Volume 1 ■ Number 1 ■ November 2008

SAARC

Journal of South Asian Disaster Studies

SAARC Disaster Management Centre, New Delhi

512

Journal of South Asian Disaster Studies

Journal of the SAARC Disaster Management Centre

Volume 1 ● Number 1 ● November 2008

512

ISSN: 0974 – 6463

Journal of South Asian Disaster Studies Journal is published two times a year and is distributed by

KW Publishers Pvt Ltd.
4676/21,First Floor, Ansari Road, Daryaganj, New Delhi 110002
email: knowledgeworld@vsnl.net / online.kw@gmail.com
www.kwpublishers.com

Typeset by Black Innovation, New Delhi

Printed and Published by P.G. Dhar Chakrabarti behalf of National Institute of SAARC Disaster Management Centre, New Delhi and Printed by Glorious Printers, A-13, Jhil Mil, Delhi 110 095 and Published at SAARC Disaster Management Centre, New Delhi, IIPA Campus, I.P. Estate, Mahatma Gandhi Marg, New Delhi 110 002.
Editor: P.G. Dhar Chakrabarti

Contents

Editor's Note

Nature has bestowed many bounties on South Asia. The majestic Himalayas shielded a large part of it from the harsh climate of the north and nestled the glaciers that supported rivers and sustained agriculture and civilization for centuries. The Indian Ocean and its twin basins of Bay of Bengal and the Arabian Sea opened a large coastline to trade and culture from the West and the East. The nature, the natural resources and the civilization of South Asia attracted travelers and traders from around the world, making it a melting pot of civilizations.

Yet sometimes the quiet grandeur of nature has taken the shape of violent furies, whirling through the surface and the air, taking an enormous toll of life and property, causing immeasurable suffering to people. The tectonic faults that underlie the mountains have generated mega earthquakes at many places resulting in large-scale devastation. The melting glaciers have created lakes on the mountains, many of them on the verge of outburst, causing flash floods in the hills and floods in the plains. In the long run the danger of many perennial rivers becoming seasonal streams is looming large, which would threaten the livelihood and food security of millions of people. The furies of cyclones and storm surges have threatened the lives and livelihood of millions at regular intervals.

All these hazards of nature have been compounded by the layers of vulnerabilities, created by poverty, illiteracy, malnutrition, unsafe building practices, to name a few, and created recipes for disasters. Some of the worst disasters of the world in the recent decades have taken place in South Asia and if the expert projections are to be believed, many more are in the waiting. Impacts of climate change and rapid urbanization in South Asia would further complicate the scenario in the coming months and years.

The countries of South Asia have to work together to deal with this complex matrix of hazards, risks and vulnerabilities. The issues have to be tackled at various levels – political, scientific, social, economic and humanitarian, and in different layers – regional, national, provincial and local. It is with the object of enhancing cooperation at the regional level that the SAARC Disaster Management Centre was set up in 2007. Within a short period, the Centre has been able to create a niche for itself and network with a large number of institutions, organizations and individuals working on different aspects and areas of disaster management at various levels. The upcoming portal of South Asia Disaster Knowledge Network would be testimony to the benefits that can follow the sharing of knowledge across the political boundaries of the countries.

The South Asia Journal of Disaster Management would be yet another milestone for sharing knowledge and experiences among the researchers and practioners from across the countries of this region. As the Director of the SAARC Disaster Management Centre and the Editor of the Journal, I have the pleasure to dedicate this journal to 1.4 billion people of South Asia, representing one-fourth of the humanity, who bear the legacies of one of the most ancient civilizations of the world and who are surging forward to create another century that would be theirs.

P.G. Dhar Chakrabarti

Notes on Contributors

- **Dr. A.S. Arya** is Professor Emeritus, Indian Institute of Technology and National Seismic Advisor to Govt. of India.
- **Mr. Anil Kumar Sinha,** IAS (Retd.), is Founder Co-Chairman of Global Forum for Disaster Reduction; was Executive Director, National Institute of Disaster Management and Senior Advisor to International Recovery Platform (IRP), United Nations Development Programme (UNDP), Kobe.
- **Mr. C.S. Murthy** is a scientist at National Remote Sensing Centre, ISRO, Hyderabad.
- Lt. Gen. (Retd.) **Farooq Ahmed Khan** is Chairman of the National Disaster Management Authority of Pakistan.
- **Mr. Fuad H. Mallick** is Professor and Director of the Post Graduate Programmes in Disaster Management at BRAC University, Dhaka.
- **Mr. Manu Gupta** is Programme Director at Sustainable Environment and Ecological Development Society (SEEDS), India.
- **Mr. Md. Rezaul Islam** is Assistant Engineer with the Local Government Engineering Department, Bangladesh working in the field of seismic microzonation.
- **Dr. Mehedi Ahmed Ansary** is a professor at Bangladesh University of Engineering and Technology and Secretary-General of the Bangladesh Earthquake Society.
- **Mr. Mohammad Aminur Rahman** is a research associate at BRAC University, Dhaka.
- **Mr. N.K. Srivastava** is Emergency-on-Call Officer (ECO) Major Disasters and Manager at ISTRAC, Bangalore.
- **Dr. Sanjay K. Srivastava** is presently Head, Hydro-met Disaster Division, SAARC Disaster Management Centre (SDMC), New Delhi.
- **Mr. P. Soma**, ISRO, is Member, Charter Executive Secretariat and Deputy Director, Navigation Systems Area, ISTRAC/ISRO, Bangalore.
- **Mr. O. Chiranjeevi** is Deputy Director, MSSA, ISTRAC, ISRO, Bangalore.
- **Dr V.S. Hegde** is Charter Board Member; Director, Earth Observations System (EOS); and Programme Director, Disaster Management Support (DMS), ISRO HQ, Bangalore, India.
- **Mr. S.K. Shivakumar** is Director, ISTRAC, ISRO, Bangalore, India.

- **Dr. Darshana R. Dave** is Faculty Member, M.B.A. Programme, G.H. Patel P.G. Institute of Business Management, Sardar Patel University, Vallabh Vidyanagar, Anand, Gujrat, India.
- **Dr. P.S. Roy** is Deputy Director, National Remote Sensing Centre, ISRO, Hyderabad.
- **Dr. Rajeev Shaw** is Associate Professor at Graduate School of Global Environment Studies, Kyoto University, Japan.
- **Dr. S. Sarkar** is a scientist at Central Building and Research Institute working in the area of landslide hazard zonation and mitigation.
- **Dr. Shailesh Nayak** was Director, Indian National Centre for Ocean Information Services (INCOIS), which developed the Tsunami Warning System for India. Presently he is Secretary, Ministry of Earth Sciences, Govt. of India.
- **Mr. Srinivas Kumar** is Programme Manager, National Tsunami and Strom Surge Warning Centre at INCOIS, Hyderabad.
- **Mr. T. Kiran Chand** is a scientist at the National Remote Sensing Centre, ISRO, Hyderabad.
- **Mr. V. Bhanumurthy,** an expert on Earth Observation applications in flood hazard analysis, works as a scientist at the National Remote Sensing Centre, ISRO, Hyderabad.
- **Dr. Kaoru Takara** is a professor at the Disaster Prevention Research Institute (DPRI), Kyoto University, Japan.
- **Ms. Mandira Singh Shrestha** is working as Water Resources Specialist at International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.

Managing The Earthquake of 2005

Lt. Gen (retd) Farooq Ahmed Khan

Abstract

On 8 October 2005, Pakistan was struck by the most devastating earthquake in its history, affecting an area of 30,000 sq km, causing over 73,000 deaths and massive destruction to public infrastructure. The scale of devastation warranted an organized swift response, while existing infrastructure was either very poor or totally destroyed. In the given situation, the Federal Relief Commission, entrusted with a comprehensive mandate to manage the entire spectrum of relief effort, conceived and implemented an elaborate National Action Plan for coherent response in coordination with Government Departments, Foreign governments, international agencies, INGOs, NGOs and civil society. The relief and rescue efforts and subsequent reconstruction and Rehabilitation programmes in the earthquake-affected areas, not only set the contours for future disaster management policies and strategies in Pakistan but also defined universal benchmarks for similar efforts in the event of future disasters.

Introduction

Disaster management is an extremely difficult undertaking, each disaster posesing its own problems and challenges there can be no set blueprint or plan to deal with every disaster — the approach and strategy to dealing with each is only really decided as it happens. Survival is not just a product of luck; there are best practices, effective strategies, good techniques and things to avoid which emerge from the experience of disaster management, and which provide a very useful — indeed crucial — base of knowledge from which to tackle each new disaster. This paper highlights the main lessons, best practices and strategies, as well as mistakes or weaknesses, which emerged from Pakistan's experience of handling the earthquake in 2005.

The 8 October 2005 earthquake, measuring 7.6 on the Richter scale, struck at 8.52 a.m.

The epicentre of the quake was situated 90km north-north-east of Islamabad, in Azad Jammu and Kashmir (AJ&K). Covering a total area of some 30,000 sq km, five districts of Azad Kashmir viz., Muzaffarabad, Bagh, Poonch, Rawalakot and Neelam, and five of NWFP, viz. Mansehra, Battagram, Kohistan, Abbottabad and Shangla were the most badly affected, with damage on a massive scale. It took a while for the full extent of the disaster to become clear: the final death toll was well over 73,000 and almost double that number of people were seriously injured. In terms of physical damage, almost 600,000 homes were destroyed — rendering 3.5 million people homeless — along with 6,000 schools and colleges, and 574 health facilities (over 73% of the total). It should be stressed that the 2005 earthquake disaster was not a one-off event. There were hundreds of after-shocks and tremors, some reaching as high as 6.0 on the Richter scale, and there was the danger of a further disaster posed by the looming harsh northern winter. Both these factors added to the urgency of rescue, relief and recovery operations and the difficulty of the task faced.

Overall Approach and Strategy

Establishment of the Federal Relief Commission. When the 2005 earthquake struck Pakistan, the country did not have a central disaster management body. As it soon became apparent that Pakistan had been hit by a massive natural disaster, which would require coordinated efforts by Government, civil society and the international community, one of the first steps the Government took was to create an agency to manage this. The Federal Relief Commission (FRC) was formed on 10 October 2005, with Lt. Gen. (Retd.) Farooq Ahmad Khan appointed as the first Federal Relief Commissioner. The mandate assigned to the FRC was straightforward: to manage and coordinate the entire relief effort. The FRC's organizational structure reflected its coordination role. It comprised a civil and a military wing, each headed by a Chief Coordinator. The civilian wing was further sub-divided into ministerial and institutional wings, the former encompassing all the key ministries involved in the earthquake response, the latter the main institutions (e.g. National Logistics Cell, Emergency Relief Cell, Utility Stores Corporation, NCMC, NADRA, SCO).

The initial challenges facing the FRC were immense. Thousands of people had been killed: their bodies needed to be recovered and buried. Thousands more were seriously injured and in need of rescue and medical attention, but the local health services had been badly decimated. The survivors needed food, water, clothing and emergency shelter. This entire search, rescue and relief work had to be carried out over a vast and physically very difficult terrain: mountainous and hilly areas, hundreds of remote villages rendered more inaccessible by destroyed roads and infrastructure. It was also important to ensure effective coordination of the assistance being provided by the plethora of different domestic and foreign organizations, institutions and individuals in response to the disaster; to ensure that basic ethical principles were followed, and that disputes and clashes were kept to a minimum.

Priorities The FRC's focus in the immediate aftermath of the 2005 earthquake was primarily on rescue and relief. Later stages of recovery, reconstruction and rehabilitation were left to the Earthquake Reconstruction and Rehabilitation Authority (ERRA) which was formed in November 2005. Within rescue and relief, the FRC prioritized a number of areas:

1. Rescue of trapped survivors
2. Medical treatment of the injured
3. Provision of food and water to survivors
4. Provision of emergency shelter, clothing and bedding
5. Restoration of communications and access to remote areas
6. Damage control and maintenance of law and order
7. Support to local efforts and capacity building
8. These were immediate priorities, while in the medium- to long-term its goals were:
9. Management of displaced people
10. Restoration of civil administration
11. Restoration of basic amenities
12. Early recovery (including restoration of livelihoods)
13. Dealing with psychological trauma and stress

Formulation of a National Plan Within days of its formation, the FRC formulated a National Plan of Action which was then shared with all stakeholders, domestic and foreign. The FRC was also able to coordinate the employment of volunteers mobilized through the National Volunteer Movement. Of all the ministries and organizations involved in the initial rescue and relief effort, those who played a particularly critical role included: the Armed Forces of Pakistan, various ministries, Utility Stores Corporation, PTCL, SCO, WAPDA, NLC and the Cabinet Division's Emergency Relief Cell. The Ministry of Foreign Affairs (MoFA) was the focal liaison point for foreign governments, coordinating their contributions and dealing with the many diplomatic teams to visit the region. Meanwhile, the Emergency Relief Cell had the very important task of purchasing relief goods. Of the 'external' or non-Pakistani institutions involved, NATO and other foreign troops, friendly countries, the UN System and civil society stand out for playing an especially vital role. in greatly assisting relief and rescue operations, providing medical assistance and helping in debris removal and restoration of services.

Challenges

Rescue and Relief Operations. The immediate priority of the earthquake response was rescuing those trapped in rubble and ensuring medical treatment for the injured. At the same time, huge sections of the population of AJ&K and NWFP were left without food or basic supplies. The relief operation had to supply people in the affected areas with immediate provisions for survival. In addition, given that it would take considerable time for restoration of livelihoods and local businesses to come about, as well as for roads and other vital infrastructure to be restored, it was necessary to ensure continued supply of food and other provisions during the transition phase. Efforts were made to provide these to people where they were (in or near their places of origin) so as to prevent mass migration to other areas. In order to ensure effective supply of goods to the quake survivors, 'Operation Lifeline' was launched. Not surprisingly, it had to overcome numerous challenges.

Management of Casualties and Health Care Provision. Pre-quake health services were, to a large extent rendered non-functional by the disaster — over 70% of health facilities were destroyed/damaged, many local medical personnel were killed. Emergency medical care was thus an immediate priority of the earthquake response, followed closely by the restoration of basic health services. It was also one of the most challenging aspects of the immediate response.

Terrain Difficulties. The terrain, spread over 30,000 sq km, was difficult at the best of times, but made infinitely more so by the destruction of roads, bridges and other infrastructure due to the earthquake.

Huge Quantities of Goods. The affected population numbered 3.5 million, meaning that huge quantities of goods were required.

Looming Winter. The looming winter, which would cut off some routes and bring severe cold, added to the urgency of the relief operation.

Absence of Local Human Resources. Normally provincial and local government personnel and resources would play a lead role in such operations, but following the earthquake there were practically no local human resources available in AJ&K and even in affected districts of NWFP.

Cargo and Goods. Huge amounts of cargo and goods were being sent in from around the country and abroad, but the country's airports and sea ports were not set up to handle such large air traffic, goods and so on.

Channelization of Philanthropists, Diaspora, NGOs/ IOs and International Community

There was an out pouring of sympathy for the affectees by the galvanised never witnessed earlier by the nation, large diaspora from Kashmir and Pakistan was keen to contribute their bit and huge number of NGOs, both local and foreign, international organizations and eighty-eight friendly countries were eventually involved in this massive relief. All these stakeholders were to be catered for, their effort coordinated to produce a synergetic effect and each one listened to and guided. This was a very serious challenge as most of the stakeholders had different past experiences, different character and expectation. To keep all of them on board you had to be available to them and have a forum to resolve issues so that strategic direction and national priorities were kept in focus by all. The UN, IOs and NGOs operated feverishly in close cooperation with the Pakistan Army and other governmental departments even in the remotest affected areas and very effectively sprinkled relief across. They pursued their mandate and operational framework while seeking an independente and interference-free atmosphere for relief and early recovery of the affectees. We respected their operational framework, created a conducive environment from the port of entry to the remotest affected area. The via media devised, brought them in league and close cooperation with all the governmental agencies, especially the Pakistan Army. It's is an example of unique environment and cooperation.

Coordination. With so many different agencies and organizations involved, huge quantities of different kinds of relief goods, supplies coming in from different sources, which was meant to be transported and distributed in the affected areas, coordination of the whole operation and integration of relief efforts was extremely challenging.

Response

There were various issues with transport of goods: finding the required number of vehicles, ensuring security of relief convoys (this was an issue in the early phase of the relief operation), bringing in the huge quantity of goods donated by the Pakistani public and restoration of essential services, communications infrastructure and civil administration through a graduated approach. With such a vast affected area and a huge number of people in need of relief, it was prudent for the FRC to involve all stakeholders to take part in the relief operation and share the load. The key agencies involved were assigned responsibility for specific areas of AJ&K and NWFP, ensuring that the areas given to a particular agency were geographically contiguous.

Rescue Operations. Rescue operations were particularly difficult because of the lack of professional expertise and specialized machinery. Debri removal, searching for and rescuing the trapped and injured was carried out by local people supported to limited extent by Pakistani and foreign soldiers, specialist teams and so on. Equally problematic was evacuation of the injured, given that the road network had been so badly damaged. Despite these problems, the rescue operations tried to ensure that the search for trapped/injured survivors was followed by rapid rescue and evacuation, and also that expert medical services were made available as soon as feasible in the circumstances. In total, more than 129,000 injured people were evacuated from the affected areas, either to hospitals in other parts of the country or to field hospitals. Of the total injured moved out, 17,000 were evacuated by helicopter. Alongside these airborne evacuations, vigorous efforts were made to restore the road system and enable evacuations to take place by road. Thanks to the efforts of Army Engineers and others the three main arteries for road traffic to the affected areas were opened for light traffic within 24–36 hours and for heavy traffic within 72 hours.

Relief Operations

Procurement of Goods. With regard to purchase and procurement of relief goods, a President's Relief Fund was established soon after the earthquake to provide a central target point for donations and resource mobilization efforts. All financial transactions and procurement were handled by the Emergency Relief Cell of the Cabinet Division, on the direction of the FRC which was responsible for identifying what goods were needed and in what quantities, arranging transport for supply of these, and ensuring their judicious distribution. The ERC took the lead in procuring additional items needed for the relief effort. It helped build up the seven days' reserve rations in forward areas stipulated in the relief supplies' policy. Thousands of tons of relief goods were provided by the people of Pakistan. Local and national NGOs, individuals, schools and colleges and many others sent supplies to help the quake survivors. Also notable was the contribution of the Utility Stores Corporation (USC) of Pakistan. The USC opened 33 containerized outlets in the affected areas and distributed over 15,000 tonnes of rations. Its contribution included supply of 73,610 bags of composite rations packs between 9 October and 14 November 2005, provision and transport of 7 days' reserve stocks for 1.5 million people (10,354 tonnes), distribution of 1,500 tonnes of rations to people short of food, and provision of CGI sheets to people in the affected areas at subsidized rates. The international community also responded generously. A total of 68 countries sent supplies to help the quake affecters. Lists of notable contributions are in Annexure A. The ICRC carried out its own needs assessment and launched its independent, self-contained relief operation. It chartered helicopters which flew 8,000 sorties and distributed 12,791 tonnes of food and 1,275 tonnes of non-food items.

Receipt and Handling of Relief Goods. All relief assistance, foreign and domestic, coming by sea, road and air, was received at a number of major bases – Islamabad, Karachi, Lahore, Peshawar and Quetta – from where it was dispatched to six forward bases in the affected areas, in accordance with their respective requirements. Chaklala-Islamabad was the main hub for receipt of goods from across Pakistan and abroad, and for onward distribution to the affected areas. as many as 983 relief flights landed at the Airbase, with a further 644 relief flights received at other civil airports: Karachi, Lahore and Peshawar. Goods from different parts of the country were transported using private civilian (hired and voluntary) vehicles, as well as NLC containers. 400 of the latter were used to move goods from Karachi to Rawalpindi. An Army Logistics Control Headquarters was set up in Chaklala by the Logistics Directorate to support the relief operation. It had two infantry battalions and one air Dispatch Company. It was primarily responsible for the receipt of relief goods from Islamabad International airport and Chaklala Airbase. Forward bases were established at Muzaffarabad, Bagh and Rawalakot in AJ&K, and Mansehra, Batagram and Balakot in NWFP. Transport was undertaken using truck convoys and heavy-lift helicopters. The ERC had additional roles as well. It made use of its own storage space and arranged extra warehouses for the FRC to stock commodities. With regard to transport, the ERC requisitioned a large number of trucks for transport of relief goods.

Transport to Affected Areas and Distribution. The transport of relief goods to the affected areas began as soon as they arrived. On 9 October aircraft began dropping supplies into the quake zone, the start of what was to become the largest air operation in the history of relief operations. Simultaneously movement of goods by land began, in which over 50,000 troops participated. Army Engineers, SCO and Signal Corps resources were mobilized to restore communications in the affected areas and reopen the main supply routes. Because of the massive destruction to road infrastructure wrought by the quake, initially the main means of getting goods to stricken populations in AJ&K and NWFP was by air. Based on guidelines from the FRC, a number of parameters were devised for the provision of aviation support. The main ones were that the primary transport route for relief goods would be by road; aviation support would be used to target inaccessible areas, to carry out emergency medical evacuations and meet other emergency needs. In terms of specific tasks and responsibilities, aviation support was used for: damage assessment, transport of rescue and medical personnel (as well as medical equipment and engineering plants) to affected areas, evacuation of injured and supply of relief goods. Helicopters and C-130s were extensively used. 129 helicopters (73 international, 56 domestic) conducted about 33,300 sorties; lifted some 6,000 tonnes of relief goods/rations to the forward areas and evacuated 17,150 causalities. The Air Force carried out 491 sorties for transportation of goods from Karachi to Islamabad, and to drop them into the affected areas. summary of relief assistance after the Earthquake is given in Annexure B. The Air Liaison Cell of the FRC also arranged 51 visits by civil and military dignitaries to the affected areas. Helicopters played a major role in the immediate earthquake response, helping evacuate survivors and carry relief goods. Mules and even human porters were used to ensure supply of relief goods to otherwise inaccessible areas. From the main bases relief goods were sent to distribution points by air/road. From distribution points they were sent to distribution nodes established by the army units, using all transport means including animals. From the nodes either the survivors collected relief goods themselves or army soldiers man-packed the items and took them to inaccessible areas. A major criterion applied in deciding the distribution of relief goods and services was height above sea-level: those areas more than 5,000 ft above sea-level were prioritized followed by those between 4,000 and 5,000 ft and then by those at low risk (under 4,000 ft). However, a detailed ground survey was also carried out to precisely assess damage. Needs were determined and relief goods provided according to set time-lines. Local people were co-opted into this initiative, through the formation of village committees. Records were maintained at village, UC and district level.

Scale of Relief Operation. The overall scale of the relief operation was massive – certainly the largest of its kind ever conducted in Pakistan. A baseline figure of 3.5 million affectees was agreed upon for relief planning and operations started to supply this number of people with the necessary goods. Also, initially it was thought that AJ&K had been hardest hit and there was greater need there than in NWFP, so the distribution of relief goods between the two provinces was done on a 60:40 ratio. However, as damage assessments were carried out and accurate information came in from different locations, this ratio was adjusted to 50:50.

Coordination. A number of mechanisms were put in place to promote effective coordination of the massive relief effort. The FRC had a central coordination role, with responsibility for overseeing the overall provision and distribution of relief, monitoring and streamlining operations. The FRC established an information management system to promote coordination and effectiveness of relief operations. This comprised a website which hosted the latest situation updates, relief data, important decisions, directives and policy matters. In addition, regular media briefings were held on a daily basis to ensure continual provision of updated information. A 20-line call centre was established to facilitate access to information by the general public. Thousands at home and abroad wanted to know the whereabouts of loved ones, what kinds of relief goods they should donate, to whom, and so on. The call centre set up by volunteers was a help in addressing these queries but insufficient to deal with the huge demand. Hence the FRC published complete information about military units in the affected areas, including locations, names of commanding officers and telephone numbers. This enabled people to access information directly from those on the ground, and thereby eased the pressure on the call centre. FRC issued a National Action Plan for giving strategic direction to all stakeholders. It also created a 'Strategic Group Leaders' Forum' which met under the FRC once a week to coordinate activities. It included all major stakeholders including military, foreign contingent commanders, INGOs, UN and civil society representatives. It was replicated at the Army Divisional Headquarters for robust coordination at operational and tactical levels. The Army also played an important role in coordinating relief efforts. It had frequent and extensive interaction with all stakeholders involved in the earthquake response. The Army was also instrumental in creating an information database, and sharing this with all relief actors. Effective coordination of the supply operation was further ensured by having focal persons in all the key agencies — WFP officials, NWFP and AJK Governments Food Secretaries.

Security. With so many foreigners — INGO and foreign aid workers, foreign military and medical personnel - coming into the country and to the affected areas, ensuring their security was a major responsibility for the Government. This was made more so by the sensitivity, from a security perspective, of AJ&K and NWFP. Security was provided for these personnel, primarily by the Army and Rangers. The Army also played an important part in ensuring security for transport of relief goods through a number of measures: route protection, provision of mobile guards, securing camps and installations, regular sharing of information, and by co-opting the Pakistan Rangers and civil police to increase security coverage. The Motorway Police played an important role in regulating traffic flows to the affected areas from other parts of Pakistan. While some law and order issues were faced in the initial days, particularly with regard to desperate people stopping relief convoys, the overall security situation in the affected areas remained stable.

Emergency Medical Care Providers and Coordination of Efforts. Mass casualty management was the biggest concern of the FRC. A team of medical experts of the Army Medical Corps (AMC) and the Ministry of Health (MoH) as embedded in the FRC to undertake this daunting task under one strategic direction. It laid down policies, priorities, kept track of patients, and coordinated deployment of local and international medical assistance. The Pakistan Army was among the first to provide emergency medical care. All Combined Military Hospitals were immediately put on high alert to prepare to receive casualties. Cuba made a particularly big contribution to health care for the survivors, sending 2,575 medical personnel who set up 30 field hospitals and formed 15 medical teams. A total of 1.3 million out-patients attended the facilities, 7,768 were admitted, 12,406 operations were conducted and 100,000 patients given physiotherapy. To ensure continuity of care and protection to survivors being discharged from hospitals to convalescence centres or elsewhere, a health policy was formulated. UN health cluster World Health Organization (WHO) played important role too and coordinated with FRC medical evacuation services, international medical teams, supply of medicines, establishment of mobile clinics and field hospitals, and other assistance provided by donor agencies and the international community. Field hospitals were quickly established in the affected areas to enable the injured to be treated there, rather than evacuated to faraway hospitals. The Health Policy was designed to ensure that patients received all the care that they needed and that they were protected. The Policy called for: All hospitals maintaining complete records of all patients treated, Data (including fingerprints and digital photographs) on all patients were collected by NADRA, All patients fit for discharge were sent to convalescence centres with proper documentation, Hospitals ensured provision of continued care to them in the centres, - Patients fully recovered were sent to shelter homes, All patient data was submitted to the Ministry of Health, Army Surgeon General and the FRC. Fully recovered orphans, destitute women and the disabled, were handed over to the Ministry of Social Welfare.

Public Health Concerns. The threat of disease and epidemics breaking out was considerable, given the crowded unhygienic conditions in the tent villages, the lack of water and bathing facilities, the cold weather and the already vulnerable state of the quake survivors. Efforts were made to provide survivors with safe drinking water, and to promote personal hygiene and basic sanitation in the tent villages and camps. Regular inspections were carried out and advice provided on food safety, disposal of solid and liquid waste and so on; health education material was distributed to raise awareness about hygiene and disease prevention, but this issue remained a matter of concern. The Disease Early Warning System (DEWS) was used, which entailed regular surveillance for communicable diseases so as to detect incidents early and take action to control their spread. Immunization against infectious diseases including cholera, typhoid, measles and tetanus was carried out by Expanded Program of Immunization (EPI) teams of the MoH, WHO, UNICEF, AMC units and other stakeholders. Thousands of people were seriously injured in the October 2005 earthquake. Many had broken/fractured bones and some developed bone infections which required proper follow-up to prevent long-term disabilities. However, there were also many who had limbs amputated or were otherwise rendered disabled. Physical rehabilitation of these people was important to promoting their long-term recovery. As an interim measure, paraplegic patients were managed at three centres: Cantonment General Hospital in Rawalpindi, the National Institute of the Handicapped in Islamabad, and PIMS Satellite Hospital. Also, some philanthropist also established such care centres, the most famous being by the owner of Melody Cinema in Islamabad which exclusively looked after female patients. However, for long-term treatment a number of specialized centres were established in the affected areas: Teams of psychological experts and counsellors sent by the MoH, Medical Directorate GHQ and volunteer groups were actively engage in assessing and providing psycho-social support to the affected population. While trauma therapy was very crucial it was a weak area. However, the strong family bonds in affected societies, where relatives provided solace and comfort to traumatized survivors, was effective in such situations.

Revival and Restoration of Health Services. Revival of primary health care entailed the use of mobile service delivery, establishment of a robust disease surveillance system to minimize the chance of epidemics, and the use of alternative structures for primary care facilities, e.g. tents, prefab containers, temporary structures made of fibreglass or other low-cost material, and use of existing buildings once they had been assessed for safety. Facility-based services were quite wide-ranging covering general outpatient consultations, first aid provision, some physical rehabilitation or reconstructive procedures, reproductive health services, limited in-patient care, basic lab services, ORS distribution, TB treatment, health and hygiene education, psycho-social counselling as well as referrals. Two areas in which health service provision had been considerably eroded as a result of the quake were treatment of patients with chronic conditions and maternal and child health care. Chronically ill patients were initially left without their medications as the stress was on the severely injured. Thus there was non-availability of insulin, anti-hypertensive drugs and TB (DOTS) treatment. However, once the acute phase was over, priority was given to filling this gap and care of chronic patients restored. With regard to Reproductive Health and Maternal Child Health, as well as damaged facilities, the shortage of female medical staff remained a serious concern UNFPA, with contributions from the Aga Khan Foundation, arranged for mobile Reproductive Health Units at Ghari Habib Ullah and Shinkiari, which made the situation relatively comfortable. UNFPA was later able to establish Reproductive Health Units (made of prefab containers) at all important sites, and in some of these was able to provide high quality care. Community-based services largely revolved around Lady Health Visitors (LHVs) and Lady Health Workers (LHWs). These carried out home visits, imparted health and hygiene education, as well as vitamin supplementation and immunization. An issue that emerged was that, because many LHVs and LHWs were also among the affectees, their services were not available in the affected areas, — creating problems in attending to female patients. Outreach medical camps were set up to facilitate access to health services. Looking beyond the acute phase of the earthquake response, a number of NGOs and organizations made commitments to support the revival of health facilities. Pre-quake facilities that were under-utilized or had been established for political reasons were thus not chosen; multiple facilities serving essentially the same catchment area were merged into one, and so on. WHO agreed to provide a pre-fab structure comprising four rooms for each facility, as well as standard medicines and electro-medical and cold chain equipment. Staff would be drawn locally — largely LHVs, medical technicians, vaccinators and Class IV employees.

Displaced Persons. Handling of displaced persons was a major component of the earthquake response. Some 3.5 million people were rendered homeless by the earthquake – many of them also had to cope with loss of family members (parents, spouses and children), injuries and loss of livelihood. The Government's policy on displaced persons was designed to ensure people were kept in their own territory as far as possible; the vulnerable were protected (in particular women and children); and adequate arrangements were made to support the transition from emergency shelter to reconstruction of permanent homes. The FRC coordinated and maintained records for the establishment of camps, distribution of relief and medical assistance through medical units and local governments. The Ministry of Interior was asked to coordinate and control movement of refugees outside the affected areas.

Emergency Shelter and Camp Management. The Government followed the UN OCHA Guiding Principles on Internal Displacement in formulating its strategy for establishment and management of camps for displaced people. The Government set up a number of organizations specifically mandated to carry out camp management: the Regional Relief Commissioner's Office in NWFP and the Camp Management Organization in AJ&K. Capacity-building of these organizations was carried out by the Pakistan Army, NGOs, and the camp management cluster. This comprised both formal and on-the-job training on camp establishment, camp management criteria, equipment, supplies, etc. and provision of resources such as telecommunications equipment to enhance capacity for this. The camps themselves fell into three broad categories: planned, spontaneous, and scattered. The Army did a commendable job of managing large number of tent villages where vocational training, educational and recreational facilities were also ensured.

Protection of Vulnerable People. Those considered 'vulnerable' after the 2005 earthquake included orphaned and unaccompanied children, widows with children and destitute women. The Government made special arrangements to ensure protection of these people. The FRC played a central role in this. It coordinated with relevant ministries, the AJ&K and NWFP governments and their concerned agencies, the UN and NGOs to share areas of concern and convey policy directions; thus the FRC focal person for vulnerable people regularly attended meetings of the Protection Cluster. A policy was issued for discharge of patients from hospitals and other health care units to guard against possible abuse. Orphans, the destitute, unattended women and children and the disabled would, on full recovery, be handed over to the representative of the Ministry of Social Welfare. One of the key decisions made early on by the Government was to ban the adoption of child survivors and instead have them taken care of by the state. Custody of 'quake orphans' in AJK was given to SOS Villages. In addition, the Social Welfare Ministry set up a protection camp ('Aashiana') at Hattian to look after vulnerable women and children. Run by an NGO, Aashiana had the capacity to house 1,000 children and 500 women, but optimal use was not made of these facilities. The Hattian centre was directed to make arrangements to meet the special needs of amputees and paraplegics. In this regard the National Database and Registration Authority (NADRA) was asked to register IDPs, and standard operating procedures for quake survivors admitted to hospitals and health care units were developed whereby updated records would be kept of all those being treated. However, early data collection remained weak. The main reasons for this were: the Government could not clearly define the various vulnerable groups; decisions on a standardized data collection form and the agency to conduct surveys were made very late; in the meantime I/NGOs and other organizations conducted surveys based on their own specific needs. This led to duplication of some data and gaps in collection of others — in the absence of comprehensive data a comprehensive policy could not be formulated. NADRA was unable to complete its task of IDP registration. Of the 3.5 million people affected by the earthquake, NADRA had registered only 83,000 IDPs. Its failure stemmed from a lack of staff and resources, and from slow processing of data entry. Following consensus on a standardized data collection form, a new two-phase survey was launched in the new year with the first phase (camp populations) results available in mid-February; data on non-camp resident quake affectees was to be collected in the second phase. In late December 2005, the Social Welfare Ministry set up an Inter-Ministerial Task Force to formulate a national strategy and plan of action for vulnerable people. The Task Force formed a number of technical working groups who addressed different aspects of the issue. The National Plan of Action provided for the distribution of several billion Rupees to compensate survivors for loss of life, injuries and damage caused to property. Responsibility for distribution was assigned to the respective governments of AJK and NWFP assisted by the Pakistan Army, while the FRC closely monitored the whole process to ensure transparency. In the case of orphans who had lost their parents in the quake, compensation was to be given to family elders. However, in practice this was problematic because neither the AJK nor NWFP governments had separate data about extended families looking after quake orphans. The need to ensure that widows and orphaned children were not deprived of their rights to land inheritance was also stressed. As of end March 2006, the FRC had paid out Rs. 22 billion in comp0ensation.

Transitional/ 'One Room Out of the Rubble' Shelters. In the immediate aftermath of the 2005 earthquake, the focus was on providing emergency shelter to all those rendered homeless. However, since reconstruction of their homes would take considerable time and since the cold northern winter was rapidly approaching, the focus then moved to provision of semi-permanent (transitional) winter-proof shelters. This as the next step on the road to long-term recovery and would prevent mass migration from the affected areas. The FRC deliberately stressed the need for people to move from tents to what would eventually be part of their permanent homes. It discouraged the concept of a 'half-way house', fearing that people would remain in those and not make efforts to rebuild permanent homes. Its policy of 'one room out of the rubble' entailed construction of one room initially, that would eventually be reinforced and added onto as the family rebuilt their permanent home. The aim was to provide 3.5 million affectees with secure shelter before the onset of winter. Thus the initial tent-based strategy was, from week 3, complemented by semi-permanent shelter solutions based on a 'one warm room' policy. Most of the materials for construction of semi permanent shelters came from the rubble of destroyed houses, but the FRC provided and Army distributed CGI sheets free of cost. People were also given tools and other non-food items based on technical specifications and guidelines, disseminated by the Emergency Shelter Cluster. In week 4 'Operation Winter Race' was launched by Pakistan and the aid community. Its initial priority was on provision of transitional shelters to 'at risk' populations above 5,000 ft. The FRC placed an order for one million corrugated iron (CGI) sheets and arranged transportation of these via rail/through the NLC, and distribution through the military to the affectees. Military and civilian construction teams were deployed on a large-scale to both construct shelters — including one room out of the rubble' — for vulnerable and needy families. Moreover, Government announced compensation policy for the earthquake affectees as under:-

a. Dead — Rs.100,000 per death (however, in cases of multiple deaths in the same family only Rs.100,000 compensation was paid in first phase so as to ensure equitable distribution of resources).

b. Injured — seriously injured people were to get Rs. 50,000; injured Rs.25,000 and mildly injured Rs.15,000.
c. Housing — Initially, irrespective of the size and value of houses destroyed/damaged, all owners were given Rs. 25,000 in compensation. For reconstruction the Government agreed to pay money to survivors in tranches, administered through the FRC and ERRA. The tranches were as follows: i. Rs. 25,000 by the FRC, ii. Rs. 75,000 by ERRA, iii. Rs. 50,000 by ERRA, iv. Rs. 25,000 if survivors followed the correct dimensions and guidelines for house reconstruction.

The transitional/'one room out of the rubble' shelter policy and Operation Winter Race can be considered a success. By the end of January 2006, over 300,000 room shelters had been built for quake survivors. The feared winter disaster was averted, and nor was there mass migration from the affected areas. This success was due in large measure to the fact that the winterization strategy was rapid and focused, and implementation was greatly helped by the scale and reach of the Pakistan military.

Restoration of Infrastructure. The earthquake caused massive damage to infrastructure in the affected areas of AJK and NWFP. While the priority of the earthquake response was opening of roads to ensure supply routes for relief goods to those in need, restoration of communications links and of electricity and other services was also important. The FRC played a lead role in efforts to restore infrastructure in the quake-hit regions. In order to ensure effectiveness, a strategy was evolved which had a number of distinctive features and components. The first was unified command, control and decision-making. Assessment of damage and prioritization of assignment of resources was done on a daily basis. These decisions were then conveyed to the operational level, where responsibility for implementation rested with the respective army field formations, in collaboration with the local civil administration and other relief agencies. A second component was the identification, mobilization and utilization of human and material resources needed for priority infrastructure restoration. The FRC made an immediate assessment of required resources. Various concerned agencies were approached and they confirmed which of these were available with them, and these resources were then allocated to specific sub-sectors and placed at the disposal of the respective army formations in charge of implementation. All this was done in a very short period of time, enabling the majority of the affected population to be reached within the first two weeks of the earthquake striking.

Education. As most of the educational institutions had either collapsed or were seriously damaged, killing over 18,000 students, resumption of classes in the affected areas was a major undertaking. Where possible, the FRC provided large tents for establishment of schools, augmented by INGOs and UNICEF. Classes thus began in temporary schools. As teachers were among the affectees and many had shifted to refugee camps, they were enrolled to run schools in the camps. The military also contributed to the running of schools in camps managed by them, as well as helping repair damaged schools. For Muzaffarabad University students who could be housed in Islamabad, arrangements were made to attend evening classes in educational institutions in the capital.

From Relief to Early Recovery and Reconstruction. The shift in the earthquake response from relief to early recovery and reconstruction was a graduated one. While recovery efforts got underway, relief operations also continued. This 'residual relief' included, for example, provision of CGI sheets for people to construct semi permanent shelters — since it would take much longer for homes to be rebuilt. One of the crucial aspects of this so-called 'transitional phase' was the need to ensure there were no gaps between relief, recovery and reconstruction, and that planning for recovery and reconstruction took place alongside relief operations. Along with everything else, the earthquake had destroyed the sources of income generation for many people. Food-for-work and cash-for-work schemes and similar programmes were introduced to enable people to start to provide for themselves; the nature of the work, e.g. rubble clearance, had the dual benefit of supporting post-quake reconstruction. For those returning to their homes and/or starting reconstruction, efforts were made to ensure they were fully informed about 'high risk', 'low risk' and 'risk-free' zones, and that the specified reconstruction materials were available, compensation had been paid, and technical support was provided for rebuilding. One of the important factors determining all reconstruction initiatives was the need to prevent, or at least mitigate against, similar disasters being repeated. This entailed, for example, ensuring strict adherence to new building codes and strengthening of existing buildings to make them quake-resistant.

