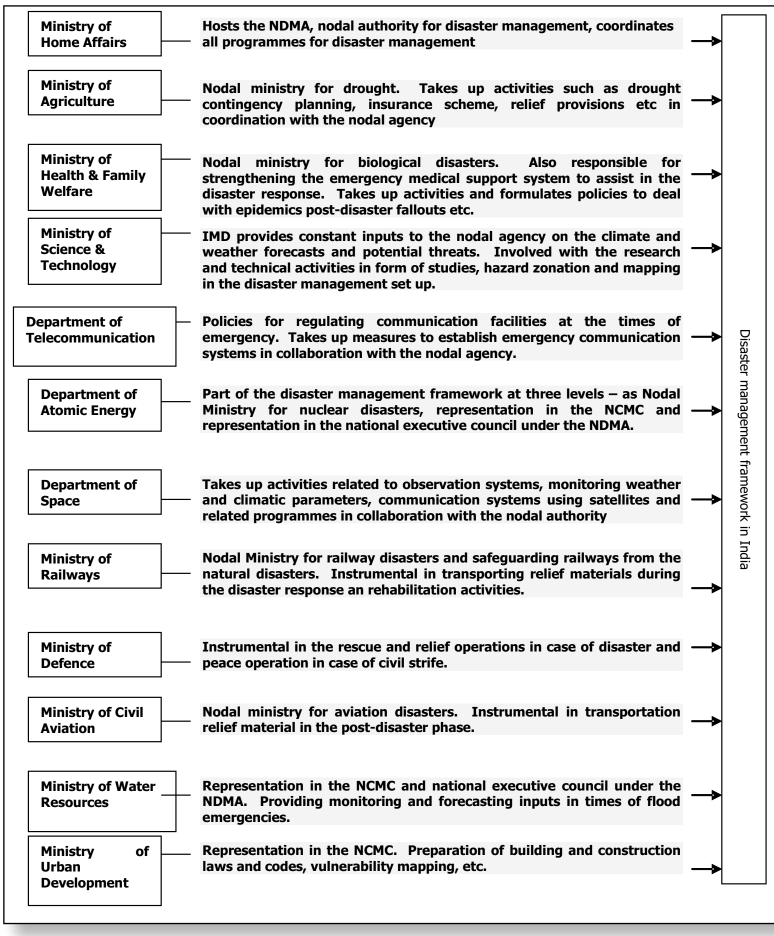
The National Disaster Management Authority (NDMA), under the Chairmanship of the Prime Minister, was set up as mandated. NDMA is an apex body responsible for laying down policies, plans and guidelines on disaster management to ensure timely and effective response to disasters. The Authority in addition to preparing the National Policy on Disaster Management in 2009 , prepared guidelines on prevention, mitigation, response, and recovery for different types of disasters viz; earthquake, flood, landslides and industrial disasters.

Figure 1



As per DMA, 2005 the State Governments are required to set up State and district Disaster Management Authorities. The provisions of the Act relevant to the States/UTs have been brought into force w.e.f. 1 August 2007. As envisaged an eight battalion-strong National Disaster Response Force has also been set up comprising of 144 specialized response teams on various types of disasters of which 72 teams are for nuclear, biological, and chemical (NBC) disasters.

***Fig-2**: Interface between the key Ministries and the disaster management framework*



Environnent Impact Assessment (EIA) Notification, 2006.

The Environment Impact Assessment Notification, 2006 envisages preparation of an Environment Management Plan which details mitigation measures for each item wise activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts as a result of the activities of the project. It also delineates the environmental monitoring plan for compliance of various environmental regulations and would state the steps to be taken in case of emergency such as accidents at the site including fire. Details called for in Form-1 under EIA include risks due to explosions, spillages, fires etc from storage, handling, use or production of hazardous substances and Effect of natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc).

Coastal Regulation Zone notification, 2011

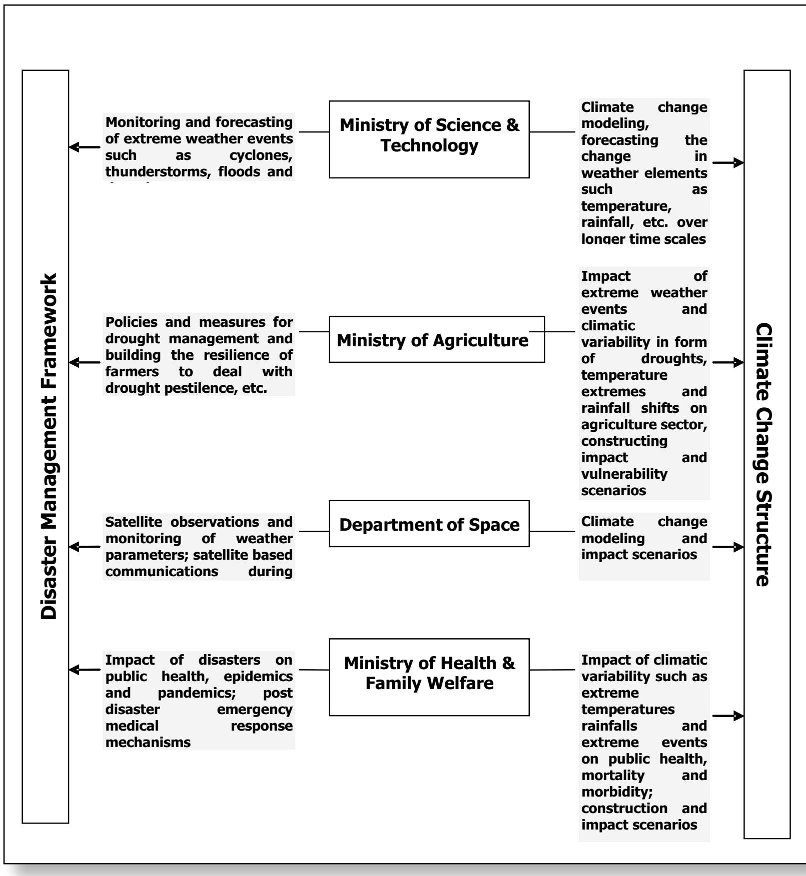
With a view to ensure livelihood security to the fisher communities and other local communities, living in the coastal areas, to conserve and protect coastal stretches, its unique environment and its marine area and to promote development through sustainable manner based on scientific principles taking into account the dangers of natural hazards in the coastal areas, sea level rise due to global warming, the Ministry of Environment and Forests (MoEF)through the CRZ notification, 2011 declared the coastal stretches of the country and the water area upto its territorial water limit, excluding the islands of Andaman and Nicobar and Lakshadweep and the marine areas surrounding these islands upto its territorial limit, as Coastal Regulation Zone CRZ) and restricted the setting up and expansion of any industry, operations or processes and manufacture or handling or storage or disposal of hazardous substances as specified in the Hazardous Substances (Handling, Management. This was in supersession of the notification of the Government of India in the MoEF, number S.O.114(E), dated the 19th February, 1991. The details sought for in respect of disaster management are as under:-

- Whether located within the hazard zone as mapped by Ministry of Environment and Forests/National Disaster Management Authority?
- Whether the area is prone to cyclone, tsunami, tidal surge, subduction, earthquake etc.?
- Could the project be affected by natural disasters causing environmental damage (e.g., floods, earthquakes, landslides, cloudburst)?

Climate Change and Disaster management

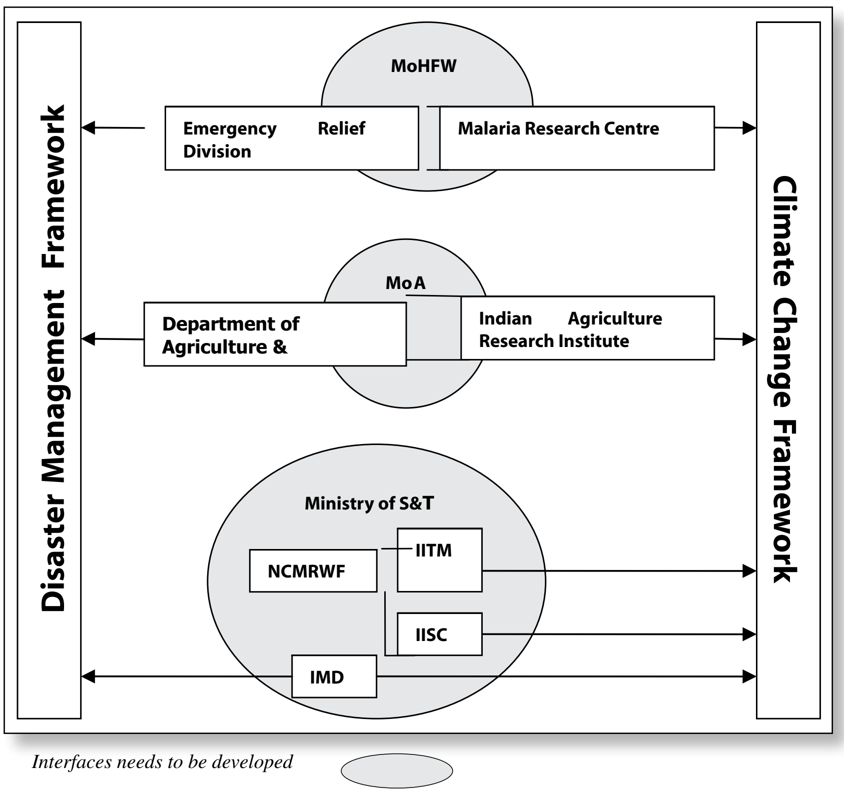
Traditionally, disasters in India have been compounded by climatic factors. Being under the monsoon regime, the country has faced frequent floods, drought and consequent famines. However, the recent developments in the fields of disaster management and climate change have overlooked these obvious links and two separate institutional structures have evolved to service climate change and disasters. Whilst both frameworks have seen parallel developments, disaster management structure receive greater political priority and command immediate attention among policy makers and users as they are associated with immediate and well known risks. Consequently, the disaster management structure in India has a more evolved setup in comparison with the structure for addressing action on climate change adaptation. The former structure, with strong legislative base, can be an effective entry point for integrating climate change adaptation concerns with the disaster management initiatives. Further, the presence of common stakeholders(fig-3) in the interfaces with the frameworks for disaster management and action for climate change make it a suitable alternative for exploring possibilities for integration. However, this will require wide-scale capacity building in the interface institutions. Robust policy measures to enhance the capacity of the interface institutions and also individuals who will be "gateway" and carriers of knowledge from one framework to the other will be required.

***Fig-3**: Common stakeholders and parallel interfaces with the disaster management and climate change frameworks*



Integration of climate change adaptation concerns in disaster management will need to be taken up at three levels – integrating adaptation to longer term climate scenarios with the disaster mitigation and response interventions; regularizing policy networks to take up climate change adaptation within the disaster management framework; and facilitating permeability among the parallel structures within the common actors in both frameworks. Lessons from India can have wider applications as many other countries share the common challenge of deciding how to best link the two parallel tracks for tackling climate adaptation and disaster management. The missing links in the institutional interface is indicated in fig-4.

***Fig-4**:-Missing links in the Institutional Interfaces*



Recommendations

The greatest challenge for mainstreaming disaster risk into development planning is political will and geographical equity. Following are some recommendations in the area of policies and legislation:-

Legislation and Governance

Disaster Management Plan and Environmental Impact Assessment mandated under the EIA for development projects and On-Site and Off-site emergency plans mandated under MSIHC and CAEPPR rules should cover Natural and applicable CBRN risks including fall out of the hazards. Valuation techniques (including the DRI) should be used to project positive contribution of risk reduction investments in development.

Disaster Preparedness

An attempt at maximizing the scares resources to improve disaster preparedness and response is needed.

Disaster Recovery and Reconstruction

R & R plan should be in readiness at all times.

Climate Risk Management

Robust policy measures to enhance the capacity of the interface institutions and also individuals who will be "gateway" and carriers of knowledge from one framework to the other will be required. Integration of climate change adaptation concerns in disaster management will need to be taken up at three levels – integrating adaptation to longer term climate scenarios with the disaster mitigation and response interventions; regularizing policy networks to take up climate change adaptation within the disaster management framework; and facilitating permeability among the parallel structures within the common actors in both frameworks Building on capacities that deal with existing disaster risk is an effective way to generate capacity to deal with future climate change risk.

Managing Risk

Natural hazard is one among many potential threats to life and livelihood. People and communities most vulnerable to natural hazards are also vulnerable to other hazards. For the poor, livelihood strategies is playing off of risks from multiple hazards sources – economic, social, political and environmental. Disaster risk reduction policy has to take into account and look for building generic as well as disaster risk specific capacities.

Knowledge for Disaster Risk Assessment

A first step towards more concerted and coordinated action on disaster risk reduction is clear understanding of the depth and extent of hazard, vulnerability and disaster loss.

Specific recommendations towards this end are to:

- Enhance National indexing of risk and vulnerability, enabling more and better country and inter-state comparisons.
- Support state and sub-regional risk indexing to enable the production of information for national decision makers.
- Develop a multi-tiered system of disaster reporting.
- Support context driven risk assessment

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Bamboo Green Belts-Innovative Option for Alternative Livelihood & Sustainable Coastal Protection

K.G. Thara

Coastal Dynamics in India

The Indian sub-continent has a long coastline, extending to a length of about 7516.60 Kms including Daman, Diu, Lakshadweep and Andaman & Nicobar Island. About 23% (ie.,1450 km) of shoreline along the Indian main land is affected by erosion, out of which 700 km is reasonably protected by construction of seawalls, groins, etc, and 750 km is yet to be protected. About 8% of the area in the country is prone to cyclone-related disasters such as storm surge, heavy winds and very heavy rainfall. Between 1891 and 2006, 308 cyclones are estimated to have crossed the east coast, out of which 103 were severe. The west coast however witnessed lesser activity, with 48 cyclones, out of which 24 were of severe intensity. Evaluation of the vulnerability of the east coast of India (Mascarenhan, 2004) from over a century (1891–2000) of cyclone data reveal that of the cyclones that formed in the Bay of Bengal, Andhra Pradesh received 32 percent, Orissa 27 percent, Tamil Nadu 26 percent and West Bengal 15 percent. Though the frequency of occurrence of tropical cyclone is low in the east coast of India and Bangladesh, these regions are highly risk prone in terms of human population at risk. In the last 30 years, strength of tropical in the Atlantic region cyclones has more than doubled nearly doubled for the Western Pacific region. This is attributed to the increased concentrations of greenhouse gases and concomitant increase of sea surface temperatures (Emanuel,2005). This change and increased sea activity is most pronounced in the North Pacific, Indian and Southwest Pacific oceans, while the least change is noticed in the North Atlantic Ocean.

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Coastal Vulnerability of Kerala & Need for Protection

The 570 Kms long coastal zone of Kerala is vulnerable not only to the perpetual threat of coastal erosion but also to the storm surge due to cyclones. The coastal belts of Kerala are one of the most densely populated regions in the country, which increases its vulnerability. Kerala constitutes only 1.18 % of the total area of Indian Union but accounts for about 3.1 per cent of Indian population.

The costal plains is important not only as a major physiographic unit of the state, but also as one of the most thickly populated zones in the world. Almost 16 per cent of the Kerala's population lives along this coastal belt, which is considered to be vulnerable to multitude of disasters such as beach erosion, cyclone ,tsunami, storm surge, sea level rise etc.

The state is also susceptible to cyclonic winds. 96.9 per cent of the total area in the State lies in the 140.4km/h wind zone (moderate damage risk zone) and rest lies in 118.8km/h wind zone. The probable maximum storm surge height in the State is 3.5m and minimum is 2.3m. If the Storm surge is during high tide, the maximum surge height in the state may reach 4.2 m and minimum storm height may reach up to 3 meters (BMPTC vulnerability Atlas of India, 2002). The Density of population is 819 persons /km2, which is the third highest density in the country (Economic review,2010).

Topographically, 54.17 per cent of the area in the state is low lands, the altitude of which is only 10-300m and the altitude of coastal plains and lagoons which constitutes about 16.40 % of the total area is below 10 m from the mean sea level.

All the above-mentioned factors make the estimated 8,43,587 fishermen population of the state(Fisheries department, 2004), extremely vulnerable. Fishermen constitute about 3 per cent of the total population and active fishermen are estimated to be 2.2 lakhs. The physiographical peculiarities, low altitude from mean sea level, small width and high density of population make the coastal population especially sensitive to sea level rise, high tides, tsunami and coastal erosion.

Risk Reduction Through Green Belts

The rapid increase in greenhouse gases in the atmosphere, land degradation, increasing floods and droughts, deforestation, loss of biodiversity and productivity are leading to an ecological crisis affecting livelihood options leading to poverty, pollution and unsustainable development. As the coastal areas are the most vulnerable, it is imperative that scientific management of disasters and augmentation of resilience through natural interventions have to be given the highest priority so as to protect the poor, who directly bear the brunt of these adversaries. This suggests, inter alia, a policy to actively encourage and support plantation of green belts to overcome these constraints.

In India, interventions for prevention of coastal erosion have primarily been centered around structural measures such as construction of seawalls, revetment, groynes, off-shore break waters etc. However, with increasing realisation of the adverse effects observed in the downstream side of all structural options, need for shifting to non- structural or soft measures such as vegetative covers, beach nourishment etc is increasingly felt by the policy makers, scientific and the local communities. Barriers of trees and shrubs which act as bio shields are increasingly becoming an option for coastal protection because of their multi-fold benefits.