Lessons and the Way Ahead

Based on the challenges and problems faced in the handling of the 2005 earthquake, the following key lessons for the future can be identified:

a. **Permanent National Disaster Management Authority.** There is a clear need for a permanent body to deal with various aspects of disaster risk management, including mitigation, preparedness, emergency response and recovery. Such an organization should have a permanent core staff but with capacity to greatly increase this at short notice. It should have access to a constantly updated national database of information and, based on this, should prepare and constantly refine contingency planning. The organization should have the authority and ability to coordinate and harness support from different Government agencies and departments, as well as wider aid agencies, NGOs and civil society. It should be In regular contact with all these stakeholders to ensure effective coordination when disaster strikes.

b. **Robust Mandate and Political Support.** The Disaster Management Authority must have a strong mandate to control and synergize national effort. It must enjoy absolute political support and accessibility to the chief executive for quick decision making.

c. **One Window Operation.** Disaster Management has to be a one-window operation. However, the procedure must be such that it does not cause a bottle neck. All government departments involved in relief and rescue including Armed Forces must become part of apex body and take instructions from it.

d. **Disaster Risk Reduction.** One of the most important lessons learnt in the aftermath of the 2005 earthquake was that promotion and adoption of risk reduction approaches from national down to community and family levels is the key to reducing loss of lives and property. Over 73,000 lives were lost because the communities in the affected regions were not aware of safe construction technologies, nor did they know what to do to save lives in the event of an earthquake. The huge losses to public sector infrastructure (including schools, health facilities, roads and bridges) showed the need to integrate an element of risk assessment and vulnerability reduction into sectoral development planning and implementation. This is essential for Pakistan to reduce losses and damage from disasters and thereby achieve sustainable social, economic and environmental development.

e. **Early Warning Systems.** Early warning systems can play a significant role in reducing loss of life and casualties in a disaster. Early warning centres should be established in various parts of the country, particularly those that are highly vulnerable to disasters, and equipped with the necessary equipment, technology and staff to enable them to function properly. Dissemination procedures and modes should be developed in advance to ensure rapid transmission of warnings to all affected (at risk) populations. Experts at these centres and other institutions should work with the NDMA and other agencies to create public awareness of the risk of disasters, measures they can take to mitigate against these, and what they should do in the event of a disaster. The media, in particular TV and radio, could be utilized for this.

f. **National Database.** A national database is an essential requisite for effective disaster risk management, including emergency response. It should contain information on population numbers and spread, livestock, demographic characteristics, infrastructure and facilities, topography, and so on. The database should be updated regularly and, while centrally controlled for effective coordination and retention of information in one location, should be readily accessible to all relevant stakeholders. Local and Wide Area Network (LAN/WAN) facilities should be provided, which can facilitate links with the various bodies involved in relief operations and thereby ensure real-time information for planners and decision-makers.

g. **Contingency Planning and Preparedness.** Contingency plans are a must to deal with all potential threats and climatic hazards. These plans should also be prepared by the provincial and district disaster management authorities, laying out the roles and responsibilities of various ministries, departments and agencies at each level. There is a requirement of close liaison among various agencies involved in disaster management for quick response. Emergency procedures, cutting down the traditional red tape found in bureaucratic operations, need to be developed and all concerned are required to educate themselves in this regard. Concerted efforts are required to be made to build the capacity of local governments and civil administration, as they are on the 'front line' when a disaster strikes. Contingency plans for local governments should include identification of clear chain of command.

h. **Logistics Planning.** The management of logistics of rescue and relief operations is one aspect of contingency planning that needs special attention and focus. The national authority should be able to calculate requirements (type and quantity) of relief goods in the event of different types and scale of disasters. Likely availability of these goods, in particular basic commodities, should be assessed beforehand. Storage, transportation and other logistical facilities at national, provincial and even local levels needs to be identified (in the public and private sector) and arrangements made in advance for their mobilization in the event of a disaster. Regional logistics hubs should be identified in areas that are vulnerable to disasters, and supplies of essential commodities stocked there to ensure speedy provision in emergency conditions. Logistics chains should be worked out and arrangements put in place to ensure flow of information in times of disaster. All national-level acquisition, movement and distribution of huge logistical stocks become an intricate exercise. National logistic resources need to be integrated well before time along with making of comprehensive SOPs.

i. **Transport Infrastructure.** Cargo handling capacity at air, sea and dry ports should be enhanced to be able to handle the considerable extra influx of goods in an emergency response. This includes equipping them with the necessary machinery and technology to be able to discharge and transfer goods speedily. In addition the railways, the major national goods carriers within the country, should be improved so as to be able to transport large quantities of goods at short notice.

Conclusion

Pakistan's handling of the 2005 Earthquake – 'the most devastating natural disaster in its history' — had much to be proud of. Given the 'back foot' from which the national quake response was launched, and the numerous challenges that had to be overcome in an extremely short period of time, Pakistan did well. However, resting on one's laurels is not an option. Many serious problems and issues were faced, and improved handling of these would have led to an even more effective humanitarian response. The analysis is expected to provide information with regard to disaster management which could be useful in the event of any calamity. It must be remembered that success will depend upon a centralized guided, national and international joint response, with decentralized execution at operational and tactical level.

Annexure A

LIST OF MAJOR DONORS IN RELIEF ACTIVITIES

Ser	Items	Quantity	Remarks
1.	Tents	950,440	
2.	Blankets	6,500,000	
3.	Ration	256,400 Tons	
4.	Medicines	3054 Tons	
5.	Miscellaneous	131,000 Tons	
6.	Aviation Sorties	33,300	
7.	Compensation Paid	22 Billion	
8.	K-2 Oil	2 Million Litres	

Annex B

SUMMARY OF RELIEF PROVIDED – EARTHQUAKE 2005

Country	Cash Donated	Amount Pledged	Tents	Blankets	Rations (Tons)	Medical Assistance	Miscellaneous Items
Thailand	-	$0.4 million	-	-	-	-	-
Turkmenistan	-	-	150	-	-	-	23.62 Tonnes
Turkey	$6.4 million	$150 million	9,000	1,050,000	55,000	9 x Field Hospital and 114 Tons medicines	81.01 Tonnes
UAE	-	$100 million	-	-	-	-	600.74 Tonnes
UK	-	$121.143 million	-	-	-	-	117.32 Tonnes
Ukraine	-	-	-	-	-	100 Bed Field Hospital	365.78 Tonnes
UN	-	-	-	-	-	-	108.03 Tonnes
USA	$4.4 million	$510 million	7,222	189,827	205	2 MASH and 105 Tons medicines	1018.57 Tonnes
Uzbekistan	-	-	-	-	-	-	16.26 Tonnes
Vietnam	$100,000	$0.1 million	-	-	-	-	-

Annex A

LIST OF ABBREVIATIONS

Ser	Abbreviation	Full Word
1.	AJ&K	Azad Jammu and Kashmir
2.	AMC	Army Medical Corps
3.	DEWS	Disease Early Warning System
4.	EPI	Expanded Program of Immunization
5.	ERC	Emergency Relief Cell
6.	ERRA	Earthquake Reconstruction and Rehabilitation Authority
7.	FRC	Federal Relief Commission
8.	GHQ	General Headquarters
9.	ICRC	International Crescent of Red Cross
10.	IDPs	Internally Displaced Persons
11.	INGOs	International Non Governmental Organization
12.	LAN / WAN	Local Area Network / Wide Area Network
13.	LHVs	Lady Health Visitors
14.	LHWs	Lady Health Workers
15.	MoFA	Ministry of Foreign Affairs
16.	MoH	Ministry of Health
17.	NADRA	National Database and Registration Authority
18.	NATO	North Atlantic Treaty Organization
19.	NCMC	National Crisis Management Cell
20.	NDMA	National Disaster Management Authority
21.	NLC	National Logistics Cell
22.	NWFP	North West Frontier Province
23.	PIMS	Pakistan Institute of Medical Sciences
24.	PTCL	Pakistan Telecommunication Company Limited
25.	SCO	Special Communication Organization
26.	TB	Tuberculoses
27.	UC	Union Council
28.	UN OCHA	United Nations Office for Coordination of Humanitarian Affairs
29.	UNFPA	United Nations Population Fund
30.	UNICEF	United Nations Children Fund
31.	USC	Utility Stores Corporation
32.	WAPDA	Water and Power Development Authority
33.	WFP	World Food Programme
34.	WHO	World Health Organization

Seismic Assessment of Masonry Buildings

Anand. S. Arya

Abstract

As per the Census of India 2001 masonry housing units constitute 84.7% of the total 249 million housing units in India. Observations in all the past earthquakes in the country as well as in the other earthquake prone SAARC Countries have shown that masonry buildings are the most vulnerable to damage and collapse under earthquake Intensities MSK VII or more. Therefore, it has been realized that such existing buildings will need upgrading of seismic resistance by appropriate retrofitting techniques. The first step in this direction is proper seismic assessment to determine the weaknesses and deficiencies in such buildings which will require action to increase the strength and remove the deficiencies. This paper deals with this subject at two stages:

First, Method of Rapid Visual Screening which could be carried out by a site inspection and noting some crucial data about the building under consideration and itscomparison with the damageability observed through MSK/European Macro Intensity Scales would give the damage vulnerability level of the building. Second, a more detailed methodology is provided for carrying out the assessment of the building by comparing the actual construction details with the safe details recommended in IS:4326-1993. By this comparison, the weaknesses and deficiencies can be listed for improvement.

In some cases material testing particularly that of the mortar quality may have to be carried out for taking the final decision about the retrofitting methodology.

Introduction

The Census of India 2001 had collected data on the house types and classified it by material of wall and material of roof. By wall material the total number of masonry houses, out of the total 249 million housing units, was as follows:

Mud & Unburnt Brick	73.8 million (i.e 29.6% of the total)
Stone	25.5 million (i.e 10.2% of the total)

Burnt Brick	111.9 million (i.e 44.9% of the total)
Concrete	6.5 million (i.e 2.6% of the total only)

It is thus seen that the masonry houses constitute 84.7% of the total housing units whereas concrete and other units constructed using materials such as wood, metal/asbestos sheets and bio-mass material put together constitute 15.3%.

It has observed that under the action of moderate to severe earthquake occurrences (e.g. Latur 1993, Chamoli 1999, Kachchh 2001 and Jammu and Kashmir 2005), the masonry buildings performed the worst, causing the largest loss of lives as well as the properties of the residents. Hence, it is considered that protection of such buildings from the disastrous impact of earthquakes will lead to reduction of vulnerability of the buildings and their occupants. This will also result in minimizing the trauma to the people as well as the relief and rehabilitation efforts in the post-disaster situation. The adverse impact on the economy of the region will also be reduced. Seismic retrofitting of such buildings in the pre-earthquake phase is considered the best option to save existing buildings. The first step before actual retrofitting is adopted as a strategy will be that an assessment of the seismic resistance of the existing buildings.

This paper deals with the procedures which could be adopted for carrying out the seismic assessment of such masonry buildings.

The Approach to Seismic Assessment

For masonry buildings, the seismic assessment can be carried out in two steps, namely: (i) Rapid Visual Screening Procedure, and (ii) Detailed Seismic Assessment Procedure. The author has developed these two procedures, which have been found to be best suited to the existing masonry buildings in India. The same can be found useful and applicable in other SAARC Countries in view of the similarity in the construction of masonry buildings.

Step 1: Rapid Visual Screening

RVS Procedure:

The Rapid Visual Screening method is designed to be implemented without performing any structural calculations. The procedure utilises a *damageability grading system* that requires the evaluator to (i) identify the primary structural lateral load-resisting system, and (ii) identify building attributes that modify the seismic performance expected for this lateral load-resisting system along with non-structural components. The inspection, data collection and decision-making process typically occurs at the building site, and is expected to take just a couple of hours for a building, depending on its size.

The screening is based on Code-based Seismic Intensity, Building Type and Damageability Grade as observed in past earthquakes and covered in MSK/European macro-Intensity scales.

The main uses of this procedure in relation to seismic upgrading of existing buildings are:

i. To identify if a particular building requires further evaluation for assessment of its seismic vulnerability.

ii. To assess the seismic damageability (structural vulnerability) of the building and seismic rehabilitation needs.

iii. To identify simplified retrofitting requirements for the building (to collapse prevention level) where further evaluations are not considered necessary or not found feasible.

Seismic Hazard in India:

As per IS 1893:2002 (Part 1), India has been divided into 4 seismic hazard zones (*see* Figure1). When a particular damage intensity occurs, different building types experience different levels of damage, depending on their inherent characteristics. For carrying out the Rapid Visual Screening, all four hazard zones have been considered. The details of different seismic zones are given in Table 1:

Figure 1: Earthquake Hazard Zones 2002

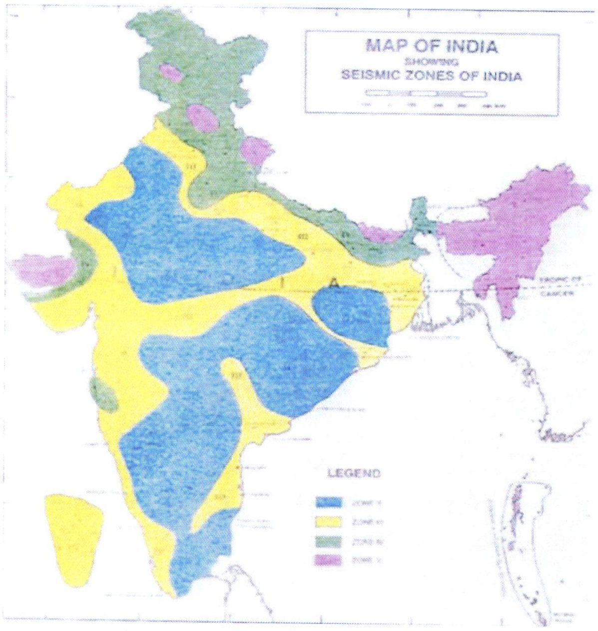


Table 1: Details of Different Economic Zones

Zone II	Low seismic hazard (damage during earthquake may be of MSK Intensity VI or lower)
Zone III	Moderate seismic hazard (maximum damage during earthquake may be up to MSK Intensity VII) Covers 30.8% of land area of India
Zone IV	High seismic hazard (maximum damage during earthquake may be up to MSK Intensity VIII) Covers 17.5% of land area of India
Zone V	Very high seismic hazard (maximum damage during earthquake may be of MSK Intensity IX or greater). It covers 10.8% of land area of India.

Building Types Considered in RVS Procedure:

A wide variety of construction types and building materials are used in urban and rural areas of India. These include local materials such as mud, straw and wood, semi-engineered materials such as burnt brick and stone masonry, and engineered materials such as concrete and steel. The seismic vulnerability of the different building types depends on the choice of building materials and construction technology adopted. The building vulnerability is generally highest with the use of local materials without engineering inputs and lowest with the use of engineered materials and skills.

The basic vulnerability class of a building type is based on the *average* expected *seismic performance* for that building type. All buildings have been divided into type A to type D based on the European Macro Seismic Scale (EMS-98) recommendations. The buildings in Type A have the highest seismic vulnerability while the buildings in Type D, have the lowest seismic vulnerability. A building of a given Type, however, may have its vulnerability *different from the average* defined for that Type, depending on the condition of the building, presence of earthquake resistance features, architectural features, number of storeys, etc. It is therefore possible to have a damageability range for each building type considering the different factors affecting its likely performance. Some variations in building type are therefore defined here as A, B, B+ etc.

The RVS procedure presented here has considered different building types, based on the building materials and construction types that are most commonly found in India (and other SAARC countries). A description of masonry buildings is presented in Table 1. The likely damages to buildings under future earthquake intensity occurrences have been categorized into different Grades, depending on the seismic impact on the strength of the building.

Table 1: Masonry loadbearing wall buildings

Building Type	Description
A	(a) Rubble (Field stone) in mud mortar or without mortar usually with sloping wooden roof. (b) Uncoursed rubble masonry without adequate 'through stones'. (c) Masonry with round stones.
B	Semi-dressed, rubble, brought to courses, with *through* stones and long *corner* stones; unreinforced brick walls with country type wooden roofs; unreinforced CC block walls constructed in mud mortar or weak lime mortar.
B+	(a) Unreinforced brick masonry in mud mortar with vertical wood posts or horizontal wood elements or seismic band (IS:4326,13828) (b) Unreinforced brick masonry in lime mortar.
C	(a) Unreinforced masonry walls built from fully dressed (Ashler) stone masonry or CC block or burnt brick using good cement mortar, either having RC floor/roof or sloping roof having eave level horizontal bracing system or seismic band. (b) As at B with horizontal seismic bands (IS: 4326,13828)
C+	Like C(a) type but having horizontal seismic bands at lintel level of doors & windows (IS: 4326)
D	Masonry construction as at C(a) but reinforced with bands & vertical reinforcement, etc (IS: 4326), or *confined* masonry using horizontal & vertical reinforcing of walls.

Grades of Damageability:

Five grades of damageability from G1 to G5 are specified in MSK and European Intensity Scale as described in Table 2:

Table 2: Grades of Damageability of Masonry Buildings

Classification of damage to masonry buildings	
Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)	
Structural:	Hairline cracks in very few walls.
Non-structural:	Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few
Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage)	
Structural:	Cracks in many walls, thin cracks in RC* slabs and A.C.* sheets.
Non-structural:	Fall of fairly large pieces of plaster, partial collapse of smoke chimneys on roofs. Damage to parapets, *chhajjas*. Roof tiles disturbed in about 10% of the area. Minor damage in under structure of sloping roofs.
Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)	
Structural:	Large and extensive cracks in most walls. Widespread cracking of columns and piers.
Non-structural:	Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)	
Structural:	Serious failure of walls (gaps in walls), inner walls collapse; partial structural failure of roofs and floors.
Grade 5: Destruction (very heavy structural damage)	
Total or near total collapse of the building.	

* *RC = Reinforced Concrete; AC = Asbestos Cement*

Relationship of Seismic Intensity, Building Type and Damage Grades:

Table 3 provides guidance regarding likely performance of buildings in the event of design-level earthquake intensity postulated in the Seismic Zone. This information has been used in the survey forms to decide if there is a necessity of further seismic evaluation of the building. It can also be used to identify need for retrofitting, and to recommend simple retrofitting techniques for ordinary buildings where more detailed evaluation is not needed.

The Indicative quantities ***Few, Many*** and ***Most*** as defined in European Intensity Scales are as follows:

Few: Less than (15 ± 5) %; Many: Between (15 ± 5) to (55 ± 5) %;
Most: Between (55 ± 5) to100%

As per MSK Intensity scale the average values of these terms may be taken as
Few: 5–15% *Many: 50%* *Most: 75%*

Table 3 is generally based on MSK descriptions.

Table 3 : Damageability Grades of Masonry Buildings under Earthquake Intensities

Type of Building	**Zone II** MSK VI or less	**Zone III** MSK VII	**Zone IV** MSK VIII	**Zone V** MSK IX or more
A	Many of grade 1 Few of grade 2 (rest no damage)	Most of grade 3 Few of grade 4 (rest of grade2or1)	Most of grade 4 Few of grade 5 (rest of grade3,2)	Many of grade 5 (rest of grade 4 & 3)
B and B+	Many of grade 1 Few of grade 2 (rest no damage)	Many of grade 2 Few of grade 3 (rest of grade 1)	Most of grade 3 Few of grade 4 (rest of grade 2)	Many of grade 4 Few of grade 5 (rest of grade 3)
C and C+	Few of grade 1 (rest no damage)	Many of grade 1 Few of grade 2 (rest of grade 1,0)	Most of grade 2 Few of grade 3 (rest of grade 1)	Many of grade 3 Few of grade 4 (rest of grade 2)
D		Few of grade 1	Few of grade 2	Many of grade 2 Few of grade 3 (rest of grade 1)

NOTE:
1. *As per MSK scale, few, Many and Most may be taken as: Few: 15%, Many: 50% and Most: 75%.*
2. *Buildings having vertical irregularity may undergo severe damage in seismic zones III, IV and V if not specifically designed. Hence they will require special evaluation. Also buildings sited in liquefiable or landslide-prone areas will require special evaluation for seismic safety.*
3. *Buildings having plan irregularity may under go a damage of one grade higher in zones III, IV and V. The surveyor may recommend re-evaluation.*

RVS Survey Forms – Special Points:

The RVS survey forms are developed here for all the seismic Zones II to V based on the probable earthquake intensities, building types and damageability grades as described above. The RVS Survey Forms are presented in Annexure 1 to 4 for Seismic Zones II to V respectively. Some special cases included therein are described herewith.

Importance of Building/Structure:

As per IS: 1893-2002, an important factor I is defined for enhancing the seismic strength of buildings & structures, as follows:

Important buildings*: Hospitals, schools, monumental structures; emergency buildings ,like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls, and subway stations, power stations, Important Industrial establishments, VIP residences and residences of important emergency persons.

**Any building having more than 100 Occupants may be treated as Important for purpose of RVS.*

For these important buildings the value of I is specified as 1.5, by which the design seismic force is increased by a factor of 1.5. Now the seismic zone factors for Zone II to V are as follows.

Zone	***II***	***III***	***IV***	***V***
Zone Factor	0.10	0.16	0.24	0.36

It is seen that one Unit change in Seismic Zone intensity increases the Zone Factor 1.5 times.

Hence to deal with the damageability of important buildings in any zone, they should be checked for one Unit higher zone. The assessment forms are designed accordingly.

Special Hazards:

There are some special hazardous conditions to be considered:

a. *Liquefiable condition:* Normal loose sands submerged under a high water table are susceptible to liquefaction under moderate to high ground accelerations; a building founded on such soils will require *special evaluation and treatment.*

b. *Landslide-prone Area:* If the building is situated on a hill slope which is prone to landslide/land slip or rock-fall under monsoon and/or earthquake, special geological and geotechnical evaluation of the site and treatment of the building will be needed.

c. *Irregular Buildings:*

Irregularities in buildings are defined in Cl.7.1 of IS: 1893 – 2002 under the following sub-heads:

i. Plan Irregularities: These are defined in Table 4 of the above Code as follows:

(a) Torsion Irregularity

(b) Re-entrant Corners

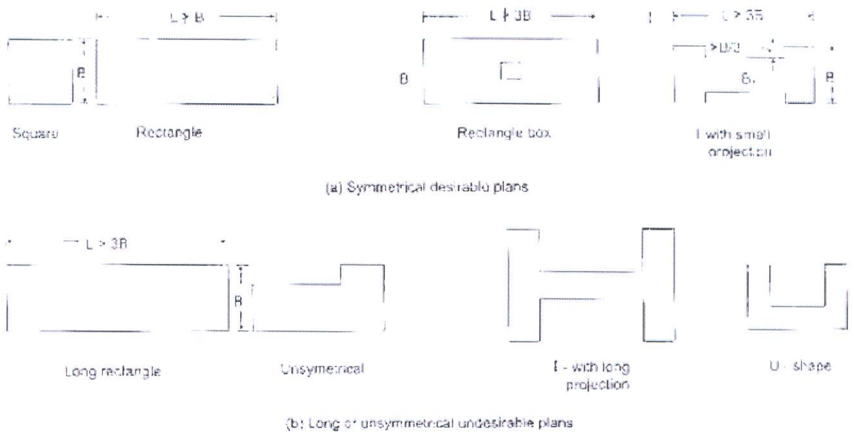
(c) Diaphragm Discontinuity

(d) Out of Plane Offsets

(e) Non-Parallel Systems

The Geometric Irregularities in building plans which can be easily identified are shown in Figure 2.

Figure 2: Horizontal Irregularities



These irregularities enhance the overall damage (increased grade of damage, e.g. at re-entrant corners). Such a building may be recommended for detailed evaluation.

ii. *Vertical Irregularities:* The following vertical irregularities may be seen in masonry buildings (*see* Figure 3).

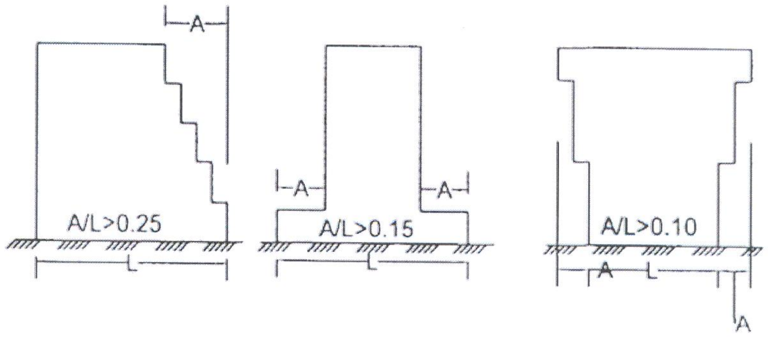
(a) Mass Irregularity

(b) Vertical Geometric Irregularity

(c) In-Plane Discontinuity in vertical Elements Resisting Lateral Forces.

If any of these irregularities are noticed, the building should be recommended for detailed evaluation.

Figure 3: Vertical Irregularities



Falling Hazard: Where such hazards are present, particularly in Zones IV and V, recommendations should make reference to these in the survey report as indicated.

Type of Foundation Soil: IS 1893-2002 defines three soil types: hard/stiff, medium & soft. No effect of these is seen in the design spectra of short period buildings, with T< 0.4 second, covering all masonry buildings, hence the effect may be considered not so significant.

Step 2: Detailed Seismic Assessment

Detailed Seismic Assessment Procedure:

In the assessment of expected seismic performance of existing load-bearing masonry wall buildings, the most direct approach will be to compare the safety provisions specified in IS: 4326-1993 for such buildings with the situation actually prevailing in the existing building. Where the existing condition is found *compliant* with IS: 4326 it will be considered safe and acceptable. But where the existing condition is found deficient, hence *non-compliant*, it will be considered as weak, requiring upgradation or strengthening or retrofitting.

Building Categories:

For specifying the seismic safety requirements and the reinforcing details in load-bearing masonry wall buildings, the buildings are categorized according to the seismic coefficient specified for design in the seismic zone and the importance factors specified for the building type. Taking these into account, the following building categories have been specified in IS:4326-1993 as amended in 2005.

Table 4: Building Categories (for use with IS 4326 &IS 13928)

Building Use	Building Category in Seismic Zone			
	II	III	IV	V
Ordinary	B	C	D	E
Important (I=1.5)	C	D	E	E+

Factors Considered in Seismic Safety as Per IS: 4326-1993:

The most important factors considered in IS: 4326-1993 for ensuring seismic safety of various category buildings are the following:

I Walls

(i) Mortar

(ii) Door, window openings in walls
(iii) Length of wall between cross walls
(iv) Height of wall above floor to ceiling
(v) Unconnected perpendicular walls, parapets, cantilever balconies, etc.
(vi)Horizontal Seismic Bands at
    (a) plinth level
    (b) door-window lintel level
    (c) ceiling of flat floor/roof or eave level of sloping roofs
    (d) gable ends and top of ridge wall
    (e) window sill level
(vii) Vertical steel bar
    (a) at each corner/junction of walls
    (b) at door and window jambs

II Roofs or Floors

(i) Roofs/floors with prefabricated or precast elements
(ii) Cantilever balconies
(iii) Roofs/floors with wooden joists with various covering elements
(iv) Sloping roofs with sheets or tile covering
(v) Jack arch roof or floors
(vi) Sloping raftered roofs

The safety requirements of the various elements as per IS: 4326-1993 are given in Annexures 5, 6 and 7 for ready reference.

Assessment of a Building:

The procedure of assessment is given in Table 5. For the building under assessment for seismic safety, first its building Category should be determined. For example, for a residential building in Delhi, the seismic zone is IV and Importance factor will be 1.0. Therefore, from Table 4, the Category of the building is D. Now compile the values for various elements for the actual building in col (2) of Table 5. The corresponding Codal values may be picked from Annexures 5–7 and entered in col (3) of Table 5. Comparing the values in col (2) with those in col (3) of Table 5 one could mark the appropriate elements as *compliant* or *non-compliant* in col (4) of Table 5. For the elements found non-compliant, improvement by retrofitting needs to be done for which suitable action is indicated in the last column of Annexures 5, 6 and 7.

Table 5 – Seismic Design Compliance Assessment of Building

Building Category (tick mark as applicable) – *C* ☐, *D* ☐, *E* ☐ , *E+*☐

S.No. (1)	Date of Building under Assessment (2)	Required as per Code (3)	Compliant Yes/no(4)
1.	Number of storeys	≤ 4	
2.	Wall building unit BB/CCB (solid)/CCBC (Hollow)	Compressive strength ≥ 50 mpa	
3.	Wall thickness G.F. I.F. II. F. III.F	BB = 230 mm CCB = 200 mm	
4.	Largest size room ....m X ...... m	8 m X 8 m	
5.	Mortar used C:S =-		
6.	Door, Window openings (Based on building height) (i) Overall (b_1 + b_2+....)/l, max = (ii) B4 min. = (iii) B5 min.=		
7.	Wall length/thickness ratio t = l = l/t =		
8.	Wall height/thickness ratio t = h = h/t =		
9.	Soil at base Soft/ hard/medium		
10.	Floor type *(tick mark)* RC slab/RB slab/ Precast beams or slabs		
11.	Roof type *(tick mark)* Horizontal flat/sloping/ RC or RB slab/trusses or rafters		
12.	Seismic Bands *(yes/no)* (i) at plinth (ii) at lintel level (iii) at ceiling or eave level (iv) at window sill level (v) at gable ends (vi) at ridge top		
13.	Vertical bar *(yes/no)* (i) at external corners (ii) at external T-junctions (iii) at internal corners (iv) at internal T-junctions (v) at jambs of door (vi) at jambs of windows		
14.	Sloping Roofs *(yes/no)* (i) rafters (any x-bracing ?) (ii) trusses (x-bracing in plan?)(x-bracing in slopes?) (iii) tile covering (with holding down systems?)		

BB – Burned Brick, CCB – Cement Concrete Block

Global Deficiencies:

During the survey of a building or from the drawings of the building some deficiencies of a 'global nature' may become apparent. Three such deficiencies are shown in the following Table along with the actions suggested during retrofitting. Where such a deficiency is seen during RVS Survey, it should be noted in the Survey Forms for detailed seismic assessment.

Table 6: Deficiencies of a 'global nature' in buildings

S.No	Item	C D E, E+	Retrofitting Action if code provision not satisfied
1.	Sloping raftered roofs	Preferably use full trusses	Convert rafters into A-frames or full trusses to reduce thrust on walls
2.	Unsymmetrical Plans	Symmetrical plans are suggested	Inserting new walls to reduce dissymmetry
3.	Perpendicular Walls not connected at corners and T-junctions	Perpendicular walls should be integrally constructed	Stitch the perpendicular walls using tie rods in drilled holes fully grouted or box them with seismic belts

Testing of Materials:

Sometimes the strength of the base soil and its liquefiability, also the strength of the building units such as bricks or blocks and the mortar will need to be tested particularly for old (heritage type) buildings. Decision in this regard will have to be taken by the engineer-in-charge and tests carried out appropriately. Particular attention in this regard may be paid to important and/or critically significant buildings so as to ensure their durability over many years of future life, besides required strength performance.

Summary of Results of Comparative Assessment:

The major deficiencies indicating non-compliance with Codal provisions should be noted. These will need to be considered for upgrading by retrofitting suitably to prevent the total or partial collapse of the building in future if and when the probable maximum earthquake intensity strikes the area.

References:

Arya A.S., "Rapid Visual Seismic Screening of Buildings", Chapter-20 in *Earthquake Disaster Reduction-Masonry Buildings Design and Construction*, KW Publishers Pvt. Ltd., New Delhi 2007

Arya A.S., "Seismic Assessment of Masonry Buildings", Chapter No. 21 in *Earthquake Disaster Reduction-*

Masonry Buildings Design and Construction, pub:, KW Publishers Pvt. Ltd., New Delhi 2007

IS:4326-1993 "Earthquake Resistant Design and Construction of Buildings - Code of Practice (Second Revision)", BIS, New Delhi.

IS:13935-2008 "Repair and Seismic Strengthening of Buildings - Guidelines (First Revision)", BIS, New Delhi.

Annexure 1

1 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone II Ordinary Building

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name ____________________

1.2 Use ____________________

1.3 Address: ____________________

____________________ Pin ________

1.4 Other Identifiers ____________________

1.5 No. of Stories ________ **1.6** Year Built ________

1.7 Total Covered Area; all floors (sq.m) ________

1.8 Ground Coverage (Sq.m): ________

1.9 Soil Type: ________ **1.10** Foundation Type: ________

1.11 Roof Type: ________ **1.12** Floor Type ________

1.12 Structural Components:

1.12.1 Wall Type: BB* ☐ Earthen ☐ UCR* ☐ CCB* ☐

1.12.2 Thickness of wall: ______ **1.12.3** Slab Thickness: ______

1.12.4 Mortar Type: Mud ☐ Lime ☐ Cement ☐

1.12.5 Vert. R/F bars: Corners ☐ T-junctions ☐ Jambs ☐

1.12.6 Seismic bands: Plinth ☐ Lintel ☐ Eaves ☐ Gable ☐

*BB – Burnt Brick, *UCR – Uncoursed Random Rubble
*CCB: Cement Concrete Block

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD
2.1 Important buildings: Hospitals, Schools, monumental structures, emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:-*** Other buildings having occupants <100	**3.1** High Water Table (within 3m) & if sandy soil, then liquefiable site indicated Yes ☐ No ☐ **3.2** Land Slide Prone Site Yes ☐ No ☐ **3.3** Severe Vertical Irregularity Yes ☐ No ☐ **3.4** Severe Plan Irregularity Yes ☐ No ☐ **5.0 SPECIAL OBSERVATION** **5.1** Length of wall between two cross walls are as per IS 4326 or IS 13828 Yes ☐ No ☐ **5.2** Percentage of openings in walls is as per IS 4326 or IS 13828 Yes ☐ No ☐ **5.3** Ratio of height & width of wall is as per IS 4326 or IS 13828 Yes ☐ No ☐	**4.1** Chimneys ☐ **4.2** Parapets ☐ **4.3** Cladding ☐ **4.4** Others ☐

RECOMMENDED ACTION:-

- ☐ Ensure adequate maintenance.
- ☐ If any Special Hazard 3.0 found, re-evaluate for possible retrofitting.
- ☐ If any of the falling hazard is present, either remove it or strengthen against falling.
- ☐ Special observation if not compliant may lead to more severe damage and will call for retrofitting

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 Masonry Building				
Damage- ability in	A	B / B+	C / C+	D	
Zone II	G2	G2 / G1	G1 / G1	-	

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Surveyor's sign: ____________________
Name: ____________________

Executive Engineer's Sign: ____________________

Date of Survey: ____________________

Annexure 2

2 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone III Ordinary Building

(Also for Zone II Important Building)

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name__________

1.2 Use__________

1.3 Address:__________

__________Pin __________

1.4 Other Identifiers__________

1.5 No. of Stories__________ 1.6 Year Built __________

1.7 Total Covered Area; all floors (sq.m) __________

1.8 Ground Coverage (Sq.m):__________

1.9 Soil Type:__________ 1.10 Foundation Type:__________

1.11 Roof Type:__________ 1.12 Floor Type__________

1.12 Structural Components:

1.12.1 Wall Type: BB* ☐ Earthen ☐ UCR* ☐ CCB* ☐

1.12.2 Thickness of wall:______ 1.12.3 Slab Thickness:______

1.12.4 Mortar Type: Mud ☐ Lime ☐ Cement ☐

1.12.5 Vert. R/F bars: Corners ☐ T-junctions ☐ Jambs ☐

1.12.6 Seismic bands: Plinth ☐ Lintel ☐ Eaves ☐ Gable ☐

*BB – Burnt Brick, *UCR – Uncoursed Random Rubble
*CCB: Cement Concrete Block

2.0 OCCUPANCY

2.1 Important buildings: Hospitals, Schools, monumental structures, emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person

Any building having more than 100 Occupants may be treated as **Important.*

2.2 Ordinary buildings:- Other buildings having occupants <100

3.0 SPECIAL HAZARD

3.1 High Water Table (within 3m) & if sandy soil, then liquefiable site indicated Yes ☐ No ☐

3.2 Land Slide Prone Site Yes ☐ No ☐

3.3 Severe Vertical Irregularity Yes ☐ No ☐

3.4 Severe Plan Irregularity Yes ☐ No ☐

4.0 FALLING HAZARD

4.1 Chimneys ☐

4.2 Parapets ☐

4.3 Cladding ☐

4.4 Others ☐

5.0 SPECIAL OBSERVATION

5.1 Length of wall between two cross walls are as per IS 4326 or IS 13828 Yes ☐ No ☐

5.2 Percentage of openings in walls is as per IS 4326 or IS 13828 Yes ☐ No ☐

5.4 Ratio of height & width of wall is as per IS 4326 or IS 13828 Yes ☐ No ☐

RECOMMENDED ACTION:-

☐ Ensure adequate maintenance.

☐ Detailed evaluation of B type for need for retrofitting.

☐ Detailed evaluation of A types for need for reconstruction or possible retrofitting.

☐ If any Special Hazard 3.0 found, re-evaluate for possible prevention/retrofitting.

☐ If any of the falling hazard is present, either remove it or strengthen against falling.

☐ Special observation if not compliant may lead to more severe damage and will call for retrofitting.

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 Masonry Building			
Damage- ability in Zone III	A	B / B+	C / C+	D
	G4	G3 / G2	G2 / G1	G1

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Surveyor's Sign :__________

Name:__________

Executive Engineer's Sign:__________

Date of Survey:__________

Annexure 3

3 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone IV Ordinary Building

(Also for Zone III Important Building)

Photograph

1.1 Building Name______________________

1.2 Use______________________

1.3 Address:______________________

______________________Pin ____________

1.4 Other Identifiers______________________

1.5 No. of Stories____________ 1.6 Year Built ____________

1.7 Total Covered Area; all floors (sq.m) ____________

1.8 Ground Coverage (Sq.m):____________

1.9 Soil Type:__________ 1.10 Foundation Type:____________

1.11 Roof Type:____________ 1.12 Floor Type____________

1.12 Structural Components:

1.12.1 Wall Type: BB* ☐ Earthen ☐ UCR* ☐ CCB* ☐

1.12.2 Thickness of wall:______ 1.12.3 Slab Thickness:______

1.12.4 Mortar Type: Mud ☐ Lime ☐ Cement ☐

1.12.5 Vert. R/F bars: Corners ☐ T-junctions ☐ Jambs ☐

1.12.6 Seismic bands: Plinth ☐ Lintel ☐ Eaves ☐ Gable ☐

*BB – Burnt Brick, *UCR – Uncoursed Random Rubble
*CCB: Cement Concrete Block

Sketch Plan with Length & Breadth

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:-*** Other buildings having occupants <100	3.1 High Water Table (within 3m) & if sandy soil, then liquefiable site indicated. Yes ☐ No ☐ 3.2 Land Slide Prone Site Yes ☐ No ☐ 3.3 Severe Vertical Irregularity Yes ☐ No ☐ 3.4 Severe Plan Irregularity Yes ☐ No ☐ **5.0 SPECIAL OBSERVATION** 5.1 Length of wall between two cross walls are as per IS:4326 or IS:13828. Yes ☐ No ☐ 5.2 Percentage of openings in walls is as per IS 4326 or IS 13828 Yes ☐ No ☐ 5.5 Ratio of height & width of wall is as per IS:4326 or IS: 13828 Yes ☐ No ☐	4.1 Chimneys ☐ 4.2 Parapets ☐ 4.3 Cladding ☐ 4.4 Others ☐

RECOMMENDED ACTION:-

- ☐ A or B evaluate in detail for need of reconstructions or possible retrofitting to achieve type C or D
- ☐ B+, C evaluate in detail for need for retrofitting
- ☐ If any Special Hazard 3.0 found, re-evaluate for possible prevention/retrofitting
- ☐ If any of the falling hazard is present, either remove it or strengthen against falling
- ☐ Special observation if not compliant may lead to more severe damage and will call for retrofitting

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 Masonry Building			
Damage-ability in Zone IV	A	B / B+	C / C+	D
	G5	G4 / G3	G3 / G2	G2

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Surveyor's
Sign :________________
Name:________________

Executive
Engineer's
Sign:________________

Date of Survey:____________

Annexure 4

4 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone V All Buildings

(Also for Zone IV Important Building)

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name__________
1.2 Use__________
1.3 Address:__________
__________ Pin __________
1.4 Other Identifiers__________
1.5 No. of Stories__________ 1.6 Year Built __________
1.7 Total Covered Area; all floors (sq.m) __________
1.8 Ground Coverage (Sq.m):__________
1.9 Soil Type: __________ 1.10 Foundation Type: __________
1.11 Roof Type:__________ 1.12 Floor Type__________
1.12 Structural Components:
1.12.1 Wall Type: BB* ☐ Earthen ☐ UCR* ☐ CCB* ☐
1.12.2 Thickness of wall:______ 1.12.3 Slab Thickness:______
1.12.4 Mortar Type: Mud ☐ Lime ☐ Cement ☐
1.12.5 Vert. R/F bars: Corners ☐ T-junctions ☐ Jambs ☐
1.12.6 Seismic bands: Plinth ☐ Lintel ☐ Eaves ☐ Gable ☐

*BB – Burnt Brick, *UCR – Uncoursed Random Rubble
*CCB: Cement Concrete Block

2.0 OCCUPANCY

2.1 *Important buildings*: Hospitals, Schools, monumental structures, emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person

Any building having more than 100 Occupants may be treated as **Important.*

***2.2 Ordinary buildings*:-** Other buildings having occupants <100

3.0 SPECIAL HAZARD

3.1 High Water Table (within 3m) & if sandy soil, then liquefiable site indicated Yes ☐ No ☐
3.2 Land Slide Prone Site Yes ☐ No ☐
3.3 Severe Vertical Irregularity Yes ☐ No ☐
3.4 Severe Plan Irregularity Yes ☐ No ☐

4.0 FALLING HAZARD

4.1 Chimneys ☐
4.2 Parapets ☐
4.3 Cladding ☐
4.4 Others ☐

5.0 SPECIAL OBSERVATION

5.1 Length of wall between two cross walls are as per IS:4326 or IS:13828 Yes ☐ No ☐
5.2 Percentage of openings in walls is as per IS:4326 or IS 13828 Yes ☐ No ☐
5.6 Ratio of height & width of wall is as per IS:4326 or IS 13828 Yes ☐ No ☐

RECOMMENDED ACTION:-

- ☐ A or B, B+ evaluate in detail for need of reconstructions or possible retrofitting to achieve type C+ or D
- ☐ C evaluate in detail for need for retrofitting to achieve type C+, D
- ☐ Wood evaluate in detail for Retrofitting
- ☐ If any Special Hazard 3.0 found, re-evaluate for possible prevention/ retrofitting
- ☐ If any of the falling hazard is present, either remove it or strengthen against fall
- ☐ Special observation if not compliant may lead to more severe damage and will call for retrofitting

Surveyor's
Sign :__________
Name:__________

Executive Engineer's
Sign:__________

Date of Survey:__________

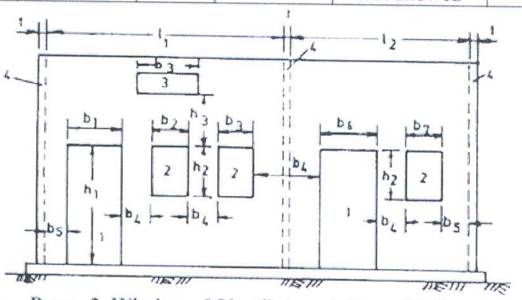
5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 Masonry Building			
	A	B / B+	C / C+	D
Damage- ability in Zone V	G5	G5 / G4	G4 / G3	G3

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Annexure 5

S.No	Item of Masonry	Requirement as per IS 4326:1993 for Building Category				Action for Retrofitting if Code Requirement not found satisfied.
		B	C	D	E, E+	
1.	**Mortar**	CLS-1:2:9 or CS-1:6		CLS-1:1:6 or CS-1:4		See cl.8.4. Alternatively, walls may be strengthened by ferro-cement plating or injection grouting.
2.	**Door, Window openings –** . b_5 minimum (See fig)	0.0	230 mm	450 mm	450 mm	Increase by building up or strengthening by ferro-cement plating.
	$(b_1+b_2+b_3)/l_1$ max. $(b_6+b_7)/l_2$ one storey	0.6	0.55	0.50	0.5	Attain the limit by closing/ narrowing an opening *Or* reinforce the opening by seismic belting.
	two storey	0.50	0.46	0.42	0.42	
	three storey	0.42	0.37	0.33	0.33	
	four storey	0.42	0.37	0.33	Not allowed	
	 1. Door 2. Window 3.Ventilator 4. Cross Wall					
	. b_4 **minimum**	340 mm	450 mm	560 mm	560 mm	Increase by build-up *or* reinforce with *belt.*
3.	**Length of wall between cross walls**	---	Max length = 35 x thickness or 8 m whichever less			If length more, provide pilaster or buttress to reduce effective length.
4.	**Height of wall from floor to ceiling**	---	Maximum = 15 times thickness or 4 m whichever less			If height more, add pilaster to increase effective thickness.
5.	**Random- Rubble walls**	• 'Through' or Header stones, one each in 0.72sq.m surface area of wall. • Long stones at corners of walls, in each wall in every alternate course.				If not provided, install RC Headers in holes made by removing stones.