Some coastal plants commonly used as green belts are Nyamplung *(Calophyllum inophyllum),* Cemara Laut *(Causarina equisetifolia),* Ketapang *(Terminalia cattapa),* Waru Laut *(Hibiscus tillaceus),* Putat Laut *(Barringtonia asiatica),* Bintaro *(Cerbera manghas).* Since the choice of species for shelterbelts is dictated largely by the local climate , soil conditions, physical and chemical properties of the substratum and the tolerance to high salt conditions, mangroves are generally the most favoured natural species in tropical coastal regions. However, these are sensitive to many ecological factors, including changes in water flow, salinity. Moreover, mangroves over large offshore regions may limit fish-farming opportunities, and establishment of shelterbelts that are contiguous onshore, may limit the types of agriculture or forestry that are available in the coastal area.

It is important to note that a shelterbelt protects an area over a distance up to its own height on the windward side and up to twenty times its height on the leeward side, depending on the strength of the wind (Eugene S. Takle, T.C. Chen and Xiaoqing Wu, 2007). In regions where the combination of exposure to tropical cyclones and soil conditions does not favour the use of mangroves, tall trees such as some varieties of coconut palms and rubber trees are already in use , especially in locations beyond the inundation. Examples of such coastal protective belts include a 3000-kilometre shelterbelt built mainly with *C. equisetifolia* along China's southern coast and use of coconut palms and rubber trees on the west coast of Indonesia (Smith, 2006). *Casuarina equisetifolia* is also used as a shelterbelt species in tropical coastal areas because of its height (up to 30 metres), rapid growth rate and high tolerance to salty environments as well as to high rainfall, although in some regions it is considered unpopular owing to its invasive habit and lack of support for an accompanying diverse ecosystem.

Bamboo As An Option

India ranks second in the world in bamboo reserve and diversity, with 136 species and an estimated 8.96 million ha. in the forest area. Though a National Bamboo Mission was formed to promote the growing and promotion of bamboo, the country exploits only one–tenth of its total potential. The history of using bamboos in day to day life such as construction of houses and buildings, poultry sheds goat farms and for making furniture, cowsheds , fencing for compound and protection of agricultural land, construction of small bridges, scaffoldings, etc., in India dates back more than 5000 years.

Bamboo is increasingly being recognized as a healthy alternative in modern sustainable architecture and there is tremendous scope for widening its utility both in urban and rural area. However, the wide scope for product diversification and use of bamboo in different type of construction such as load bearing structures, thatching ,partition walls, staircase reelings, flooring , frame in minor RCC work etc is not fully utilised. Bamboo thrives in warm climates where the earth is kept moist with frequent monsoons and there is also scope for promoting the skill of Artisans and to strengthen the marketing through its value added products. Ability to mature to a height of 20 meters or more in a mere four years and an extensive root system which remains intact, allowing for rapid regeneration , are qualities which make bamboo an ideal plant for areas threatened with the potentially devastating ecological effects of soil erosion. Apart from bamboo basketry, woven boats made of bamboo splits are also used for rescue operations in disaster situations in countries such as Vietnam.

Kerala state has approximately 3600 hectares of shelterbelt plantations and another 1800 hectares is planned to be brought under the green belt to address the escalating risk factors in the coastal regions. Apart from reducing State's Vulnerability to Cyclones and storms, this is expected to stabilize the coast and prevent the erosion of sand by the winds, protection of life and property from cyclonic storms and floods and ensure sustainability of coastal zones.

Social and Economic Benefits of Bamboo as a Green Belt

Introducing bamboo in the shelterbelt and coastal forests is proposed as an environmentally attractive, innovative and sustainable option, in the light of its status as an ideal species capable of achieving conservation of soil and moisture, repair of degraded land, ecological, food and nutritional, livelihood and economic security ,its manifold uses and industrial applications.

Most species of bamboo produce mature fibre in about three years and grows much faster than any tree species. Some species grow up to one metre a day, with the majority reaching a height of 30 metres or more. Despite the National Bamboo mission actively involved in the promotion, research and marketing of bamboo and bamboo based handicrafts, its use as a coastal protection belt is yet to be explored in a large scale. Bamboo can also be used in many building products, including bamboo-glass fiber composites, plywood substitutes, and laminated flooring and are ideal in disaster resistant construction. By virtue of its structural advantages such as strength and light weight, bamboo buildings are inherently resistant to wind and earthquake forces. These properties can be effectively exploited through promotional plantations and construction initiatives along the coast.

Bamboo as an Alternative Source of Livelihood & Income Generation

In recent years, the demand for bamboo has increased within the country and abroad as a raw material for furniture making, as panel boards substituting wood, as agricultural implements, house/construction related uses and also as a vegetable. It can also act as the 'poor Man's steel' in disaster resistant construction techniques. Bamboo plantations are expected to :

- Increase employment opportunities
- Provide an alternative source for employment
- They are renewable, are harvested with no harm to their natural habitat, and produce materials that promote a healthy human environment

It is pertinent to note that 54 per cent of fishermen in Kerala, have an income of less than thousand rupees per month only and are below poverty line. Sixty four percent of fisher men household in Kerala are in debt because of financial loans they have availed for purchase of fishing implements. Coast related disasters simply strip these populations off their only means of livelihood, spiraling them into more and more debts and deprivation. The tsunami of 2004 stand a testimony to the severe damage and destruction they can wreak in infrastructure, assets, services and economic activities. Bamboo cultivation would help the fishermen and fisherwomen to become more self –reliant by ensuring a minimum wage, through a simultaneous promotion of bamboo-based handicrafts and innovative construction technologies. This is significant especially in a country which has a 7516 Km stretch of sea coast.

Conclusions

Dynamics of the coastal stretch of the country and the high risk of the communities to multitudes of hazards such as cyclone, storm surge, beach erosion, sea level rise, tsunami , high tides etc makes it imperative to protect thee life and property of these populated areas. Adverse effect observed in the downstream side of all structural options necessitates promotion of soft-structural measures for reducing or preventing impacts of cyclone, sea surge and beach erosion. Introduction of bamboo as an innovative option in green belts will not only ensure environmental conservation and eco development, but also help our economy by generating alternative income and employment opportunities for those communities whose livelihood options are threatened during any disasters. Qualities such as ability to mature to a height of 20 meters or more in a mere four years and an extensive root system which remains intact make bamboo an ideal plant for areas threatened by coastal hazards and its structural advantage can also be exploited in the construction of disaster resistant construction.

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Invasive Alien Species – A Massive But Slow Way to Catastrophes

Sas Biswas

Introduction

An invasive species is of floral or faunal origin, alien to an ecosystem. International Union for Conservation of Nature and Natural Resources (IUCN) defines alien invasive species as an alien species which becomes established in natural or semi natural ecosystems or habitats threatening native biodiversity. Such species occupies a larger area of indigenous species, thus it becomes gregarious and dominant and ultimately causes ecological stress and economic loss. Invasive alien species are recognized as one of the leading threats to the environment and biodiversity imposing enormous costs on agriculture, forestry, fisheries, and other human enterprises, as well as on human health. Rapidly accelerating trade, tourism, transport, and travel over the past century have dramatically enhanced the spread of invasive species, allowing them to surmount natural geographic barriers. Issues related to invasive flora and fauna have been stressed in different international concerns such as in Convention on Biological Diversity (CBD), IUCN, World Trade Organization (WTO) addressing to various aspects of mitigation and eradication. Ship ballast water is presently one of the most common ways that the alien species are introduced into foreign lands. In order to prevent an ecological crisis international community is aiming at developing new technologies and legislation such as the Ballast Water Convention.

Climate change and invasive alien species

Global climate change which is now a reality has begun to show its impacts on the biological world. These impacts include alterations in species distributions and changes in abundance within existing distributions and interaction among the species and the ecosystems.

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Invasive species find the changes in climate and the topography more conducive for their colonization, establishment and spread. The slow change in climate results into slow but sure impact of invasive alien species. McNeely (2000) believes that as the climate changes, patterns of production and trade in agricultural commodities are likely to change as well, with crops adapted to tropical conditions being grown more competitively in higher latitudes and altitudes. The sources of tropical invasive species that may contaminate such crops will also increase.

Ecological Aspects of Invasion

According to Williamson (1998) of those species that are introduced, about 10% become established. So, as a rule of thumb, about 1% of introductions are likely to become invasive. The probability of a species becoming invasive increases with the initial population size, so species introduced intentionally and marketed over a long period of time often have greater likelihood of establishment. Species having larger native geographic ranges are more likely to be invasive than those with smaller native ranges. A species that is invasive in one country or location is likely to be invasive in an ecologically or climatologically similar country or location. Species with specialized pollinators are unlikely to be invasive unless their pollinators are also introduced. Successful invasions generally require that the new habitat be compatible, especially in terms of climate conditions (McNeely,2000).

Biological Features and Early Warning on Invasiveness of Flora

Rejmanek and his colleagues (2000) explained in general that small genome size within a generic status of taxa indicates plant invasiveness in disturbed landscapes; invasiveness of woody taxa in disturbed landscapes is associated with small seed mass, short juvenile period, and short intervals between large seed crops; vegetative forms of reproduction are an important factor, with the importance of this factor increasing with latitude; species of exotic nature are more likely to be invasive than alien taxa with close relatives in the native flora; taxa that depend on generalized pollinators and seed dispersers rather than specialized ones are more likely to be invasive; and species with numerous, relatively small, soil-stored seeds are pre-adapted for human dispersal, and hence invasion. It is mentioned that the disease organisms of invasive nature reproduce fast hence can spread quickly. The age of reproductive maturity, disturbance frequency, habitat disturbance and fecundity are characteristic of invasiveness . Propagules of plants as spores and seeds travel over long distances by water, wind, domesticated animals etc at remarkably high speeds.

Monocarpic plants and parthenogenetically developed species of fauna become sporadic, gregarious and ultimately invasive after having distributed phyto/ zoogeographically.

Factors Responsible for Invasion

Human-driven changes in land use (e.g., clearing of forests to create more edge habitats) and climate (e.g., longer growing seasons) provide new and expanded habitats where invasives can thrive. In fact, the invasion of natural system by aggressive, non-native species has been identified as one of the most significant drivers of modern environmental change, second only to direct habitat conversion. When invasive alien species disrupt ecological processes, they can reduce the economic viability of local, resource-dependent economies leading to social instability and economic hardship. The invasive alien species in the beginning are slow in dispersal, establishment, colonization, invasion, spreading and out- competing before becoming gregarious and becoming obnoxious. This could be in slow motion for the present requiring rapid action and management at faster pace.

Invasives – Massive but Slow Way to Catastrophes

Invasion of several species through vegetative and reproductive stages of succession can be considered in slow motion at present, awaiting conducive and opportune time and space to make disastrous effect. Species such as *Prosopis chilensis* (*P. juliflora*), water hyacinth (*Eichhornia crassipes*), *Salvinia*, *Lantana, Mimosa, Mikania, Parthenium*, *Eupatorium,* etc. are aggressively invasive, very destructive and their spread remains unchecked. Some of our best forests have been suffering from the infestation of *Lantana*, *Parthenium, Eupatorium*, etc. Similarly, the bane of tropical wetlands is the pernicious weed water hyacinth. Scotch broom (*Cytisus scoparius*) and *Ulex europaeus* are destroying very large patches of prime shola grasslands of the Nilgiris. In open canopy forests exotic weeds like *Mikania micrantha* and *Chromolaena* are taking over while *Mimosa invisa* is choking the grasslands in the northeast. It is considered that 40% of the species in the Indian flora are alien, of which 25% are invasive. The major adventive weeds becoming gregariously invasive are *Lantana camara, Parthenium hysterophorus, Eupatorium species, Chromolaena odoratum, Mikania micrantha, Ageratum haustonianum, Salvinia molesta, Mimosa pigra* etc. *Parthenium* is an exotic species of tropical American origin and invaded into bioclimatic to agro-climatic regions to urban landscape. Its invasion was first reported in the year 1951 from Pune in Maharashtra. This species is an aggressive colonizer of degraded areas and exposed soil such as fallow wastelands, roadsides and overgrazed pastures. *Mikania micrantha*, a perennial fast growing invasive of neotropical origin has become rampant in north eastern and south west regions of India and have resulted into loss of biological diversity, prevention of regeneration and growth and development of forest species etc. Lantana was introduced in India as an ornamental during 1809-1810 and has spread fast in different habitats particularly in the areas disturbed by various activities by man. High nutrient extraction efficiency has contributed to its colonization on the degraded sites with shallow soils.

Invasions are sometimes caused by deliberate release, whereas often the species by virtue of its reproductive behavior and ecological need become rampant. Several methods such as mechanical, cultural, chemical and biological have been attempted to check the forest invasive species such as *Lantana* and *Parthenium*. The environmental requirements of invasive species cause a change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability etc. The effective management of invasive species depends upon the knowledge about their morphology, phenology, ecology, physiology, allelopathic cycle, nutrient requirement, utilization etc.

Various insect pests and pathogens of plants have become introduced into newer localities along with the planting material such as seeds, cuttings, corms, rhizomes etc. Among the most common examples of invasive insect pests of forest plants are *Quadrispidiotus perniciosus* (poplars, willows), *Icerya puchasi*, (Acacias), *Heteropsylla cubana* (*Leucaena*), *Pineus leavis* (pines), etc. Some of the invasive pathogenic fungi of forest introduced in India are *Cercospora pini-densiflorae* (needle cast of pines), *Cryphonectria cubensis* (stem canker of eucalypts), *Monochaetia unicornis* (Cankers Cupressus, junipers), *Sarocladium oryzae* (on bamboo) etc. The recent outbreak of eucalyptus gall insect (*Leptocybe invasa*) epidemic in south India and its unhindered spread to the northern parts of India is a striking example of an invasive insect species reaching India with imported planting material. Some of the invasive pathogenic fungi introduced in India are *Cercospora pini-densiflorae* (needle cast of pines), *Cryphonectria cubensis* (stem canker of eucalypts), *Monochaetia unicornis* (cankers in cupressus, junipers), *Sarocladium oryzae* (bamboo blight), *Ceratocystis ulmi* (Dutch elm disease of *Ulmus* spp.), *Cylindrocladium* spp. (blight in eucalypts), etc. Several of the aforementioned species were slow in establishment at onset but later became invasive and obnoxious.

Management strategies

Management strategies on invasive alien species should aim at carrying out studies on the Impact of alien species on the ecosystem goods and services of an area vulnerable to invasion, Identification of activities responsible for spread of invasive species for threat value assessment and conservation of affected species, Integrated management approach covering bio-control, bio-mitigation and phyto-sanitation, development of mechanism for surveillance of invasive species covering recording and early warning, besides rapid action, building capacity and sensitization of stakeholders, and development of National Strategy and Action Plan covering invasive species of different ecosystems and landscape.

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Environmental Knowledge for Management of Hydro-meteorological Disasters

Anil K. Gupta [1], Sreeja S. Nair[2] and Vinod K. Sharma[3]

Introduction

In recent years, 90% of natural disasters worldwide have been related to water and climate; floods account for nearly 70% of the people affected in Asia. During the period 2000 to 2006, 2,163 water-related disasters were reported globally in the EM-DAT database, killing more than 290,000 people, afflicting more than 1.5 billion people and inflicting more than US$422 billion in damages. The United Nations University Institute for Environment and Human Security (UNU-EHS) warns that unless preventative efforts are stepped up, the number of people vulnerable to flood disasters worldwide is expected to mushroom to two billion by 2050 as a result of climate change, deforestation, rising sea levels and population growth in flood-prone lands.

In general, all water-related disasters events increased between 1980 and the end of the twentieth century. Floods and windstorm events increased drastically from 1997 to 2006, but other types of disaster did not increase significantly in this period. Floods doubled during the period 1997 to 2006 and windstorms increased more than 1.5 times. Drought was severe at the beginning of the 1980s and gained momentum again during the late 1990s and afterwards. The numbers of landslides and water-borne epidemics were at their highest during the period 1998–2000 and then decreased. Waves and surges increased between 1980 and 2006.

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United National International Decade for Disaster Reduction (IDNDR) has devoted its 1997 year campaign on the theme 'water..….too much….too little , leading cause of disasters' is still relevant even after 15 years of worldwide efforts of understanding and reducing risk of natural disasters. Environmental changes in particular – climate-change, natural resource degradation and land-use changes, are known to cause new hazards besides aggravating impact of existing hydro-meteorological disaster risks. Loss of environmental resources and ecosystem resilience noted worldwide and in particular in developing regions like India, has been identified as a key concern in managing the livelihoods, agricultural productivity, health and thus, the overall vulnerability toward impact of water and climate related disasters. Management of land-resources and land-use has significant role in reducing risk and vulnerability especially of the climatic disasters and in coastal and mountain environments. Coastal zone management is recognized with serious concern for reducing the risk of major disasters like catastrophic cyclone, tsunami, coastal erosion, flooding, salt water intrusion, etc. In mountain areas the approached of ecosystem management in particular the watershed protection, rangeland management, joint forest management, etc. are directly associated with resilience against climatic disasters.

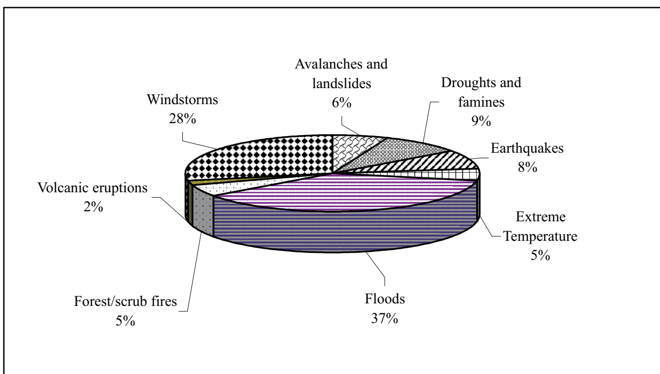

Figure 1: Global natural hazards by categories (1993-2002) (WMO).