Annexure 6

S.No	Item of Masonry	Requirement as per IS 4326:1993 for Building Category				Action for Retrofitting if Code req. not found satisfied.
		B	C	D	E, E^+	
1.	**Horizontal Seismic Bands-** Plinth Lvl	Needed if soft (type III) soil at base.				Provide seismic belt if plinth height ? 90 cm
	. Door window lintel level	Needed in all cases with varying reinforcement and thickness specified in each case.				Provide seismic belt of equivalent strength on both sides of walls
	. Ceiling or eave level	Needed in sloping roofs or floors and roofs of prefabricated elements.				-do-
	. Gable or ridge wall	Needed in case of pitched roofs.				-do-
	. Window sill level or dowels	Not required.	Not required.	Required in 3- & 4 storeyed buildings only.	Required in all buildings.	-do-
2.	**Vertical bar at each corner and T-junction of wall**	Needed in only 4-storeyed building.	Needed in 3-and 4-storeyed buildings.	Needed in all buildings.	Needed in all buildings. (4 storeys not permitted)	Install equivalent bars or vertical belts at corners and T-junctions.
3.	Vertical bar at jambs of window &door	Not needed.	-do-	-do-	-do-	Install equivalent seismic belts around the opening.

Annexure 7

S.No.	Item of Roof/Floor	Requirement as per IS 4326:1993 for Building Category				Retrofitting Action if code provision not satisfied
		B	C	D	E	
1.	**Roof/floor with prefabricated/ pre-cast elements**	Tie beam all round.		All-round tie beam and RC screed.		Provide RC screed and seismic belt or band around.
2.	**Roof/floor with wooden joists, various covering elements (brick, reeds, etc.) & earth fill**	—	All round seismic band and integration of units as a rigid horizontal diaphragm.			Provide seismic belt around, inter-connect beam ends through wooden planks and diagonal x-ties.
3.	**Jack arch roof/floor**	—	Connect the steel joists by horizontal ties at intervals to prevent spreading and cracking of the arches. Provide seismic band all-round.			Install steel flats as ties by welding them to the steel joists and provide seismic belt.
4.	**Sloping roofs with sheeting or tile coverings**	—	(i) Horizontal x-bracing at level of ties of the trusses. (ii) X-bracing in the planes of the rafters and purlins.			Install the x-bracings as per the code IS:4326. Anchor trusses into walls and rafters into seismic belt at eave level.
5.	**Sloping rafter roof**	-	Preferably use full trusses.			Convert rafters into A frames.
6.	**Cantilever balcony**	-	To be taken out from RC floor or anchored back for $A_v = 3\,A_h$			Upgrade the anchorage.

Addressing the Risk of Tsunami in the Indian Ocean

Shailesh Nayak and T. Srinivasa Kumar

Abstract

Identification and forecasting of tsunamis require detection of a tsunamigenic earthquake and its parameters, generation of model scenarios to estimate travel time and run-up height, monitoring of sea level, a decision support system, a standard operating procedure and mechanisms for timely delivery of information. India has successfully set up the First Tsunami Warning Centre in the Indian Ocean in record time, which has been operational from October 15, 2007. The Indian Tsunami Early Warning System comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR) and tide gauges to detect tsunamigenic earthquakes and to monitor tsunamis. Tunami N2 model has been used for the purpose of predicting surges for different scenarios of earthquakes. For operational early warning, a large spatial database (about 8 Terabytes) of pre-run numerical simulations has been created, which can be accessed at the time of an earthquake event to generate forecast of tsunami travel time and run up estimates for different parts of the coastline of the Indian Ocean. A state-of-the-art early warning centre has been established at the Indian National Centre for Ocean Information Services (INCOIS) with all the necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure. The end-to-end performance of the system was validated against the earthquake and tsunami event of September 12, 2007. It was observed that the system performed extremely well, enabling reception, display and analysis of the real-time and model data sets as well as generation and dissemination of timely and accurate advisories following the standard operating procedure.

The instrumentation of the Indian System capable of detecting tsunamis originating from both known tsunamigenic sources in the Indian Ocean. India has begun providing regional tsunami watch services from its national system for the Indian Ocean region. At present, it provides earthquake source information to assess potential tsunami threat and travel times.

Introduction

The ocean is the cornerstone of the life support system for all creatures on planet Earth and a source of several natural phenomena that are beneficial to humankind. However, oceans are also associated with disastrous events such as tsunamis, cyclones and associated storm surges. Tsunamis can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Tectonic earthquakes (of amagnitude of more than 7 on the Richter Scale), are a particular kind of earthquakes that are associated with the earth's crustal deformation. When these earthquake occur beneath the sea, the water above the deformed area is displaced from its equilibrium position and can generate a tsunami. Underwater volcanic eruptions and landslides can also generate tsunami. The tsunami waves behave very differently in deep water than in shallow water as their speed is related to the water depth. The tsunami's energy flux, which is dependent both on its wave speed and wave height, remains nearly constant. Tsunami waves form only a small hump, barely noticeable and harmless, which generally travels at a very high speed of 500 to 1,000 kmph. The tsunami's speed diminishes as it travels into shallower water to only tens of kilometres an hour, consequently increasing the wave height. Because of this shoaling effect, a tsunami, imperceptible at sea, may grow to be several metres or more in height near the coast forming large destructive waves.

Risk Assessment of Tsunamis in the Indian Ocean

Risk refers to the consequences of a natural hazard and is the probability of a loss, which depends on the hazard, vulnerability and exposure. The goal of risk assessment is to determine the probability of a tsunami striking an area, and the magnitude of damage that occurs. In the Indian Ocean, the two tsunamigenic source regions are the Makran and Andaman-Sumatra subduction zones. The risk assessment for the Indian Ocean region is estimated by considering the historical earthquakes, their magnitudes, historical tsunamis, location of the area relative to a fault (ANSS, 2007; HS, 2007; NGDC, 2007; ISC, 2007; USGS, 2007; Rastogi and Jaiswal, 2006) and also by preparing the coastal vulnerability maps and inundation models for various possible earthquakes that can occur.

The Historic Seismicity of India

India has a database of devastating earthquake events since year 1500. However, there is no well documented information on prehistoric events of tsunamis in the region which caused potential damage. Geographically, the seismic activity in the Indian continent can be divided into four regions: (a) Himalaya (continent collision in the north) (b) Andaman-Nicobar Islands (subduction zone in the east) (c) Peninsular India (intra-plate activity) and (d) Makran coast (subduction zone in the west). The historical seismic activity of magnitude 6.0 and above in the Indian Ocean region since year 1800 is shown in Figure 1.

Historic Tsunamis in the Indian Ocean

The Indian coastal belt has not recorded many tsunamis in the past. Waves accompanying earthquake activity have been reported over the north Bay of Bengal. During an earthquake in 1881, which had its epicentre near the centre of the Bay of Bengal, tsunamis were reported. The earthquake of 1941 in Bay of Bengal caused some damage in the Andaman region. This was unusual because most tsunamis are generated by shocks which occur at or near the flanks of continental slopes. During the earthquakes of 1819 and 1845 near the Rann of Kutch, there were rapid movements of water in the sea. There is no mention of waves resulting from these earthquakes along the coast adjacent to the Arabian Sea, and it is unlikely that tsunamis were generated. Further west, in the Persian Gulf, the 1945 Makran earthquake (magnitude 8.1) generated a tsunami of 12 to 15 metres in height. This caused a huge deluge, with considerable loss of life and property at Ormara and Pasi. The estimated height of the tsunami at Gulf of Cambay was 15 metres but no report of damage is available. The estimated height of waves was about 2 metres at Mumbai, where boats were taken away from their moorings and casualties occurred.

A list showing the tsunamis that affected the Indian coast prior to the Sumatra earthquake of December 26, 2004, is given in the Table 1.

Table 1: Tsunami that affected Indian Coast before 2004

Date	Cause	Impact
12 April 1762	Earthquake in Bay of Bengal	Tsunami wave of 1.8 m at Bangladesh coast
31 December 1881	Magnitude 7.8, earthquake beneath Car Nicobar	Entire east coast of India, including Andaman & Nicobar coast was affected by a tsunami
27 August 1883	Eruption of Karkatoa volcano (Sunda Strait) Indonesia	East coast of India was affected and a 2-m tsunami was reported at Chennai
26 June 1941	8.1 magnitude earthquake in Andaman	East coast of India was affected by a tsunami
27 November 1945	27 November 1945 (21 hour 56 mins. 50 sec UTC) in the Makran subduction zone *(Baluchistan, Pakistan)* (24.5° N & 63.0° E) with Mw of 8.1	West coast of India was affected by a tsunami

Tsunamigenic Source Identification

The east and west coasts of India and the island regions are likely to be affected by tsunamis generated mainly by subduction zone-related earthquakes from the two potential source regions, viz. the Andaman-Nicobar-Sumatra island arc and the Makran subduction zone north of the Arabian Sea. These two possiblilities are shown in the blue ellipses in Figure 1.

Modelling as a tool for vulnerability assessment:

Tsunamis and cyclonic storms result in the generation of waves of different periods and heights that are termed as surges. These wave parameters depend on earthquake source parameters in the case of tsunami, bathymetry, beach profile, coastal land topography and presence of coastal structures. These surges cause flooding of seawater into the land as much as 1 km or even more, resulting in loss of human life and damage to property. To minimise such losses, it is imperative to prepare coastal vulnerability maps indicating the areas likely to be affected due to flooding and rending. The vulnerability of the coasts to tsunamis and the inundation that may occur during the tsunami are estimated by tsunami modelling. Tsunami modelling is done by using the TUNAMI N2 and MOST software all around the globe.

In India, TUNAMI N2 Model (Imamura, F. 2006) is being used with the existing bathymetry and coastal topography to estimate the tsunami hazard in terms of inundation for the Indian coasts. The generated inundation data by modelling are validated with the observations from the December 2004 tsunami. Efforts have already been launched for generating high-resolution bathymetry and coastal topography data that will substantially improve the accuracy of the model results. The community-level inundation maps will be extremely useful for assessing the population and infrastructure at risk. They could be used for better land-use planning, building of shelters, planning evacuation routes, etc.

Establishment of the National Early Warning System for Tsunami and Storm Surges

Components of the Indian Tsunami Warning System

The Indian Tsunami Early Warning System comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR), tide gauges and a 24X7 operational tsunami warning centre to detect tsunamigenic earthquakes, to monitor tsunamis and to provide timely advisories to the vulnerable community with back-end support of scenario database, vulnerability modelling and Decision Support System by means of various available communication methods (Gupta, 2005). The performance of the system was tested on the September 12, 2007 earthquake of magnitude 8.4 off the Java coast.

Observation Networks

A network of land-based seismic stations for earthquake detection and estimation of focal parameters in the two known tsunamigenic zones is a prime requirement of the warning centre. The Indian National Centre for Ocean Information Services (INCOIS) is receiving real-time seismic data from international seismic networks as well as from the India Meteorological Department (IMD) and has been detecting all earthquake events occurring in the Indian Ocean in less than 15 minutes of occurrence. Necessary software has been installed for real-time data reception, archiving, processing and auto-location of earthquakes, as well as for alert generation and automatic notification.

In order to confirm whether an earthquake has actually triggered a tsunami, it is essential to measure the change in water level near the fault zone with high accuracy. BPRs are used to detect the propagation of tsunami waves in open-ocean and consequent sea-level changes. A network of BPRs has been installed close to the tsunamigenic source regions to detect tsunamis, by the National Institute of Ocean Technology (NIOT). These BPRs can detect changes of 1 cm at water depths up to 6 km.

A network of tidal gauges along the coast helps to monitor the progress of a tsunami and to validate the model scenarios. Near-real time data from national and international centres has been received. Necessary software for real-time reception, display and archiving of tide gauge data has also been developed.

Tsunami Early Warning Centre

A state-of-the-art early warning centre has been established at the INCOIS with all the necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, it analysis and generation and dissemination of tsunami advisories following a standard operating procedure. A host of communication methods has been employed for timely dissemination of advisories. Seismic and sea-level data are continuously monitored in the early warning centre using a custom-built software application that generates alarms/alerts in the warning centre whenever a pre-set threshold is crossed. The data is organised in a central database on a storage server and affords analysis and retrieval. A display wall facilitates visualisation of various data streaming in, pre-run model outputs and vulnerability maps. Tsunami advisories like warnings/alerts/watches are generated on the basis of pre-set decision support rules and disseminated to the concerned authorities for action, following a Standard Operating Procedure (SOP). The database is also linked to the dedicated tsunami website through which data/information/advisories are made available to users.

Tsunami Modelling for operational forecast

One of the most important requirements for a tsunami warning system is to generate simulations of expected travel time (i.e. time taken by the tsunami wave to reach the particular coast) and run-up height for the tsunamigenic earthquakes. The TUNAMI N2 (Tohoku University's Numerical Analysis Model for Investigation of Near field tsunamis version 2) model has been used for the purpose of predicting surges for different scenarios of earthquakes. This model uses available earthquake parameters and assumes worst slip rate (Mansinha, and Smylie, 1971). As the model takes about sixty minutes of time to provide output on travel time and run-up, a database of pre-scenario need has been created for the entire Indian Ocean (Kuwayama, 2006). For operational early warning, a large spatial database (about 8 Terabytes) of pre-run numerical simulations of about 50,000 scenarios has been created (Figure 3) that can be accessed at the time of an earthquake event to generate forecast of tsunami travel time and run up estimates for different parts of the coastline of the Indian Ocean. The scenarios are generated for the epicentres all along the two tsunamigenic sources regions for different magnitudes (Papazachos et al.,

2004) and focal depths. The model scenarios provide information on 1,800 forecast points, which are generally towns, cities and settlements as well as location of BPRs and tidal stations.

High Resolution Database on Bathymetry and Coastal Topography

Generating and updating a high-resolution database on bathymetry, coastal topography, coastal land use, coastal vulnerability as well as a historic database on tsunami and storm surge to prepare and update storm surge/tsunami hazard maps. The accuracy of model predictions is directly related to the quality of the data used to create the bathymetry and topography of the model area.

Coastal Bathymetry is the prime determinant of the height of the tsunami wave or storm surge as it approaches the coast. High resolution coastal bathymetry is thus the key input for various tsunami and storm surge prediction models. Preliminary surveys have already been conducted to acquire high-resolution bathymetry for a few vulnerable areas of the coastline. The Naval Hydrographic Office (NHO) has been providing detailed bathymetry data.

Topography of the entire coastline of the country is required at 1:25000-scale with contours at intervals of 0.5 m to 2 m up to 20 m. Preliminary maps have been prepared of coastal topography using CARTOSAT-1 stereo data for the Indian coast. The National Remote Sensing Agency (NRSA) has been mapping the topography of about 15, 000 sq km area with airborne LIDAR and Digital Camera data in conjunction with GPS control survey using photogrammetric techniques. An area of 3000 sq km has already been mapped. These products have been used to prepare coastal vulnerability maps.

Generation of Vulnerability Maps

The TUNAMI N2 model has been used for the purpose of predicting surges for different scenarios of earthquakes and to indicate the extent of inundation of seawater into the land. An Inundation scenario database for all possible earthquakes that may occur in the two subduction zones is being created as the generation of the inundation maps for an occurred earthquake takes very long computational hours. The extent of inundation is mapped on to cadastral level maps (Figure 4) that are being used for hazard zonation. The maps will be provided to central-and state-level departments that are involved in disaster management. These vulnerability maps are very useful for taking precautionary and mitigation measures such as evacuation of people, avoiding human settlements, large investment, designing of appropriate structures, etc. in the risk-prone areas. Information from remote sensing and field investigations are being integrated in GIS for modelling and mapping of inundation of seawater for determination of setback lines, planning coastal defences, etc.

Standard Operating Procedure at the Early Warning Centre:

The criteria for generation of different types of advisories (Warning/Alert/Watch) for a particular region of the coast are to be based on the travel time. The warning criteria are based on the premise that coastal areas falling within 60 minutes', travel time from a tsunamigenic earthquake source need to be advised solely on the basis of earthquake information and estimated water levels, since enough time will not be available for confirmation through real-time water-level observations from BPRs and tide gauges. At the time of the event, the closest scenario is picked from the scenario database for generating advisories.Those coastal areas falling outside the 60 minutes' travel time from a tsunamigenic earthquake source have been put under a watch or alert status, based on estimated water levels and upgraded to a warning only upon confirmation of real-time observed water-level data. For example, if a tsunamigenic earthquake happens in the coast of northern Indonesia, parts of the Andaman and Nicobar Islands falling within 60 minutes' travel time of a tsunami wave will be put under Warning/Alert status based on estimated water levels from the closest scenario. Other areas will be put under Alert/Watch status and upgraded/downgraded to a Warning/All Clear based on real-time water-level observations from BPRs or tide gauges. This implies that the possibility of false alarms is higher for areas close to the earthquake source; however, for other regions, since the advisories are given only after confirmation of water-level data, the issue of false alarms does not arise. The flow chart of a decision support system and standard operating procedure is shown in figure 5.

Capacity Building, Training and Education

Easily understandable publicity material on earthquakes, tsunamis and storm surges in vernacular languages is being created to distribution for the general public. A dedicated multilingual website is also being developed to provide information on tsunamis and storm surges.

Performance of the System — Case Study of September 12, 2007

INCOIS generated a database of model scenarios considering various earthquake parameters. The pre-run scenario for the September 12, 2007 event was used to calculate the estimated travel time and run-up heights at various coastal locations and water-level sensors (tide gauges and BPRs). The directivity map generated from the selected scenarios showed that the south-east and south-west Indian coast was likely to be affected by a minor tsunami (~ 20 cm) and Andaman and Nicobar Islands (~10cm), which is evident from the observations of tidal stations at Chennai and Port Blair.

The estimates from the model scenario matched well with the observations from BPRs and tidal stations, as is evident from Table 2:

Table 2

Location	Estimated arrival time (IST)	Estimated water level (cm)	Observed arrival time (IST)	Observed water level (cm)
Padang	1751	80	1754	60
Coco's Island	1748	40	1748	50
Sabang	1903	20	1903	30
TB3	1903	2	1913	1
TB10A	1931	1	1941	2
TB10	1930	2	1945	1
Port Blair	2010	10	2013	8
Chennai	2105	20	2110	18
Male	2054	12	2058	13

The end-to-end system performed extremely well, enabling reception, display and analysis of the real-time and model data sets as well as generation and dissemination of timely and accurate advisories following the SOP. An description of the errors in the initial estimate of earthquake parameters and the run-up is given in Table 3.

Table 3: Description of errors in initial estimate of earthquake parameters

Parameters	Performance Target	Performance Achieved
Elapsed time from earthquake information issuance (distant)	15 min	13 min
Accuracy of earthquake hypocentre location	30 km	20 km
Accuracy of earthquake hypocentre depth	25 km	5 km
Accuracy earthquake Mw magnitude	0.2	0.1
Accuracy of the tsunami forecast amplitude/height	Factor of 2	~ 25 %

This information was used to provide necessary advisories to the concerned authorities, thus avoiding unnecessary public evacuation for this event.

Contribution to the Indian Ocean Region

The Indian tsunami early warning centre is equipped with world-class computational, communication and technical support facilities and is considered the "Most Modern Tsunami Warning Centre in the World" as on date. The instrumentation of the Indian system is established in a way such that it is capable of detecting tsunamis originating from both known tsunamigenic sources in the Indian Ocean. It has robust application software based on geospatial technologies to generate and disseminate timely tsunami advisories to the Indian Ocean countries. INCOIS has also set up the warning centre infrastructure so as to utilise the capabilities of a Regional Tsunami Watch Provider. India has begun providing regional tsunami watch services from its national system for the Indian Ocean Region. At present, it provides earthquake source information of potential tsunami threat and travel times. Shortly, information apart from earthquake parameters, travel time, run-up height, and potential threat zones will be provided. The warning centre can also support the generation of inundation maps as well as risk and hazard assessments.

References

ANSS, 2007. *Global earthquake composite catalog search (1898 to present), Indian Ocean,* http://www.ncedc.org/anss/catalog-search.html (Accessed 26th June 2007).

HS, 2007. *Harvard Seismology, Global Centroid Moment Tensor Catalog (1976 to present), Indian Ocean,* http://www.globalcmt.org/CMTsearch.html, (Accessed 26th June 2007).

NGDC, 2007. *Natioanl Geophysical Data Centre (NGDC), the Significant Earthquake Database (-2150 to 2007) rectangular area search, Indian Ocean,* http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1, (Accessed 26th June 2007).

ISC, 2007. *International Seismological Centre, Online catalog rectangular area search, Indian Ocean,* http://www.isc.ac.uk/search/bulletin/rectang.html, (Accessed 26th June 2007).

USGS 2007. *Earthquake Hazards Program, U.S. Geological Survey, Global Earthquake search, Significant Worldwide Earthquakes (2150 B.C. - 1994 A.D.) & India (1063 – 1984), Catalog search* http://neic.usgs.gov/neis/epic/epic_ global.html, (Accessed 26th June 2007).

USGS 2007. *Earthquake Hazards Program, U.S. Geological Survey, Rectangular area search, Indian Ocean,* http://neic.usgs.gov/neis/epic/epic_rect.html, (Accessed 26th June 2007).

Rastogi, B.K. and. Jaiswal, R.K. 2006, '- Science of Tsunami Hazards, Vol. 25, No. 3, page 128-143.

Imamura, F. (2006), TUNAMI-N2 *(Tohoku University's Numerical Analysis Model for Investigation of Near Field Tsunamis version 2)* Manual draft, http://www.tsunami.civil.tohoku.ac.jp/hokusai3/J/projects/manual-ver-3.1.pdf, (Accessed 16th Dec 2006).

Gupta, Harsh. (2005). *Mega-tsunami of 26th December, 2004: Indian Initiatives for Early Warning System and Mitigation of Oceanic Hazards.* Episodes, 28 (1):2-5.

Mansinha, L. and Smylie, D. E. 1971. *Displacement fields of inclined faults. Bull. Seismological Soc. Am.* 61, 1433-1440.

Kuwayama, T. (2006), *"Quantitative Tsunami Forecast System", JICA Tsunami Seminar* – Unpublished report

Papazachos, B.C., Scordilis, E.M. Panagiotopoulos, D.G., Papazachos C.B., and G.F. Karakaisis, G.F. (2004), *Global relations between seismic fault parameters and moment magnitude of earthquakes, 10 th Congr. Hellenic Geol. Society,* 14–17 April 2004, Thessaloniki, pp. 539–540.

Figure 1. Tsunamigenic source regions in the Indian Ocean

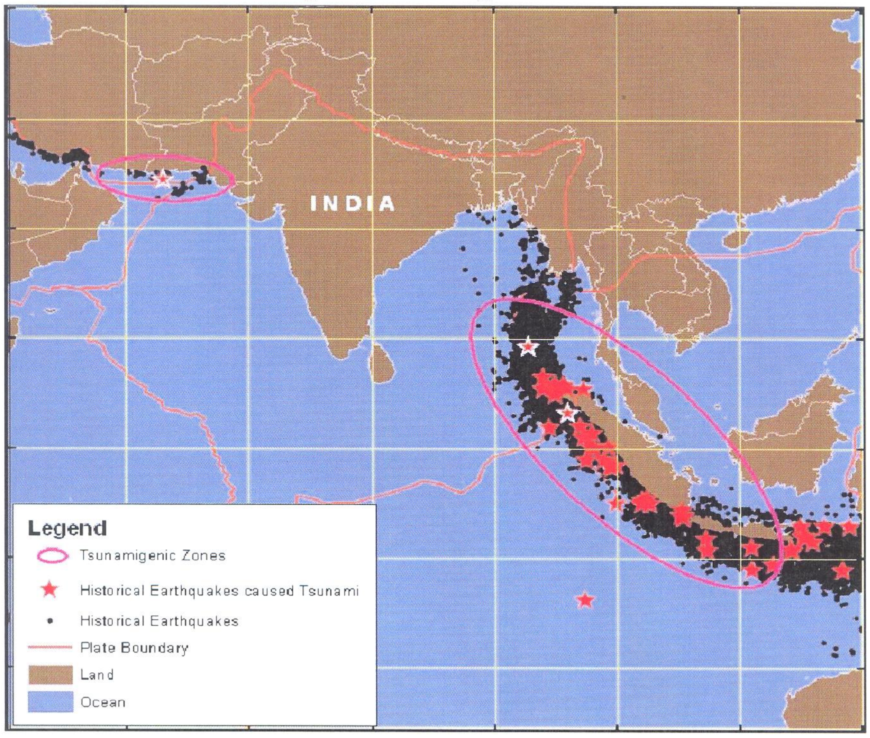


Figure 2. A snapshot of the Tsunami Early Warning Centre at INCOIS

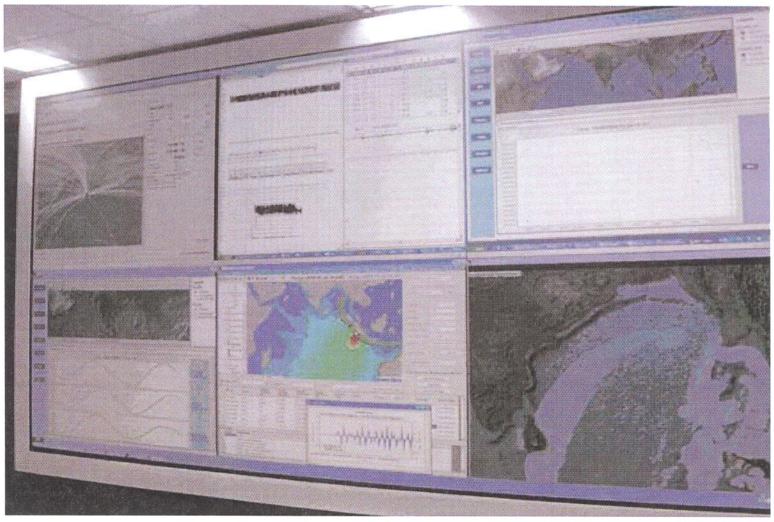


Figure 3. Database of about 50,000 scenarios for Indian Ocean

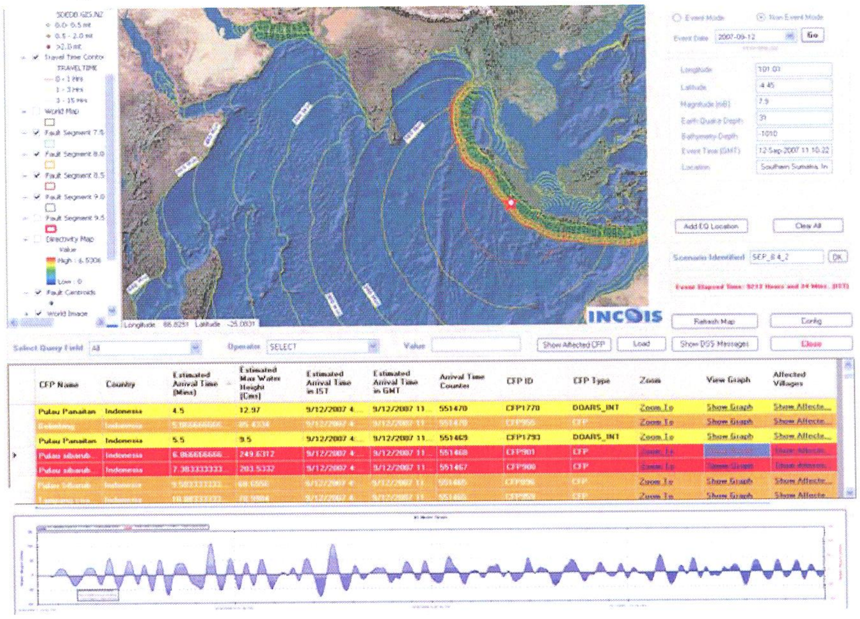


Figure 4. Vulnerability maps for Cuddalore District

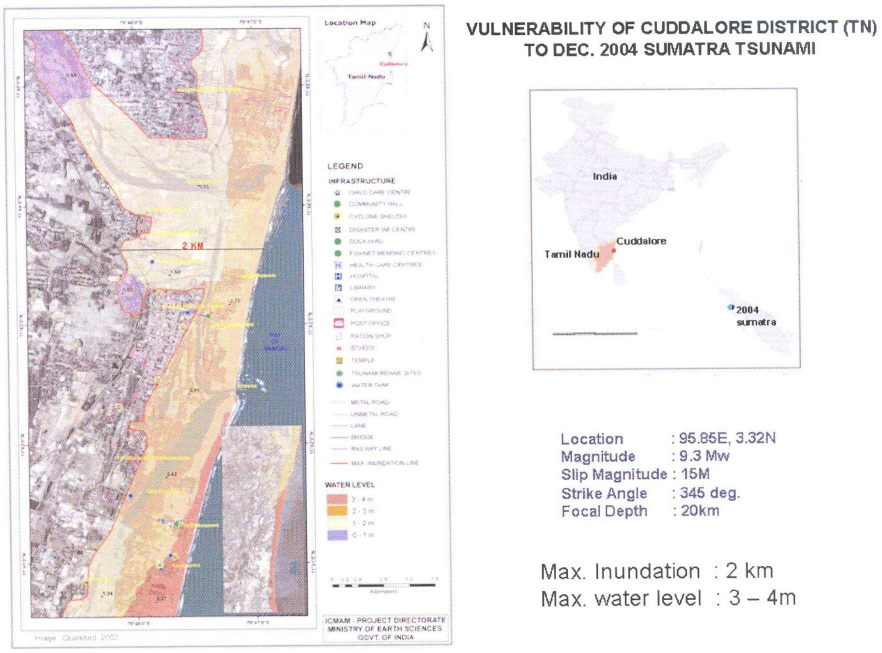
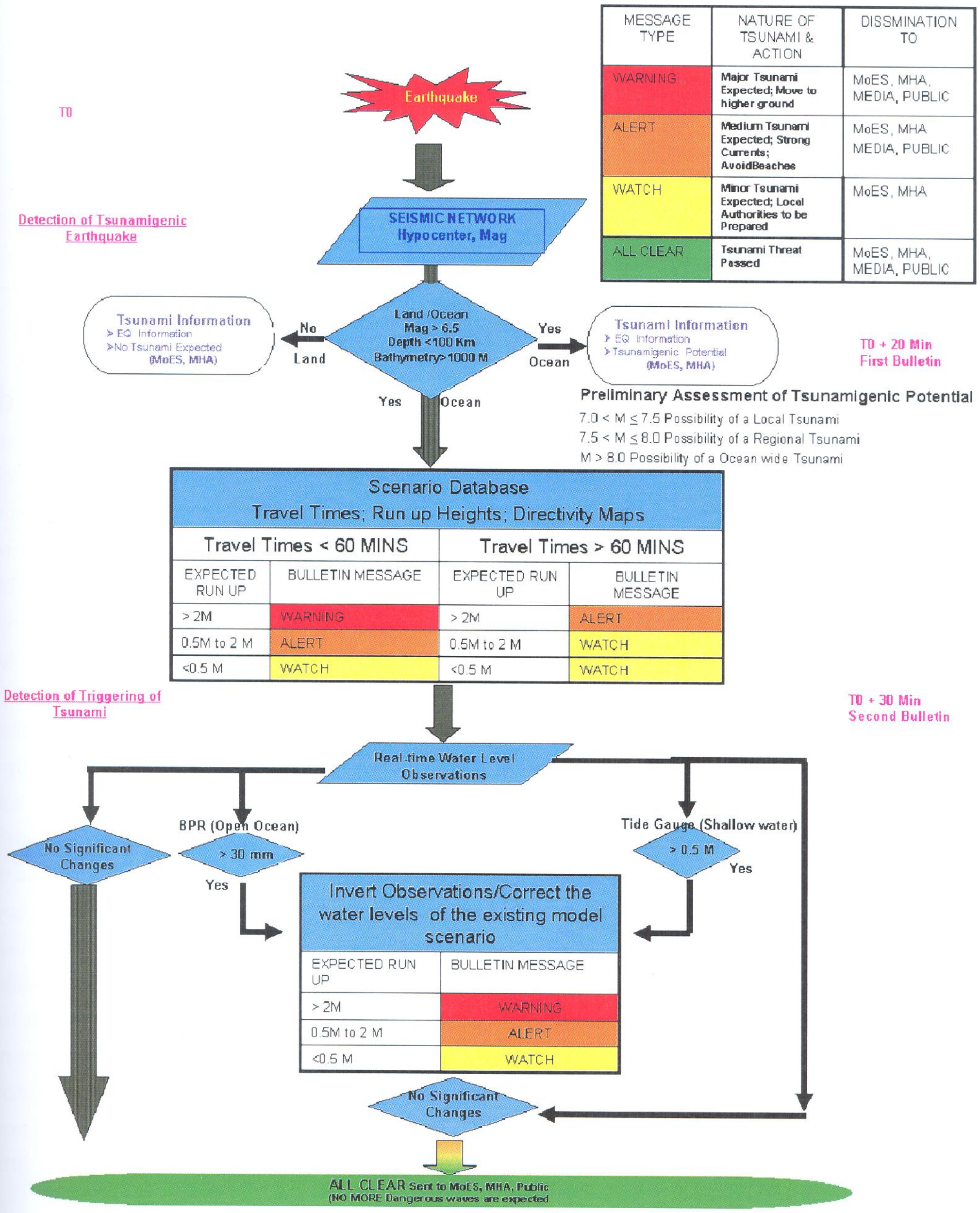


Figure 5. Standard Operating Procedure for generating advisories



Cyclone Shelters and Alternatives for Sustained Development in Bangladesh

Fuad H Mallick and Mohammad Aminur Rahma

Abstract

Cyclones have caused extensive damage to Bangladesh time and again. One way of saving lives during cyclones is for the population to take refuge in shelters which are able to withstand the strong winds and storm surges. In the 1990s a major program for the construction of cyclone shelters along the coastline was undertaken and since then a large number of them have been built. In combination with a formidable early warning system and the help of thousands of volunteers these have been able to reduce the loss of lives in the recent cyclones. The traditional houses of the coastal areas are not engineered to withstand cyclones and there continues to cause massive destruction to the housing stock of the affected areas, and is hence a setback to development of the communities at risk. The cyclone shelters are not designed for extended stay and once the cyclone has passed the people have to go back to the destruction with no houses to live in. It is also seen that when cyclone warnings are issued some people are reluctant to go to the shelters leaving behind their livestock or possessions, or to stay back with family members who are not fit to go to the shelters. Living conditions in shelters are at best described as overcrowded and facilities inadequate, particularly for women. Having a stronger house, resistant to strong winds would not only enable the people to feel safe at home but would also mean less destruction to the housing stock. Some experiences suggest that the cost of building a stronger house or structurally strengthening an existing one is not very much and at the cost of building a cyclone shelter a lot of stronger houses can be built. This presents alternatives in terms of combining long term development of a community and its resilience to destruction from cyclones. Cyclones shelters are needed to save lives but for long term development and resilience stronger houses are needed. A rebuilding scheme that includes stronger houses in combination with better cyclone shelters can be an alternative for sustained development.

Introduction

Over the years Bangladesh has been ravaged by cyclones that have caused extensive damage to its economy, infrastructure, livelihoods of the population, agriculture, housing, livestock and so on, and have resulted in the death of hundreds of thousands of people. The country's attempts towards development have time and again been hampered by natural calamities. Each time a cyclone strikes Bangladesh, the development activities that took years to build up are compromised, setting back its pace. Construction of cyclone shelters was initiated in the 1960's In the 1990's a major programme was undertaken and cyclone shelters were built in the coastal areas. Supported by a formidable early warning system and thousands of volunteers, these shelters have reduced the loss of lives by providing safe havens for the population during cyclones. During normal times they serve as schools, health and community centres, and house other functions. During cyclones they protect people and provide shelter for a few days in the aftermath. Then people go back to their lives which have to be rebuilt from scratch. There are no homes to go back to and no possessions left. While these shelters are life savers, they are not effective in rebuilding the community. If each homestead were to be a shelter of sorts, rebuilding would become easier and the community would be more resilient. Rethinking the whole approach to cyclone shelters and incorporating structural strengthening of the community as a whole may have better implications for its sustained development.

Bangladesh and Cyclones

Bangladesh stretches between 20°34'Œ and 26°33' North latitudes, and 88°01'and 92°41' East longitudes. The total area is 147,570 sq km, the maximum extension being about 440 km in the East-West direction and 760 km in the North north-west-South southwest direction. The 580 km coastline of Bangladesh is at the head of the Bay of Bengal.

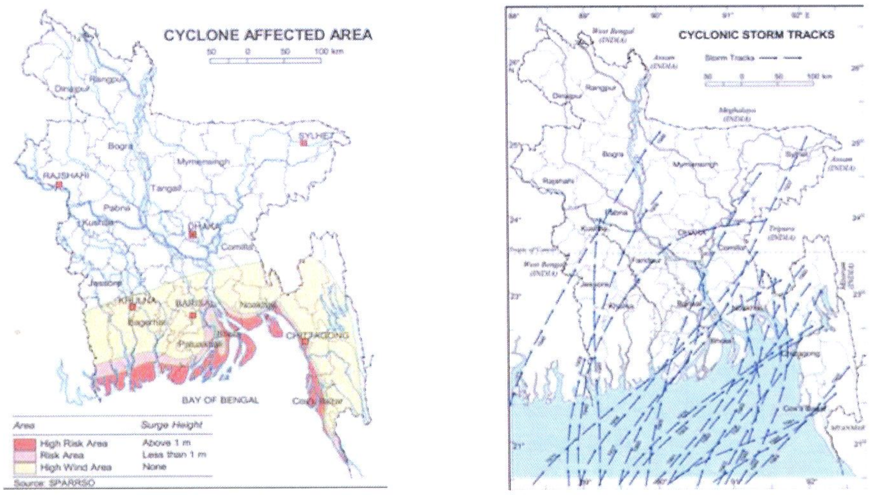
The Bay of Bengal is said to be the breeding ground for tropical cyclones. Because of the funnel-shaped coast, Bangladesh very often becomes the landing ground for cyclones formed in the bay and is their worst victim in terms of the fatalities and economic losses they cause. The global distribution of cyclones shows that only 1% of all the cyclones that form every year strikes Bangladesh; but the fatalities they cause here is 53% of the whole world (Ali 1999).

Table 1: Percentage of human casualties due to some historical catastrophic cyclones in Bangladesh.

Sl.No.	Date of occurrence	Total population of the	Population of the area exposed to country	Death toll	% of human casualties with respect to	
					Population cyclone of the country	Population of the area exposed to cyclone
1.	November 1,	1876	2,00,00,000	30,00,000	2,00,000 `	1.00 6.667
2.	November 12,	1970	7,00,00,000	50,00,000	3,00,000	0.429 6.00
3.	April 29,	1991	11,00,00,000	80,00,000	1,38,000	0.125 1.725
4.	November 15,	2007	14,00,00,000	-----	4,000	-----
			(approx.)		(approx.)	

Source: Shreshtha and DMB.

Figure 1: Maps of Bangladesh showing cyclone-prone areas and some historic cyclone tracks



Cyclone Shelter Programme

In the 1960s, a programme for the construction of 2000 units of two-storeyed buildings as Coastal Community Centres and single-storeyed buildings as Sub-Coastal Community Centres was undertaken by the then government. At normal times these would serve as Union Parishad (Union Council) offices, and be used as cyclone shelters, when necessary. This programme was reported to have been abandoned after the construction of 100 units (BUETBIDS 1993).