Irony from experience is that the disaster manager's often fail to recognize the environmental dimensions of disaster risk, vulnerability and also of the post-disaster actions, whereas environmental managers seldom focus on evaluating disaster risk aspects within their studies. There is also a need to analyze and/or to develop approaches, tools, techniques and methodologies, legislative framework, statistical and decision support systems of environmental management for their role in disaster risk management.

"Development is neither a simple, nor straightforward linear process. It is a multi-dimensional exercise that seeks to transform society by addressing the entire complex of interwoven strands, living impulses, which are part of an organic whole" (Haqqani, 2003). With increasing number of environmental hazard-induced disasters leading to ever increasing human tragedy and economic costs, the international community is calling for the substantial reduction of disaster risk by 2015. The Hyogo Framework for Action sets out the path for the International Strategy for Disaster Reduction (ISDR), and since its adoption in 2005, disaster risk reduction (DRR) has a come a long way with respect to concept development and practical application.

United Nations agencies including UNEP, UNDP, IUCN, UN-ISDR and UNU Institute of Environment and Human Security, jointly with many international organizations like ADPC, WWF, GFMC, ProAct Network, SEI, and the Council of Europe, have formed a Partnership for Environment and Disaster Risk Reduction (PEDRR) in year 2008 with headquarter at Geneva. UN-OCHA has setup a joint Environment Unit with UNEP to emphasize environmental aspects of disasters and their management. UN-ISDR and IUCN have come up with a number of publications on linkage of environment and disasters with particular focus on hydro-meteorological risks. However, at national levels the initiatives for emphasizing the linkages between the two are yet to be institutionalized in India.

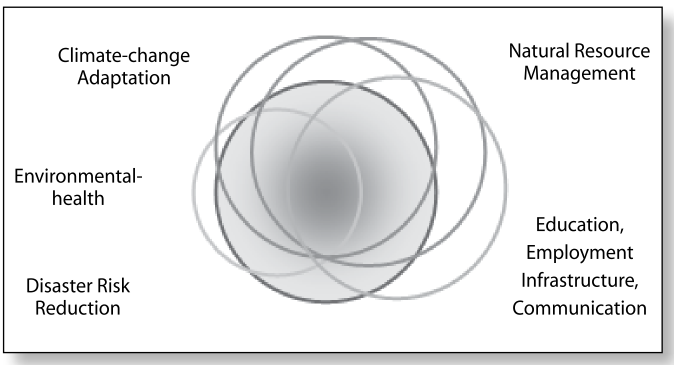

Figure 2: Environment-development interface for disasters and adaptation.

Environment and Disasters

Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems, habitat and the loss of natural homeostasis. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable, be it quantitative or qualitative.

Environmental degradation is one of the Ten Threats officially cautioned by the High Level Threat Panel of the United Nations including World Resources Institute, UNEP, UNDP and the World Bank. Disasters are the events of environmental extremes which are inevitable entities of this living world. Over the years, with the increasing human intrusion in the natural systems and the changing global environment, the frequency and impact of the disasters is augmenting. Following are the three major faces of environmental change primarily responsible for causing or aggravating hydro-meteorological disasters (figure 2):

- Climate-change
- Natural resources
- Land-use changes

Environment and disasters are inextricably linked, particularly in context of hydro-meteorological hazards, climatic risks and epidemiological challenges. It is now widely recognized in terms of following interface:

Environmental degradation leads to water & climate related disasters: Environmental degradation can occur owing to natural processes or due to human induced impacts. Alteration of natural systems and processes, destruction of habitats, loss of quality of environment and exploitation of resources are the broad indicators of environmental degradation. Climate-change and natural resource degradation are known to generate or aggravate disasters especially of the hydro-meteorological origin. Increasing trend in these disasters like floods, drought, cyclone, pest-attack, fires, (and erosion, slides or epidemics) as secondary impacts), worldwide and especially in continents of Asia and Africa is a serious concern for governments and communities.

Environmental degradation causes vulnerability: Besides causing new hazards and aggravating precursors of disaster events, degradation of environment increases socio-economic vulnerability by reducing water, food and nutrition, sanitation and health, livelihoods, housing, bioproductivity, entrepreneurship, and thus, overall economics jeopardizing the coping capacity of people. Low capacities result in high exposures to hazard prone locations and conditions of high disaster risk. Poor environmental quality and degraded natural resources also cause social conflicts and political instability.

Disasters impact environment: Disaster events are also known for causing serious impacts on environment affecting natural processes, natural resources and ecosystems, and thereby creating conditions for secondary or future disasters including complex emergencies. Natural disasters can also trigger chemical or technological disasters. Environmental sustainability is also compromised during disaster management operations and recovery process due to improper disposal of disaster and relief wastes, acute exploitation of natural resources and inappropriate land-use/landscape modifications.

Environmental Management and Disaster Management Cycle

Knowledge of environment is crucial in all stages of disaster management cycle including pre-disaster prevention and mitigation, and during post-disaster response, relief, reconstruction and recovery (figure 2). Experience of the past disasters indicated that environmental services like shelter, water, food safety, sanitation and waste management form crucial components in emergency relief especially in case of water and climate related disasters. On the other hand, concern on disaster risk and mitigation is equally important in all stages of environment management from prevention of hazards and environmental degradation, control, impact minimization, remediation, rehabilitation overall sustainability in environmental systems.

A well-managed environment can act as a buffer against disasters. This can happen in two ways. A healthy or well-functioning ecosystem can regulate or mitigate the hazard itself, thus preventing a disaster from taking place or reducing its impacts. In addition, healthy ecosystems reduce people's vulnerability to disasters by increasing the resilience of communities through meeting basic needs (water, food, health, fuel, etc.) and supporting sustainable local livelihoods and economies. Opportunities of integrating environmental management and disaster risk management together, hence, are a prime concern emerged globally. Environmental laws and strategic instruments viz. EIA, Risk & Vulnerability Assessment, Ecological modeling and predictions, Auditing, Environmental Laws facilitate at key stages of disaster risk management.

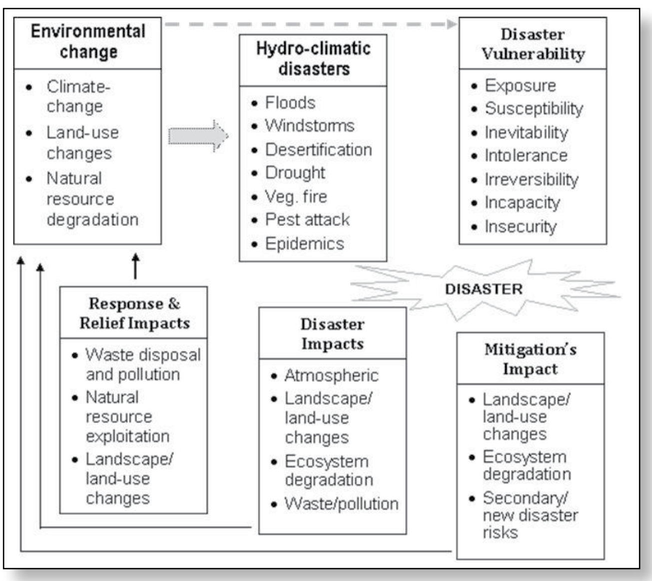

Figure 3: Environmental aspects in various stages of disaster management

Hydro-meteorological Disasters: Implications of climate-change

Hydro-meteorological hazards are the natural processes or phenomena of atmospheric, hydrological or oceanographic nature, which may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hydro-meteorological hazards include: floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and windstorms, blizzards and other severe storms; drought, desertification, wildland fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches. Hydro-meteorological hazards can be single, sequential or combined in their origin and effects.

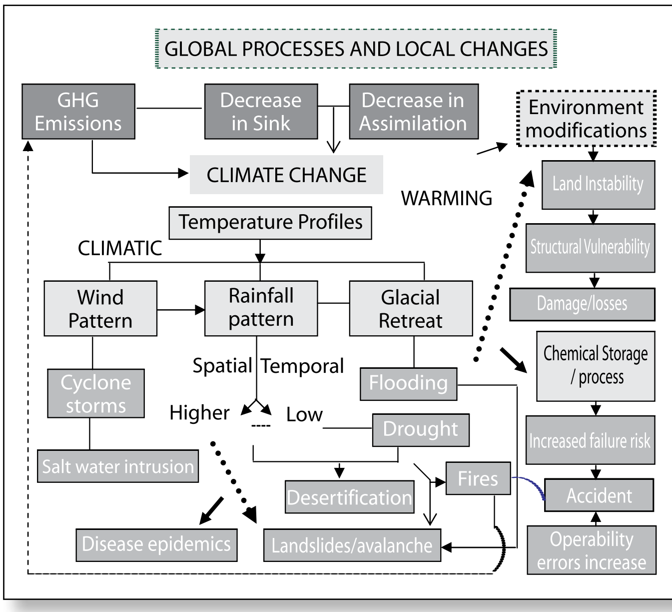

Figure 4: Climatic and environmental implications on disaster risks (Gupta, 2010).

India is among the world's most disaster prone areas. India support 1/6th of the world's population on just 2 % of it landmass. Nearly 59 % of India's land area is prone to earthquakes of moderate to very high intensity, over 40 million hectares (12 % of land), is prone to floods, close to 5700 kms of its 7516 km coast line (about 8%), is cyclone prone and exposed to tsunamis and storm surges, 2% of land is landslide prone, and 68% of India's arable land is affected by droughts. Of the 35 States and Union Territories, as many as 27 are disaster prone (GoI, 2004). Most disasters in India are water related.

These trends are likely to exacerbate in future with climate change. The projected increase in precipitation and rainfall, the glacial meltdown and rising sea levels will affect India particularly severely, creating conditions for more hazardous events and will lead to increase in incidence of floods, cyclones, and storm surges. Though it is not possible to predict the future frequency or timings of extreme events but there is evidence that the risk of drought, flooding, and cyclone damage is increasing and will continue to do so. Climate change is also likely to threaten India's food security, increase water stress, and increase occurrences of diseases especially malaria. Implications of global processes and local changes driven by climate-change that results or aggravates disasters are shown in figure 4. Lack of availability and access to technological and financial resources coupled with a high dependence on climate sensitive sectors-agriculture, fisheries, forestry-have made India highly vulnerable to climate change. A large and growing population, densely populated and a low-lying coastline, and an economy closely tied to its natural resource base, further intensifies this vulnerability.

Ecosystem Approach to adaptation and DRM

Ecosystem-based Adaptation (EbA) options are often more accessible and affordable to the poor than adaptation interventions based on infrastructure and engineering. It is consistent with community-based approaches to adaptation; can effectively build on local knowledge and needs; and can provide particular consideration to the most vulnerable groups of people, including women, and to the most vulnerable ecosystems. Improved ecosystem management practices need to be developed and promoted to strengthen adaptation to climate change impacts (figure 5). As examples, at the local specific level, these include appropriate agricultural and water management practices, breeding techniques for introduction of

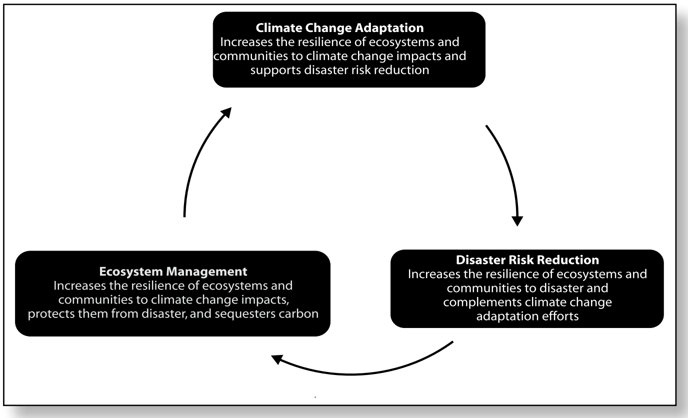

Figure 5: Linking climate change adaptation, ecosystem management and disaster risk reduction (Source: UNEP 2009)

drought-tolerant, salt-tolerant, and standing-water tolerant crops and tree species; improved livestock management and fodder management practices. At the systems level, this might include alternative cropping or land-use model, strengthening the extension system, or supporting more effective decentralized planning processes for watershed management that can enhance more locally specific adaptive processes. A more systematic approach of integrated natural resource management for cyclone risk management is shown in figure 6.

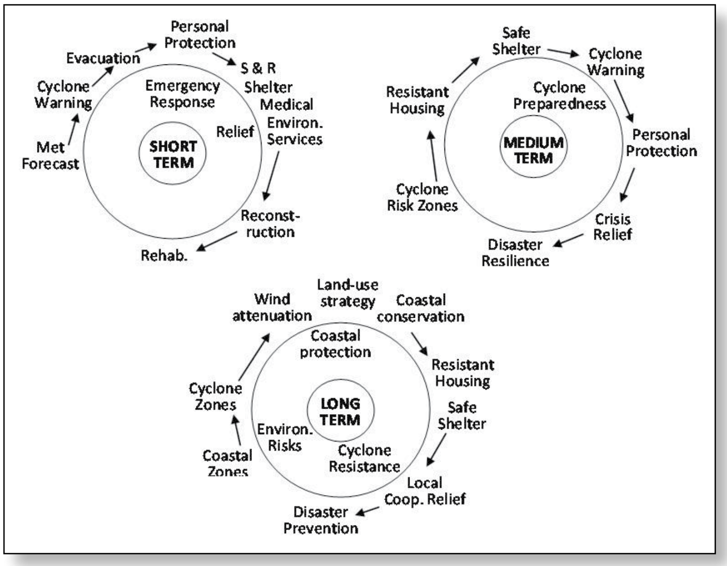

Figure 6: Coastal management framework for short-term and long-term mitigation for cyclone disaster

EIA as a decision making tool helps in identifying viable and sustainable option for structural or non-structural measure of disaster mitigation, whereas post-disaster EIA forms a part of damage, loss and needs assessment that enables planning for reconstruction and recovery. Although most EIAs implicitly have focus on natural disaster risk in the project site context and include a Disaster Management as part of EMP, the information contained therein the state of environment section and predictions under the section on environmental impacts can be used for carrying out detailed risk assessment and disaster management planning as well. However, there is a need to carry out a systematic analysis of these policies and laws for applying these legal provisions for various activities under disaster management. Role of environmental knowledge in disaster risk management is depicted in figure 7.

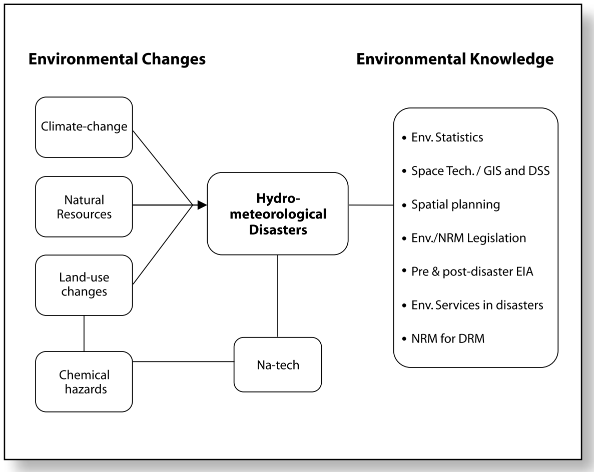

Figure 7. Central concept of environmental knowledge for disaster risk management (ekDRM)

Legal and Institutional Framework

Disaster management has primarily been a concern for emergency response and a post-disaster focused approach until the realization of paradigm shift from 'response and relief' to 'prevention and preparedness'. The climate-change awareness globally has brought-in a greater understanding on role of global, regional and local environmental aspects in disaster management (risk assessments, mitigation, early warning and effective response). In many countries, the framework of disaster management has been functional in total separation from the systems that deal with environmental protection and natural resources management. However, at international level the guiding documents like Agenda-21, Hyogo Framework of Action, Millennium Ecosystem Assessment, IPCC 4th Assessment Report, Ramasar Convention, Convention on Desertification, and many other strategic documents have recently emphasized environmental aspects of disaster management and vice versa with intense focus.

At national levels as well, for example in India, the disaster management act and policy has defined '*substantial damage to….environment*' as a disaster, and has focused on environmental compatibility and sustainable development as strategic issue in disaster management cycle. On the other hand, policies and legal framework on environment – water, forests, agriculture, land-use, atmosphere and climate-change, waste management, besides constitutional provisions on environment, have provided options for reducing hazards and vulnerability in context of disasters. For example, the National strategy on climate-change actions and missions thereof, policy statement on conservation of natural resources, coastal zone regulation, area specific notifications like one on Doon valley, are of key importance in disaster risk management.

In India the National Disaster Management Authority is the apex national organization for developing guidelines and plans on various aspects of disaster management, whereas Ministry of Environment & Forests is nodal agency for environmental protection including dealing with issues of climate-change, forest and habitat conservation, environmental quality, EIA, coastal zone, river conservation, Himalayan ecosystem, etc. Various aspects of land-use and natural resources are dealt by different Ministries/Departments like Rural Development (Deptt of Land Resources), Water Resources, Agriculture, Earth Sciences, Science & Technology, Biodiversity Board, etc. National Institute of Disaster Management has also set-up a specialized 'Environment, Climate-change and Disasters Cell' for interdisciplinary activities under Hydro-meteorological disasters division of the institute. Similarly Indian Institute of Public Administration has institutionalized a Centre for Environment, Climate-change and Drought Management for focused activities of research and capacity building.