The devastating cyclone of 1970, which resulted in the loss of some 300,000 lives lead to the construction of designated cyclone-shelters for the first time. During the period 1972–79, some 238 shelters were constructed in various locations in the coastal belt of Bangladesh. Intentional Development Association, IDA funded this Coastal Area Rehabilitation and Cyclone Protection Project and the Public Works Department (PWD) under the Ministry of Works was responsible for the design and supervision of the project.

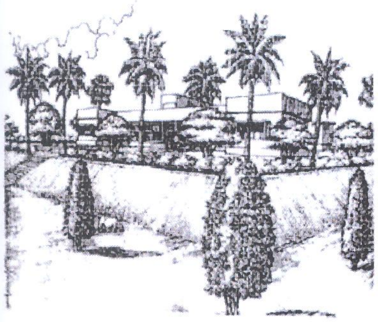
Following the 1985 cyclone, the Bangladesh Red Crescent Society (BDRCS), with assistance from the League of Red Cross, undertook an ambitious project of building 500 shelters in five years starting from 1986. However, they could not achieve their target because of financial constraints. Nevertheless, by the year 1990, some 62 shelters were constructed in 16 different districts along the coast. Later, many organizations adopted the BDRCS typology for construction of cyclone shelters.

The catastrophic cyclone of April 29-30, as many as 1991 again demonstrated the inadequacy of the number of cyclone shelters in Bangladesh. 138,000 deaths were reported officially while the actual death toll was said to be far more. Following this incidence, many governmental and non-government organizations started working on construction of more cyclone shelters in the cyclone-hit coastal areas. The government, under the aegis of the United Nations Development Programme and the World Bank, undertook a holistic approach to study the need for construction of multipurpose cyclone shelters in the coastal areas of Bangladesh. An international task force was formed to undertake the project, entitled Multipurpose Cyclone Shelter Programme (MCSP). The major objective of the study was to formulate a framework for the establishment of a cyclone shelter network in the coastal areas which would define the basic concept, strategy and location pattern to be followed in all future construction. As part of the study, all types of existing shelters were required with the aim of finding suitability for specific locations.

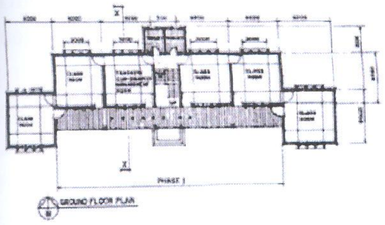
After an extensive study considering almost all relevant aspects, the MCSP estimated the need for a total of 2,500 cyclone shelters in the coastal areas, considering the demand in the year 2002 for a projected population of 4.7 million. Of the 2,500 proposed shelters, 76% were to be located where there were existing primary and secondary schools and *madrasas,* and the rest built to house new primary schools.

There are some 2,000 cyclone shelters in the coastal areas of Bangladesh at present; however, considering the increase in population over last couple of years and future growth, it is now estimated that another 2,000 cyclone shelters would be required to ensure the safety of the coastal population.

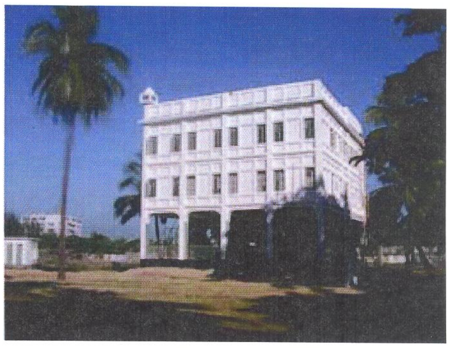
Figure 2: Cyclone Shelters (with and without *killa*)



Perspective of Shelter on Killa



Plan of Shelter on Killa



Taking Shelter during Cyclones

In a study conducted by the Research and Evaluation Division of BRAC and the Post Graduate Programmes in Disaster Management of BRAC University on the evacuation of households to cyclone shelters during the false tsunami warning of 12 September 2007, it was found that about 70% of the households in the coastal and offshore islands went to the cyclone shelters. About 60% of the male members of the households did not evacuate, their average age was around 25. Of these, 45% stated that the reason for as not wanting to leave their 4 household assets unprotected and 15% wanted to stay back with other family members. Interestingly, only 9% thought it was a false warning (BRAC 2007). This suggests that while there is considerable faith in the warning system, there is great reluctance to leave behind assets. Those who went to the cyclone shelters complained of a host of problems in terms of facilities and amenities. Among them are: lack of sleeping arrangements and food, overcrowded conditions, scarcity of drinking water, inadequate arrangement for women, lack of security, etc. Only 3% said that they did not face any problems. The problems are quite understandable since the design of cyclone shelters allows 2- 4 square feet per person for a stay period of 12 hours.

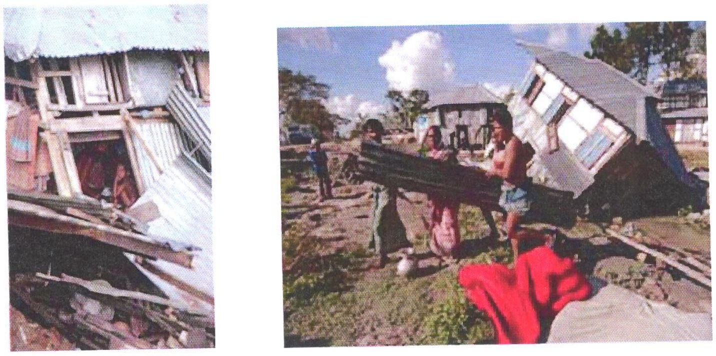
Another problem identified in the initial studies for the cyclone shelter was that people did not want to leave their livestock behind. For this it was proposed that shelters be built on raised ground or 'killas' so that the livestock can be kept there for protection against the storm surge that accompanies a cyclone. These 'killas' have to be sufficiently large to accommodate the footprint of the shelter as well as to have enough free space for animals. One alternative would be to design a shelter on stilts on high ground. The land for cyclone shelters in most is given by the community cases and therefore tends to be in remote locations where there is not much productive use for it at normal times.

Destruction of Homes and Homesteads

Almost all of the houses in the rural coastal areas are non-engineered, made from basic materials, and of low structural strength. The materials are bamboo, timber, thatch, corrugated iron (CI) sheets, etc. Joinery is of rope, metal wire and nails. CI sheet roofs tend to blow away and are a cause for injury. In the areas hit by the cyclone SIDR on 15 November 2007, the typical house construction did not have foundations, i.e. the house frame is embedded on a mud plinth just enough to keep it standing. Joinery is weak and gives way to winds even weaker than those generated by SIDR.

A lot of deaths were caused by falling trees. It was observed that most of the trees that were uprooted were of species not originally belonging to the region, whereas local varieties survived.

Figure 3: Houses destroyed by SIDR



Source: The Daily Star; The Daily prothom Alo

Strengthening a house

There is evidence to suggest that some indigenous knowledge regarding the construction of strong houses does exist. But, it are not practised, mainly due to economic constraints. Also, this knowledge is based on common sense and experience and does not have an engineering basis. It may therefore be possible to come to an amalgamation of indigenous and engineering knowledge supported by economic parameters where reasonably stronger houses can be built.

A case in this point is a small project sponsored by the International Union for the Conservation of Nature (IUCN) in the cyclone-prone Noakhali district of Bangladesh (IUCNBRAC University 2007). Working with a team of architects, landscape architects, engineers, masons and carpenters, the local community exchanged knowledge about house construction. With the introduction of some simple measures, such as cross-bracing of the frame, stronger anchoring of it to the ground, strengthening of the rafters of the roof frame, etc. a few houses were constructed as test cases. Basic engineering calculations suggest that they would be able to withstand moderate cyclones and suffer less damage in severe ones.

Along with the house construction, site planning issues were also considered, as was landscaping. Trees and plants local to the area were planted, some of which offer protection from high winds to the homestead as a whole.

The cost of constructing such houses was more than regular but not substantially so. Furthermore, the homeowners were willing contributors in this effort.

Figure 4: Reinforced frame of a house in Noakhali and the completed house

Cost Comparisons

The cost of building a cyclone shelter is around US$ 215,000. On shelter can accommodate 1800 people during a cyclone. This has to necessarily be a reinforced concrete frame construction with brick masonry infill. Materials have to be transported to the site and require technical supervision during construction. There is also a certain degree of maintenance required, which is not always carried out. Many cyclone shelters built in the 1990s have fallen into disuse because of little or no maintenance.

To build a stronger house in Noakhali, it cost about US $850, part of which was contributed by the owners. The construction was entirely of local materials and was carried out by local masons and carpenters who were given some training. In the event of a cyclone, the house could accommodate up to 10 people.

Therefore, at the cost of one cyclone shelter, about 250 such houses could be built. Given that the construction had very basic strengthening measures and that the design needs to be improved, it can be assumed that it would cost a little more. Assuming an increased cost of US $1000 per house, there could still be more than 200 houses built for the cost of one cyclone shelter. It may not be as strong as a cyclone shelter, but it would certainly much stronger than before.

Alternatives for Sustained Development

As mentioned earlier, cyclones not only cause massive destruction, they also set back the development process. Whatever progress people had made in their lives is compromised, a major element in which is the destruction of the homestead.

Having a secure home is a prerequisite for a household which is trying to make its life better. A good and strong house also gives a sense of security and makes possible other activities towards progress. The overall development of a community is definitely related to its housing condition. In cases where they are susceptible to destruction, the houses' ability to withstand the forces is important. Even if they are damaged, the ease with which they can be rebuilt is important to improve resilience.

For a developing country like Bangladesh, vulnerable to natural disasters, it is not only important to take measures to protect lives but also to create resilient communities who can quickly absorb the destruction and get back on their feet.

The northern parts of Bangladesh are generally not vulnerable to cyclones do not need shelters. These areas are comparatively less developed than the rest of the country and are therefore deprived of the facilities that cyclone shelters provide in the coastal areas at normal times, causing a further imbalance in development of the country as a whole.

While cyclone shelters save lives and provide a place to live in for a few days afterwards, the people eventually have to go back to destruction. Cyclone SIDR completely destroyed 563,877 houses and partially damaged 955,065 others, making 8,923,259 people homeless (DMB). Many agencies are now building houses for the affected people and not all of them have been designed to withstand cyclones. In the event of another cyclone, the results of all these efforts may be lost.

For sustained development of the affected communities, effort should be directed towards making their homes stronger. If each house were to act as a cyclone shelter, it would be an ideal scenario. But that would be too expensive to achieve. If not all houses, but some of the bigger houses were to serve as small-scale community cyclone shelters, people would not have to travel far to reach them nor would they have to leave their belongings at home. This would further ensure proper maintenance since they would be under regular use as houses, while designated cyclone shelters most often lack proper maintenance and consequently become unusable.

Stronger houses would also mean less rebuilding afterwards, therefore there would be less interruption in the development process.

If the whole concept of the cyclone shelter is deconstructed and looked at with smaller catchments in mind, the cyclone shelter could become a part of the daily lives of the people. One would then not have to 'go' to a cyclone shelter but be part of it.

Conclusion

Cyclone shelters are needed because they are stronger and can protect people, whereas not all houses can. People cannot stay in cyclone shelters for more than a few days after which they have no house to go back to.

They can come back to a house which is still standing or has suffered little damage, repairable within means and life does not have to start all over again.

Along with cyclone shelters that are more meaningful to the community, with better facilities, and within easy reach, attempts can also be made to build stronger houses. It has been seen that this may not require a lot of money. Rather the allocation for cyclone shelters can be revised and a balance between them and stronger house construction sought. There can be communal 'killas' or high ground for the protection of livestock Protection from natural disasters should also take into account protection of the processes of development. For a country to sustain development, it is vitally important to make the housing stock structurally stronger. Comprehensive rebuilding following a cyclone can be an opportunity to do so.

References

Ali, A. (1999) *Ghurnijhar* (Cyclone), Bangla Academy, Dhaka.

Bangladesh Meteorological Department (2005) *List of Major Cyclonic Storms from 1960 to 2004 which caused huge loss of lives and properties in Bangladesh*, BMD, Dhaka (unpublished document).

BRAC (2007) Measuring the Impact of False Tsunami Warnings in Bangladesh, Research and Evaluation Division, BRAC, DHAKA (unpublished document).

BUET-BIDS (1993) *Multipurpose Cyclone Shelter Programme*, Government of Bangladesh and UNDP/World Bank.

Disaster Management Bureau (DMB), Ministry of Food and Disaster Management, Government of Bangladesh. http://www.dmb.gov.bd/

IUCN-BRAC University (2007) *Improved Design and Construction of Rural Housing in Noakhali, Bangladesh*, Dhaka.

Shreshtha, M.L. (ed) (1998) *The Impact of Tropical Cyclones on the Coastal Regions of SAARC Countries and Their Influence in the Region.* SAARC Meteorological Research Centre, Dhaka.

An Overview of Urban Risk of South Asia: Issues, Approaches and Thoughts

Rajib Shaw

Abstract

Urban risk is complex, and it is increasing, especially in the developing South Asian nations. Disaster risk issues in urban areas are linked to environmental and developmental needs of urban management. Experiences show that these urban management and environmental issues can be considered as critical entry points of urban risk reduction, especially for facilitating collective actions at community levels. It is easier to address a mega-city problem, when it is disintegrated into local levels. For successful urban risk reduction, it is required to break the disciplinary boundaries, go beyond the conventional ideas of risk reduction, and find innovative solutions through incorporation of local and regional levels.

Introduction: Urban Risk and Challenges

Urbanization is a complex dynamic process playing out over multiple scales of space and time. It is both a social phenomenon and physical transformation of landscapes that is now clearly at the forefront of defining current and future trends of development. This phenomenon is now being accelerated by the rapid globalization and expansion of local economies, especially in Asia. Thus, vulnerability caused due to urbanization is also increasing, which is reflected in different major disaster in recent times in urban areas. As engines of economic growth, cities offer opportunities for sustainability, but at the same time they also present many challenges, such as poverty, pollution and disease. Therefore, without focusing on the urban areas, it is difficult to reduce the impacts of poverty and disasters. Urbanization effects should be considered in relation to the insufficient adaptation of the infrastructure to the phenomenon of rapid economic activities.

Urban landscapes represent probably the most complex mosaic of land cover and multiple land uses of any landscape and as such provide important large-scale probing experiments of the effects of global change on ecosystems (e.g. global warming and increased nitrogen deposition). Urbanization and urban landscapes have recently been identified by the Millennium Ecosystem Assessment as focus areas where significant knowledge gaps exist. Due to its high stakes in built environment, the urban areas are prone to both geological hazards like earthquake and landslides, as well as hydro-meteorological disasters like typhoons (cyclone) and flooding.

The world is steadily becoming more urban (Boulle et al., 1997), although urbanization rates vary across the world. The level of urbanization is far higher in countries like the USA and UK as compared to China, India or Vietnam, but the annual 'urbanization rate' is much slower. Many consider urbanization as an irreversible process and thus urban vulnerability becomes a reality (Quarantelli 2003). Virtually all of the world's future population growth is predicted to take place in cities and their urban landscapes — the UN estimates a global increase from the 2.9 billion urban residents from the 1990s to a staggering 5.0 billion by 2030. By 2030, 1 in 4 persons will live in a city of 500,000 people; and 1 in 10 persons will live in a city of 10 million population.

In the Asian context, the combinations of economic and environmental pressures increasingly keep forcing the rural poor to search for alternative living in nearby towns or cities. Supply of developed and safe land is always short of demand in urban areas and often the result is mushrooming of informal settlements, slums, and squatters through encroachment on public and private land. Cities' commercial, industrial and residential locations prove to be livelihood center for the urban poor, who are left with no choice but to settle on dangerous locations subject to natural or man-made hazards. The pace of urbanization in the developing world is led by Asia. The high population density in Asian cities is creating additional vulnerability, as reflected in the informal settlements. In the Asian mega cities like Manila, Mumbai and Jakarta, almost 25 to 30% of the population lives in these informal settlements, and are exposed to different types of disasters like floods and typhoons. Population density, combined with recent effects of climate change is creating new risk in the urban areas of Asia. Urbanization is increasingly located in the developing countries: in the 1970s, 50% of urban residents lived in developing countries, which increased to 66% in the 1990s, and is projected to be 80% by 2020. A majority of Asia's urban growth will be in seven developing countries: Bangladesh, China, India, Indonesia, Pakistan, the Philippines and Vietnam.

Urban hazards vary considerably as compared to their rural counterparts. They are not only represented by one-off events like earthquakes or cyclones but also get exaggerated due to hindrances in accessing basic services or public health services. The pace of urbanization in the developing world is led by Asia.

In this context, this paper is not a highly scholarly publication with original data analysis. This paper also does not deal with the disaster statistics or history (events) in cities. Rather, it attempts to highlight some of the issues and challenges of urban risk, especially focusing on the South Asian region. The paper also suggests some non-conventional approaches to urban risk reduction, and tries to argue that urban risk reduction should be linked to larger land use and eco-system management.

Problem Setting: Focus on Resilience and Urban Future

The idea of resilience suggests a proactive stance towards risk. The local effects of the global environmental change and economic, political and cultural globalization are adding greater uncertainty to development planning in general, and more specifically to the prediction and management of natural hazard and human vulnerability. In the 1970s, people were focusing on urbanization and in the 1980s on human development and sustainable development. From the 1990s onward, the focus has been changed to more sustainable cities as the concept of urbanization. Resilient cities have two specific implications. First, the concept of sustainable cities focuses on the balanced approach of urban ecosystem, where there should be an equilibrium of natural and built environment. The other aspects of resilience should be reflected in the dynamic changes of risk. While risk is changing over time, it is important that the resilience should also evolve over time to reduce the impacts of disasters.

An example of a threshold-breaching event, which threatened to disrupt the stability of an urban system, comes from Metro Manila. Here, a minor earthquake put one small section of the track of the city's 15-km light rail system out of alignment. This minor failure caused the system to be closed for a number of days and reduced its overall capacity for several months, putting more traffic on the road network. The other example is from the Loma Preta earthquake in the USA, where collapse of Oakland expressway and closure of the San Francisco Bay Bridge did not lead to disruption of the Bay area's transport system due to a high degree of redundancy in the metropolitan transport network. These examples highlight one way through which systems can be designed to have resiliency to unanticipated change such as natural disaster shocks. Similar examples are often observed in different parts of south Asian cities like Mumbai, Karachi and/or Dhaka.

Recent natural disasters (e.g. Hurricane Katrina, Indian Ocean Tsunami, Kashmir and Wenchuan Earthquakes) have highlighted the need for urban systems to cope with unexpected shocks. While there is an emerging research focus on sustainable cities (urban landscapes), there remains a poor scientific technical understanding of the processes and factors that make some cities vulnerable to shocks and others resilient. This may be due in part to the fragmented nature of urban science and policy. It is required to develop the cities as complex adaptive social-ecological systems, developing ways of assessing urban vulnerability and identifying principles and opportunities for building resilience in urban systems. Building resilience is particularly important in areas such as coastlines, cities, agricultural land and industrial zones which are often the most impacted by humans. It is the same area that people value highly, both economically and aesthetically, and upon which society often depends.

While there has been a great deal of attention on the increase of mega-cities, a more important, but less discussed aspect of urbanization had been the phenomenal growth of smaller cities with population less than 0.5 million, especially in the south Asian region. The growth of medium-sized cities of population between 1 and 1.5 million, together with the associated growth of urban–rural linkages through flows of goods, services, people, capital, and information are observed in the developing and developed countries. Thus the global future population distribution is likely to be a continuum of urban space of varying densities linking mega-cities and rural populations with population distributed according to human activities, resource availability and cultural preferences.

South Asia: Major Urban Challenges

South Asia is experiencing a major demographic transition. During the last fifty years, India's total population more than doubled, while the urban population grew by more than five times. In 1996, the urban population in Bangladesh was 23 million. By 2020, it will increase to 58 million. The urban population in Nepal, during the same period, will grow from 2.6 million to 7.7 million, and in Sri Lanka it will double to more than 8 million.

South Asia's expanding urban areas face a complex set of challenges that must be overcome if they are to fulfill their potential as hubs for economic, social and political innovation and leadership. The challenges are particularly great because of the speed at which their populations are growing. The pressures caused by geometric population growth continue to create huge environmental, health and infrastructural problems. This can, in turn, lead to social unrest. Local governments are well positioned not only to best understand the problems of their municipalities but to take the steps needed to solve them.

Urban Growth and Poverty: Serious poverty has accompanied urbanization. It is as much a result of rural-to-urban migration as it is the inability of the formal economy's capacity to keep pace with the growing population of unskilled labour. In many Indian states with large shares of urban population, for example, Maharashtra (38 %), Gujarat (34 %), and Tamil Nadu (34 %), the share of urban population below the poverty line is greater than in rural areas. According to the World Bank, 50 % of Indian urban dwellers live in slums and squatter settlements and these areas grow at twice the rate of urban areas. Nepal and Sri Lanka urban dwellers seem to be doing slightly better with 19% and 28% of their urban populations falling below the poverty line.

Poor entrepreneurs in the urban informal sector are extremely vulnerable to macroeconomic changes, more so than their rural counterparts as they tend to be almost completely dependent on the cash economy for production inputs. An increase in domestic prices for a poor entrepreneur with little or no savings can be devastating. It is possible that they may no longer be able to afford the inputs they need for production or to keep themselves healthy.

Water, Sanitation and Solid Waste Management: Only 50% of the urban population in Bangladesh has any access to safe water. Nepali urbanites do slightly better as 60% has access to clean water. Although the majority of urban residents in India and Sri Lanka have access to some water supply, it is not uncommon for piped water supply to be available sporadically. Further, access to potable water often means the existence of one or two standpipes in a slum area. The pipes must provide services to a thousand or more people and rarely run for more than a few hours a day. Moreover, the actual quality of the water changes considerably from season to season. Sewage service coverage is well below that for water supply. Less than half the urban population in India has access to adequate toilet facilities, and sewage treatment is virtually nonexistent, creating one of India's most serious environmental problems surface and ground water contamination. The situation is virtually the same in Nepal, Bangladesh and Sri Lanka.

South Asian cities are drowning in their own waste. In New Delhi and Mumbai, more than 1.5 tonnes of garbage is left rotting on the streets or in improperly maintained pits every day. Dhaka is only able to collect about 50% of its waste each day. Further, since the city of Dhaka is growing so quickly, dumpsites must be located further from the Dhaka centre, making it more costly to haul the garbage out of the city. Kathmandu faces similar challenges. The piles of garbage that clog street drains in South Asian cities contribute to floods during the rainy season, which seriously jeopardize the health of nearby residents.

Urban Health: The health of the urban poor is often worse than that of their rural counterparts. Child mortality rates among populations in the lowest income quintiles, for example, are higher in urban areas than in rural areas. Children from poor families who live in urban areas are also more likely to be underweight and experience stunted growth than their rural counterparts. Air pollution is another important health challenge of urban residents in South Asia. In Delhi, one out of ten school children has asthma. Premature deaths due to air pollution in Indian cities were estimated to have increased by 30% between 1992 and 1995. High levels of lead pollution in the air lead to stunted growth in children as well as hyperactivity and brain damage.

Disaster Perspective of Selected South Asian Cities

Urbanization in South Asia is variable, with many large cities and megacities, but also with substantial numbers of intermediate and small settlements. With the exception of Afghanistan, strong states with good administrative capacity have led disaster management. During recent years, civil society has gained its strength, and in India, in particular, partnership with the state has built resilience. Political tensions in the region and within countries constrain risk reduction capacity. South Asian cities, like other Asian or world cities in developing countries, are fought with several disaster and environment-related problems, like: growth and diversity of urban areas, environmental change and poverty, modification of hazard environment, impacts of climate change, vulnerability of urban slums, building control and land use planning issues, etc.

Mumbai, India:

Mumbai Metropolitan Region of 18 million residents is the world's fifth most populous metropolitan region. Mumbai is India's entertainment and financial capital, yet also the city with the largest slums. It contributes 40% of the national income tax and 60 % of customs duty. In purchasing power parity (PPP), Mumbai is estimated to have a US$143 billion economy. Per capita income is US $12,070, which is almost three times the national average. Traffic congestion, loss of wetlands, and flooding as well as the critical housing issues and slums are key challenges facing Mumbai. Some projections state that Mumbai could overtake Tokyo as the world's largest city by 2050. Mumbai sits on a seismically active zone owing to the presence of three fault lines in the vicinity. The area is classified as a Zone III region, which means an earthquake of up to magnitude 6.5 on the Richter-scale may be experienced. Mumbai lies over more than ten seismic fault lines. The coastal plain to the east of Mumbai is prone to earthquakes of even higher intensity, up to 7.5 on the Richter scale (Mumbai pages, 1998). A recent global screening study by OECD (2007) to rank port cities with high exposure and vulnerability to climate extremes ranked Mumbai top (in terms of exposed population) among the studied 136 cities having more than a million population. Seasonal flooding during the monsoon became a regular feature in many areas of Mumbai. This disrupts many important civic services and infrastructure in addition to paralyzing daily living of a significant population. The incessant and torrential rains in the afternoon of 26 July 2005, amounting to 94.4 cm during a span of only 14 hours not only caused a deluge in Mumbai, but was also a horrifying memory for its citizens. The Indian Institute of Tropical Meteorology noted that from the year 1876 onwards, incidences of rain in a single day are inconsistently increasing. Climate change experts expressed that such catastrophic flooding events will be more frequent and will also accompany killer winds and towering tides in future.

Urban risk in Mumbai encompasses complex dimensions. Widely acknowledged is the fact that urban hazards and vulnerabilities are greatly interconnected whereas there are many other factors, which contribute significantly as 'risk multipliers'. Urban hazards in Mumbai vary considerably compared to its counterparts (other mega cities) in developed countries. They are not only represented by one-off events like floods or cyclones but also get exaggerated due to environmental, social or political stresses or their combination. To understand Mumbai's vulnerabilities, it may be appropriate to deconstruct the underlying factors making Mumbai more critical than in any other built environment. Some of these factors are: population growth, population density, urban mal-planning, reclamation of low-lying areas, encroachment through informal settlements, poor civic services, poor civic sense, lack of community-based approaches, etc.

Among all these problems, there has been an innovative approach in community-based activities. The Advance Locality Management (ALM) is a unique example of community–government partnership existing in Mumbai since the year 1996. This movement was started by motivated citizens who were concerned with neighbourhood problems and resultantly growing localized risks. These citizens have encouraged and convinced a majority of the locality (neighborhood) to coordinate in improvement of quality of life in surroundings. The collective efforts initially grew fast in the areas facing high environmental degradation, including medium and low-income residential settlements. Being a volunteer initiative, people themselves contributed small amounts to upkeep the functioning of ALM. Looking at the greater advantages of this growing movement, MCGM's Solid Waste Management Department (SWM) came forward to partner this initiative. The 'Good urban governance campaign', started as a joint project between the Government of India and MCGM, in collaboration with United Nations Center for Human Settlements (UNCHS) further formalized and boosted this initiative. Finally, since 1998, ALM is a community-based approach for effective management of civic services at the grass roots level. Eventually, in many cases, NGOs/CBOs also joined in and thus, this became community-civic society-local government cooperation for better managing civic services at the local level.

A recent study by Surjan (2008)10 shows that the areas which had these ALM programmes, were effective in rapid response to the catastrophic flood of 2005. Through specific analysis of Mumbai and Puri, the study suggested that the key of urban disaster reduction in community practices in the neighborhood and community levels.

Dhaka, Bangladesh:

Dhaka is one of the most populated mega cities in the world with a total population of over 12 million and an area of 276 sq km Dhaka City Corporation (DCC). The city is situated at the centre of the country and surrounded by a river system comprising Buriganga, Balu, Turag and Shitalakhya. The city has a long history from the pre-Mughal, Mughal to Bangladesh period. The growth of the city Dhaka basically started from the current extreme south and along Buriganga River and then it expanded earlier to the West (Hazaribagh) and the East (Gandaria) and later to the North (Mirpur). However, in last few decades the city has experienced huge population growth and rapid industrial, commercial, business, residential and infrastructure development, which have significantly expanded the physical feature of Dhaka all around. Still many of the development activities are taking place in an informal way within Dhaka City Corporation (DCC) area, the main part of the mega city.

A number of environmental issues have been discussed in several environment-related reports and documents. The major environmental issues of Dhaka include: air pollution, surface water contamination, groundwater declination, solid waste management, sewage management, noise hazards, land use violation, water logging, drainage congestion, transport congestion, slums and squatters, as mentioned earlier. These problems are aggravated through disaster-related problems related to flooding. The recurring floods disrupt and damage governmental, non-government and personal property, road-transport system, drainage system, water supply system and other utility services network in Dhaka city. It has been reported that at least 170 km2 areas of the city is below 6 metres mean sea level. The city experienced heavy floods at least 9 times during 1954 to 2004 causing huge damage and disruption to human lives and livelihoods.

Experiences indicate that 100% of eastern Dhaka was submerged by the floods in 1998 and 2004 while western Dhaka was nearly 75% affected in the same years respectively. The Dhaka Integrated Flood Protection Project (DIFPP), was implemented by BWDB and funded by the Asian Development Bank (ADB) and GoB. Under this project, a flood protection embankment cum bypass road was constructed in the western part of Dhaka during 1992–1997. In fact, after the flood tragedy in 1988, the ADB has played an active role assisting the GoB to implement the Flood Action Plan (FAP) and for the better management of existing flood control and drainage infrastructure. The ADB supported $95.4 million to GOB for Flood Damage Rehabilitation Project. The government has also taken a decision to construct an eastern bypass, which may protect the city from being further affected by flood.

While the local communities have innovative approaches to cope with flooding, it is also required to establish proper institutional systems, and a legal support system for local and national governments. Another important stakeholder in Dhaka is its strength of civil society, which works hand-in-hand with the government sectors for service delivery.

Kathmandu, Nepal:

Nepal's urban population is accounted to be around 15% a tremendous increment in comparison to its urban population of 30% some 50 years ago. The rapid increase in urban population in the last 50 years has manifested in unplanned and haphazard urban growth. Urbanization shows the trend of shift in employment from the agricultural sector to non-agricultural sector; however, in Nepal despite the increase in urban population, the economy is still dictated by the agricultural sector. Urbanization is creating and adding new risk to the existing risk of natural hazards like earthquake, landslide, flooding. Building a culture of safety is the key to building resilience of communities to disaster and involvement of the community in managing risk is instrumental in reducing the adverse impact of disasters. Public awareness in dealing with disasters and responding to emergency situations can save many lives.

The increase in urban population can be accounted for by three factors: "(i) Defining and redefining of urban areas by the government; (ii) Increase in the size of municipalities and merging of neighbouring Village Development Committees in the municipalities; and (iii) Migration of population in the search of jobs and opportunity." Therefore, the sudden increase in urban population in the year 1980-90 is because of the government's decision to raise the status of some rural (village) areas to urban (municipal) areas. The increment trend, therefore, does not directly depict the change in economic activity or development pattern. Furthermore, urban areas do not necessarily have urban facilities and infrastructures as villages were converted to urban areas only on the basis of their population rather than their qualification to meet urban standards. However, the rise in armed conflict in remote areas in the later part of 1990s has been one of the leading factors in increase in urban population. The influx has been more in Kathmandu valley than anywhere else.

As part of the Kathmandu Valley Earthquake Risk Management Project (KVERMP), The Kathmandu Valley Earthquake Management Action Plan, 1998 was prepared by the National Society for Earthquake Technology (NSET) Nepal and Geo-Hazards International, USA. Based upon the study, NSET formulated a strategy to be implemented in order to reduce the earthquake disaster risk in Kathmandu Valley. The strategies included: building support for the Plan and Earthquake Risk Management in general and supporting individual Initiatives and revising and keeping the Plan up to date. NSET has been actively involved in the School Earthquake Safety Programme (SESP), mason training, public awareness creating and training to engineers and architects. The NSET SESP programme has been tremendously successful because of the fact that the effect trickles down to the communities. Currently a regional course on Hospital Preparedness for Emergencies (HOPE) is being conducted in Bangladesh, India, Nepal and the Philippines with the assistance of US office of Foreign Disaster Assistance (OFDA). NSET has also been instrumental in carrying the message to the community at risk and many ward-level communities now actively carry out training and drill regularly.

The government of Nepal started preparing a seismic hazard map of Nepal and developed building code, which was implemented and made mandatory only in 2004. It is now mandatory that new structures in municipal areas are constructed with seismic guidelines and code provision with engineers' consent. The agenda of disaster risk management has become also a priority for the government. Realizing the challenge ahead and immediate action required, the government has laid emphasis on disaster management in Tenth National Plan (2002–2007). The main objective formulated in the Tenth National Plan is "to contribute substantially to make the public life secure by managing the natural and manmade disaster systematically and effectively and by making the development and construction related programs in the country sustainable, reliable, and highly gainful."

Emerging Issues and Challenges

To understand the urban risk and its impacts on local environment, it may be appropriate to deconstruct the underlying factors making urban risk more critical than in any other built environment. These factors may be summarized as follows (Surjan and Shaw, in press):

Urban population: By 2050, the world population is expected to grow by 3 billion people. By 2030, 1 in 4 persons will live in a city of 500,000 people; and 1 in 10 persons will live in a city of 10 million population. Data shows that some 1.5 billion extra people will live in urban areas of various sizes during the period 1994 to 2025. Urban areas are characterized by high density population, which results to higher exposures. A combination of a high vulnerability and exposure causes higher degree of urban risk.

Urban setting and urban planning: The tendency of cities to be located and expanded on river banks or coastal areas for economic reasons makes them more vulnerable to disasters. A number of densely populated areas in the world are in river deltas, coastal areas, seismically active zones, etc. In fact, population started growing in productive floodplains and coastal zones, fertile volcanic slopes, etc. as these offered the most lucrative place on the earth to settle in. The major cities in Asia are either located in the floodplain or in the coastal areas. A recent study shows that nations with the largest urban population in the Low Elevation Coastal Zone (LECZ) are China, India and Japan.

Urban structures: In most of the countries in Asia, the cities have poor infrastructures, with specific problems in water and electricity supply, sanitation and the drainage system. Moreover, the vital infrastructures in many Asian cities are of poor quality, which is evident in several recent disasters in the earthquake of 2005 in northern Pakistan, 2008 in the Wenchuan earthquake in China.

Compact urban forms: Even in large urban areas, population density varies and determines the severity concentration in specific pockets of the city. Moreover, day-time and night-time density varies significantly. In downtown or in commercial and office areas, day-time population concentration is very high on working days. In the case of Mumbai, although average city density is 27,000 people per sq km for the city, some areas have a density as astronomically high as 114,001 people per sq km.

Urban dependence on rural areas: Urbanization has its origin from the time industrialization gradually emerged in different parts of the world. The environmental impact of the city on its adjoining areas kept growing resulting in larger 'environmental footprint' than ever. The ecological footprint of Tokyo is five times of Japan's land area.

Urban primacy: Many cites including Asian megacities are increasingly becoming the concentration of a particular country's major functions including physical, economic, social, political and cultural assets, which are being exposed to different types of disaster risks. For example, a hazardous event in a mega city like Manila, which is the hub of political, administrative, and economic activities of the Philippines, may lead to complete disruption in the country as a whole. This makes Manila more as vulnerable compared to other cities. A major earthquake striking in a city like Tokyo could have a global impact, especially damaging the economy.

Urban informal settlements: The form and structure of informal settlements can vary from one urban context to another; however, they remain 'illegal constructions'. In the urban megacities in Asia, like Manila, Mumbai and Jakarta, almost 25 to 30% of the population lives in these informal settlements, and is exposed to different types of disasters, like flood and typhoons.

Urban economic imbalances: As discussed earlier, the poor tend to live in an unsafe environment. They live in most vulnerable housing, in absence of or degraded environmental conditions and hazard-prone locations, with very poor personal assets to help themselves even in minor emergencies. The socio-economic opportunities provided by Asian cities enable people from a wide range of income brackets to interact and live, but also create vulnerabilities resulting from lack of access to urban goods and services.

Urban services: The bigger the city, the more complex is the infrastructure service systems it will have. In developed countries, urban services generally consist of a complicated network spread across the city and are dependent on high-energy inputs and require sophisticated technology to fix problems. Dependency on infrastructure in developed world is much higher as compared to developing nations. The intricate web of services makes it difficult and expensive to repair but needs attention during disasters. Provision of water supply, sanitation, become more crucial in disaster-struck regions.

Urban environment: Urbanization itself, in most cases, has proved detrimental to local and regional environment. Once ecologically fragile areas now have been swallowed by expanding cities resulting in loss of biodiversity, a disrupted balance of eco-systems and threat of extinction to many living organisms. In addition to this, ground subsidence, underground excavations, surface and groundwater contamination, water table reduction, are some of the counter-products of urbanization. In the city of Bangkok, the land subsidence is a crucial issue. In some places, the subsidence rate is almost 25 to 30 cm per year, which is caused due to over-exploitation of underground water. The urban eco-system is characterized by interplay of the built, natural and socio-economic environment, which separately and collectively generate much of the risk that cities face today.

Urban management: Urbanization as a result of the complex socio-economic process, poses a daunting task of managing cities. A heterogeneous societal structure, an opportunist political system, lack of administrative capacities, very poor resource-generation capabilities, archaic urban planning and development legislation, etc. contribute collectively in making the city more vulnerable to poor management and disaster risks. Appropriate governance and a decision-making system are the core of risk reduction in urban areas. Special focus should be given to vital infrastructures like schools, hospitals and key public buildings.

Non-conventional Approaches to Urban Risk Reduction

Srinivas et al. (in press) presented a non-conventional approach of urban risk reduction framework. It has a threefold objective: (a) to develop awareness and educate on issues related to urban risk reduction; (b) to assist in policy and programme development; and (c) to facilitate monitoring and evaluation. For effective development and implementation of the framework, a broad coalition of actors and stakeholders in the urban arena, includeing government agencies, planners and planning bodies, NGOs, donor agencies, community groups, academics, etc. need to come together. These can be highlighted as follows:

- Urban risk reduction poses a challenge for effective distribution and management of global resources.
- For effective urban risk reduction, there is a need to strike a balance between natural and built environments and between ecological and economic objectives.
- There is a need to develop a structure of goals/visions and a methodology to achieve urban risk reduction in order to identify the action that has to be taken.
- Steps need to be taken that are relevant in the short-term in order to gain wider acceptability, but keeping long-term goals in mind.
- Access, sharing and dissemination of information have to be a priority to achieve greater understanding of the issues involved.
- Collaborative efforts in 'knowledge transfer' at the community to community level and city to city level have to be encouraged, particularly between developed and developing cities.
- There is a need to understand and enact the concept of sustainable development and sustainable living, in all its varied definitions, to achieve urban risk reduction objectives.
- Development of new technologies that are clean, green, and practical has to be encouraged and exchanged between national and city/local governments to combat environmental problems.

While the contents of the framework provide a broad vision, its applicability lies in establishing policies, programmes and projects that operationalize the objectives in the long term, and set up mechanisms to monitor and evaluate at every stage.

Conclusion: the Way Ahead

In conclusion, there are innovative ways of addressing the urban risk issues, which go beyond the traditional and conventional ways of risk reduction. In the complex urban scenario, it is of utmost importance that new innovative ways are adopted to provide implementable solutions to this ever-increasing issue. The following are some of the synoptic thoughts which can be starting points or entry points for providing solutions to the urban risk reduction.

Urban rural linkages: Two aspects on urban–rural linkages should be emphasized here. First, the population transition between urban and rural areas. Much of the urban population comes from the rural areas as migrants. Their roots are very much in the neighbouring rural areas. Thus, any urban risk reduction plan should look at this aspect both in terms of physical, social, economic vulnerability. The other aspect is the dependency of the urban system on its rural surroundings. The urban ecological footprint has a larger connotation of inter-linkages with the rural areas, in terms of food, water and energy. Thus, while doing resource planning for the urban risk reduction, this dependency issue should be highlighted, and can be a possible vehicle to redistribute urban risk in the larger areas, and take appropriate risk reduction measures.

The Neighbourhood-level approach: It is often argued that managing urban risk in megacities is a challenge. Indeed, the megacity problems have larger dimensions and need significant amount of resources. However, when these problems are disintegrated into smaller levels, like ward, community or neighbourhood, then specific grass-roots levels solutions can be applicable and become feasible. Therefore, any megacity complex problem has its community dimension, when appropriate scale is determined to solve these problems.

Daily environmental problems as entry points: Daily issues (like waste, pollution, etc.) provide crucial entry points of community actions. Several cases have proved that community activities which are built on daily problems, are grown as collective actions, and ultimately linked to the community's social capital and resilience. This is very crucial to urban areas, where collective actions needs time, efforts and resources.

Turning problems into potential: There are several issues related to urban risk, which are seen as problems, but have the potential to turn into solutions. In several cities, waste management is considered a problem. However, as a shown in the Mumbai experience, waste management can be turned into an income-generation activities for the local communities, thereby enhancing collective action at community levels. Thus, innovative approaches can turn problems into potential, which is important for the urban areas with limited resources.

An Effective risk communication framework: To enhance collective action, it is required to communicate risk appropriately to the communities and local residents Neighbourhood watching (in terms of town watching) is found to be an effective educational tool for this purpose. Town watching has two specific aspects: (i) to look at the risk of the neighborhood, as well the potential of the community (to appreciate both good and bad parts), and (ii) to have a collective survey with different stakeholders (like students, parents, community leaders, NGOs, local governments, academic institutions).

Bringing academic expertise: There has been an increasing trend of action research, where the research outputs are applied in real-life problems, and the mutual learning cycle is enhanced. The key point here is the link between research and practice. The academic comfort zones of disciplines (like urban planning, disaster risk management, environmental management, etc.) should be broken in order to facilitate field-based multi-disciplinary action research.

Synergy of international and local knowledge: In the age of information sharing, it is of great value to establish the link of the local and regional and/or international knowledge. UNISDR (United Nations International Strategy for Disaster Reduction) has established an Asia Regional Task Force for Urban Risk Reduction to facilitate interactions among different stakeholders. The task force has undertaken mapping of good practices of urban risk reduction, and has initiated some training programs for urban managers. The task force can play a crucial role in linking local and regional knowledge of urban risk reduction.

Acknowledgement

This write-up was made possible with collective activities of education, research and implementation with different people and organizations over a period of time. I am thankful to my students (Akhilesh Surjan, my co-editors and chapter providers of the book Anshu Sharma, Hari Srinivas, Jishnu Subedi and Golam Rabbani), colleagues in the Task Force (Etsuko Tsunozaki and Yuki Matsuoka). Support from the GCOE Project (Human Security Engineering in Asian Megacities) is highly appreciated.

References

ADB Urban Report 2003.

Boulle P., Vrolijks L., Palm E. Vulnerability Reduction for Sustainable Urban Development, in Journal of Contingencies and Crisis Management', Vol 5, No 3, Sept 1997, pp 179-188.

id21 insights 71, January 2008

Pelling M. (2000): The vulnerability of cities, 212 pages.

Quarantelli EL. *Urban Vulnerability to Disasters in Developing Countries: Managing Risks.* In Alcira Kreimer, Margaret Arnold, and Anne Carlin (Eds.), *Building Safer Cities: The Future of Disaster Risk.* Washington D.C.: The World Bank. 2003.

Rabbani G. (in press): Environmental Risks of Dhaka City: Present initiative and the Future Improvements.

In: *Urban Risk: An Asian* Perspective, Shaw R., Srinivas H. and Sharma A., eds., Springer Publication

RTF-URR (2008): Asia Regional Task Force for Urban Risk Reduction, available at and accessed on October 2008: http://www.adrc.or.jp/events/ RTFmeeting20080130/PDF_Presentations/Minutes_RTF-URR1-Kobe_Final.pdf

Srinivas H., Sharma A. and Shaw R. (in press): Urban risk reduction: the way ahead. In: In: *Urban Risk: An Asian Perspective,* Shaw R., Srinivas H. and Sharma A., eds., Springer Publication

Subedi J. (in press): *Urban Disaster Risk* Management in Kathmandu. In: Urban Risk: An Asian Perspective, Shaw R., Srinivas H. and Sharma A., eds., Springer Publication

Surjan A. (2008): Resilience to Disaster & Climate Risk through Community Based Environmental Improvement in Urban India, PhD thesis, Kyoto University, Japan.

Surjan A., Redkar S., and Shaw R. (in press): Community based urban risk reduction: case of Mumbai. In: *Urban Risk: An Asian Perspective,* Shaw R., Srinivas H. and Sharma A., eds., Springer Publication.

Surjan A. and Shaw R. (in press): Urban risk and disaster risk reduction. In: *Disaster Management: Global challenges and local solutions,* Shaw R. and Krishnamurthy R. eds., University Press.

UNESCAP (2005): Urban Environmental Governance for Sustainable Development in Asia and the Pacific: A Regional Overview, UNESCAP, UN Publication, Bangkok.

UNHABITAT (2007): Global Report on human settlement: enhancing urban safety and security, Chapter 7: pp 167-194.

Urban Resilience Research Program (2007): A Resilience Alliance Initiative for transitioning urban systems towards sustainable future.

USAID (2008): South Asia Brief. Available at (accessed on: October 2008): http://www.makingcitieswork.org/urbanWorld/south-asia#growth.

Impacts of Floods in South Asia

Mandira Singh Shrestha and Kaoru Takara

Abstract

The impact of natural disasters is an increasing problem in South Asia, as illustrated by the recent tsunami and earthquake. Recurring floods of various magnitudes continue remain to adversely affect South Asia. Though floods are important for the replenishment of the soil for agricultural productivity and fisheries for the sustainable liveellihoods of the people, large floods result in loss of lives and property, affecting the development of the region. This paper reviews the global disaster databasesdatabase on floods. It provides an analysis of flood data available on the International Disaster database (EM-DAT) from 1976- to 2005 for South Asia and presents trends in terms of frequency, number of people killed, affected and economic damage. In the period 1976-2005, Asia'`s share iwas 41% of global occurrence of flood disasters accounting for 65% of people killed and 96% of those affected. South Asia accounts for 33% of the floods in Asia, 50% of those killed and 38% affected. A Rreview of the database underlines the importance of systematic data collection and management, which still remains a challenge in the region. Standardization of data collection and appropriate methodologies are urgently needed for improved hazard and vulnerability analysis, establishment of early warning systems and for devising appropriate policies on disaster risk reduction.

Introduction

In the last decade of the 20thth century, floods killed 100,000 persons and affected over 1.4 billion people around the world (Jonkman 2005). It is estimated that the annual cost to the world economy due to flooding is about 50-60 billion US dollars. According to a study by the United Nations (UN), floods claimed an average of 22,800 lives annually and caused an estimated damage of US $ 136 billion to the Asian economy (UNESCO 2003). The losses incurred by developing countries are five times higher per unit of gross domestic product than those of rich countries (UNESCO 2006).

South Asia covers about 3.2 % of the world land area and 10 % of Asia, with over a population of over 1.46 billion accounting for 25 % of the world population (CIA, 2005). South Asia comprises of eight countries, viz. Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka and houses about 40% of the world`s poor.

The major rivers of South Asia are the Indus, Ganges, Brahmaputra and the Meghna. The Kabul river originates in Pakistan and flows through Afghanistan. It and is one of the major tributaries of the Indus. The Indus and its tributaries flow south and west to empty into the Arabian sSea. The Ganges and the Brahmaputra and their tributaries flow south and east to enter the Bay of Bengal. These rivers areprovide sustenance to more than 500 million people of the region, supplying water for drinking, irrigation, hydropower generation, fisheries, and inland navigation, as well as for the maintenance of wetlands and biodiversity. But these rivers are also the source of different types of floods that adversely affect the socioeconomic development of the region.

The climate of South Asia is dominated by the South-Wwest monsoon, with significant spatial and temporal variations in rainfall and temperature throughout the region. The heaviest average annual precipitation of 11,873 mm has beenis recorded at Mawsynram, a small town near Shillong, in the Meghalaya Hills in India (Bandyopadhyay, 2006). From the east to the west of the region, the rainfall decreases, with some areas having with less than 400 mm of rainfall annually. Given the varying topography, geographical location and meteorological conditions from North to South and East to West, floods of varying types occur including flash floods, debris flow, landslides, and glacial lake outburst floods. etc.

Most of the countries in this region have a large rural population dependent on agriculture and with high population density. About 28% of the total population is urban. The economic growth is relatively low compared to that of other regions of the world. The per capita income varies from a minimum of US $ 250 in Afghanistan to US $ 2,390 in Maldives. Compared to the development indicators of other regions, South Asia prtraysoccupies a grim picture. Besides the existing physical and environmental factors in South Asia, suchthese poor social and economic conditions further increase the vulnerability to different types of disasters like floods, landslides, earthquakes, and others. The key development indicators of South Asia that contribute to increased vulnerability are provided in Table 6.1.

Disaster data are vital for identifying trends in the impacts of disaster and tracking relationships between development and disaster risk (IFRCRCS, 2005). For any flood event, loss of lives, total number of people affected as well as the economic damage can be considered as indicators for assessing flood impacts. There have been some studies in the past that looked into global and country- specific perspectives of floods. Jonkman (2005) has investigated the loss of life statistics for different types of floods and regions concerning a large number of flood events worldwide with information from the OFDA/CRED Emergency Disaster Database (EM-DAT) from 1975- to 2002. A study by Dutta and Heradth (2004) has analysed trends of flood disasters in Asia for a thirty- year period from 1973- to 2002 using the EM-DAT database. The study, is however, is limited to analyzing the flood frequency.

This study investigates the statistics on loss of life, total people affected and economic damage due to floods in South Asia based on the statistics available from the EM-DAT. The paper provides a review of the global databasesdatabase on disasters, particularly on floods and presents the analysis of the trends in South Asia during the last thirty years.

Table 6.1. Key indicators of South Asia

Indicators	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
Area (km2)	647500	144000	47000	3,287,590	300	147181	803,940	65,610
Population (millions) 2005	21.9	141.8	0.66	1094	0.33	27.1	155.8	19.6
Annual growth rate(%)*	4.4	1.9	2.4	1.4	2.5	2	2.4	0.8
Infant mortality rate (per 1,000 live births) 2004		56	67	62	35	59	80	12
Agricultural land (% of land area) 2000	58.3	69.8	12.2	60.8	33.3	29.3	32.6	36.5
Access to safe water (% of population)2004	39	74	62	86	83	90	91	79
Access to sanitation (% of population)1995	12	35	69	16		23	39	
Adult literacy rate (% of people 15 & above) 2003	51 (M); 21 (F)	54(M); 32(F)	60 (M); 34 (F)	70(M); 48(F)	91(M); 97(F)	63(M); 35(F)	62(M); 35(F)	95(M); 90(F)
Per capita commercial energy use: annual (Kg of oil equivalent) 2003		159		520		336	467	421
Per capita electricity consumption (KWh)2003		128		435		68	408	325
Population below national poverty line (%)	53 in 2003	45 in 2004		25 in 2002		31 in 2004	32.0 in 2000	32
Per capita GNI (US $), 2005	250	470	870	720	2390	270	690	1160

Source: FAO's Information System on Water and Agriculture, World Factbook, 2005, CIA, (http://www.fao.org/ag/agl/aglw/aquastat/water_res), Bhutan census 2005, World Bank Report

Note: Blank spaces in the table indicate that there is no data available

Review Of Available Disaster Database

A review of the existing disaster- related databasesdatabase available online has beenwas conducted. A summary of the reviewed disaster database in this study is presented in the Table 6.2. The summary includes the coverage, period of data available, type of natural disaster and the source of information. It also provides the web addresses from where detailed information can be accessed. The reviewed databasesdatabase wasere limited to the comprehensive databasesdatabase which collects data systematically and provides statistics on the loss of life, affected and economic damages on natural disasters focusing on floods and includes EMDAT, NatCat, Sigma, Darthmouth Flood Observatory, Glide and DesInventar.

A wide number of global, regional, sub-regional and national disaster databasesdatabase are found to be available which documents the impacts of natural and technological disasters. The disaster databases available online are quite varied in nature in terms of the details of the parameters reported. There is no single uniform, standardized method that has been followed for data collection of disasters by any of the databasesdatabase. The data available in these databasesdatabase are primarily from secondary sources like the aid agencies, insurance companies, newspapers and media reports, etc. Only limited data is available from the government agencies. Each of the databases is found to focus on a particular purpose and hence differs in its definitions, analysis and reporting.

The EM-DAT is a public database initiated in 1988 with a global observation level and a national resolution level and provides data and statistics on the occurrence and impacts of natural disasters over a period of time. It and is the most complete database available. The EM-DAT has arranged and provided information according to country and thematic aggregations. EM-DAT contains data on the occurrence and effects of over 12,800 disasters in the world from 1900 to the present. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. The main objective of the database is to assist humanitarian action at both national and international levels. There is a set criteria for entering a disaster into a database, for example, when at least 10 or more people are reported killed, 100 people reported affected, declaration of a state of emergency or call for international assistance (http://www.em-dat.net). Often small- scale disasters at a local level are not included in this database. A study by Guha Sapir et al. (2002) has conducted a comparative analysis of three global datasets: EM-DAT, NatCat and Sigma.

NatCat is maintained by Munich Reinsurance Company and is a private international level database on natural disasters with a focus on economic losses (http://mrnathan.munichre.com/). Partial information of the database is available to the public with natural hazard maps, list of major disasters and country profiles. The major disasters for different periods from 79 AD are presented in maps and reports are available on individual events thatwhich list the number of dead, affected and economic damage. At a country level the degree of exposure to different hazards and percentage of area affected is illustrated by bar charts.

Sigma is a global natural disaster database including man- made disasters and is maintained by the Swiss Reinsurance Company. Events are recorded from 1970 to the present. Sigma presents annual information on insured property losses, plus economic and human losses. A Llesser amount of entries of disaster event is available on this database since information on countries with low insurance density is limited. The worst disasters in terms of victims and insurance losses for different years are presented in charts and tables and available on the website. In-depth research on worldwide insurance markets are published in Sigma series, which includes risk perception, technical publishing and focus reports.

DesInventar is a database intended for use in the local and national management of risks. DesInventar was developed in 1995 to capture datasets at a local as well as national level of all different disasters including small and medium- scale disasters. This database registers disaster data thatwhich are not available or reported in global and large- scale natural disaster data bases. DesInventar gives details of every type of effect disasters have. DesInventar is useful for governmental organizations for prevention and mitigation of disasters and for planning and decision making. It is also useful for researchers, humanitarian and non-governmental organizations, health institutions, etc., from local to international scales. The DesInventar was first developed for the Latin American countries and now has been introduced in Nepal and India through UNDP to apply the methodology and use the software. The International Strategy for Disaster Reduction (ISDR) has conducted a comparative analysis of EM-DAT and DesInventar in 2002, aiming towards improving the quality, coverage and accuracy of disaster data (ISDR 2002).

The Dartmouth Flood Observatory provides an archive of extreme flood events, which is geo-referenced to the nearest degree from 1985 to present (http://www.dartmouth.edu/~floods). It seeks to promote research and better understanding of extreme events and its causes and improve access to satellite- based measurements and mapping. The information is available in the public domain. The observatory detects, maps, and measures major flood events worldwide using satellite remote sensing. The database is expected to be useful to predict where and when major flooding will occur and to analyze trends over time. The long-term history of flooding observed from space is compiled as a World Atlas of Flood Hazard. Rapid response inundation maps of large floods are also available. Information and data on loss of lives, affected people and economic losses have not been found to be reported in this database.

The Asian Disaster Reduction Centre (ADRC) documents disaster information of countries from Asia and South East Asia primarily for? its

members (http://www.adrc.or.jp). It provides information about all types of natural disasters since 1998. All the information is provided in chronological order. Each event that is reported is provided a unique global identifier (GLIDE) number, location, date, number of dead, evacuated and material damage. The GLIDE number is given to each individual disaster event for all

databasesdatabases and hence maintains the uniformity in reporting of disasters. This database provides a country- wise searchable disaster data. Information is provided from various sources and includes UN agencies (OCHA), Reuters and international news agencies, Relief Web and NGOs. ADRC has also analyzed and published disaster data from 2000, the latest being the data book for 2004.

A summary of the reviewed disaster database in this study is presented in the Table 2. The summary includes the coverage, period of data available, type of natural disaster and the source of information. It also provides the web addresses from where detailed information can be accessed.

Analysis of Flood Data for South Asia

Methodology of Temporal and Spatial Reporting of Flood Events

The EM-DAT database provides disaster datasets according to location, timeframe and disaster type. On a spatial scale, datasets are reported for 17 regions as well as country wisefor individual countries. The datasets are available over 10- year period intervals as well as for each individual year. In the EM-DAT, disasters are broadly categorized into two main types: namely, natural and technological. Natural disasters include hydro meteorological, geological and biological disasters. Hydro- meteorological disasters includes floods and wave surges, storms, droughts and related disasters (extreme temperatures and forest/scrub fires), and landslides &and avalanches. The EM-DAT database defines flood as a '"significant rise of water level in a stream, lake, reservoir or coastal region'". Floods due to cyclones are included under different hazard categories (windstorm and wave/surge). Geophysical disasters include earthquakes, and volcanic eruptions. Biological disasters cover epidemics and insect infestations. Country profiles provide a summary and profile of disasters for a particular country. A disaster list is also available in the EM-DAT database, which allows one to generate a list of events for a particular spatial scope, period of time and disaster type. Given the comprehensivenss of the EM-DAT database, this has been selected for the current study for further anlaysis of the impacts of flood in South Asia.

In the database, nine countries are included under South Asia as per the UN`s sub region. In the current study, the countries thatwhich are members of the South Asia Association for Regional Cooperation: are: Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka have been included excluding Iran Islam Republic (inclusions/exclusions n not clear) have been included. The Asian Development Bank (ADB) also uses the same grouping. The current analysis uses data period for three decades from 1976- to 2005.

Table 6.2. Review of Global Flood Databases

Database	Coverage	Period	Type of Natural Disasters	Source of Information
EM-DAT (OFDA/CRED) Emergency Disaster Database (www.em-dat.net)	Global, regional and country wise (about 12,000 entries)	1990-present	All types of Natural Disasters and man made disasters including conflict	UN agencies, Govt agencies, IFRC, research centres, insurance agencies, press, media and private
Dartmouth Flood Observatory (www.dartmouth.edu/floods)	Global coverage	1985-present	Large Floods	Wide variety of news agencies, governmental, instrumental, and remote
NatCat (Munich Reinsurance Company) (http://mrnathan.munichre.com)	Global (about 20,000 entries with about average 800 entries per year)	79 AD-present (only major events recorded prior to 1980)	Natural Disasters including volcanic eruption, floods, storms, earthquake and others	Insurance related media and publications, online databases and information systems from news agencies, govt and non-govt organizations, media reports worldwide network of scientific and insurance contacts, technical literature, Munich Re clients and branch offices
Sigma (Swiss Reinsurance Company) (http://www.swissre.com)	Global (about 7000 entries)	1970-present	Natural and man made disasters excluding drought	Daily newspapers, Llyod's list, primary insurance and reinsurance periodicals, internal reports, online databases
DesInventar	16 countries of Latin America and Caribbean.	Varying	Natural Disasters	Newspapers, official data from various governments.
Asian Disaster Reduction Centre (http://www.adrc.or.jp)	Global	1998-present	All types of Natural Disasters including floods	UN agencies (OCHA), Reuters and international news agencies and NGOs.

Analysis of Datasets

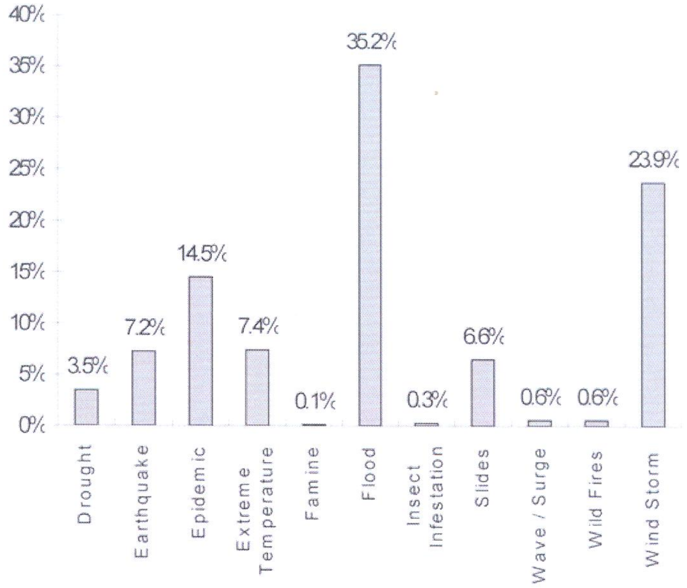
Individual country statistics of these eight countries of South Asia available in EMDATthe database database have been reviewed and analyzed. A total of 332 flood events are recorded in the database over three decades from 1976- to 2005. A list of flood events for South Asia was generated for the period 1976- to 2005. The list provides details of the event, which includes type of flood, location, start and end dates, people killed, and affected as well as economic damage. Out of the 332 reported flood events, 20 events were categorized as flash floods and 3 as valley floods. A close inspection of the location and types of floods reported in the database revealed that there was no consistency and uniformity in the reporting. In the database, many of the floods that are likely to be flash floods have not been reported as such but under a general category of floods, for example, in Chittagong in Bangladesh and Himachal Pradesh in India, where flash floods isare common. A Ssimilar kinds of lack of completeness was wasere observed in many of the recorded events. Therefore, with the available datasets for the period 1976-2005, categorization and analysis for different types of floods could not be conducted. This study is limited to the general flood disasters in the region with no sub types of floods. All the data available on reported events have been used for the analysis.

All of the 332 events that have been reported in the EM-DAT database for the thirty-year period are not separate individual events. In some cases multiple, separate events are aggregated to one record. This inconsistency in data reporting could to some extent affect the interpretation of the data, as was also cautioned by Jonkman (2005) as a spatial aggregation issue.

Distribution of Natural Disasters in South Asia

During the lpast three decades (1976-2005), the reported number of natural disasters in South Asia is 943, out of which those caused by floods is 332, accounting for 35% of the natural disasters. The is is higher than the global value is aboutof 30%. showing that in In South Asia, floods are a major hazard followed by windstorms, which include cyclones. The distribution of natural disasters in South Asia is presented in Figure 6.1.

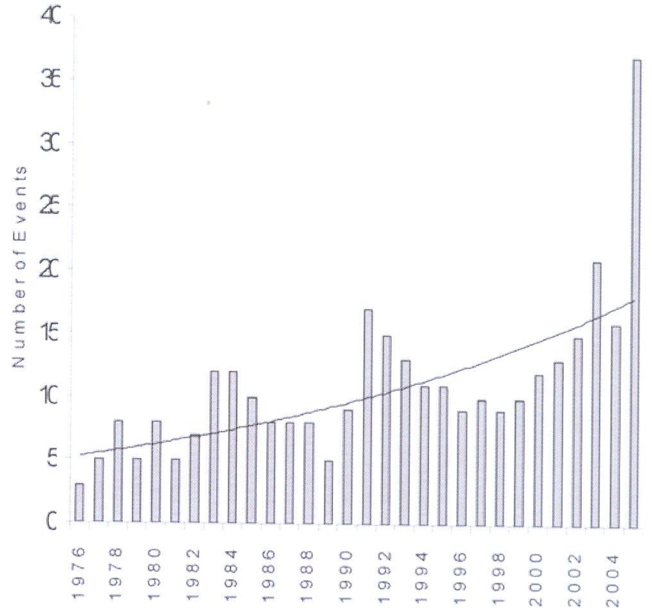
Figure 6.1.: Distribution of Natural Disaster in South Asia: 1976-2005



Total Number of Flood Disasters

The reported number of flood disasters has dramatically increased over the last three decades, as shown in Figure 6.2. A Ssimilar increasing trend has also been observed for Europe (Hoyois and Guha, 2003) as well as globally (Jonkman, 2005). To some extent, this increase in flood disasters can be attributed to improved information communication technology (ICT), leading to increase in reporting activities; however this in itself isn not the only the cause. It could also be attributed to the increased socioeconomic vulnerability and development processes leading to increased number of disasters. The impacts of population and economic growth, rapid urbanization, environmental degradation, and climate change are some of the factors that contribute to this increased trend.

Figure 6.2.: Total Nnumber of flood disasters reported in South Asia: 1976-2005



It must be recalled here that theThe UN World Conference on Disaster Risk Reduction was also held in January 2005 in Kobe, Japan. It which provided recommendations and the Hyogo Framework for Action (HFA) to decision makers and risk managers for disaster risk reduction, including flood disasters. The HFA has highlighted the need for improved compilation of information on disaster risk and impact at all scales for sustainable development. The recent 2005 report entitled 'Natural Disaster Hotspots: Case Sstudies' launched by World Bank claims 2005 to be a record year of natural disaster-related incidents, which killed more than 90,000 people and affected more than 150 million lives worldwide (2005).

Total Number of People Killed by Floods

During the last three decades a total of 491,074 deaths hasve been reported due to Nnatural disasters in South Asia. Hydro meteorological disasters resulted in 337,917 deaths (~70%), out of which floods account for 64,658 numbers of deaths (~20%). The loss of life due to the 2004 Ttsunami has skewed the percentage. Over the period 1976-2005, on an average 2,154 people awere killed annually due to floods in South Asia. Though there is a variation in the number of people killed annually, in general there is an increasing trend, as shown in Figure 6.3. The five flood events that killed the most number of people in South Asia over the thirty- year period are given in Table 6.3. The floods in Northeast India in 1978 and the floods in Bangladesh in 1988 stand out prominently. Here it should be noted that some of the flood reports in the EM-DAT isare a mixture of several individual events lumped into one record. This is the case for the 1994 as well as the 1998 events reported in India, which combines the floods from different parts of the country occurring in the same month under one record.

Figure 6.3.: Total number of reported killed due to floods in South Asia : 1976-2005

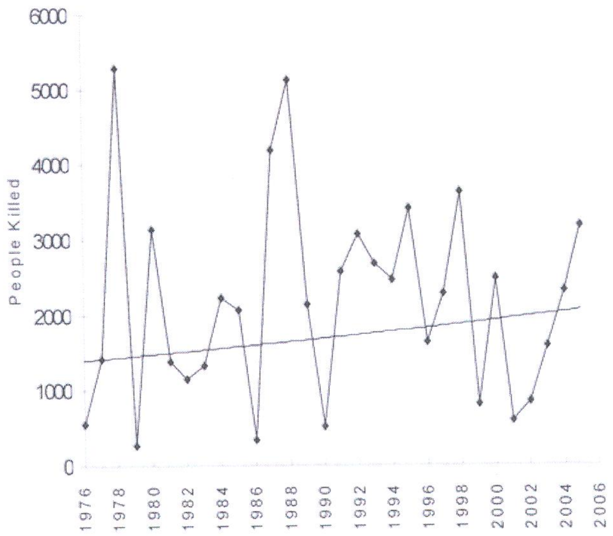


Table 3 Flood events in South Asia with most number of people killed: 1976-2005

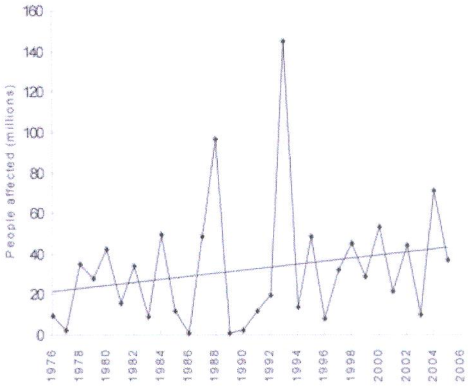
Country	Year	Month	Killed	Total affected	Description
India	1978	7	3800	32,000,000	North, Northeast
Bangladesh	1988	8	2379	73,000,000	
Bangladesh	1987	7	2055	29,700,000	Rangpur, Netrokona, Gaibandha, Noagaon, Kurigram, Jamlpur, Cox's Bazar, Chittagong, Noahkali districts
India	1994	5	2001	12,060,050	Assam, Arunachal Pradesh, Jammu and Kashmir, Himachal, Punjab, Uttar Pradesh, Goa, Kerala, Gujarat states
India	1998	8	1811	29,227,200	Assam, Arunachal, Bihar, Kerala, Meghalaya, Punjab, Sikkim, Uttar Pradesh, West Bengal states

Total Number of People Affected by floods

The total number of estimated people affected by floods in South Asia in the last three decades from 1976- to 2005 is close to 1 billion. The 1988 floods in Bangladesh have been reported to have affected more than half the population totaling to about 73 million people. Similarly, in 1993 floods in different parts of India affected more than 100 million people in the states of Punjab, Haryana, Himachal Pradesh, Gujarat, Jammu and Kashmir, Rajasthan, Madhya Pradesh, Chandigarh and Assam States.

In South Asia there is an increasing trend in the number of people affected by floods. India has the highest number of people affected by floods, followed by Bangladesh. The number of people affected by floods in South Asia from 1976- to 2005 is shown in Figure 6.4.

Figure 6.4:. Total Number of people affected by Floods in South Asia: 1976-2005

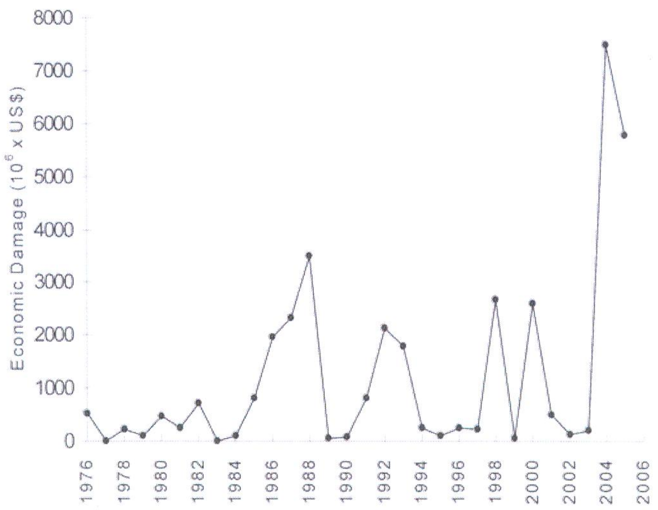


Economic Losses due to Floods

The total economic loss reported for the 30- year period from 1976- to 2005 is about 32 billion dollars. Figure 6.5 shows the reported economic losses due to floods. In 1988, Bangladesh experienced one of the worst floods in living memory, which resulted in a total cost of approximately US $2 billion to the national economy of approximately US $2 billion killing 2440 around 2,400 people. In 2004, Bangladesh is reported to have experienced a huge economic loss due to floods in the tune of US $7 billion. This huge economic loss compared to previous years can be attributed to increased population density, higher per square kilometere GDP and infrastructural development in floodplains and urban centres. This steep rise in economic loss for 20045 may also be attributed to the incompleteness in the data recorded in previous years as compared to 2004.

World Disasters Report 2005, published by the International Federation of Red Cross and Red Crescent societies also report that data are most incomplete for economic losses for natural disasters (IFRCRS, 2005). It further states that due to lack of standardized methodology, loss estimates from Iran'`s Bam earthquake in 2003 ranged from US$ 32.7 million to US $ 1 billion. Livelihood losses, especially in the informal sector, are also poorly understood and rarely recorded. The reports available on the EM-DAT database on economic losses due to floods in South Asia are limited. Some of the countries have no reports on economic losses, for example, Bhutan while those available appear to be incomplete. Due to the incompleteness in the recorded data as well as lack of standardized methodology, caution should be exercised in using the data for any kind of interpretation.

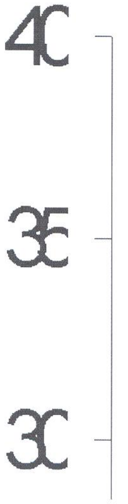
Figure 6.5.: Economic Losses due to Floods in South Asia: 1976-2005



Trend Analysis

In the last thirty years annual flood frequency has doubled. From 1976- to 1985 there were 75 flood events, which increased to 105 in the next decade and then to 152 from 1996- to 2005. These results for South Asia with respect to the flood frequency agree with the result obtained by Dutta and Heradth (2004) in Asia for the period 1973-2002. The increasing number of frequency of flood disasters can be attributed to improved communication technologies resulting in better reporting as well as climate change, land use change and surface degradation. Table 6.4 provides the reported number of flood events over the last three decades.

Table 6.4.: Number of flood records in South Asia (1976-2005)



The trend in flood impacts in terms of people killed and affected has been analyzed for each decade as well as for the thirty- year period. Analysis on a decade- wise basis shows that there is an increasing trend in number of people killed and affected by floods from first decade, 1976-1985 to the second, 1986-1995. In the third decade, from 1996- to 2005 there is a slight decrease in the number of killed as well as the number of those affected. . The increasing trend from the first decade to the second is in agreement with those reported in the second World Water Development Report but not for the second to the third decade. With limited data available, it is difficult to pinpoint the cause of this decrease. However, it should be noted here that three of the five extreme events reported in South Asia over the thirty- year period isare from 1986- to 1995, as was presented in Table 6.3 earlier. The extreme events in that decade could possibly affect the trend.

For the entire thirty- year period however, there seems to be an increasing trend in the number of people killed and affected. The increase is more significant in the number of people affected in comparison to the number of people killed, as can be observed in Figure 6.6. These results agree with the findings of the impacts of global flood disasters reported by Jonkman (2005).

Flood impact analysis by country

In this section the impact of flood disasters during the period from 1976-2005 by country is provided. Table 6.5 shows that India has a larger percentage of impact compared to other countries in South Asia. During the thirty- year period, about 40% of the events were reported from India, followed by Bangladesh (17.2%), Pakistan (12.3%), Afghanistan (12.0%), Sri Lanka (10.2%), Nepal (7.2%), Bhutan (0.9%) and the Maldives (0.3%). About 58% of those killed are reported from India, followed by Bangladesh (16.4%). Similarly, about 68% of those reported affected are from India, followed by Bangladesh (26.4%). The bulk of the economic damage is also reported to have been contributed by India and Bangladesh, with nominal damages reported by other countries. The large size and the population of India contribute to larger flood impacts. A study conducted by Dhar and Nandargi (2003) has shown that the flood problem in India is mostly confined to the states in the Indo- Gangetic plain, northeast India and occasionally in the rivers of Central India. The area vulnerable to floods in India is 40 million hectares (12% of the total land area) and the average area affected by floods annually is estimated to be about 8 million hectares, leading to 1,793 deaths annually (HYPERLINK "http://www.nidm.net/flood.asp"
http://www.nidm.net/flood.asp). While iIn Bangladesh about 80% of the total land are is vulnerable to floods exposing a larger population to flood hazard.

Figure 6.6. Trend Analysis of number of people killed and affected in South Asia:1976-2005

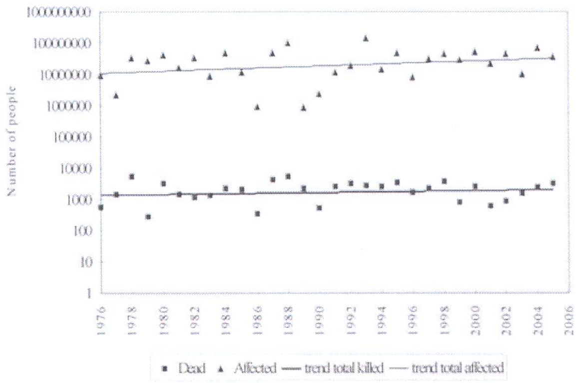


Table 6.5.: Country- wise

flood impact analysis for South Asia

Country	Number of flood events	Total killed	Total affected	Economic damage US $
Afghanistan	40 [12.0%]	3160 [4.9%]	758,560 [0.1%]	376,000 [1.2%
Bangladesh	57 [17.2%]	10,636 [16.4%]	257,581,101 [26.4%]	13,373,500 [41.5%
Bhutan	3 [0.9%]	222 [0.3%]	1600 [0.0%]	
India	132 [39.8%]	37,504 [58.0%]	665,801,325 [68.2%]	15,312,592 [47.5%
Maldives	1 [0.3%]	0	300 [0.0%]	6,000 [0.0%
Nepal	24 [7.2%]	4792 [7.4%]	2,387,994 0.2%]	990,313 [3.1%
Pakistan	41 [12.3%]	7505 [11.6%]	42,573,967 [4.4%]	1,843,230 [5.7%
SriLanka	34 [10.2%]	839 [1.3%]	780,3381 [0.8%]	353,944 [1.1%

Note: numbers is parenthesis [ ] denotes percentage

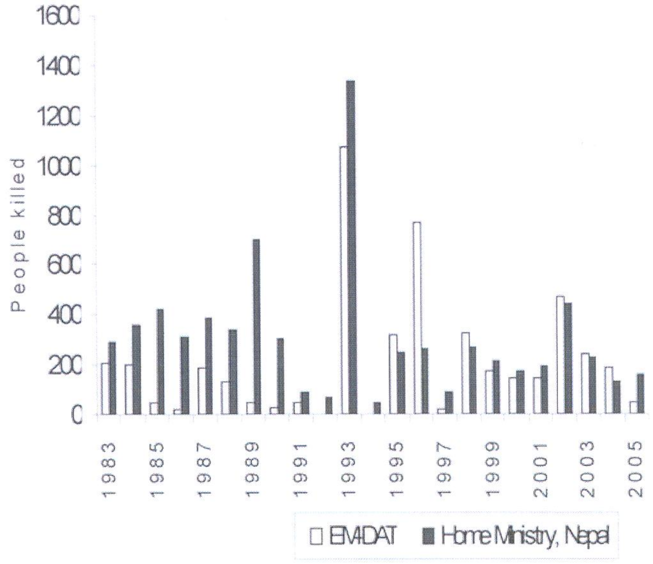
The United Nations Development Programme Bureau for Crisis Prevention and Recovery (UNDP-BCPR) has developed the Disaster Risk Index (DRI) to assess natural hazards such as floods, cyclones, droughts, earthquakes. This index allows global ranking on the basis of relative vulnerability of countries. This is a mortality- based index and the physical exposure of population to the hazard. The physical exposure has been derived on the basis of ed on population distribution and the frequency of hazards for that particular area and represents the average number of people affected yearly by the hazard (UNDP, 2004). According to the report prepared by UNDP–BCPR, most of the countries of South Asia are high in general with Bhutan ranking asto be the most vulnerable to flood disasters, followed by Nepal, Afghanistan and Pakistan. Though the number of people dead and affected by floods in India and Bangladesh isare greater as per this DRI, they rank 5 and 6 respectively in South Asia. The indicator over a period of time can help regions and countries to monitor and assess the effectiveness of risk reduction measures.

Flood Impact analysis: Comparison of EM-DAT and National Dataset

This section tries to explore the difference in reporting in the EM-DAT database compared to the data obtained from national agencies responsible for the disaster data in a country. The data from EM-DAT and those obtained form from the Home Ministry of Nepal, which is the focal Ministry for collecting and compiling all disaster- related data, is compared. Since systematic data collection on the impacts of various types of disasters started in Nepal from 1983, the period of comparison is from 1983- to 2005.

Figure 6.7 shows the comparison of the loss of lives due to floods from the two datasets. The figure verifies the fact that there is less number of events reported in the EM-DAT, indicating that probably the small- scale disasters at a local level are not reported in the global dataset though it is observed that there is better agreement after 2000. From the current data we find that about 30 % of the number of people killed is under- reported in the EM-DAT database.

Figure 6.7: Comparison of EM-DAT data with National Agency Data: Nepal



Comparisison Comparison Of Flood Statistics With Other Regions

In this section the flood statistics of South Asia is compared to the statistics of Asia and the other continents. The global distribution of flood disasters of 30 years shows Asia's extreme vulnerability to flood disasters. Globally, over a period of 30 years from 1976- to 2005, over 2 billion people have been affected by floods, killing close to 200,000 people with more than US $ 300 billion reported economic damage. Table 6.6 provides an overview of the number of flood records, total people killed and affected by regions. About 41% of these flood disasters occurred in Asia, 18% in Africa, 25% in Americas, 12% in Europe and the rest in Oceania.

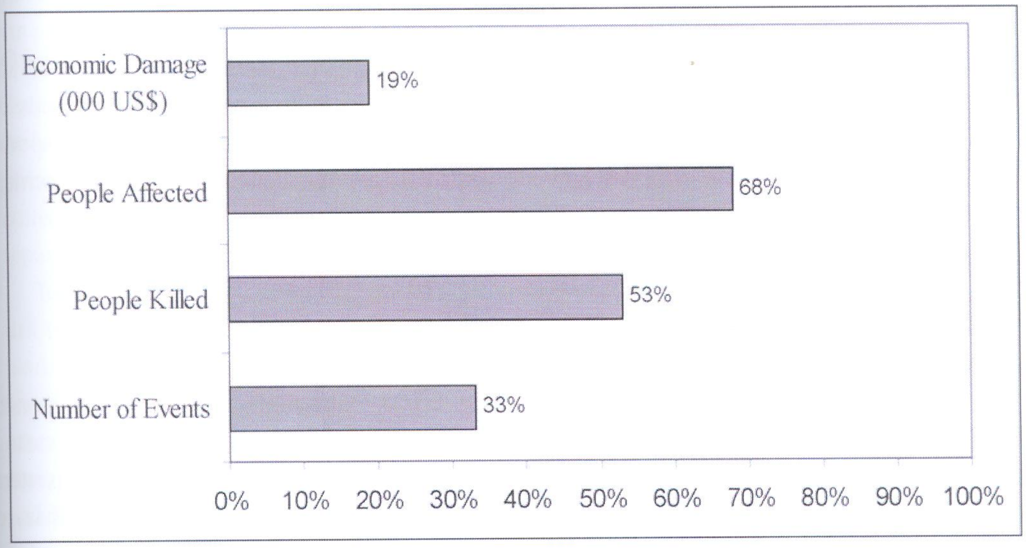
Though Asia'`s share is 41% of the global floods disasters, it accounts for 65% of the people killed and more than 96% of those affected globally, as shown in Table 6.6. South Asia accounts for 33% of the floods occurring in Asia, 5053% of those killed and 38% affected, as shown in Figure 6.8.

In comparison, when you look at the economic loss, Asia accounts for about 60% of the global economic damage out of which only about 16% is reported to have been contributed by South Asia. This low figure of economic damage in South Asia could be due to a number of reasons,. FFirst,ly poor and incomplete reporting. Second,ly there are limited economic damage assessments in the countries of South Asia and a lack of standardized methodology for reporting. Further, it could be a reflection of the state of development of the countries and its relationship with disaster risk since primarily the countries in South Asia are categorized as Least Developed countries with limited resources and economic development. Strong linkages have been identified between poverty, high social vulnerability to and low capacity to cope with water- related hazards and disasters (UNESCO, 2006).