Since the environmental degradations resulting into disaster risk are either slow onset process or have wider geographic extents, local administrators and planner's understanding usually not sound enough to analyze cause-consequence relationship may result in inappropriate strategies for disaster mitigation and response. However, many good case examples of utilizing environmental knowledge and management into disaster risk management and also disaster risk reduction's significance in sustainable environment are available particularly in context of hydro-meteorological disasters in mountain and coastal areas and also in context of urban flooding, epidemics and agro-ecosystems.

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Disasters and the Environment: A Review of Opportunities

Charles Kelly and N.M. Prusty

Introduction

The intersection of the environment and disasters has been gaining increasing salience in recent years. The United Nations Environment Program (UNEP) has a unit devoted to disaster issues[3] and cooperates with the UN Office for the Coordination of Humanitarian Assistance (OCHA) on a joint environmental emergencies response unit.[3] The American Red Cross and World Wildlife Fund (WWF) US have recently cooperated on developing guidance on environmental sound recovery[3]. A number of other organizations focus on the nexus of the environment and disasters, for instance ProAct Network[3] and Groupe URD,[3] among others.

Efforts by these organizations and others have led to the creation of a number of guides and tools to assess the impact of disasters on the environment, the environment on the environment and relief and recover on the environment. UNEP's Disasters and Conflict Program has assembled a wide range of these guides and tools on disasters and the environment into a single web-based point of access[8].

It is also increasingly common for environmental issues to be given some level of attention following disasters. For instance, both UNEP[3] and the US Agency for International Development (Kelly and Solberg, 2011) conducted rapid disaster impact assessments following the 2010 Haiti earthquake. The Ministry of Environment, WWF Chile / WWF Internacional and Antofagasta Minerals conducted a rapid assessment following the 2010 Chile earthquake and tsunami (Ministry of Environment, 2010).

Environment Advisors were assigned to the Shelter Cluster[10] in Haiti following the 2010 earthquake and the 2009 earthquake in Sumatra, Indonesia. UNEP has been active in post conflict and post disasters assessments, including Haiti, Sudan and the Democratic Republic of the Congo, as well as in on-going conflict in Darfur. Both ProAct Network and Groupe URD have been active in developing reports on environment and disaster related issues, or per-

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forming field work on specific environment-disaster issues (e.g., improved energy supplies in Darfur[10]).

Yet, with all this action to date, recognition of the importance of the environment in the post disaster (relief and recovery) context still does not ahve a high salience in relief or recovery policy making or operations.

- While rapid environmental impact assessments are done, the results rarely seem to be used.
- While an environment advisor may be assigned to one sector in one disaster response (e.g. Haiti), another of similar scale disaster will receive may limited and late support, at best (e.g., Pakistan).
- While relief and recover personnel may raise environment-related questions, finding answers to such questions is neither systematic nor linked to decision making structures. For instance, well documented lessons on the provision of fuel efficient stoves have been relearned in several recent disaster responses.
- While the value of environmental impacts reviews are well established for large scale expenditures such as one finds in disaster recovery, actual recovery plans often avoid such reviews for reasons of expediency, and later result in avoidable environmental damage and a waste of natural resources and recovery funding. For instance, the $11.6 billion recovery plan for the Haiti earthquake[1] received no formal environmental review. As a result, there was no overall idea of the scale of natural resources needed for the recovery or whether there were environmentally more positive options to the plans proposed.

It may seem that the integration of the environment into disaster relief and recovery is a glass half empty: despite considerable effort to bring the environment into the disaster recovery process, real progress and impacts have been limited, with lessons not learned and mistakes repeated.

Rather, the remainder of this paper will take a glass half full approach and discuss opportunities for further integrating environmental issues into relief and recovery. The intent is to lay out a set of action points of sorts to identify where further progress can be made towards a fuller integration of environmental issues into the recovery from disaster.

Opportunities to Integrate the Environment into Disaster Recovery

A Preamble

The integration of the environment into disaster recovery is usually presented in terms of projects to improve environmental conditions, frequently involving tree planting. The following sections focus on managing the impact of recovery assistance on the environment rather than on using recovery funds to impact specific segments (e.g., deforested hillsides) of the environment. While environmental improvement efforts have considerable merit, they can't be pursued in ignorance of the environmental impacts of excessive resource use for housing construction or the siting of this housing in areas liable to flooding, two common environment-links challenges follows disasters.

Force Results From Assessments

A range of post disaster environmental impact assessment tools exist, including:

- The Environmental Needs Assessment in Post-Disaster Situations: A Practical Guide for Implementation (UNEP, 2008),
- Fast Environmental Assessment Tool (Joint Environment Unit, 2009),
- Technical Manual for Post-Disaster Rapid Environmental Assessment (Ecoengineering Caribbean Limited, 2003), and
- Guidelines for Rapid Environmental Impact Assessment (Kelly, 2005).

However, as indicated above, when these tools are used they do not always have a clear and definable impact on recovery plans or process. This failure of impact assessments to have an impact can arise because the assessment results:

- Are not relevant to immediate relief and recovery requirements,
- Are not presented in a way which are understandable,
- Point out significant gaps in on-going operations (and thus are embarrassing enough to be ignored),
- Lack a champion within the upper levels of the recovery planning and management structure.

Of the four, the most challenging is the last, the lack of a champion for assessment results. Solving the other three issues still will not mean they will be acted on if there is no person or unit which can ensure the results will be used. This need for a champion is particularly acute where procedure or policy allows recovery planning and assistance to proceed without normal environmental reviews (often justified by a lack of time to conduct environmental reviews).

The person or unit to champion assessment results may not be evident from an organization chart. Investigation may be needed to identify who within the recovery structure is most amenable to considering environmental issues, and most capable to having the issues addressed. Why a champion may take up the environmental assessment results could lie in a pro-environmental perspective. But it is more likely the reason lies in an interest to avoid problems (and impact assessments normally identify problems), particularly when environment-linked problems have been encountered in the past. Even when a champion is found, interest may only be in one or two issues, which necessitates accepting that one entry point is better than none.

Where a champion can't be located it may become necessary to more directly force the assessment results on the recovery process. The most traditional approach to doing this is to engage with local environmental organizations and have them use their capacity for advocacy to promote the assessment results. An alternative, but somewhat more risky, approach is for those involved in the assessment to directly advocate for the assessment results, through the print and electronic media, including blogs and similar communication tools.

The risk, of course, that the recovery institution will simply ignore or pay lip service this type of forcing of the assessment results. At the same time, post disaster environmental impact assessment results which are not acted on are useless so some process for forcing assessment results may need to be pursued if the assessment process is not an exercise in futility.

Any Entry Point is Better than no entry Point at all

As suggested above, one entry point is better than none. This may mean that only a few of the issues identified in an assessment can be effectively pursued within the recovery structure. When faced with limited entry points it would be idea to select those which match the prioritization of recovery programming, for instance, putting environmentally sound waste management over reforesting hillsides.

However, the reality is that entry points, and particularly those created by champions with specific interests, may be of very limited scope and allow for addressing only one or two low priority issues. At the same time, successfully addressing environmental issues at one entry point may lead to greater involvement in other environmental issues across the recovery effort.

Another entry point issue arises as to when environmental issues are to be assessed and considered. In theory, initial assessments should begin as soon as immediate lifesaving needs are being met, and assessment results should be available to decision makers as soon as plans are being developed for the recovery process. In most cases, given that the environment is not seen as a post-disaster priority, the assessment process can begin weeks or even months after the disaster.

In this context a *rapid* assessment of environmental issues may not mean rapidly after a disaster but done rapidly due to limited funding or time. Even if an environmental impact assessment is done months into the recovery period the results can provide guidance on how to redirect on-going assistance or re-direct assistance to address unmet needs.

In the same way, if environment-focused assistance, such as training in environmentally sustainable recovery or assistance on specific issues such as waste and debris management begins several months after a disaster then these interventions should be used to establish and expand the scope of environment-focused recovery efforts. In the end, a late entry point is better than no entry point at all.

Pick the best possible fruit

As suggested above, it may not be possible for all the issues defined in a post disaster assessment to be address immediately, or over the course of the recovery process at all. As a result, it is necessary to prioritize assessment identified actions by considering (a) what is of greatest need to be done and (b) what will have the greatest impact when it is done.

This trade-off process is not one which can be set in stone and should include consultations with the disaster survivors (a core part of any post disaster impact assessment). The process of deciding which assessment results to push forward on, and how to do the pushing, needs to strive not for the perfect fruit, or the lowest hanging fruit, but the best possible fruit which reflects the needs identified by the assessment, the disaster survivors and the resources and institutional support available.