Table 6.6. Number of flood events, people killed, total affected, and economic damage by floods in South Asia compared to other regions: 1976-2005

Region	Number of Events	People Killed	People Affected	Economic Damage (000 US$)
Africa	438 [18.1%]	13825 [7.4%]	35,251,124 [1.3%]	3,286,204 [1.0%]
Americas	605 [25.1%]	48506 [25.9%]	43,131,426 [1.6%]	54,821,027 [16.5%]
Asia	994 [41.2]	122521 [65.5%]	2,560,004,272 [96.7%]	200,190,203 [60.1%]
(South Asia)	332	64658	976,908,228	32,255,579
	(33% of Asia)	53%	68%	16%
Europe	292 [12.1]	1975 [1.1%]	7,596,848 [0.3%]	72,482,012 [21.8%]
Oceania	86 [3.6]	219 [0.1%]	528,052 [0.0%]	2,229,155 [0.7%]
World	2415	187046	26,465,411,358	333,008,601

Figure 6.8. Impact of flood disasters in South Asia in comparison to Asia: 1976-2005



Conclusions And Recommendations

Conclusions

EM-DAT's efforts in archiving disaster data are appreciable. The database provides a general overview of the impacts of disasters globally. However, before making concrete conclusions, one has to keep in mind, the limitations of this database as media reports may vary with source. Thee There is no clear distinction between riverine and flash floods and an absence of a global standard for reporting floods, for example, some events is a mix of individual flood event as well as for a period of time over a month or a season. This has made the analysis on an event basis difficult. Some floods are not reported typically for South Asia and economic loss/property loss is not often reported or not valued. It should not be interpreted as zero property losses, but as a lack of mechanism to evaluate and report the loss of property. South Asia is one of the poorest regions in the world. People lack the education, resources or opportunities to insure their property (insured value may be used as a good method for determining property losses) against flood disasters.

Nevertheless, this paper has used the database to analyse and compare general vulnerability of South Asia, which is, quite clearly highly vulnerable to flood disasters. In the period, 1976-2005, 332 flood events killed about 7065,000 and affected a billion people in South Asia. Statistically, these account for 14% of all reported disasters globally but 35% of lives lost and people affected. These figures indicate that floods have greater impacts in South Asia and therefore a higher relative vulnerability. The economic and social fabric is disrupted because of floods and has effects on culture and livelihoods. So, what makes South Asia more vulnerable? Is it due to greater magnitude of floods or increased population pressure or poverty and hence limited resources to adapt/respond to disasters. Perhaps, the effect is a combination of all factors to some extent, which cannot be proved with this data that has been analysed.

Recommendations:

On Impacts

The impacts of flood disasters cannot be negated easily. Vulnerable communities live with risk albeit full knowledge of impending disasters. The impetus should be on providing early warning for the vulnerable communities to evacuate their homes on time. Disasters should not be treated in isolation. They must be integrated with other hazard management. A total disaster risk management (TDRM) approach should be adopted.

On data sharing

A basin approach should be adopted in order to understand and provide additional lead time to vulnerable communities. Many organizations such as ICIMOD are already working to achieve this challenging task. ICIMOD is working on regional cooperation for sharing flood information and works towards increasing the national capabilities to predict floods and save lives and properties.

bilities to predict floods and save lives and properties.
t floods and save lives and properties.
lives and properties.
es.

On Policy

On database

Developing and maintaining a global disaster database is an enormous task. There is a need for a standardized and systematic data collection, including formats and methodology. Standard guidelines for collection of disaster data at various levels could avoid ad hoc reporting. Some efforts are already being made to standardize the process of identifying and reporting disasters such as GLIDE. The GLIDE should be adopted universally. It will eliminate some discrepancies, if not all.

On reporting

Because the main source of data on EM-DAT database is media, the role of media should be highlighted. Ideally, disaster news should always come from the same source from a given country. The leading government agency could be requested to verify data collected by various media. Disasters and their types and events should be reported separately with a separate index number.

To conclude, in all the countries there is need to design and streamline the disaster risk reduction policies and measures with long term social and economic development planning. Flood disasters should not be treated in isolation but be integrated with other hazard management. Capacity building and institutional strengthening as well as education and awareness on disaster preparedness should be promoted. As most of the major rivers are transboundary in nature, resulting in adverse impacts due to riverine and flash floods across national boundaries, basinwide integrated flood management is considered most suitable for coping with increased challenges in flood disaster mitigation. Standardization of data collection and appropriate methodologies are urgently needed for improved hazard and vulnerability analysis, establishment of early warning systems and for devising appropriate policies on disaster risk reduction. There is an increasing need for sharing of data and information and strengthened regional cooperation in flood disaster mitigation. The International Centre for Integrated Mountain Development (ICIMOD), together with its regional member countries isare working on regional cooperation for sharing flood information in the Himalayan region and is working towards increasing the national capabilities to predict floods and save lives and properties. Standardization of data collection and appropriate methodologies are urgently needed for improved hazard and vulnerability analysis, establishment of early warning systems and for devising appropriate policies on disaster risk reduction.

References

Asian Disaster Reduction Center (2004). Natural Disaster Data Book 2003: An analytical overview, Kobe: ADRC [Monograph], available at http://www.adrc.or.jp

Bandyopadhyay J., 2006. A Framework for Research on Integrated Water Systems Management in South Asia, Centre for Development and Environment Policy, Indian Institute of Management, India.

Dhar, O.N. and Nandargi, S.: 2003 Hydrometeorological Aspects of Floods in India, Natural Hazards 28, 1-33

Dutta, D. and Heradth, S.: 2004. Trend of floods in Asia and Flood Risk management with integrated rivers basins approach, Proceedings of the 2nd International Conference of Asia-Pacific Hydrology and Water Resources Association, Singapore, Volume I, pp. 55-63.

Guha Sapir, D., and Below, R.: 2002, The quality and accuracy of disaster data - a comparative analysis of three global data sets, The Pro Vention Consortium, The Disaster Management Facility, The World Bank.

Jonkman, S.N.: 2005, Global Perspectives on Loss of Human Life caused by Floods, Natural Hazards 34, 151-175

Hoyois, P., and Guha Sapir, D.: 2003, Three decades of Floods in Europe: a preliminary analysis of EMDAT data, working draft prepared for Centre for Research on the Epidemiology of Disasters.

http://dictionary.laborlawtalk.com/South_Asia, http://en.wikipedia.org/wiki/South_Asia

http://www.dartmouth.edu/~floods

http://www.em-dat.net (The OFDA/CRED International Disaster Database - Université Catholique de Louvain - Brussels - Belgium)

https://www.cia.gov/library/publications/the-world- factbook/ - The World Factbook, 2005, CIA

http://dictionary.laborlawtalk.com/south_asia, 13.http://en.wikipedia.org/wiki/South_Asia

http://www.un.org/special-rep/ohrlls/ldc/list.htm

http://www.finfacts.com/irelandbusinessnews/publish/article_10007597.shtml

National Institute of Disaster Management, Ministry of Home Affairs, Government of India (http://www.nidm.net/flood.asp)

International Federation of Red Cross Red Crescent Societies (IFRCRCS): 2005, World Disasters Report 2005: Focus on information in Disasters.

International Strategy for Disaster Reduction (ISDR),: 2002, Comparative Analysis of Disaster Databases, Final Report prepared for UNDP.

United Nations Disaster Programme (UNDP). 2004. Reducing Disaster Risk: A Challenge for Development. New York, UNDP/BCPR Bureau for Crisis Prevention and Recovery (www.undp.org/bcpr/disred)

World Water Development Report 1:2003, Water for People Water for Life, Chapter 11Mitigating Risk and coping with uncertainty, UNESCO (http:// www.unesco.org/ water/ wwap/wwdr1)

World Water Development Report 2: 2006, Water: A shared responsibility, Chapter 10 Managing Risks, securing the gains of development, UNESCO

Pre-Disaster Planning for Post-Disaster Recovery

Anil K Sinha

Abstract

Disaster recovery is evolving rapidly in different forms and also gaining ground in the context of implementing Hyogo Framework of Action (HFA). The present paper outlines the concept and principle of Pre-Disaster Recovery Planning (Pre-DRP). Pre-DRP recognizes that recovery as an integrated process involving relief, rehabilitation and reconstruction phases may lead to sustainable development; recovery as mlti-sectoral and highly dynamic phenomena also provides an opportunity for 'build, back and better' than before. Case studies from the high risk developing world have been analyzed to demonstrate some of these new paradigms of recovery management.

The International Recovery Platform (IRP) has placed considerable focus on Pre-DRP in its work plan. The perspective of IRP has been highlighted taking into account variety of contemporary efforts, applications and different facets of recovery. The efforts of IRP partner-agencies — ILO, FAO, UN HABITAT and World Bank on Pre-DRP have been placed into the context. The prospects and challenges with regard to large-scale operationalization of Pre-DRP in high-risk and low capacity South Asian countries have also been brought to the fore in support of promoting risk reduction in recovery processes worldwide.

Introduction

Quite often, post-disaster recovery leads to rebuilding risk; recovery efforts are not informed by lessons learnt and experiences from previous disasters; recovery needs assessment has not been demand driven; stakeholder consultative processes is weak; institutions set up to manage recovery have not led to sustained national and local capacities for disaster reduction. Further, the event of disasters attracts huge financial, logistic, other physical and technological supports, which often go beyond the ability of high-risk developing countries to manage and channel them effectively in risk reduction.

It is therefore felt necessary to have recovery plan in place providing insights and guidelines to support post-disaster recovery interventions/operations - their structural and non-structural dimensions, which could lead to risk reduction as envisaged in Hyogo Framework of Action (HFA). Structural dimensions viz. roads, streets, bridges, culverts, embankments, drainage, spurs buildings etc. and nonstructural dimensions, viz. existing vulnerabilities and capacities, rules, regulations, planning, skills, knowledge, awareness, community support systems, social transactions in terms of reciprocity, trust and exchange of labour and skills, etc are essentiall to contextualize and package in the form of recovery planning. Recovery planning could be both a pre- and post-disaster task. While pre-disaster could be based on the lessons and best practices, the post-disaster makes adjustments depending on the situations on the ground and may not be holistic.

The recovery plan aims at reducing future risk and effectively enables post-disaster recovery using an integrated disaster risk reduction approach. It is an integral part of risk reduction. In fact, the inclusion of recovery planning in disaster risk reduction signals a shift away from rehabilitation and brings into fore the interconnection between risk reduction and sustainable development. This shift enables looking beyond realizing the pre-disaster situation in the spirit of 'build back and better' than before. This is what brings in the concept of Pre-disaster Recovery Planning (Pre-DRP) for risk reduction in recovery and reconstruction efforts. The Pre-DRP also takes into account the provision of assistance or intervention during or immediately after a disaster to address short-term crisis management as well as long-term risk reduction strategies in an integrated and a holistic manner.

The present paper outlines not only the conceptual aspects of Pre-DRP but also highlights the efforts in this direction by international agencies especially International Recovery Platform (IRP), partner agencies and also by the governments of high risk and low capacity countries. Besides, the efforts have been made to connect Pre-DRP with HFA strategies, lessons learnt and the gaps in recovery practices followed by some of the major disasters experienced in the recent times.

The Dynamics of Recovery

While relief triggers the quality of recovery, it also attracts all kinds of supports and investments in the aftermath of a disaster. As reported by UN OCHA, total relief cost around US$ 2.5 billion during 1992 to 2003, of which 80% (US 2 billion) went to top 20 countries starting from China, India, Bangladesh, Egypt, Mozambique, Turkey, Afghanistan, El Salvador, Kenya, Iran, Pakistan, Indonesia, Peru, Democratic Republic of

Congo, Poland, Vietnam, Colombia, Venezuela, Tajikistan and Cambodia. Further, an assessment of emergency lending reveals that the total emergency lending and loan relocation from 1980 to 2003 of US$ 14.4 billion, 12.2 US$ billion went to the top 20 countries like India, Turkey, Bangladesh, Mexico, Argentina, Brazil, Poland, Colombia, Iran, Honduras, China, Chile, Zimbabwe, Dominican Republic, El Salvador, Algeria, Ecuador, Mozambique, Philippines, and Vietnam. The recovery challenges therefore starts from here in terms of channeling these financial resources in addition to knowledge and other resources leading to creation of a less more vulnerable and resilient society.

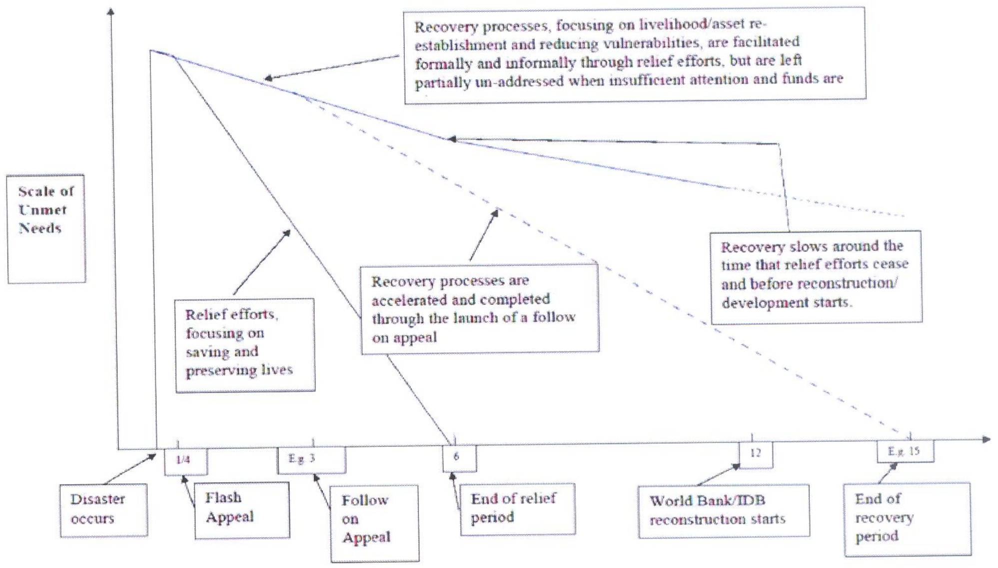
In the overall dynamics of recovery, the emergency phase still continues. Recovery is yet to become an integral component of preparedness and mitigation. Post-disaster recovery is often understood to return to where it was before the disaster, which too often means rebuilding pre-existing conditions of disaster risk, thus preparing the ground for future disaster. (Box I). The dynamics of recovery captured in Figure 1 highlights the 'gaps' as well as 'speed' with the backdrop of scale of unmet needs (basically indicating quality of recovery) and timeline (shows the speed of recovery). The challenge lies in realizing recovery as an opportunity for building the resilient society with the notion of build-back and better-than before with reasonable speed.

Box I. Recovery led to rebuilding the risk and vulnerability and enhance disaster risk further

- In the Vietnamese city of Hue, expansion of infrastructure, including bridges, railway lines and roads, has created a barrier across the valley within which the city is located. As a result, excess rainfall can no longer soak away quickly and problems of flooding have become more severe.1 Similar problems have occurred in several villages in Gujarat, India, following the construction of a donor-funded highway.
- Following widespread devastation caused by *Hurricane Hugo* in 1989, a new aid-funded hospital was built at the foot of a volcano in the Caribbean island of Montserrat. This hospital was subsequently destroyed by pyroclastic flows after the volcano began eruptive activity again in mid-1995.
- Following the devastating 2004 Indian Ocean tsunami, some housing in Aceh, Indonesia, was reconstructed in flood-prone areas, leaving families vulnerable to future hazard events.

(Source: Tool for Mainstreaming Disaster Risk Reduction, ProVention Consortium, Jan 2007)

Figure 1: Dynamics of recovery (Source: UNDP 2005)



Transition from relief to recovery calls not only for material and financial resources but also requires knowledge inputs and local capacities, apart from overall operational coherence across actors, activities and various disaster management phases; building linkages across humanitarian and development initiatives; and undertaking risk reduction as a conscious part of recovery. The efforts have to be focus on building and sustaining the momentum and support for all of the preceding activities to rebuild critical infrastructure while simultaneously improving the lives and livelihoods of those affected and building national and local capacity to prepare for future disasters.

Phases of Recovery

While restoration of livelihoods of the poor and vulnerable population makes the recovery process difficult (Box II), it is important to recognize that recovery has three distinct phases (Box III) and has been characterized by two stages, followed by the international agencies:

Early recovery

Early Recovery is recovery that begins early in a humanitarian setting. It is a multi-dimensional process and should be guided by development principles in the long run. It aims to generate self-sustaining, nationally-owned, and resilient processes for post-crisis recovery. Early Recovery encompasses governance, livelihoods, shelter, environment and social dimensions, including the reintegration of displaced populations. It stabilizes human security and addresses underlying risks that contributed to the crisis.

Recovery

A recovery approach focuses on how best to restore the capacity of the government and communities to rebuild and recover from crisis and to prevent relapses. In so doing, recovery seeks not only to catalyze sustainable development activities but also to build upon earlier humanitarian programmes to ensure that their inputs become assets for long term development. The transition between early recovery and recovery is a process of identifying development needs and beginning the work of recovery as early as possible, drawing upon existing development resources and creating new, appropriate and adapted resources for development to respond to these needs.

As the recovery effort moves forward, it should be critical to sustain support to the affected governments and communities for such recovery activities and to align recovery programming as well as government and community priorities with an awareness of the existing socio-economic situation. Development processes, with long-term objectives, extending beyond two years, and presume conditions of security and a functioning administration pursuing national objectives and strategies in partnership with external actors, need to get accelerated following the recovery and thus leading towards build, back-and better-than before.

The Challenges of Recovery

In pursuing recovery operations especially while responding to major disasters in the recent times, the following challenges have been identified:

- Lack of skill, knowledge and institutional support to develop an integrated recovery plan and strategy
- Establishment of support systems for vulnerable groups, e.g. psychosocial care especially for the elderly and other vulnerable groups
- Coordination and synchronisation of timelines of recovery interventions of various agencies
- Assessing damage and needs with local community participation
- Lack of effective institution and system for recovery, including exchange of best practices and experiences
- Addressing opportunity for social equity and change considering socio-cultural,

economic and political structures in developing recovery programs recovery and reconstruction without rebuilding risks

- Lack of division of roles and responsibilities between different international actors in recovery
- Lack of uniform and standardized methodology for recovery needs assessment
- Limited capacity of national and local government to plan and manage recovery problems in transferring past experiences to new disaster situations in crosscultural setting

In the aftermath of a disaster, there has always been pressure to quickly restore support systems, livelihood and repair damages. In most of the cases, this undermines the quality of relief, reconstruction and rehabilitation works. The pressure of time and other constraints such as the difficulties in communication and transport in the post-disaster environment make it difficult to restore lives and livelihoods with enhanced resilience.

Pre-disaster planning is necessary to address these, besides ensuring that adequate materials are available following a disaster and to ensure that builders, homeowners and government agencies are aware of damage reduction measures and construction techniques that can reduce vulnerability to future hazard events.

Box II. What makes recovery difficult?

The pace of transition to recovery varies from country to country and does not follow uniform pace for different cross-section of populations. It also depends upon the impacts of disasters on different sections of the people (Table 1). A study (Ref....) on this trend suggests that:

- Disaster impacts are felt across social groups, but the poor are disadvantaged in recovery, by limited access to resources, and fewer options for recovery.
- Because of the devastating impact disasters have on livelihoods of the poor, recovery programming may combine poverty targeting and disaster risk reduction.
- Past practice however, has shown that recovery programming is often not pro-poor, that likely poverty reduction resulting from recovery programming is not systematically tracked.

Table 1. Impact of disasters on different sections of the people - A trend (Source - FAO)

Effect	Impact on different cross-sections of the population		
	Affluent	Medium	Poor
Loss of lives	Low	Moderate	High
Loss of assets	High	High	Low
Loss of livelihoods	Low	High	Very high
Recovery	Short	Moderate	Long

Box III: Disaster Recovery Phases

The Disaster Recovery Phase begins once all life-safety issues have been addressed and initial damage assessment has occurred. This phase is divided into three stages: the Short-Term Recovery Stage, the Mid-Term Recovery Stage and the Long-Term Recovery Stage.

Short-Term Recovery Stage

During the first hours and days after an emergency event [Short-Term Recovery Stage], the principal objectives are to restore the necessary structural [facilities, critical systems/infrastructure, roadways and grounds] and non-structural, (power, water, sanitation, telecommunications and)

Mid-Term Recovery Stage

In the first weeks after a major emergency event [Mid-Term Recovery Stage], the principal objectives are to ensure the restoration of the all pre-identified business functions considered to be critical to normal livelohood operations.

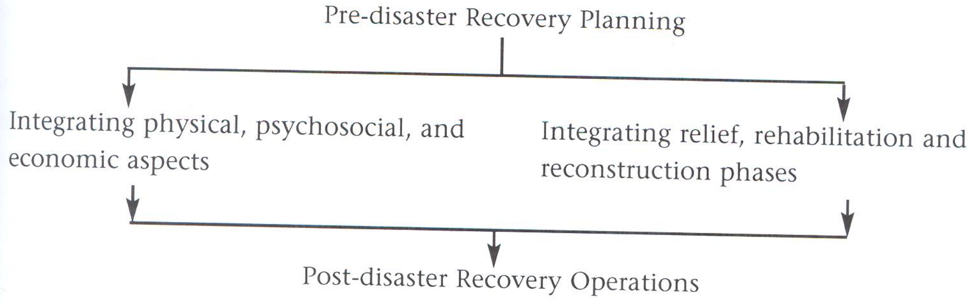
Long-Term Recovery Stage

During the Long-Term Recovery Stage, the principal objective is to resume normal operations integrated with long term development. It is during this stage of recovery that the emergency phase gets deactivated, and pre-disaster structure of governance and delivery comes into being.

An Outline of Pre-Disaster Recovery Planning (Pre-DRP)

Essentially, pre-disaster recovery planning is aimed at supporting post-disaster recovery operations. In recovery planning, two levels of integration are required. First is integration among physical, psychosocial, and economic aspects of the recovery and the second is integration among relief, rehabilitation and reconstruction phases.

Figure 1

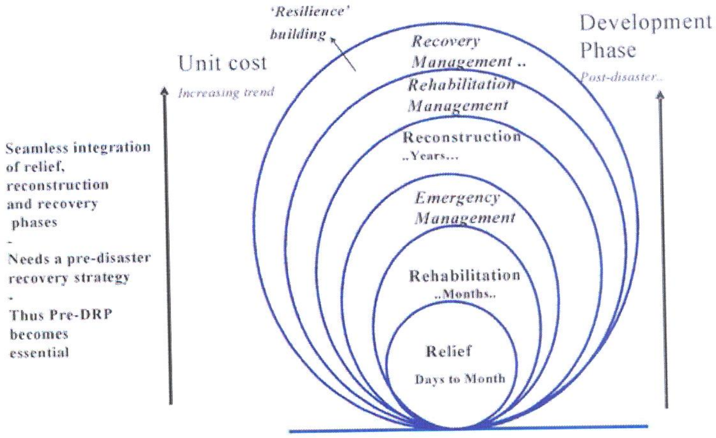


Inherently, there has not been harmony of thoughts and action between the established perceptions of stakeholders involved in short-term relief and those related to long-term development. Essentially to arrive at first level of integration, theses two are to be fully integrated in a seamless manner and recovery is to be regarded as a single process with a sequence of connected phases. It is important to ensure that there must not be any negative consequences of early decisions taken without regard to their long-term impact.

As depicted in Figure 2, under the unified recovery management framework there are three definable phases of recovery with unit costs indicating the overlaps between the successive recovery processes with a rough approximation of their costs.

Unification of the various aspects of recovery process depends on complex social, physical, and political factors. There have been the dilemmas of change versus restoring the status quo; speed versus safety; quality versus volume; decentralised participation in decision making versus centralised decision making, and normal planning processes versus extraordinary measures taken under the extreme pressure of a post-disaster situation.

Figure 2: Integration of recovery phases (Modified from Alexander)



The conceptual foundations of Pre-DRP thus lie in unification of recovery processes/interventions. Towards this, the HFA strategies have been helpful in creating grounds for the concept of 'Linking Relief, Rehabilitation and Development' (LRRD) though it is quite complex and challenging 15. The Pre-DRP is to structure in the manner that:

- LRRD finds scope and expressions
- enables a paradigm of recovery in terms of having a set of effective strategies, tools and guidelines in resolving the perennial dilemmas viz. speed verses safety/quality, etc.

- harmonizes the thoughts and action of diverse stakeholders engaged in recovery ultimately leading to risk reduction.

The unification recognizes that disaster recovery and development are the integrated processes through which vulnerabilities are reduced and capacities increased. Based on these, Pre-DRP finally should lead to post-disaster recovery interventions/operations.

The Principle of Pre-DRP

The formulation of Pre-DRP may include the following principles:

Localization, Participation and Ownership: Considering that (i) the action points of all disaster risk reduction efforts are locale specific, (ii) local community and infrastructure bear the real burnt of disasters, and (iii) all recovery efforts are to be integrated. With community participation and ownership, the PreDRP has to be locally 'relevant' and 'actionable'. It has to capture contextual dynamics of physical and social vulnerability, coping and resilience of community recognizing that resilience is highly contextual and dynamic with regards to absorbing shocks, bouncing back after disaster impact, and adapting during the recovery process to accommodate essential changes (Box IV).

In the most simplistic terms, Pre-DRP has to be holistic covering housing, infrastructure, education, livelihood, health, psychosocial care, etc. in the local context. Localization of the global best practices of knowledge, experiences and other support mechanism takes into account the risk and vulnerability dimensions at local level 16. For example, hazard zonation and risk assessment — the derivatives of other maps such as land cover, geological, climatic and poverty do provide the insights about localization of global best practices or to evolve innovative solutions locally relevant. It is in this context that land cover maps indicate ecological vulnerability; geological maps based on three-dimensional Digital Elevation Models (DEM) to geophysical and terrain vulnerability, climate maps to climatic vulnerability and poverty maps to socio-economic vulnerability. Aggregating all these enable hazard zonation and risk assessment, which provides the scientific basis localization of Pre-DRP to encourage participation and ownership (Box V).

Integration of Recovery Processes and Coordination: In the traditional sense, disaster recovery is split into different phases and recovery gains immensely from being regarded as a fully integrated process and well coordinated. The concept of LRRD is the central focus of Pre-DRP and thus assumes greater significance. The three levels of Pre-DRP are visualized: (i) short term up to 30 days mostly emergency planning viz. search and rescue, health, shelter, food, clothels, restoration of critical infrastructure, etc. (ii) intermediate planning ranging from 1 to 6 months that includes intermediate shelters, health care, psycho-social care, etc; and (iii) long-term planning (6 months to 3 yrs) on permanent resilient housing and other physical and social infrastructure, livelihood and psycho-social recovery, documentation of experiences/lessons learnt 19, which are to be well integrated. Besides these, the Pre-DRP also envisages integrating the components of every relevant sector, especially risk reduction and community development sectors. It also envisages the ways and means of ensuring better coordination among various sectors in different levels, may be in the form of manuals and Standard Operating Procedures (SOPs).

Box IV: Pre-disaster Planning for Post-disaster Recovery: Recovery Plans for Antigua and Barbuda and St. Kitts and Nevis

Recovery Plans for Antigua and Barbuda and St. Kitts and Nevis outline s set of the critical activity, plans and training materials to assist in post-disaster reconstruction efforts to ensure that the reconstruction efforts result in a more hazard-resistant housing sector. The Housing Sector Recovery Plans provide guidance and recommended action items for the respective governments, construction sectors, finance and insurance sectors, and homeowners in each nation. The general population intends the Reference Guides for use during disaster preparation and disaster reconstruction. The Training Outlines are used for short courses offered on a continuous basis or immediately after a hazard event. In addition, links to hazard reconstruction manuals are provided for in-depth information on construction techniques, standards and materials. Out of this exercise, a set of short- and medium-term suggested action for pre-disaster planning has been developed. Implementation of these actions aims to reduce the disaster recovery period and significantly increase the resilience of buildings reconstructed in the post-disaster period.

Housing Sector Recovery Plans

- Housing Sector Recovery Plan, Antigua and Barbuda
- Housing Sector Recovery Plan, St. Kitts and Nevis

Reference Guides

- Flyer: Hurricane Coming and you don't have much time?
- Homeowner's Guide to a Safer House
- Checklist for Monitoring Builders and Tradesmen
- Guide to Safe Building Practices for Tradesmen, Builders and Contractors
- Training Outlines

Training in hazard-resistant construction techniques is especially important in the post-disaster period, as the demand for construction assistance typically far outstrips the available supply of skilled labor. Outlines for a series of training course were developed. These courses can be offered in the immediate post-disaster period, as well as.on an on-going basis to strengthen hazard-resistant building practices.

- Training Outline for Builders and Upgrading training)
- Training Outline for Part-time Builders
- Training Outline for Part-time Building Supervisors

Hazard-resistant Construction Resources

- Basic Minimum Standards for Retrofitting
- Make the Right Connections: A manual on safe construction techniques
- Diagrams to accompany the Organisation of Eastern Caribbean States Building Guidelines
- Toolkit: A manual for implementation of the hurricane-resistant home improvement program in the Caribbean

Source: www.oas.org/en/cdmp/safebldg.htm

The early attention to recovery in the relief phase is very dynamic as well as crucial. For example, in post-tsunami early recovery phase in Indonesia, rubble removal operations undertaken under the concept of 'cash for work' injected cash into the local economy, while also providing a psychological boost to the participating population of some 11,000 people. Such initial actions affect all future actions. A study of 30 disaster and relief and reconstruction efforts have come to the conclusion that initial actions either support longer-term development or undermine it. PreDRP essentially aims to connect these short-term processes to the long-term recovery operations.

**Box V. Encouraging localization and ownership:
Experiences from Tsunami recovery**

Community ownership and participation in the design and implementation of recovery programmes is a critical component. It is also important to strengthen capacities on the ground. Participation of local disaster management authorities/experts and technicians help in addressing the needs and capacities of the affected population. Yet another aspect is involvement of national decision makers to building consensus around recovery priorities, roles, responsibilities and resources.

To ensure that such ownership takes hold, external support must build up local actors and institutions through the transfer of technology and know-how and through public education. In tsunami recovery operations, support provided to the Government of Indonesia by international actors has included planning, mapping, shelter and employment development at the national, provincial and district levels. In Sri Lanka, international teams have supported needs assessments and data collection. In India, post-tsunami humanitarian and recovery operations were boosted by close collaboration among government authorities, local communities and Indian United Nations volunteers. Indian United Nations volunteers were also assigned to assist the recovery programming and implementation in the Maldives and Sri Lanka, and reportedly have been instrumental in accelerating recovery efforts. In Thailand, national task forces were established to work with their international counterparts and follow-up on critical issues in the recovery phase. However, greater support and field-level coordination between national and international partners for the rehabilitation and reconstruction phase, including longer-term strategic planning, is needed.

Multi-sectoral coordination among international and national actors in the early recovery phase is another dimension to be included in PreDRP. For example, during tsunami recovery process, multi-sectoral coordination in the reconstruction phase, led by the Governments of Indonesia and Sri Lanka with the assistance of the World Bank, ADB, United Nations agencies and nongovernmental organizations, resulted in the development of national reconstruction plans, which have mapped out all reconstruction actors and activities into a coherent strategy. Overall coordination of disaster recovery requires some more learning experiences. It is important that recovery processes should be guided by clear and universally accepted coordination standards and tools and this is where PreDRP has to be in place for more effective coordination.

Inclusiveness: The experieces worldwide have been indicationg exclusion and marginalization of poor and vulnerables in the recovey processes. Pre-DRP has to promote inclusiveness, to help in engaging a larger number of partners, including national and local governments, regional and intergovernmental institutions, major International NGOs, civil society, regional development banks and other players. The overall approach of the Pre-DRP should address tackling the challenges of equity in recovery process. Global inequity — both among people and nations — is among the greatest challenges of our times and often accentuated in the aftermath of a disaster (Box VI) . Existing severe disparities have become further reinforced during relief and recovery operations in various areas such as land tenure, housing, livelihoods, health, education, etc. Despite the urgency and importance of ensuring that recovery reduces rather than increases inequity, Pre-DRP should help in integrationg our understanding of the factors, forces and consequences that contribute to inequitable recovery.

Box VI. Example of inter-ministerial collaboration

Republic of Uganda In Uganda, the Department of Disaster Management and Refugees in the Office of the Prime Minister presents a good example of multi-sectoral coordination at various levels institutionalized with the government itself. This department does both vertical as well as horizontal coordination and collaboration in disaster risk reduction, besides being the secretariat for an inter-ministerial policy committee that gives coordinated policy direction in disaster management. With UN/ISDR support, a national platform of disaster focal points from relevant ministries, such as environment, water and lands, health and education was established to plan and implement disaster risk reduction mitigation, response initiatives and disaster recovery planning. The national platform, viz., the Inter-Ministerial Technical Committee, brings together the sectoral disaster focal point officers assigned to mainstream disaster reduction issues into sectoral work plans and budgets.

These officers chair sectoral working group forums, each of which have in place sectoral plans and include civic society at the district level to streamline coordination at all levels. It has been successful at engaging international support (from United Nations Development Programme and German Technical Cooperation) to integrate crisis management and disaster risk reduction in sustainable development. The Government of Uganda has also incorporated disaster risk reduction into its Poverty Eradication Action Plan.

Source: www.opm.go.ug

Targeting the poor and vulnerable has always been a constraining factor in recovery planning. Remote sensing and GIS databases have been quite helpful and demonstrated their criticality. For example, multi-date satellite data capturing more than 50 flood waves in Brahamputra basin, India depicts the pockets of flood vulnerability in Lakshimpur district, Assam, India. Integration of these data with survey, census and scio-ecomomic data through GIS highlights and targets those poor who are perennially vulnerable too (Figure 2). Pre-DRP using such information wherever avialable may address inclusiveness issues more effectively.

Box VI. Living near the edge: Disasters and the 'near-poor'

Strategies to reduce vulnerability need to take into account the needs of the 'near-poor', as well as the poor, as disasters can force additional people into poverty. For instance:

- In El Salvador, the two earthquakes in 2001 led to an estimated 2.6-3.6 per cent increase in poverty.
- In Honduras, the percentage of poor households increased from 63.1 per cent in March 1998 to 65.9 per cent in March 1999 as a consequence of Hurricane Mitch in October 1998. The number of rural households living in extreme poverty or indigence rose by 5.5 percentage points.
- In Vietnam, it is estimated that a further 4-5 per cent of the population could be pushed into poverty in the event of a disaster.
- In Aceh, Indonesia, the 2004 tsunami is estimated to have increased the proportion of people living below the poverty line from 30 per cent to 50 per cent.

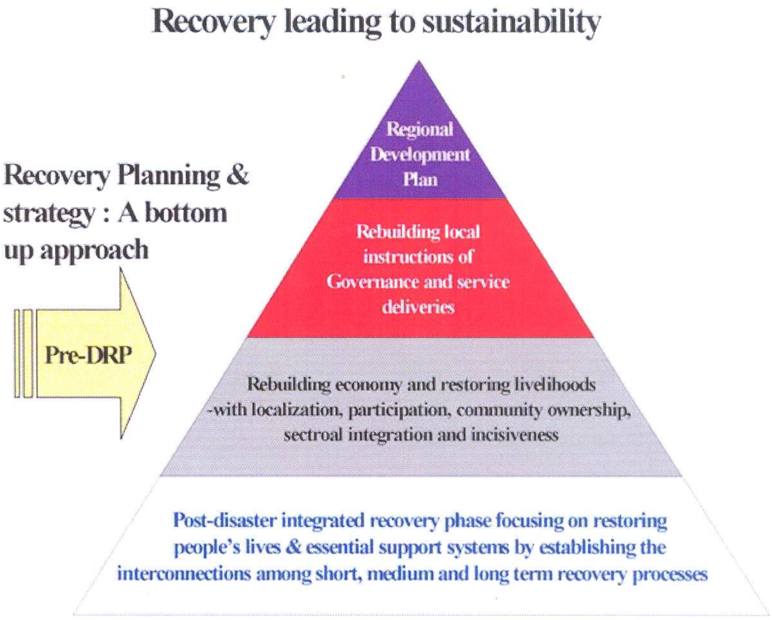
(Source: Tool for Mainstreaming Disaster Risk Reduction, ProVention Consortium, Jan 2007)

Sustainability: Sustainability of recovery operations is to be visualized and promoted as an integral part of ongoing development processes at all levels. The recovery framework of development has proved to be a good practice and also demonstrated sustainability (Box VII). Pre-DRP is essentially to capture the prevailing social and economic conditions and the vulnerability levels. Recovery needs focusing on restoring the capacity of the government and communities to rebuild and recover from disasters and prevent future relapses are required to figure out in Pre-DRP. Recovery essentially has to be treated as an opportunity to reduce the development deficits and not to simply replace the damaged infrastructure. Pre-DRP as an input to for improving the institutional and legislative systems can contribute to new or modified policies for disaster risk reduction. The critical sectors typically addressed in a recovery framework envisaged under Pre-DRP include damaged infrastructure, employment, livelihoods, lifeline facilities, environmental and water resources management, housing and resettlement of families. In fact, disaster risk reduction and the promotion of development that is participatory and equitable are at the heart of the sustainability sought in any recovery programme, and will help ensure that the recovery is demand driven and addresses the needs of the vulnerable populations. Particular attention should be paid to the vital role that women play as community leaders and members. Also, considering the recurrent nature of many natural hazards, capacity building should always guide and be a component of recovery actions, even in ad-hoc interventions.

With the bottom-up approach leading to broad based sustainability, an unique framework for recovery and reconstruction in course of post tsunami rebuilding the New Aceh and North Sumatra has been visualized 18. In the recovery operations, it has started with five goals (Figure 4):

- To restore people's lives – clean water to drink, workable road conditions, roofs over head, at least a minimum source of income; most importantly establishing the interconnections among different phases of recovery i.e. decisions/interventions taken in one phase should have positive impact on the subsequent phases;
- To restore the economy – jobs, markets for people to sell and buy daily necessities, banks that lend small-scale enterprises; to rebuild livelihoods providing social stability with their active participation in the recovery processes;
- Rebuilding the institutions of governance and delivery of services addressing the needs and aspirations of the community;
- To impart sustainability in terms of having politically stable and economically vibrant society- resilient and with enhanced coping mechanism.

Figure 4: Pre-DRP to take into account bottomup pyramid approach to facilitate sustainable recovery



Build Back and Better than Before:

In the recent years especially in the context of tsunami recovery, the notion of build back and better than before has gained momentum. In the words of Bill Clinton, UN Secretary-General's Special Envoy for Tsunami Recovery, December 2001 25 - "...throughout the world, we must work harder in the recovery stage to avoid reinstating unnecessary vulnerability to hazards. ..."building back better" means making sure that, as you rebuild, you leave communities safer than before disaster struck." Promoting build back better approaches and supporting the development of enhanced recovery capacity at a regional, national and sub-national level with a particular focus on high-risk low-capacity countries has thus to be factored in Pre-DRP.

Box VIII. An example of sustainability driven by prudent with environmental planning and management in Vietnam

Here is an excellent example of imparting sustainability through ecological interventions in Vietnam. The Thai Binh branch of the Vietnam Red Cross undertook an environmental preservation project to address two issues affecting the coastal population of the Thai Thuy district, Thai Binh province. The motivation for undertaking this project was that eight to ten typhoon storms strike the coast of Vietnam annually and tidal floods often breach sea dykes causing economic losses to the local population engaged in aqua culture. The project involved creating 2,000 hectares of mangrove plantations, which served two important purposes. Firstly, the trees act as a buffer zone in front of the sea dyke system, reducing the water velocity, wave strength and wind energy. This helps protect coastal land, human life and assets invested in development. Secondly, the plantations contribute to the production of valuable exports such as shrimp and crabs, high-value species of marine fish, molluscs and seaweed for agar and alginate extraction. This offers new employment opportunities to help what was a poor population to improve their livelihoods. By helping to protect the sea dykes the mangroves contributed to the economic stability of the communities. All members of the community benefit as their homes, livestock and agricultural land are better protected from the risk of flooding. Poor families, with little money to repair or replace material losses from storm damage, are the greatest potential beneficiaries. The project area was struck by the worst typhoon in a decade two months before the project evaluation. Lack of any significant damage to the sea dyke and aqua culture pond systems in Thai Thuy provided the best possible indicator of the effectiveness of the mangroves.

Source: World Wide Fund for Nature, 2002

Among the best practices where recovery opportunities have led to 'build, back and better', Gujarat Earthquake Emergency Reconstruction Programme (GEERP) followed by Bhuj Earthquake 2001 exemplifies how recovery could lead to sustainable development. The GEERP being implemented by Gujarat State Disaster Management Authority (GSDMA) identified 28 products and services in terms of reconstruction and rehabilitation packages addressing housing, rehabilitation for orphans, women, artisans, industry, trade and services, agriculture and tourism which could pave the way for revival of livelihood and economy, trade and enterprise resurgence, renewal of social capital and reinforcement of critical infrastructure. Major international financial agencies, UN organizations, international donors and Government of India have been supporting the recovery process. It is important to recognize that most of these packages are knowledge products supported by governmental policy, plans, preparedness strategy and public private partnership. Reasons for GSDMA's success include: (i) institutionlization of recovery operations taking into account all the principles listed out earlier section - (i) managed by senior state government officials with required functioal autonomy, (ii) well integrtaed with line departments and had an independent financial and executive authority to disburse funds and to review progress as well as to take corrective policy measures based on field assessments and (iii) it is able to use the existing field agencies of the state governments, such as the collectorates, the district councils and the line departments of public works, education, health and water supply to implement programmes. The GSDMA continued after the closure of the Gujarat Project and became the disaster prevention and management organisation of the state on a permanent basis, thus ensuring that lessons learned were institutionalised into state disaster management plans. Lessons learned from India include (i) the importance of following through by applying the lessons from disaster recovery to build more resilient communities and improved patterns of administration; (ii) the need to build risk reduction into recovery management; (iii) the importance of recovery organisations being fully integrated within the governmental system but with designated authority to act decisively 21, 29.

Pre-DRP — from Know How to Do How?

Pre-DRP essentially draws substance from the lessons learned from previous disasters as well as knowledge of risk reduction measures, to avoid the reconstruction of risk and to address the underlying causes. To develop a recovery plan that reduces future risk, the following steps have been recommended (adapted from Tool for Mainstreaming Disaster Risk Reduction, ProVention Consortium, Jan 2007):

- Outline and projectize Pre-DRP related activities taking into account the recovery principles highlighted earlier;
- Document the information on physical and economic development and redevelopment plans; assess the hazards and activities, institutions and structures most at risk from those hazards and their vulnerability; review capability assessments to ascertain what resources and capabilities are available to respond to and recover from disaster; examine the strengths and weaknesses of the organizations responsible for responding to emergency situations, managing recovery and reducing losses;
- Analyse risk and capacity assessments to determine needs and appropriate responses

to various kinds of disaster events, as well as the kinds of mitigation measures that should be built into recovery and reconstruction from various disaster scenarios;

- Identify lead agencies for undertaking recovery planning and implementation to various types of disasters and assign roles;
- Create systems for communicating situation information, needs and orders to and from those in charge;
- Establish linkages and mechanisms for coordination between agencies, levels of government and with the private sector and the public;
- Draft a plan for recovery and consult with government departments, interested organisations, businesses and the public. Establish a mechanism for receiving reviews and addressing concerns;
- Make necessary changes, publish and arrange for adoption and signing of the plan by representatives of all affected organisations;
- Widely disseminate and publicise the major tenets of the recovery plan;
- Establish processes for testing, exercising and revising the plan in accordance with changing circumstances and requirements.

Planning based on vulnerability and capacity assessment

It is important to recognize that people's vulnerability and capacity in the context of recovery. Recovery planning apart from LRRD concept could follow the basic approaches to vulnerability and capacity assessment and analysis (VCA) by aiming at:

- identify vulnerable groups;
- identify the factors that make them vulnerable and how they are affected;
- assess their needs and capacities; and
- ensure that recovery operations address these needs, through targeted interventions or prevention and mitigation of potentially adverse impacts.

VCA takes into account a wide range of environmental, economic, social, cultural, institutional and political issues that create vulnerability (Table 1)

Table 1: Sectoral components of recovery planning

Vulnerability	*Capacity*
Social sector ■ Occupation of unsafe areas ■ High-density occupation of sites and buildings ■ Lack of mobility ■ Low perceptions of risk ■ Vulnerable occupations ■ Vulnerable groups and individuals ■ Corruption ■ Lack of education ■ Poverty ■ Lack of vulnerability and capacity analysis ■ Poor management and leadership ■ Lack of disaster planning and preparedness	■ Social capital ■ Coping mechanisms ■ Adaptive strategies ■ Memory of past disasters ■ Good governance ■ Ethical standards ■ Local leadership ■ Local non-governmental organisations ■ Accountability ■ Well-developed disaster plans and preparedness
Physical sector ■ Buildings at risk ■ Unsafe infrastructure ■ Unsafe critical facilities ■ Rapid urbanisation	■ Physical capital ■ Resilient buildings and infrastructure that cope with and resist extreme hazard forces
Economic Sector ■ Mono-crop agriculture ■ Non-diversified economy ■ Subsistence economies ■ Indebtedness ■ Relief/welfare dependency	■ Economic capital ■ Secure livelihoods ■ Financial reserves ■ Diversified agriculture and economy
Environmental Sector ■ Deforestation ■ Pollution of ground, water and air ■ Destruction of natural storm barriers (e.g.,mangroves) ■ Global climate change	■ Natural environmental capital ■ Creation of natural barriers to storm action (e.g.coral reefs) ■ Natural environmental recovery processes (e.g.,forests recovering from fires) ■ Biodiversity, responsible natural resource management

Some sectors in a recovery plan:

The following sectors are included in recovery planning (adapted from Tool for Mainstreaming Disaster Risk Reduction, ProVention Consortium, Jan 2007).

Rehabilitation/recovery of infrastructure and critical facilities: The rapid rehabilitation of primary infrastructure such as primary roads, bridges, water supply and sanitation systems, primary power generation and distribution facilities, irrigation and agricultural facilities, health, education and other social facilities, will lead to economic revitalisation of the affected region. The key for an effective rehabilitation programme is an accurate and thorough damage assessment, which will provide the necessary information on why infrastructure was damaged or destroyed and will determine the modality of including risk reduction in rehabilitation and reconstruction.

Employment and livelihoods: Support agriculture and livestock production, through the provision of seeds, tools, micro-credits and other means; support small business through the provision of credits or other means; support reconstruction of the housing sector using local technologies, construction materials, local know-how, to ensure that construction activities have a direct positive impact upon the local economy; support short-term gendersensitive alternative employment generation to compensate lost livelihoods in the immediate post-disaster period.

Housing: Housing rehabilitation/reconstruction is a key element in closing the gap between emergency relief and sustainable recovery. It is a first step toward reactivating the productive economy. Building the capacity of local authorities to promote, supervise and guide planning and construction processes is key for a successful and sustainable reconstruction process. Local authorities should be enabled to set up legislative and regulatory frameworks to promote local initiatives and local involvement in planning and construction issues;

Resettlement of families: Often in the aftermath of a disaster, experts and government officials promote a safer location for settlement of people at risk. Experience shows, however, that resettlement of populations on new sites presents major challenges and often leads to resettled people returning back to their original sites.

Major stakeholders

Recovery planning should involve finance, planning, urban, infrastructure line ministries, non-governmental organisations, private construction industry and corporate sectors. It is important that skilled and experienced people in this area form part of the plan development team so that recovery becomes an integrated component of the planning and preparedness process.

Action points

The following actions can facilitate the integration of recovery into disaster preparedness activities:

- Accurate risk assessments and development of likely disaster scenarios;
- Participation of authorities from provincial and local levels with executive authority for planning and implementing post disaster recovery and reconstruction plans;
- Focus on the participatory aspect of the planning process more than the resulting plans, as buy-in is necessary in plan implementation;
- Ability to involve finance and budgeting authorities to earmark upfront resources for disaster recovery.

International Recovery Platform (IRP) And Pre-DRP

The International Recovery Platform (IRP), a thematic platform of the International Strategy for Disaster Reduction (ISDR) system, has been mandated to address the gaps and constraints currently experienced in the context of disaster recovery and functions as an international source of knowledge on good recovery practice. The IRP's efforts focus on mainstreaming a culture of prevention, mainly by supporting and facilitating the adoption of appropriate recovery practices by disaster-affected populations and their governments with a particular focus on high risk/low capacity countries. The work of the IRP is manifested in (i) a regular high level event – the Kobe Recovery Forum – bringing together a broad range of senior policy makers and recovery practitioners for an exchange of experience and frank discussion towards the advancement of resilient recovery and achievement of the HFA; (ii) close cooperation with regional organisations in promoting and building capacity for resilient recovery; and, (iii) development of tools and resources to fill identified gaps in recovery practices and capacities, such as the framework for Post Disaster Needs Assessment (PDNA) for Recovery (Box IX). An interactive web-site (http://www.recoveryplatform.org) provides the gateway for a current exchange of knowledge and experience amongst members of the IRP Community of Practice.

Box IX. Post Disaster Damage and Needs Assessments (PDNA) for Post-Disaster Recovery

A longstanding methodology exists for assessing the direct and indirect economic impact of a major natural disaster developed by the Economic Commission for Latin America and the Caribbean (ECLAC) is usually applied by the World Bank and regional development banks in order to provide the justification for multilateral loans for reconstruction. The ECLAC methodology is widely accepted by governments, donors, the IFIs and the UN system and capacities have been developed at all levels for its application following disasters.

PDNA is a set of methodologies and guidelines accurately and reliably assessing disaster-related physical damages and economic losses, identifying and defining early recovery needs on the basis of those damage and loss patterns and for planning early recovery activities on the basis of the needs identified. The guidelines also address medium and longer-term recovery needs and planning including a risk reduction strategy.

It is a set of tools to underpin the methodologies and guidelines, capable of analyzing and displaying data on physical damages and economic losses with a national level of observation and local level of resolution in the temporal, spatial and semantic domains.

The primary purpose of the PDNA is to provide all actors in the recovery process, including national and local authorities, international agencies and local communities, with a multi-sectoral, technical overview of the damage and loss patterns and the principal rehabilitation and reconstruction needs and priorities to be addressed during post disaster recovery. In fact, PDNA based strategy for need assessment process for humanitarian disasters/ER Clusters taken up by UN HABITAT and ILO-FAO livelihood assessment strategies is compatible. UN HABITAT development of the rapid need also fits into the PDNA. The compatibility was rehearsed and demonstrated in very specific cases of Bolivia floods in early parts of 2007.

Source: Richardo Zapata-Marti (2007)

The IRP's work plan at the local/national-level includes Pre-DRP components ranging from documenting lessons learned; dissemination of knowledge products, tools and methodologies, including needs assessment tools; facilitation of sharing of local and international experiences on recovery by organizing technical workshops and other learning events; creation of communities of practice on recovery at the national level encouraging participation and input from line ministries, academics, local communities and civil society, using constituted national platforms when available; and, supporting pre-disaster planning for recovery in high-risk low-capacity countries.

Pre-DRP based on Lessons Learnt Exercises (LLEs)

In context of Pre-DRP, IRP recognizes the lessons learnt experiences (LLEs) for different types of disasters and by the countries having diverse range of vulnerability are the valuable knowledge bases on recovery. These LLEs could be the powerful tools in the hands of decision makers to take crucial decisions as a means of PreDRP. IRP envisages having a dynamic knowledge repository as an integral component of PreDRP, which will have comprehensive the knowledge bases emanating from LLEs. To enable this to happen, it is important that these LLEs are to be appraised, analyzed and applied (AAA) in the recovery efforts and to prepare for future disaster scenarios like Asian Tsunami 2020, Bhuj earthquake 2010 etc.

Appraise, Analyse and Apply (AAA)

The strategy of AAA is widely used and found to be the most appropriate tool for event-history simulation purpose (Figure 2). This deals with three key elements, namely:

Appraisal exercise will focus on:

- Lessons learnt exercises (LLEs) based on the disaster impact levels such as major/minor disasters
- Macro and Micro level LLEs which deal with international organizations and local level organizations respectively
- Preparation of templates to be deposited in the Knowledge Repository of IRP.

Analyze exercise will focus on:

- Impact Evaluation and Categorization of Good and Best practices of Recovery in accordance with Disaster Types (earthquake, flood, drought, typhoon, tsunami, etc.) and Sectors (Agriculture, Industry, Service, etc.).
- Evaluation of country's current recovery frameworks, policies,laws and strategies and the level integration into the planning process.
- Preparation of templates to be deposited in the Knowledge Repository of IRP.

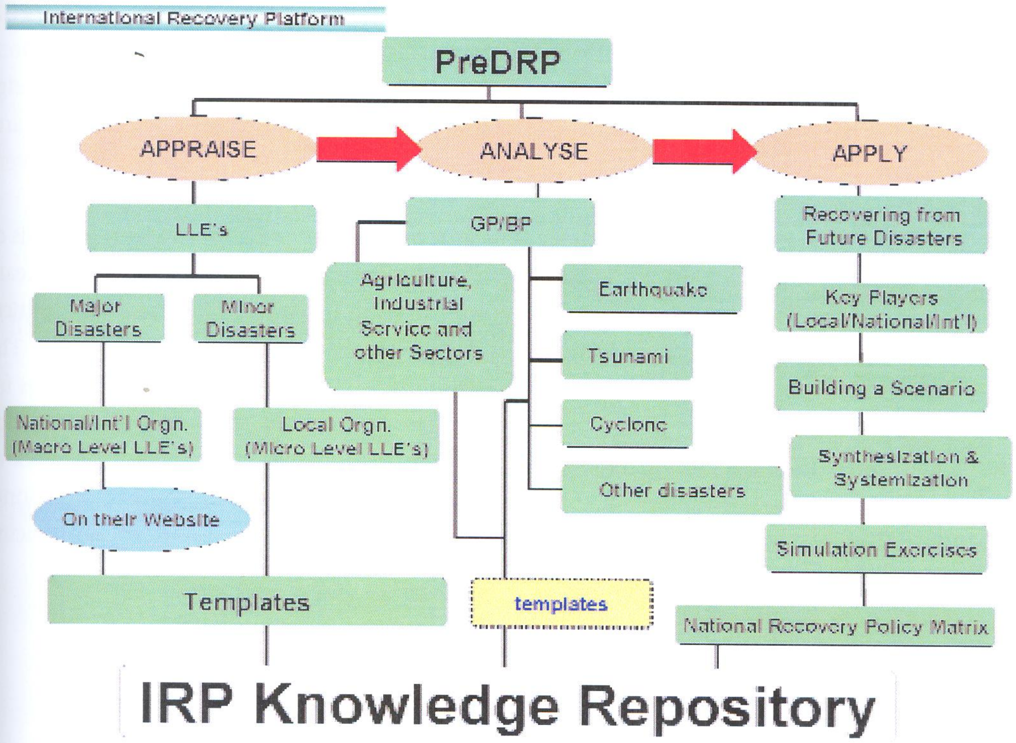
Apply exercise will focus on:

- Recovering from future disasters.
- Identifying key players such as International/Regional/National/Local bodies.

- Building disaster scenarios.
- Synthesization and Systemization of LLEs and recovery methodologies.
- Simulation exercises
- Capacity-Building programs designed for objective and systematic analyses of disasters by individuals and instituions.
- Creation of a National Recovery Policy Matrix.
- Preparation of templates to be deposited in the Knowledge Repository of IRP.

IRP has already started knowledge retrievable documentation of LLEs along with the documentation of good and best practices in disaster risk reduction and recovery planning focusing on policies, legislations, institutional arrangements, reforms and stakeholder partnerships.

Figure 2: Evolving IRP knowledge repository based on LLEs facilitating PreDPR



5.2 Promoting Pre-DRP through Networking

In pursuit of populating Pre-DRP concept, IRP is making efforts to create and develop an exhaustive database of lessons learnt exercises and good/best practices on recovery related experiences and make them available on the website of IRP as clearing house and convert them as a powerful tool in Disaster Risk Reduction and Recovery Planning for subsequent use by various countries and other organizations. It is envisaged that such knowledge repository would:

- help build and enhance the capacity of national and local governments and other relevant key institutions for PreDRP
- develop a detailed framework for PreDRP especially for a high-risk and low-capacity country
- work out a calendar of follow-up activities, event matrix and roadmap for different component of Pre-DRP.

The Pre-DRP is yet another unique IRP product envisaged to take into account the provision of assistance or intervention during or immediately after a disaster to address short-term crisis management as well as long-term risk reduction strategies. Knowledge products with regards to facilitating Post Disaster Damage and Need Assessment and National Recovery Policy Matrix are another set of deliverables to enhance recovery operations.

The IRP envisages promoting capacity building not only by developing human skills or societal infrastructures within a community or organization including UN Country team needed to reduce the level of risk and also strengthening institutional, financial, political and other resources, such as technology at different levels and sectors of the society. The IRP aims at providing an open, clear and user-friendly inventory of available resources for capacity building worldwide, with a special emphasis on training offerings and knowledge tools at international, regional, national and local level. With the well-knit network of associating agencies, IRP capacity building efforts are expected lead institutional strengthening at various levels. The IRP deliverables are thus tailored for enhancing recovery and disaster risk reduction (Box X).

Box X. IRP Thematic Areas of Work

The IRP workplan is developed around four thematic areas that are central to the achievement of the IRP agenda. These include:

I. *Advocacy and development of recovery partnerships:* The IRP develops and pursues a concise and effective advocacy agenda for disaster risk reduction in recovery through the organisation of and participation in relevant recovery fora worldwide as well as through the dissemination of relevant publications and the analysis of trends relevant to resilient recovery. The IRP strives to forge linkages, promote partnerships and serve as a catalyst among stakeholders to facilitate consultation for developing a common agenda for recovery. It provides a forum to generate cutting edge ideas and collaborative initiatives through dialogue, deliberately provoking debate and critical analysis.

II. *Knowledge management:* Knowledge on recovery and risk reduction enables disaster-affected communities and governments to understand their risks and effectively manage their own recovery. The IRP connects actors with different fields of expertise on recovery and catalyzes knowledge generation. The IRP, through an agreed comprehensive knowledge sharing and communication strategy, collects and shares knowledge generated through evaluation of project activities and makes use of broader exchange and learning fora. This involves stocktaking, and where necessary development of templates that enable national institutions and others to document lessons learnt from major disaster recovery operations that are made available on the IRP website, www.recoveryplatform.org.

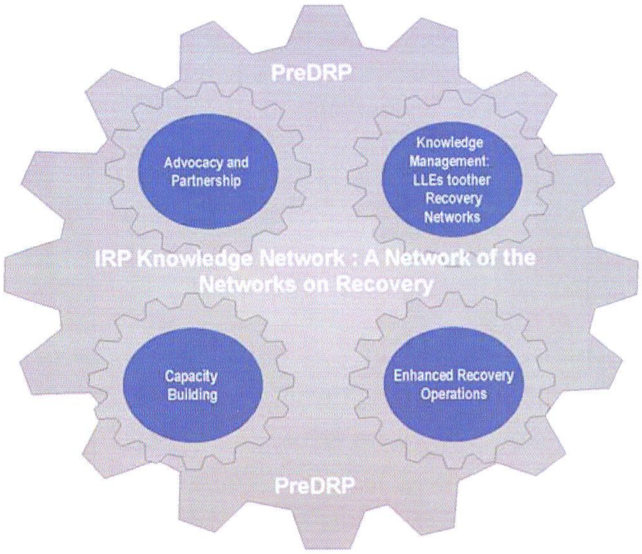
III. *Capacity Building:* The IRP contributes to the enhancement of post-disaster recovery operations by supporting the development of necessary capacities through training, experience sharing and technical exchanges. The IRP supports the development of recovery and risk-reduction skills and capacities of local, national and international recovery stakeholders.

IV. *Effective recovery operations:* The IRP supports more effective recovery operations through the development of relevant tools and resources, such as the framework for Post-Disaster Needs Assessment (PDNA) for Recovery, in close cooperation with the IASC CWGER. It seeks to identify opportunities of coordination and closer cooperation amongst recovery actors and capacities at the national, regional and international levels with a particular focus on South-South cooperation.

Pre-DRP is factorized well in the strategic partnership and work plans of IRP. Promoting the goals of Pre-DRP by way of knowledge network as a network of the networks on recovery populating micro-level mapping of events and learning therein to national, regional and global levels is an important step. IRP as a network of the networks has been putting considerable efforts, as element of PreDRP, to activate, facilitate and accelerate (i) the processes of knowledge management cycle, (ii) the knowledge bases of LLEs to get networked and synergized with other recovery initiatives, (iii) capacity-building efforts, and (iv) risk resilient 'transformative' recovery planning (Figure 6). With regards to the outcome of IRP Pre-DRP, the endeavour aims at facilitating development of National Recovery Policy Matrix in terms of some key aspects/sectors like:

- Physical
- Social
- Psychological
- Economic
- Environmental

Figure 7. Visualizing IRP as a recovery network of networks and as an element of PreDRP.



This policy matrix is to serve as the major component in national disaster management road map of a particular country.

The ILO-FAO Joint Initiatives on the Livelihood Assessment Toolkit for Recovery Planning

UN agencies like UNDP, ILO and FAO, within the International Strategy for Disaster Risk Reduction and its thematic International Recovery Platform, are spearheading an inter-agency initiative to establish standards and guidelines for pre-disaster recovery planning. A framework spells out priorities, obtain systematic data and information about recovery, compares approaches and analyzes trends, contribute to knowledge management and transfer of good practices, identifies gaps and addresses them through new or improved policies and plans.

In livelihood recovery planning, assessing the impact of disasters on it and also the capacity and opportunities for quick recovery and increased resilience to future events is an important element. The current systems of assessment are not strongly linked to livelihood recovery interventions. Towards addressing these needs, FAO and ILO have jointly developed the Livelihood Assessment Toolkit (LAT) within the concept of the *Livelihood Assessment and Response System* (LARS) as a part of the wider Post-Disaster Needs Assessment (PDNA) framework coordinated by UNDP within the Cluster Working Group on Early Recovery.

The LAT consists of three main technical elements: *Livelihood Baseline Information* (which is set-up pre-disaster); *Immediate Livelihood Impact Appraisal* (undertaken immediately after the disaster); and *Livelihood Assessment* (undertaken within three months after the disaster). As far as LARS is concerned, it consists of the LAT plus assessment preparedness and detailed Livelihood response planning. In the process of development, parts of this tool-kit have been tested and refined in a number of countries, most recently in Bolivia, in the aftermath of the serious flooding of early 2007. Yet another example of this was, immediately after the October 2005 earthquake which struck the Kashmir region, ILO and FAO experts assessed the needs of local populations for livelihood recovery and started collaborating under a UNDP led programme for the provision of training, labour-based and employment promotion initiatives.

The toolkit creates a robust platform for joint elaboration of strategies and project proposals to the international donor community for the recovery of the livelihoods and employment opportunities in rural and urban contexts, aiming at restoring local food production, supporting the recovery of job opportunities, re-establishing economic and trade networks and revitalizing local markets by reviving demand for local services and products. Indeed, in every country where the Livelihood Assessment tool has been used so far, it has led to the immediate development of a livelihood recovery plan.

Initiatives by other international agencies

World Bank under Track III of Global Facility for Disaster Reduction and Recovery envisages accelerated disaster recovery in low-income countries in terms of an incentive-based mechanism to invest in ex ante risk management, greater institutional preparedness among all stakeholders, rapid and predictable financing available for a sustainable disaster recovery operation. Pre-DRP is being promoted to implement Track III. Shelter continues to be one of the most pressing issues in the recovery effort and UN HABITAT efforts in this direction as PreDRP is notable.

Pre-DRP: Prospects And Challenges

It is evident that actions taken during the first weeks and months after a disaster have a major impact on the recovery process to follow. They need to be planned before a disaster strikes. As the choices made immediately following a disaster — regarding shelter, resettlement, debris clearance, distribution of relief, and the like — affect the later choices for longer-term solutions, a pre-disaster recovery strategy has been helpful in risk reduction. Pre-disaster actions also need to include the development of the capacities, knowledge, and skills that will be required for the recovery process. *Pre-disaster recovery planning* is therefore an imperative need with a view to putting in place appropriate measures prior to the occurrence of a disaster. The concepts and principles of Pre-DRP are also getting crystallized with the focus on integration of relief, rehabilitation and reconstruction phases.

The UN agencies, viz. IRP, World Bank, UNDP, ILO, FAO HABITAT, etc. have been playing a key role to promote Pre-DRP as an important component of risk reduction through recovery operations. Each one of these agencies has developed well-known and accepted procedures and mechanisms of Pre-DRP to support national governments in risk prone countries and to promote Pre-DRP as an integral component of recovery. The challenges lie in building capacities in high-risk countries, in the UN system or amongst a cadre of experts to apply such tools, techniques and methodologies in practice. It is important that Pre-DRP could find large-scale operationalization especially in high-risk and low-capacity countries. Yet another challenge is building a broader base of community of practices with Pre-DRP, especially by private sectors, NGOs and field-based agencies. A shared concern has arisen amongst humanitarian and development actors that not enough is known about the mechanics of effective disaster recovery practice, that not enough is done to work with and support governments of high-risk countries in developing capacity to effectively manage recovery processes and, that more can be done in bringing together recovery stakeholders in order to ensure a coherent and timely support of national recovery efforts. Pre-DRP as a tool creates an opportunity to bring together all the recovery stakeholders; to harmonize recovery practices and address the existing gaps and inadequacies in recovery operations.

References

ALNAP and ProVention Consortium. South Asia Earthquake (2005): Learning from previous recovery operations. *Active Learning Network for Accountability and Performance in Humanitarian Action and ProVention Consortium, 2005.* http://www.alnap.org/publications/pdfs/ALNAP-ro Vention_SAsia _Quake_Lessonsb.pdf

Beck T. (2005) Learning Lessons from Disaster Recovery: The Case Study of Bangladesh, *World Bank Publication;* Washington DC

ADPC. Proceedings: Regional Workshop on Best Practices in Disaster Mitigation – Lessons Learned from the Asian Urban Disaster Mitigation Program and Other Initiatives, 24–26 September 2002, Bali, Indonesia. Bangkok: Asian Disaster Preparedness Center, 2004.

IRP (2006) IRP Database on Post-Disaster Recovery: Good Practices and Lessons Learned (www.internationalrecoveryplatform.org).

ISDR (2005) *Hyogo Framework for Action: Summary Document International Strategy for Disaster* Reduction (ISDR): Geneva.

ISDR, (2005). *'Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters'.* International Strategy for Disaster Reduction (ISDR): Geneva

Words in Action: Implementing HFA, Document for Consultation Drat Nov 2006, International Strategy for Disaster Reduction (ISDR) Geneva, 2006.

World Bank. (2005). *Natural Disaster Hotspots: A Global Risk Analysis,* Maxx Dilley, Robert S. Chen, Uwe Deichmann, Arthur L. Lerner-Lam, and Margaret Arnold, with Jonathan Agwe, Piet Buys, Oddvar Kjekstad, Bradfield Lyon, and Gregory Yetman. Washington, DC: The World Bank.

International Recovery Platform – *UN Proposal Supported by Govt of Japan and the Asian Disaster Reduction Centre* (ADRC), UNDP/IRP Kobe, Japan, 2005.

Tool for mainstreaming disaster risk reduction: guidance note for development organizations, Charlotte Benson and John Twigg with with Tiziana Rossetto, ProVention Consortium, PO Box 372, CH – 1211 Geneva 19, Switzerland, January 2007: www.proventionconsortium.org

Thapliyal BK, Training Module on Planning for Disaster Preparedness and mitigation, *A Hand Book for Training on Participatory Local Development,* FAO Regional Office for Asia and the Pacific (RAP) Publication 2003/07, Bangkok

UNDP Local Governance in Tsunami Recovery: Lessons Learned and Emerging Principles UNDP Regional Centre in Bangkok Serving Asia and Pacific UNDP: Bangkok, 2006.

UNDP (DP/2001/14, paragraph 48), UNDP.

Alexander, D. Principles of Emergency Planning and Management. NY: Oxford Univ. Press, 2002.

Davis, I (2007), Learning from Disaster Recovery – Publication from IRP supported by ADRC, ISDR and UNDP, IRP Kobe.

Srivastava, Sanjay K, Knowledge inputs to disaster management and poverty alleviation: an operational perspective based on space technology applications in India; Disasters, 2007 (in press).

Sanjay K Srivastava, S Bandyopadhayay, B Manikiam, V S Hegde and V Jayaraman, A Geo-Informatics based Approach for Disaster Risk Assessment: A Perspective Analysis.

www.oas.org/en/cdmp/safebldg.htm

Dhar Chakrabarti, PG, *Strengthening Recovery Capacities in SAARC Region,* Lecture delivered during Side Event of Global Recovery Platform for Disaster Risk Reduction, June 6, 2007, ISDR Geneva.

Anderson, Mary B., and Peter J. Woodrow. (1989). Rising from the Ashes. Boulder, CO: Westview.

World Bank. (2006) *Hazards of Nature, Risks to Development: An IEG Evaluation of World Bank: Assistance for Natural Disasters.* Washington, DC: World Bank, Independent Evaluation Group.

www.opm.go.ug

Indonesia: Notes on Reconstruction The December 26, 2004, Natural Disaster, The Consultative Group on Indonesia January 19-20, 2005, A Technical Report Prepared by BAPPENAS and the International Donor Community (No 31381), The World Bank Office, Jakarta 12190, Indonesia.

World Wide Fund for Nature, 2002.

UN Special Envoy for Tsunami Recovery President Bill Clinton, (2005): Transcript of Remarks to UN Economic and Social Council (ECOSOC), Humanitarian Segment, Panel *"Lessons Learned From the Response to the Indian Ocean"* July 14th 2005, United Nations, New York (www.unisdr.org/eng/media-room/point-view/WJC-ECOSOC-transcript.pdf).

World Bank. *Lessons from natural disasters and emergency reconstruction.* Washington, DC: World Bank, Operations Evaluation Department, 2005.

Sinha Anil, Book: Gujarat Earthquake, 26th January, 2001, New Delhi, Indian Institute of Public Administration, 2002.

Sinha Anil, Lessons Learnt from Gujarat Earthquake; Inter-country meeting on Disaster Preparedness; World Health Organization Regional Office for South East Asia; Bali, Indonesia- June, 2001.

Parveen Pardesi communication to Ian Davis as referred in *Learning from Disaster Recovery* – Publication from IRP supported by ADRC, ISDR and UNDP, IRP Kobe, 2007.

Davis, I., Haghebaert, B. and Peppiatt, D. Social Vulnerability & Capacity Analysis. Workshop. Geneva, 25–26 May 2004. Geneva: ProVention Consortium, 2004 (www.proventionconsortium.org/themes/default/pdfs/VCA _ws04.pdf).

Richardo Zapata-Matri, *Post-disaster Need Assessment (PDNA) – an emerging tool for better recovery,* Lecture delivered during Side Event of Global Recovery Platform for Disaster Risk Reduction, June 6, 2007, ISDR Geneva.

Theme Paper, Planning for Livelihood Recovery: An Event at the ISDR Global Platform for Disaster Risk Reduction, Organised by ILO and FAO in collaboration with UNDP/BCPR, June 7, 2007, Geneva.

Report of the United Nations Secretary General on international cooperation on humanitarian assistance in the field of natural disasters, from relief to development (A/61/314).

World Bank and UN/ISDR. *Global Facility for Disaster Reduction and Recovery: A partnership for mainstreaming disaster mitigation in poverty reduction strategies.* Washington, DC and Geneva: World Bank and United Nations International Strategy for Disaster Reduction, 2006.

Sinha Anil, Sinha Ravi, Verma Amit; Book- *Disaster Reduction for Sustainable Development: Involving Corporate Sector,* New Media Communication Pvt. Ltd., ISBN 81-903585-0-2; Mumbai, January 2006

Investments in a Safe Future: Disaster Reduction in Schools in South Asia

Manu Gupta

Abstract

Disaster risk reduction can most successfully be brought about through education. Schools provide the most appropriate entry towards building a culture of safety in society. At the same time, considering the large loss in lives of schoolchildren in recent disasters, disaster management practitioners need to hold themselves responsible for ensuring that schools and schoolchildren are protected at any cost. Ensuring zero mortality of schoolchildren by preventable disasters by 2015 is a concrete target that governments, NGOs and other stakeholders should earnestly strive for.

This paper describes some of the pilot initiatives taken up by governments and NGOs on school safety in South Asia. The author has summarized the approach to school safety based on successes and lessons learned so far in implementing disaster risk reduction in schools. The author emphasizes the importance of prioritizing specific aspects of school safety, considering the principal causes of disasters as well as the given constraints of resources among developing countries in South Asia. The final part of the paper describes the salient features of some of the recent international initiatives taken in setting the framework for school safety activities in the region.

A series of natural disasters leaving thousands of children dead or injured has brought the issue of disaster prevention in schools to the centre of all attention.

No civilization can bear the loss of its children. Little wonder that public angst in China, following the May 2008 earthquake in the Sichuan province, was primarily aimed at the government for not taking responsibility for weak school buildings. And over 9000 children and teachers died in their classrooms when the 7.9 magnitude earthquake struck at Sichuan (14:28:01 CST) on May 12, 2008.

The message is simple. We as adults are accountable for the safety of our children. As the little girl in the remote school in Nepal wrote in an essay competition, *"I think that* *it is our right to know about earthquakes. This is because when earthquake comes everybody including our parent, teachers will try to save their own lives. At that time they may not take care of us. So we ourselves need to know what to do during earthquakes...... Also it is our right to have a safe school. We don't build our school building ourselves. But if it is very weak then earthquake will destroy it and kill us. Why should children die from weakness which others create? That is not because of our fault. It is their fault who build houses. So we request all our parents, teachers to build safe school buildings for us." (Written by Sony, a student in Nepal)*

Safety in Schools: The starting point for DRR

Fortunately, the winds of realization that have brought about a paradigm shift from disaster response to disaster risk reduction have recognized schools as an important forum to address sustainable disaster prevention issues.

The South Asian region has been exposed to a series of devastating disasters in recent years. Real experiences thus turned into lessons that were quickly translated into action.

In **India**, the UNDP-supported Disaster Risk Management Programme of the Government of India has reached out to 169 most vulnerable districts of the country. Among the beneficiaries, school communities have responded most enthusiastically. Teachers and students more often then not took the lead in taking disaster reduction issues into the community. The Government's Central Board of Secondary Education (CBSE) introduced disaster education in the curriculum for senior classes. The board caters to 900,000 children in schools across India.

Encouraged by the enthusiasm of teachers and students, SEEDS, along with Gujarat State Disaster Management Authority, designed a pilot programme to promote school safety in the State. For people in Gujarat this was a case of learning and applying lessons from their most recent experience (2001, Gujarat Earthquake) in which they had lost friends and family members. The mutually reinforcing efforts of government, civil society organizations, school community and parents have resulted in the programme's gaining significant momentum and appreciation.

The Cascading effect of pilot initiatives

The Hyogo Framework for Action provided the direction and tied it in with other interventions in risk reduction. The result of some of the intial successes as well as strong international advocacy by United Nations International Strategy for Disaster Reduction (UN-ISDR), Coalition for Global School Safety (COGSS) was the development and recognition of tools, techniques and mechanisms aimed at promoting a culture of safety in schools all across India.

During 2005 SEEDS, in association with State Governments and the international humanitarian community, introduced school safety programmes in four regions across India.

The Andaman School Safety Initiative, covering 40 schools in Andaman & Nicobar Islands is using the window of opportunity offered by the post-tsunami rehabilitation process. The project supported by Christian Aid, Danchurch Aid and subsequently by Save the Children has been carried out in association with the Andaman Nicobar administration in schools located in Port Blair, the capital of Andaman & Nicobar Islands. The tsunami experience has brought the international community together in the most unique way. One interesting case of sharing and learning at grass roots has been the effort of the Asian Disaster Reduction and Response Network, with support from the Asian Disaster Reduction Centre, Japan. It has brought a famous Japanese folktale, Inamura-no-hi, to be shared in nine local languages in schools across tsunami-hit countries in Asia. The story relates how Goryo Hamaguchi, a village elder in 19th-century Japan, saved his fellow villagers from an impending tsunami by burning his rice sheaves, thus attracting people away from sea coast. This story is now being shared among school children thousands of kilometres away in the Andaman & Nicobar Islands. Children have begun to overcome their fears by learning to know about tsunamis and the precautions that are needed for protection.

In the capital city of New Delhi, which has been fortunate not to experience any major earthquake for a long time even though it lies in a high seismic zone, children learnt about non-structural hazard mitigation. Buildings do not always collapse in earthquakes, but the elements within the building can become potential hazards, injuring or killing people. Non-structural hazard mitigation thus becomes important for safety against small and medium earthquakes that happen much more frequently than large ones. The message on non-structural mitigation taught through simple 'hazard-hunt' forms was picked up by students in schools and shared further with their families at home. This was piloted by SEEDS in partnership with GeoHazards International and support from USAID in the Ludlow Castle School.

In the north, the attention has been on the Himalayan belt that was most recently hit by a devastating earthquake in October 2005. The Himalayas are notorious for some of the most devastating earthquakes in history. The 1905 Kangra earthquake was the worst in Indian history. Thereafter, many earthquakes have struck the region claiming a large number of lives. In spite of such high risk, physical development in the region has continued unabated without incorporating any safety standards. The building construction is largely un-engineered, haphazard and likely to collapse even in medium-level tremors. In and around Shimla city, the capital of Himachal Pradesh, SEEDS with a benevolent support of Christian Aid and European Commission launched a school safety programme with a four-pronged strategy: (i) Structural retrofitting of school buildings to prevent their collapse in future earthquakes; (ii) Implementation of non-structural mitigation measures to avoid injuries from falling hazards in schools; (iii) Education of school management and construction workers on safe infrastructure; and (iv) Preparation of school disaster management plans and training of school communities in immediate response, evacuation and first aid. In the emerging concrete jungle that continues to accrue unmindful of the growing risk, the selected school buildings will serve as models of a safe community.

In the coastal states of Orissa and Tamil Nadu, school safety work has been extended to include local neighbourhoods and their active participation in joint risk assessment and disaster management planning. Disaster Risk Reduction Strategies are now focused on making schools 'safe havens' for local communities during disasters. Schools are thus strengthened and equipped to serve as temporary relief shelters for communities. This also provides impetus for early restoration of education following disasters, an important priority that is now voiced by the humanitarian community internationally. (INEE 2008)

Nepal

In the schools in **Nepal**, both the buildings and its occupants face extreme risk from earthquakes because of highly vulnerable building stock, high occupancy in it, and high seismic hazard. On an average, Nepal is hit by a major earthquake once every 100 years and a medium-sized earthquake once every 40 years. In 1988, eastern Nepal experienced an earthquake that measured 6.6 on the Richter scale. More than 950 school buildings were damaged.

Most of the Nepalese school buildings are produced by the community itself, mostly employing local craftsmen who play a pivotal organizational and technical role. Most of these craftsmen have no formal training, and some are illiterate. The process is characterized by a high degree of informality. The local availability of the construction materials such as fired or unfired bricks, stone in mud mortar, timber, controls the construction process. The use of modern materials such as cement, concrete, and steel bars is limited by affordability and accessibility, and is confined to urban areas and areas accessible by transport. Since so much school construction in Nepal takes place locally in a decentralized, traditional, and informal manner, a Nepalese NGO, the National Society for Earthquake Technology Nepal (NSET) and ADPC conducted a programme to strengthen existing school buildings and promote earthquake-resilient school building construction, with support from USAID (programme started in 1997). The programme incorporated strengthening of structural as well as non-structural components of the school buildings for seismic safety. This programme involved craftsman training, technology development and transfer, and community awareness. Such activity focused on schools has far-reaching effects. By raising awareness in schools, the entire community is reached because lessons trickle down to parents, relatives, and friends. When designing seismic retrofitting or earthquake resilience for new construction, NSET's focus has been on socio-cultural and economic issues that affect acceptance by the community. An approach was developed, with outreach to all stakeholders—school staff, students, local community, local clubs, local and central government. They have all been involved in the process so that they become aware of the risk and support the solution. School building construction was taken as an opportunity to train masons and to transfer simple but effective technology to others in the community, including house owners. By 2003, four non-reinforced masonry schools had been retrofitted and 16 new constructions were completed in Kathmandu valley. The project's key success has been to demonstrate that trained local masons transfer knowledge and safety messages within the surrounding community, leading to replication of earthquake-resilient construction.

Sri Lanka

Following the 2004 Tsunami, under the leadership of Ministry of Education and National Institute of Education, and with the support from German Technical Cooperation and India's National Institute of Disaster Management (NIDM), a concerted effort was undertaken to integrate DRR into the school curriculum and train the teachers for in its implementation.

In response to the tsunami, ActionAid also spearheaded a nationwide 'Back to School' campaign in Sri Lanka. Teachers participated in psychosocial care training sessions, lead by ActionAid staff, and positive impact on the lives of both children and adults was documented. The emphasis was on return to normal life. Handouts and materials were provided to parents to give to their children, in the context of the traumatic upheaval of disaster.

The Asian Disaster Reduction Centre has also implemented a project, 'Enhancing Natural Disaster Education in School' with support from USAID and Department of Education, Sri Lanka, from March 2006 to March 2007. This project covered Galle District, which was severely affected by the 2004 tsunami disaster. This project targeted 437 schools in Galle including 15 pilot schools, which can promote disaster education as leaders for others. Under the programme, consultative meetings conducted on the development of curriculum for disaster education and training workshops were conducted, and the pilot lessons implemented in 15 schools.

Pakistan

On 8th October 2005 in Pakistan, over 8,000 out of 9,000 schools were either destroyed or damaged beyond repair by the earthquake. Over 17,000 school-age children perished in collapsed schools, there were approxiately 23% of total deaths and over 20,000 more suffered serious injury. Over 80% schools in Pakistan are unprotected from similar risks. To address these risks, a concerted effort was required to advance further to protect the children. Under the backdrop of the October 2005 earthquake and loss of lives of innocent school children, Aga Khan Planning and Building Services and Focus Humanitarian Assistance agencies launched a two-day international conference on School Safety (15th-16th May 2008) at Islamabad. As a result, the Islamabad Declaration on School Safety came into the picture. The International Conference on School Safety aimed to highlight the major risks inherent in construction and design of current school structures and the devastating consequences following natural disasters. The Conference also aimed to identify ways in which school safety could be further enhanced to help better protect school communities.The Islamabad Declaration also set forth practical recommendations for civil society and private organizations to act as the critical partners in implementation of the action plans. The other Conference partners included the Pakistan Ministry of Education, UN/ISDR, ADPC, United Nations Centre for Regional Development, Swiss Agency for Development and Cooperation, Austrian Development Agency and Institute of Architects Pakistan.

Maldives

As per the historical data, the risk level is quite moderate. However, there are possibilities of damage due to tsunami and cyclone because of the coastal zone. Following the 2004 tsunami, the approach of the past was found deficient in dealing with a disaster of that magnitude. Later, Govt. of Maldives came out strongly by setting up a National Disaster Management Centre and formulating a draft National Disaster Management Policy. Agencies like UNDP, UNICEF and American Red Cross came forward to assist the Govt. of Maldives for advocating on the safe buildings, psychosocial programme and integrating the school safety initiatives. Meanwhile, Care Society Maldives, a national NGO of Maldives also embarked on a 5-month disaster preparedness programme, covering the integration of DM in the school system. Later, a comprehensive study was carried out by Insight Consultancy Services for Care Society Maldives to assist the Ministry of Education regarding the Disaster Preparedness Policy for Schools in the Maldives.