Demonstrate value

Whether one or more champions have been identified or not, post disaster environmental impact assessments and environment-related technical support need to demonstrate that they can add clear value to relief and recovery operations. The perception is often that environmental issues are not urgent in the post-disaster period and can be addressed later in the recovery effort, if at all.

This view often arises from the perception that post disaster environmental interventions are linked to longer term improvements to the environment, through actions such as tree planting or watershed management. Such interventions, while important in the long term, are often not seen as critical to relief and recovery.

To gain relevancy in relief and recovery efforts, environment-focused assessments and technical support need to focus on the immediate problems facing these efforts. Such environment-linked interventions include, among others,

- Debris management, including quickly removing and recycling debris,
- Standardized transitional or permanent shelter design to reduce environmentally damaging resource requirements, such as the use of fired bricks when alternatives are available.
- Liquid and solid waste management, particularly establishing waste management sys-

tems which improve hygiene and sanitation conditions and limit the spread of diseases,

- Advice on avoiding recovery assistance which will lead to an overexploitation of natural resources, for instance in the provision of boats and equipment which increase fishing capacities above those existing before a disaster, and
- Natural hazard assessments to ensure that temporary or permanent settlements are not located in unacceptably hazardous locations.

This list is not exhaustive. The challenge for environment-focused personnel in the relief or recovery phases is to find ways in which calling attention to environmental issues also generates solutions which can solve problems or make relief and recovery efforts more effective. In other words, assessment and technical support should not just raise environmental problems, but also provide practical solutions which demonstrate the value of integrating an environmental perspective into relief and recovery.

Change from the field up

The idea of environmental champion discussed above implies this role is filled by persons or units higher up in the relief and recovery establishment. In fact, significant pro-environmental action can also be initiated at the field level, and particularly through a mid-level management which is aware of environment-base opportunities.

For instance, a field manager running camp for relocated disaster survivors can have a considerable influence over waste management, sanitation and general living conditions in the camp. In a similar fashion, the manager of WASH activities for a group of communities can have a significant influence on how latrines are constructed, the supply and use of water or whether waste is dumped in a swamp or composted.

It is necessary to reach out to field personnel and provide them with the tools and knowledge needed to implement relief and recovery projects in environmentally wise ways. Such an effort is incorporated into the Global Shelter Cluster's assignment of an environmental advisor to some country-level Clusters. A broader approach to support the capacities of field personnel is incorporated onto the World Wildlife Fund and American Red Cross **Green Recovery and Reconstruction Training Toolkit for Humanitarian Aid** and associated training (World Wildlife Fund and the American Red Cross, 2010). Other support is available on such issues as stoves, transitional shelter and refugees, with additional field guidance expected in the near future.

The real challenge is to ensuring this wealth of information on environmentally sound relief and recovery reaches the field staff who need specific information. Making the information available on the web (as it currently the case) is important. But, given the work load pressure which many field personnel face it is unlikely that most will have to time or background to effectively search for and digest information on environmentally sound relief and recovery.

As a result, it is likely to be more effective to have an out-reach capacity in the field, through the use of environmental advisors. These advisors do not necessarily need to be experts in relief and recovery (although this will not hurt) but would need to focus on

- Defining what critical environment-related issues are being faced in the field and
- Package information available on addressing these issues in a way which can be used by field personnel in a quick and easy manner.

As noted, posting environmental advisors has been done by the Global Shelter Cluster. This effort needs to expand to additional sectors as well as become a standard part of relief and recovery operations rather than being an occasional event.

Knowledge as power, and a foot in the door

The process of furnishing environment-focused information as describe above provides the environmental community a degree of power to influence the way in which relief and recovery aid is provided and the impacts which can be expected. Further, many post disaster reconstruction challenges relate to location within the environment (e.g., where to locate disaster displaced, where to rebuild roads, etc.). An environmental, and more specifically, an ecosystem services approach to assessing recovery options and impacts can be of considerably utility in the reconstruction process in defining how best to site and provide recovery assistance.

Here again, the focus is not (only) on defining what the environmental issues with reconstruction or recovery efforts are in general, but defining how these process can be sustained by wise use of the environment and how potential problems can be solved in a similar manner. Given the common misperception noted that a focus on the environment is limited to longer term improvement of natural conditions, knowledge about the environment needs to be used to improve the overall recovery process and specifically focus on improvements to specific recovery activities. Providing one package of knowledge which improves one element of the recovery effort also provides a foot in the door for greater access to improve the overall environmental sustainability of recovery efforts.

Conclusions

This paper argues that progress in integrating an environmental perspective into disaster relief and recovery has been uneven but also somewhat successful. The paper suggests that many of the tools and guidance needed for a better integration of environmental perspective into relief and recovery are already available. Under these circumstances, moving the integration process forward requires efforts in six areas:

- Effectively using assessment results,
- Finding entry points into the relief and recovery process,
- Focusing on the best possible match of reducing negative environmental impacts and recovery programming,
- Demonstrating the clear value of an environmental perspective on recovery,
- Ensuring field personnel know about how to effectively integrate an environmental perspective into their work, and
- Using knowledge about the environment to influence and shape the recovery agenda,

The prospect is for environmental considerations, and an awareness of environmental issues, to be increasingly accepted as an integral part of relief and recovery. However, this process can occur though demonstrated failures of relief and recovery due to a failure to consider environmental impacts and options. Or this process can occur though a more proactive integration and problem avoidance, as suggested above. The argument for this latter course is that it will lead to better relief and recovery, and less suffering and hardship for the disaster survivors. And anything which will reduce the suffering of disaster survivors should be pursued with vigor.

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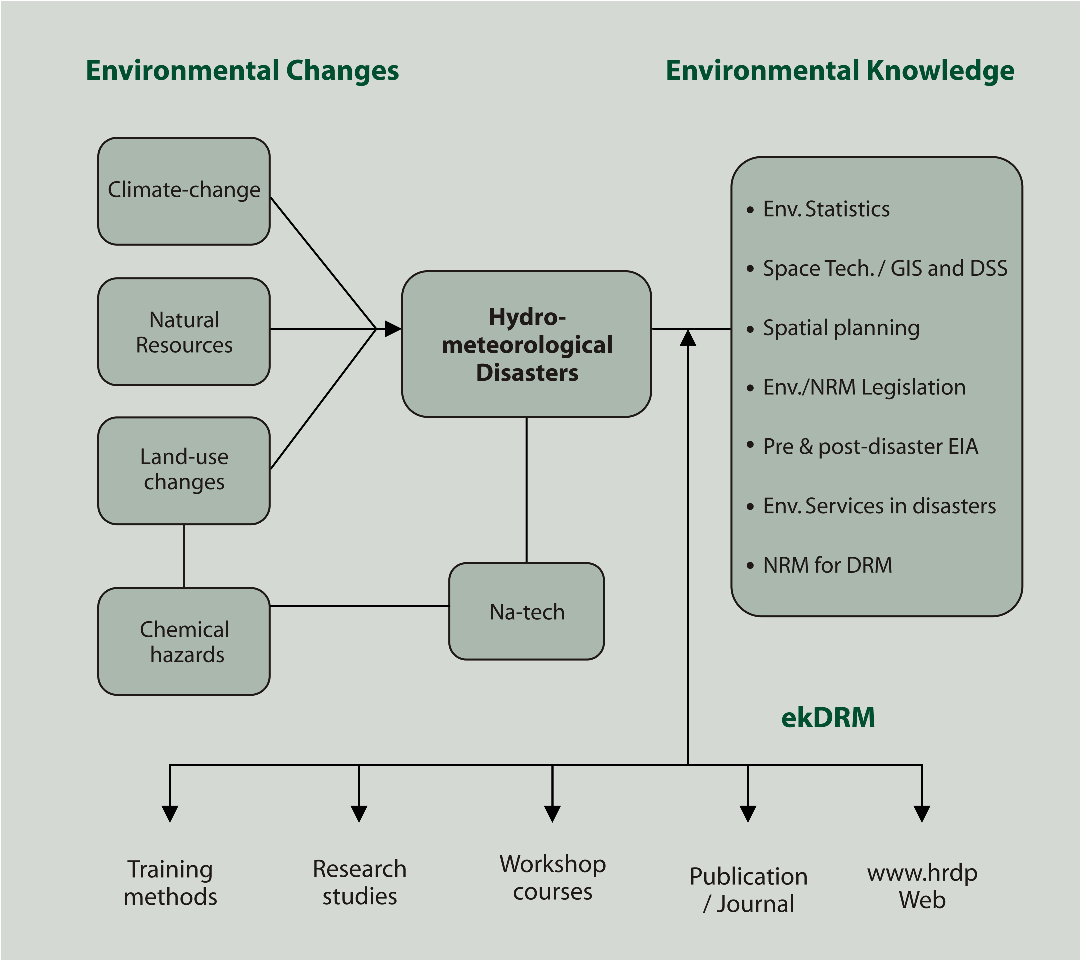

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