SEEDS, primarily a national NGO of India, with financial support from MERCY Malaysia, are currently working with the Government of Maldives and CARE Society, a national NGO in Maldives for implementing school safety activities in the Maldives. As a pilot project, 10 schools have been selected for the initiative. As a part of this, a sensitization workshop on school safety was held in Male, capital of the Maldives. It was attended by five schools from various Atolls identified by CARE society. Group activities were held for identifying school-specific hazards and vulnerabilities and the participants were given an overview of the school safety programme. After the orientation, specific trainings was provided on Fire safety, Search & Rescue and First Aid. Later, mock drills also conducted to check the preparedness level. Few members of the CARE Society Maldives have also been trained in India at SEEDS Delhi Office.

Bangladesh

In 2007, cyclone destroyed 496 school buildings and severely damaged approximately 2110 buildings in Bangladesh. Before that, in 2004, a total of 1,259 school buildings were lost and 24,236 buildings damaged due to floods. This country has faced many other disasters in the past, but now some INGOs and NGOs are also coming forward, apart from the Govt. and playing a very important role in DRR through schools projects. For example, ActionAid has piloted many initiatives here regarding floods and cyclones. A joint programme of local NGO and international NGO Action Aid adopted the DRR educational board game and activity book for children into Bangla language and local context, and presented these during the students extra curricular weekly period. Disaster education for school teachers was evaluated.

In Patuakhali area, ActionAid and SAP-Bangladesh have conducted intensive work on the DRR. Primary school teachers and students have been trained on DRR. With special focus on cyclone, a modular teaching pack was produced, covering contingency, lifesaving devices, warnings, First Aid, rescue, hygiene etc.

Bhutan

Here also the focus has is now on the disaster management component, with reference to school safety. Disaster Management has now been included in schools and colleges through the course curriculum. Here in Bhutan, the key agencies involved in disaster management school safety component are UNDP, UNICEF and one organization from Nepal. They have assisted the Govt. of Bhutan on this issue. Through the concerted efforts of all these agencies, now the school safety initiative has picked up momentum.

In Bhutan, a few pilot projects have been launched on DRM by the government at the national level, in association with UNDP and UNICEF. Now these are being cascaded down to the district level, by conducting the sensitization programmes, training workshops and mock drills at the school level. Despite no past record of any major disaster, here progress is quite significant at the school level. And a partnership amongst the concerned stakeholders is clearly visible.

Afghanistan

Here the school buildings are weak, old and poorly maintained. Infrastructure is not so good. Most crucially, the knowledge resources on mitigation and preparedness are extremely scarce. This country has a vast experience of facing disasters such as earthquakes, floods, sandstorms and the extreme climatic conditions. This makes response and recovery quite difficult. This country has also faced two decade-long wars. As part of the community, both schools and school children suffer from both disasters and post-war conflicts.

In 2003, under the arrangement of UNAMA and Deptt. of Disaster Preparedness, Govt. of Afghanistan, SEEDS carried out the consultation process for National Disaster Management Plan for Afghanistan, and its dissemination. It also included the awareness and capacity building of schools on DRM. SEEDS produced a range of educational material on school safety for wider use in Afghanistan. This is currently being disseminated through the national government and NGO partners. The objectives of the project were: to introduce concepts of disaster management to school teachers and students, orient them according to their role, form task forces, develop the evacuation plan and conduct rehearsal of evacuation. In 2007, the structural and non structural hazards were identified in school buildings, fire safety demonstration carried out and mock drills also conducted. TOT workshops were conducted in Kabul. In Afghanistan schools, the important aspect is to be prepared and better respond for disasters is to build capacity of people (schoolteachers, students and staff) along with community involvement and integration with the government systems. Here the involvement of national government and its will to take up school safety as a large programme is a very positive element.

Approach to School Safety

Addressing school safety in schools has been a challenging process. Schools and the education system in India face heated public debate on the usefulness of the current curriculum and the need to address rapidly changing social and economic realities. Introducing a new subject, therefore, was not always welcomed. The programme had to be designed as to cause minimal additional stress on students, while sending the message across succinctly in a manner that makes the absorption process natural. Dr. Daisaku

Ikeda's proposal, The Challenge of Global Empowerment: Education for a sustainable future, aimed at introducing environmental education in schools provided a useful cue in designing the disaster education intervention. The approach adopted was to help students, teachers and school management To Learn, To Reflect and To Empower.

To Learn: Students deepen their awareness about hazards and risks through understanding realities and knowing facts. Recent natural disasters have been well documented and shared. These serve as case studies for teachers as well as students. Wherever needed, disasters are simulated with the help of portable models. Curriculum changes strengthen the learning process.

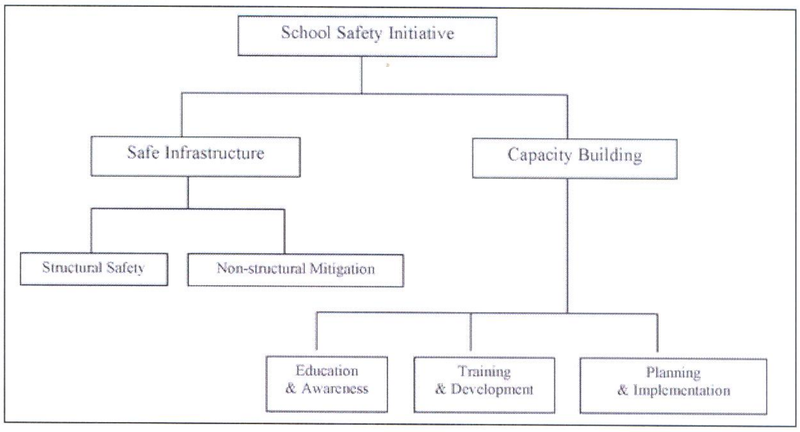
To Reflect: Students analyze reasons that have lead to loss of life and injury in disasters. They are able to make a distinction in development practices and people's actions that can cause disasters or prevent them. Students connect to their own local communities and families and share their learning with them.

To Empower: Students take concrete action toward lowering risks in the environment. Classroom and school exercises are introduced to help them take small definitive actions that can become a precursor to bigger investments for disaster risk reduction. School Management prepares school disaster management plans in which roles and responsibilities are identified and rehearsed periodically.

The stated approach translates into the following interventions carried out at school level:

- Raising awareness of disaster issues among the targeted stakeholders (students, teachers, school management and others) through lectures, discussions, posters, drama (street play) and demonstration;
- Identifying and listing hazards and vulnerabilities outside the school as well as structural and non-structural hazards inside the school;
- Identifying and listing ways of reducing vulnerabilities;
- Identifying the roles and responsibilities of various stakeholders;
- Training teachers how to prepare a school evacuation plan and preparing a school evacuation plan;
- Building emergency response capacity, focusing on skills such as rescue and first aid (training provided to student groups);
- Listing, in the school disaster management plan, the contact information of all facilities and resources for emergency management;
- Conducting a mock drill at the end of the school safety activities, to demonstrate the evacuation, rescue and first aid skills acquired by the students;
- Keeping targeted schools informed through a newsletter;
- Promoting School Safety Clubs to sustain risk education.

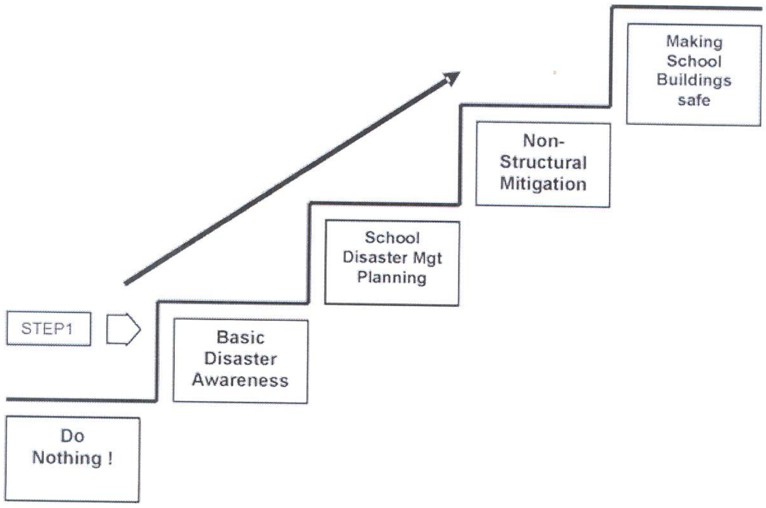
Figure 8.1 : Approach to School Safety



In a nutshell, the approach to school safety may be described in two broad categories : Safe Infrastructure and Capacity Building (Figure 8.1). The capacity-building component comprises establishment of basic disaster awareness (BDA) among all stakeholders—school children, teachers, school management and parents. Activities such as children-led risk assessments, curriculum-based studies, and practical lessons on preparedness, games and quizzes are carried out as part of BDA. As part of training and development, select groups of senior students in school as well teachers and administration staff are given specific skill-based training on aspects such as first-aid, search and rescue, evacuation, fire safety. Each task force is given specific roles and responsibilities based on possible disaster scenarios. As part of planning and implementation, school disaster management plans (SDMPs) are prepared. These plans are a compilation of basic set of actions before, during and after a disaster, along with an inventory of resources. These plans are made specific to each school and include details about its vulnerability and access to resources.

As part of safe infrastructure, school buildings are strengthened to withstand strong hazards and protect lives. At the same time, non structural mitigation is carried out to prevent injuries and enable safe evacuation of children.

Figure 8.2: Steps to School Safety



Steps to School Safety

Considering the constraints of resources and the magnitude of the problem in South Asia, a feeling of helplessness is inevitable. Ensuring basic education is a millennium development goal, and governments in South Asia are redoubling their efforts in putting more and more children in school. In the given situation, we are in a dilemma of either doing nothing and waiting for a disaster to happen, or taking the first steps towards school safety. Ideally, we can aim for every school building to be safe against natural hazards, so that lives are protected. However, in real world terms, this is a monumental task to be achieved. It requires resources, sustained political will and a coordinated approach between various government and private agencies, all of which is hard to come by in the South Asian Region, where demands from other sectors are equally compelling.

Therefore, the author is of the firm conviction that a beginning has to be made somewhere. Once a good beginning has been made that gains popular support and goodwill, taking the subsequent steps would become easier. As a first step (Figure 8.2), a concerted effort is needed to create awareness on disaster risk reduction among all school students irrespective of their location and local vulnerabilities. If this is done, it would create a culture wherein schools would be motivated to take initiatives on planning. One step would lead to the other taking them higher on levels of safety that can be achieved. It is remarkable how Families for School Seismic Safety in British Columbia, Canada through successful grass roots advocacy have ensured a US$1.3

billion commitment by the State Government to ensuring the all schools are brought up to acceptable life safety standards by 2019. (Monk, 2007).

Safe School Buildings: Safe Havens

The importance of having safe school buildings needs to be underscored. During the May 2008 China Earthquake, Ye Zhiping, the principal of Sangzao Middle School in Sangzao, was been credited with proactive action that spared the lives of all 2,323 pupils in attendance when the earthquake happened. His school in Peace County very likely withstood the 8.0-magnitude earthquake because he pushed the county government to upgrade it. Just 32 km north, the collapse of Beichuan Middle School buried 1,000 students and teachers. During a three-year period that ended in 1999, the Principal oversaw a major overhaul of his school. During that time he obtained funds from the county education department, and utilised the funds to widen and strengthen concrete pillars and the balcony railing of all four storeyes of his school, as well as securing its concrete floors. An estimated 10,000 children were crushed in their classrooms by this earthquake.

Measures such as the one taken by the school in Sangzao amply describes how school building safety compared to all other steps can so critical in deciding between life and death. A recent discussion among experts in the field makes a compelling point:

"Dear All:

The point is that we have been focusing more on what to teach children about disasters rather than how to protect children from disasters. We can't keep misleading children (and everybody else) by telling them that they will be safe from crushing-heavy concrete slab buildings by ducking underneath their desks. We can't hope by teaching about disasters at school, somehow the next generation will be all committed and will solve the problem. Children learn many things at school that, when it all blends in does not make them DRR soldiers when they are adults. Including disaster risk management in the curriculum of schools is important, but it does not help this generation or the next one, or may not even be the one after. If we want to protect children, we must address the structural issue of thousands and thousands of schools that are unsafe, not only in China but in most countries of the world. For the millions of children who are at risk everyday in their schools, being in a safe building is only one parameter that will save their lives. Everything else is just rhetoric. Let's not go into endless debates, and do what it takes to protect these children. For those who are not convinced I give one single undeniable fact: Since 1933 when California enacted *the Field Act that demands and imposes competent earthquake construction for schools, not a single school has collapsed or was heavily damaged, and not a single child or teacher or parent was injured or died in a school due to earthquakes. There are 60,000 public schools in California, and there many many earthquakes. We have an ocean to cross. We have to take the right ship to do it. We cannot reach the other side of the ocean by rowing in a little boat. No matter how hard we row together, we will never get there.*

Kindly,

Fouad Bendimerad, Ph.D., P.E., Chairman of the Board, EMI"

Bendimerads makes a strong point here, even to the extent of labelling all other approaches as 'misleading' and dismissing them as rhetoric. Indirectly, the point strengthens the author's case here for having safe school buildings as the ultimate goal for ensuring that all schoolchildren are safe. Different regions, cultures need different approaches. Unless stakeholders are sensitized to potential impact of natural hazards, it is very unlikely that they can devote their scarce resources to an ambitious target, such as Bendimerad argues above.

Empowering teachers

At the level of the school, teachers play a crucial role in ensuring the safety of children in school. The authors' experience in interacting with teachers during the implementation of school safety programmes revealed their keen interest in contemporary issues that catch the attention of the children. Stories from live events, such as most recent major catastrophes, their scientific perspective and follow-up steps that children are expected to take, are areas of interest which teachers like to incorporate in their lessons.

Further, teachers act as guardians to children in school. In the event of emergency evacuation, the teachers take on the role of 'Emergency Managers', guiding actions that children need to take.

Teachers also serve as links between parents and children. Parents rely on teachers for the welfare and upbringing of their children. Hence, there is, an implicit trust reposed on teachers. A trust that can potentially be reinforced if teachers can also provide a guarantee to parents that children are 'safe' under their teachers' care.

In a formal school set-up, however, school-level disaster management does not figure in the 'job task' of the teachers. Teachers find it as an 'additional responsibility' and sometimes, even a burden to be learning skills and practising disaster management.

The approach to school safety therefore needs to take a 'complementary' approach where teachers are able to view the subject as an extension of their existing curricula. Much work needs to be done in interpreting disaster reduction through mainline subjects such as science, mathematics, physical education and social studies. Currently, in most cases, disaster management is integrated with geography; however, viewed from a larger perspective this may not be adequate. Practical lessons in life saving skills add value to existing classes on physical education. Similarly, the subject of science can provide a useful framework for understanding cause–effect relationships, which would help students reflect better on the inherent links between ourselves and our natural environments.

Setting Achievable Goals

Coinciding with the United Nations' International Strategy for Disaster Reduction campaign for 2006-07, 'Disaster Reduction Begins at School', an International Conference on School Safety took place at Ahmedabad, India from the 18th to 20th of January 2007. An important outcome of the conference is the 'Ahmedabad Agenda of Action for School Safety' which summarizes important contributions made by school safety champions, as well as 'users'–school communities that have been exposed to safety programmes.

Reaffirming the Priority for Action 3 of the Hyogo Framework for Action 2005-2015, to use knowledge, innovation and education to build a culture of safety and resilience at all levels, and the UN Millennium Development Goals (Goal 2) to Achieve Universal Primary Education by the year 2015, the Ahmedabad Agenda of Action for School Safety sets the goal of achieving:

'Zero Mortality of Children in Schools from Preventable Disaster by the year 2015'

Towards achieving this goal, the following immediate actions have been laid out:

- To include disaster risk reduction in the formal curriculum both at primary as well as secondary levels.
- To promote disaster risk reduction through co-curricular activities in schools acknowledging that school children need to develop 'survival skills' first, along with 'life skills' and 'academic inputs'.
- Complete risk assessment and safety measures must be undertaken to ensure zero potential damage to new school buildings.
- Mandatory safety audit of all existing school buildings with respect to their location, design and quality of construction and prioritizing them for demolition, retrofit or repair.

- Mobilize parent, student, local community and school staff to champion school safety.

In addition to the aforesaid 'immediate' priorities, the Agenda outlines the following long-term actions with targets for 2015 :

- Promote exclusive initiatives among children in schools that make them leaders in risk reduction in the community.
- Ensure effective partnership among schools to share risk reduction education and achieve higher levels of school safety.
- Develop, implement and enforce codes with the performance objective of making all new school buildings ready for immediate occupancy following any disaster to serve as shelters or safe havens for the community as well as to restore educational functions in the shortest possible time.
- Implement a systematic plan to retrofit and/or repair existing schools to meet minimum standards for life safety in the event of known or expected hazards. Demolish unsafe irreparable school buildings and replace them.
- Implement routine checks to ensure that schools adhere to minimum standards and safety measures are not undermined.
- Schools to prepare and implement school safety plans, including measures to be taken both within the school premises and in the immediate neighbourhood. This must include regular safety drills.
- Promote active dialogue and exchange between schools and local leaders, including police, civil defence, fire safety, search and rescue, medical and other emergency service providers.
- Schoolchildren must practise safety measures in all aspects and places of their lives.

Bangkok Action Agenda

Subsequent to the Ahmedabad Action Agenda, the issues were reconfirmed in the Bangkok Action Agenda for Asia Pacific (provide details). The Bangkok Action Agenda called for further localization of school safety programme by way of incorporating local traditional knowledge into the education curriculum, and develop minimum standards for safe school buildings with appropriate material available locally.

The Bangkok Action Agenda called for immediate action on ensuring that every new school henceforth be built as a safe school. It further reconfirms the mandatory declaration of schools as 'Zones of Safety'by the UN General Assembly.

The Islamabad Declaration on School Safety

In the light of the huge loss of lives in the earthquake that struck Pakistan in October 2008 which led to the loss of over 17,000 schoolgoingage children, the Islamabad Declaration on School Safety drafted during the conference in May 2008 calls for a Resilient School Movement and urges national governments to develop a National School Safety Programme. The underlying message in the Islamabad Declaration is to make school safety part of the mainstream development process.

Conclusion: Can words be translated into accountable actions ?

Recent initiatives by decision makers, DRR practitioners, technical communities and citizens at large is indeed encouraging. However, the proof of commitment lies in concrete action that covers every schoolgoing child. How quickly can we act on agenda set before us? How many precious young lives are we able to save in future? These are questions that need to be addressed by the disaster management community not just as experts in the field, but also as responsible members of our families where our children too are going to schools.

In Pakistan, over 80% of schools are unprotected to risks such as the great earthquake that struck in October 2005. The story is the same in the rest of South Asia. In India, over 41 million children go to schools that lie in seismic Zones IV and V, where earthquakes with possibility of causing very high damage can occur. Likewise, there are millions of other children exposed to risks of coastal hazards, flooding, landslides etc. in the rest of South Asia.

Without forgetting the statement by the little girl from Nepal, we as disaster management practitioners need to hold ourselves accountable for the safety of our schoolchildren.

[The author is grateful to his colleagues in SEEDS, members of COGSS and civil society partners in South Asia for helping to compile the information shared in this paper.]

References

Organisation for Economic Co-operation and Development (OECD), Keeping Schools Safe in Earthquakes, (2004)

Asian Disaster Reduction Centre (ADRC), Inamura-No-Hi, Tsunami Awareness Education Material, www.adrc.or.jp/publications/inamura/top.html

Ministry of Home Affairs, Government of India, School Awareness and Safety Programme, www.ndmindia.nic.in

Central Board of Secondary Education, (CBSE), Social Science Syllabus for Classes IX & X, www.cbse.nic.in

Sustainable Environment & Eco Development Society, (SEEDS), School Safety Programme. www.seedsindia.org/schoolsafety

Inter Agency Network for Education in Emergencies (INEE), INEE Minimum Standards Tool Kit, (2008).

Ikeda Daisaku, The Challenge of Global Empowerment: Education for a Sustainable Future.

www.sgi.org/english/President/environ_prop/global.htm

Monk, Tracy, (2007) School Seismic Safety in British Columbia, *Regional Development Dialogue*, Vol. 28, No. 2. United Nations Centre for Regional Development.

United Nations International Strategy for Disaster Reduction, (UNISDR), Towards a Culture of Prevention: Disaster Risk Reduction Begins at School, Good Practices and Lessons Learned, (2007), ISDR.

Sharma Anshu & Gupta Manu, (2007) Building Community Resilience through Education, *Regional Development Dialogue*, Vol. 28, No. 2. United Nations Centre for Regional Development.

Gupta Manu & Sharma Anshu, Disaster Reduction in Schools, in Real Risk, (2006), Tudor Rose, UK.

Bendimerad, Fouad, (2008), Re: School Collapse in China Earthquake : GOING BEYOND RHETORIC [Sent to ENDRR-L@GROUPS.PREVENTIONWEB.NET , 13/05/2008]

Space for Disaster Management: Lessons and Perspectives

P.S. Roy, V. Bhanumurthy, C.S. Murthy and T. Kiran Chand

bstract

dia is one of the most disaster-prone countries of the world. With recurring disasters, the country witnessing large scale-human distress and economic loss. There has been a paradigm shift in saster management in recent years from relief-centric to preparedness through a holistic proach.

Having more than two decades' experience in the application of remote-sensing technology for erational disaster monitoring and risk assessment, the Department of Space (DOS), Government India has embarked upon the Disaster Management Support Programme (DMSP), to take the nefits of aerospace technology towards disaster management in the country. The Decision pport Centre (DSC) has been established at The National Remote Sensing Centre (NRSC) to serve a single window delivery point for disseminating value-added information on five major natural sasters.

The DSC keeps a constant watch on the prevailing disasters in the country, by gathering formation from different sources. The near real-time information on prevalence, severity level d persistence of disasters — floods, drought and forest fires — being generated using the data om different satellite sensor systems, finds increasing utilization by the decision makers to reduce e risk and hardships.

Many new initiatives such as creation of multi-scale baseline data in hazard-prone districts, borne Laser Terrain Mapping and establishment of automatic weather stations have been taken to strengthen the risk/damage assessment capabilities. An exclusive jet aircraft is being acquired monitor disaster-affected/prone areas in the country and to meet the information requirements. state-of-the-art indigenous microwave satellite, RISAT, to be launched in the year 2009 will to ther enhance the availability of space images for disaster management in all weather conditions.

Introduction

The global risks due to disasters seem to be increasing, with billions of people living in more than 100 countries being periodically exposed to at least one natural disaster, causing more than 184 deaths per day (www.undp.org). Further, there has been a rise in the frequency and intensity of natural disasters, due to global climate change. Diverse geoclimatic conditions, increasing population, unscientific exploitation of natural resources, inadequate carrying capacity of river systems, poor drainage characteristics, uncertain monsoon conditions, large areas of dry deciduous forests, environmental degradation have all made India one of the world's most disaster-prone countries. Empowering the public to overcome the risk in pre-disaster phase and to adopt efficient coping mechanisms at the time of disaster occurrence, still remain major challenges to most of the federal Governments, more particularly in the developing countries like India.

Disaster-related information; its objectivity, timeliness and outreach has become very critical and almost a driving force to evolve disaster management strategies. The application potential of the advanced technologies such as remote sensing, geographic information system, global positioning system and communications is being increasingly recognized to address the various issues related to management and mitigation of disasters. The Earth observation satellites covering large areas at various spatial and temporal scales in real-time have become valuable sources of information related to atmosphere and earth surface. Polar orbiting satellites have the advantage of providing much higher resolution imageries, even though at low temporal frequency, which could be used for detailed monitoring, damage assessment and long-term relief management. Geo-stationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring. The vast capabilities of communication satellites are available for timely dissemination of early warning and real-time coordination of relief operations. The advent of Very Small Aperture Terminals (VSAT) and Ultra Small Aperture Terminals (USAT) has enhanced the capability further by offering low cost, viable technological solutions towards the management and mitigation of disasters. Satellite communication capabilities — fixed and mobile — are vital for effective communication, especially in data collection, distress alerting, position location and coordinating relief operations in the field. However, capturing a disaster event in real time, along with the appropriate spatial attributes — characterizing the impacts, precursors and other inter-relations — is critically a missing link.

Natural Disasters in India

India has perennially been vulnerable to various natural disasters. About 60% of the landmass is prone to earthquakes of various intensities; over 40 million hectares is prone to floods; about 8% of the total area is prone to cyclones and 68% of the area is susceptible to drought. Forest fires are considered one of the major drivers of climate change having deleterious impacts on earth and environment. Fires are intentional, unintentional or natural and are largely determined by the vegetation type, bioclimatic factors like temperature, rainfall and length of dry months, local topography and anthropogenic activities in their intensity and spread. These factors need to be considered and properly emphasized to study the source and behaviour of wild fires, to enable effective fire mitigation measures. Out of around 230 million poor living in the country, the majority are found in the disaster-prone regions, especially in the arid, semi-arid regions and floodplains (Status Report, MHA, 2004). Though India's poverty figures for the 1990s recorded a substantial dip, its vulnerability to natural disasters is still on the rise. Based on records form 1950 it has been observed that the natural disasters can be listed according to their impact on life and property with flood, earthquake and drought taking the highest toll are rated the highest, followed by cyclones, crop pests and diseases, forest fires, epidemics, hailstorms, thunderstorms, landslides and tornadoes. The disaster events, earthquake, cyclone and floods, for example, are instantaneous and hence it is difficult to take up any actions for near real-time management. Drought is a weather-based phenomenon with slow occurrence and progression, and because of its complex interactions, it has become the least understood natural disaster. Therefore, the overall observational strategy for capturing disaster intensity differs significantly from one disaster to the other.

India's vision in disaster management is to build a safer and disaster-resilient country by developing a holistic, proactive, multi disaster and technology-driven strategy for disaster management through collective efforts of all Government Agencies and Non Governmental Organizations (www.ndma.gov.in). There has been a paradigm shift in the disaster management approach from relief-centric/crisis management to prevention, mitigation and preparedness.

The Disaster Management Support Programme of ISRO

In last couple of decades, space applications to disaster management have gone through the phases of experimental demonstration, semi-operational and operationalisation in certain areas of disaster management. In the process of demonstrating the operational capabilities of the space systems to support disaster management activities of the country, the DOS had several interactions with the mainstream bodies concerned with the disaster management such as the HPC and the

Working Group on disaster management. In this background, a strong need was felt to evolve and execute a programme for integrating operationally the space technology inputs and services on a reliable and timely basis for strengthening country's resolve towards disaster management. Thus, the Disaster Management Support (DMS) Programme has been identified as one of the major activities of the DOS during the Tenth Five-Year plan. In consonance with the programmatic goals, the DMS Programme addresses: (i) creation of digital databases at appropriate scales for hazard zonation, damage assessment, etc. in perennially disaster prone areas, (ii) development of appropriate RS and GIS-based decision support tools and techniques and demonstrations catering to the information needs at different levels, (iii) acquisition of close contour information for priority areas, (iv) strengthening the communications backbone for addressing the real-time/near real time information transfer needs, and (v) networking of scientific institutions for exchange of data, information and knowledge. Towards enabling the operational services, as cited above, it has been proposed to establish a Decision Support Centre (DSC) at NRSA, as a single-window service provider, interfacing with the National/State disaster management agencies. Department of Space established a Decision Support Centre (DSC) at National Remote Sensing Agency (NRSA) under ISRO Disaster Management Support Programme (DMSP).

DSC is an operational service provider for space-enabled inputs together with other important data layers for its use in disaster management by the State and Central Govt. A VSAT-based satellite communication network has been put in place for online transfer of space enabled inputs to the State and Central Govt. user departments. At present, DSC is addressing five natural disasters, viz. Flood, Cyclone, Agricultural Drought, Forest fires, Earthquake and Landslides.

Data from various satellite sensor systems and aerial sensors are being analysed continuously to generate disaster-related information. Integration of multiple data sets related to disasters in a GIS environment is being done for better assessment and visualization of the prevalence and progression of disasters at different spatial and temporal dimensions. The near real-time objective information on the intensity of disasters is of immense help to the decision makers to evolve risk reduction strategies.

Operational use of space technology

Floods

India is the most flood-affected country in the world after Bangladesh (Agarwal and

Sunita 1991) accounting for one-fifth of global death count due to floods. About 40 million hectares (mha) or nearly 1/8th of India's geographical area is flood-prone (National Flood Control Commission Report 1980) and the country's vast coastline of 5,700 km is exposed to tropical cyclones originating in the Bay of Bengal and the Arabian Sea. The annual average area affected by floods is about 7.57 mha and the affected crop area is about 3.5 mha. The average loss in financial terms is about Rs. 13,000 million. On an average the human lives lost are about 1595 (Gopalakrishnan, M. 2002). The chronic flood prone river basins in India are the Ganga and Brahmaputra. India is affected by floods due to the high discharges in the Ganga-Brahmaputra river system. The main causes of floods are widespread heavy rainfall in the catchment areas and inadequate capacity of the river channel to contain the flood flow within the banks of the river. The Himalayan rivers, the Ganga and its tributaries flowing down the hills cause flood problems in Uttar Pradesh, Bihar and West Bengal due to high discharges concentrated during monsoon months (June to September) and large volumes of sediment is carried to the plains. Drainage problems also arise concurrently if floods are prolonged and the outfalls of major drainage arteries are blocked. On account of frequent changes in river courses and braiding of channels, erosion of riverbanks also assumes importance as one of the major problems associated with floods. Different methods of flood protection, structural as well as non-structural, have been adopted in different states depending upon the nature of the problem and local conditions. Though various measures were implemented, the flood damages have shown an increasing trend. One of the reasons can be, that for planning effective measures, reliable latest data derived on scientific grounds is very much essential. One of the most important elements in flood disaster management is the availability of timely information for taking decisions and actions by the authorities (Miranda et al. 1988, Okamoto et al. 1998). Most of the time, the required information is not available due to various reasons, and decisions are being taken based on past knowledge and experience, which may be erroneous. The process of collection of information by conventional means is time consuming and not cost effective. In this context, the Earth Observation satellites provide comprehensive, synoptic and multi temporal coverage of large areas in near real-time and at frequent intervals, which enables to compare the data before and after flood disaster. Remote sensing data coupled with Geographic Information System (GIS) tool proves to be capable of overcoming some of the critical limitations that are being faced using conventional techniques.

Flood products from Aerospace data

Using the hydro-meteorological data from ground as well as web resources, a constant watch is kept on the flood/cyclone situation in the country.

Under Near Real-Time Flood Mapping and Monitoring activity, major floods and cyclones in the country are monitored and mapped through aerial and satellite data and disseminated to the user community in near-real time. The flood situation is mapped and monitored through multi-temporal satellite data acquired on the affected areas.

Accordingly, optical and microwave Synthetic Aperture Radar (SAR) data is planned and acquired from Indian and foreign satellite missions. Indigenously developed SAR instrument mounted on an aircraft is flown on the affected areas depending on the requirement.

Currently, images from Resourcesat 1, Radarsat and ENVISAT are being used extensively. Indigenously developed SAR instrument mounted on an aircraft is also flown on the affected areas depending on the requirement. Using automated procedures, the satellite data is analysed and flood inundation layer is delineated. Flood maps are composed at various scales ranging from 1:500, 000 to 1:25,000. Flood maps depicting the ancillary information like administrative boundaries, settlements, roads and rails, are being widely used for carrying out relief and rescue operations specifically for airdropping relief material.

The flood inundation layer is intersected with the database consisting of districts, taluks, villages, landuse/landcover/road network, railway network, and flood damage statistics like district-wise flood inundated area, length of submerged rail/roads, submerged crop area and number of villages submerged are estimated.

Spatial inundation map, along with estimates on submergence are being generated within 6 hours of receiving satellite data product and disseminated to the Ministry of Home Affairs, Central Water Commission and State Relief Commissioners through electronic means for further use in relief and rescue operations. There has been a systematic feedback mechanism, through which the decision makers are able to interact with the DSC to get the required value addition to the information.

India had witnessed widespread flooding during 2006, with major floods in Andhra Pradesh, Gujarat and Orissa states. The acquired data was analyzed and flood inundation maps at state-level, district-level and area-specific level were prepared and provided to the concerned user departments in near real-time. About 68 flood maps covering 11 states were prepared using multi-temporal and multi -satellite data sets. Figure 1 shows the flood inundation in various states along with frequency of monitoring. Figure 2 shows the flood inundation maps generated for floods in Orissa state. Figure 3 shows the Synthetic Aperture Radar (SAR) data of Radarsat satellite, used to study the impact of floods occurred in Bihar state located in northern part of India during October, 2007.

Figure 4: provides the corresponding flood map prepared based on the analysis of the Radarsat SAR data.

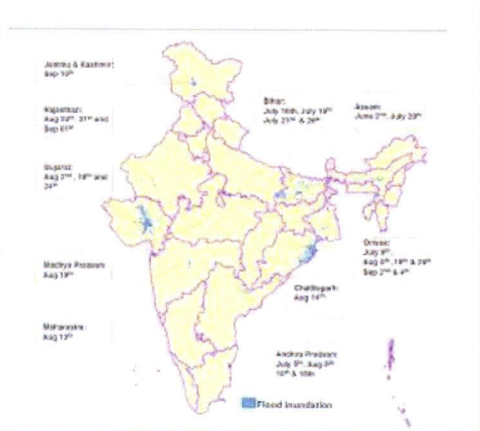


Fig. 1 Flood inundated areas in 2006 as observed from satellite data

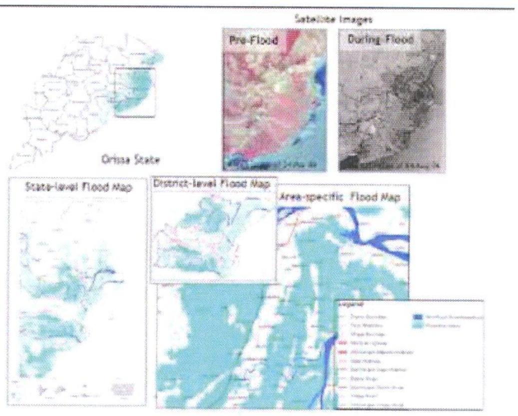


Fig. 2 Flood inundation maps for Orissa State at different levels

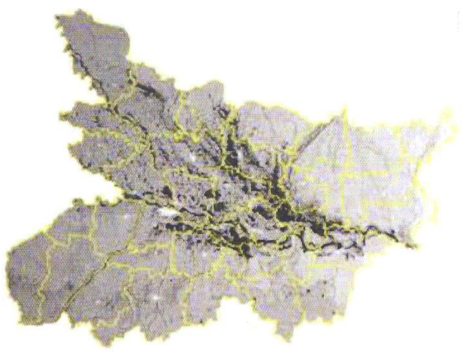


Fig. 3 Radarsat SAR image of October 2007 showing flood situation in Bihar state

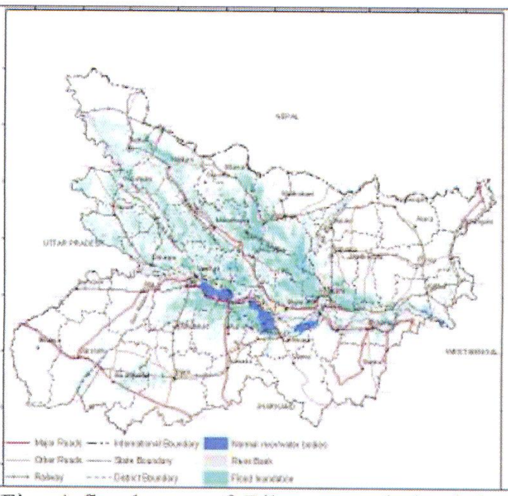


Fig. 4 flood map of Bihar state derived from Radarsat data

The flood map generated showing flood inundated areas and the information is being furnished to the National Disaster Management Division, Ministry of Home Affairs and other State and Central Government Departments.

Flood hazard zonation

Historic satellite data acquired during different flood magnitudes have been analysed and frequency of flood inundation over the chronic flood prone areas in Assam was determined. The flood inundation was integrated with the ancillary information and the extent of damaged caused was estimated. Based on the analysis, flood hazard zones in Brahmaputra, basin were delineated which helps in planning non-structural flood management measures.

Flood mitigation

High-resolution satellite data during different time periods will be procured, classified and bank lines during different time periods will be delineated. By digitally superimposing the bank lines the erosion pockets can be easily identified. The erosion maps prepared can be effectively used for planning bank protection works and town protection works. Using historic flood inundation information derived from satellite data flood hazard maps are prepared for chronic flood-prone rivers for panning nonstructural flood control measures.

Agricultural Drought

Despite significant technological advances since Independence, Indian agriculture continues to be periodically affected by drought. About two-third of the geographic area of India receives low rainfall (<1000 mm). Of the net sown area of 140 million hectares roughly 68% is reported to be vulnerable to drought conditions. India experiences localized drought almost every year in some region or other. In the post-independence era, major droughts that affected more than 1/3rd of the country were reported during 1951, 1966-67, 1972, 1979, 1987-88 and 2002-03 (Subbaiah 2004). On an average, severe drought occurs once every five years in most of the tropical countries. More than 500 million people live in the drought-prone areas of the world and 30% of the entire continental surface is affected by droughts or desertification process. In 2004, wide spread drought in much of Asia resulted in loss of agricultural production of hundreds of millions of dollars. The direct impacts of droughts are wide ranging; physical, social, economical and environmental (Rathore 2004).

The Conventional Approach to Agricultural Drought Assessment

Currently agricultural drought conditions are characterized by ground observations of rainfall, aridity and agricultural conditions in terms of cropped area and yield. Rainfall as an agricultural drought indicator is limited by the sparse ground observations (especially in view of high spatial variability of tropical rainfall) as well as the lack of spatially and temporally unique relationship between incident rainfall and vegetation development. The India Meteorological Department has been bringing out weekly aridity anomaly charts, based on data from different observatories, covering the south-west monsoon period.

These charts show the departure of actual aridity from normal aridity giving indication of the severity of water deficit to water demand relationship on weekly basis. But this data is only representative of large areas such as meteorological sub-divisions. The aridity anomaly suffers from the same limitations as that of rainfall (www.imd.gov.in).

Though the ground observations of agricultural conditions by the State Departments of Agriculture and Revenue are exhaustive such a system involves a significant amount of subjective judgment at various stages. The periodicity and extent of ground observations also vary significantly between different states. The nature of sparse ground observations also makes it difficult to assess, in near real-time, average drought conditions. Thus, ground monitoring of both causative as well as impact factors, for drought intensity assessment, suffer from various limitations such as sparse observations, subjective data, etc.

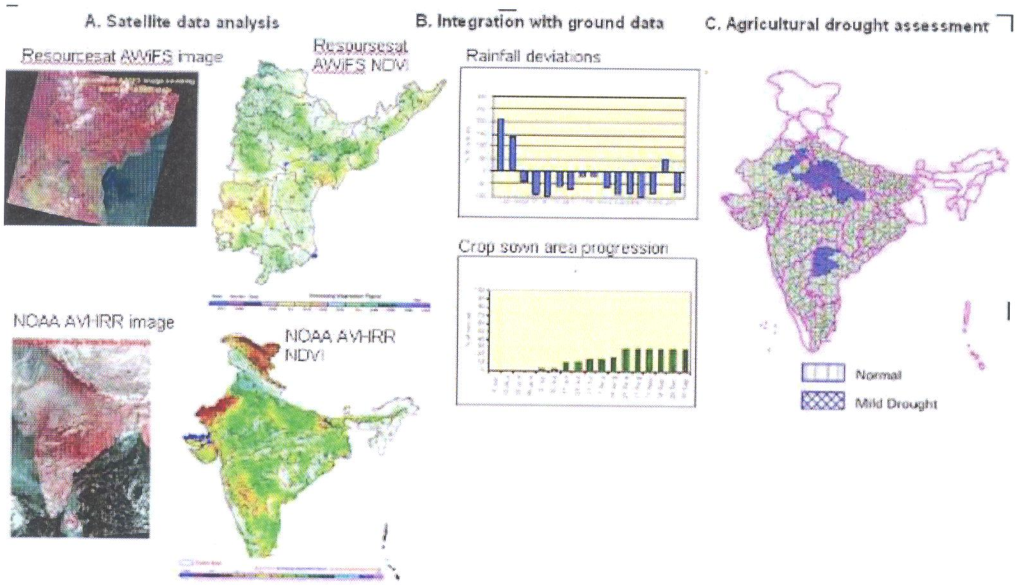
National Agricultural Drought Assessment and Monitoring System (NADAMS)

In India, the National Agricultural Drought Assessment and Monitoring System (NADAMS) was initiated towards the end of 1986, with the participation of National Remote Sensing Centre, ISRO, Government of India, as the nodal agency for execution, with the support of the India Meteorological Department (IMD) and various state departments of agriculture. NADAMS was made operational in 1990 and has been providing agricultural drought information in terms of prevalence, severity and persistence at state, district and subdistrict levels. Over a period of time, the NADAMS project has undergone many methodological improvements such as use of moderate resolution data for disaggregated level assessment, use of multiple indices for drought assessment, augmentation of ground data bases, achieving synergy between ground observations and satellite-based interpretation, providing user-friendly information, enhanced frequency of information, etc. The NADAMS project covers 13 agriculturally important and drought vulnerable states of the country. Monitoring of drought is restricted to Kharif season (June–Oct/November), since this season is agriculturally more important and rainfall dependent. Agricultural conditions are monitored at state/district level using daily observed coarse resolution (1.1 km) NOAA AVHRR data for 9 states. Moderate resolution data from Advanced Wide Field Sensor (AWiFS) sensor of Resourcesat 1 (IRS P6) of 56 m and Wide Field Sensor (WiFS) of IRS 1C and 1D of 188 m are being used for detailed assessment of agricultural drought at district and sub district level in four states, namely, Andhra Pradesh, Karnataka, Haryana and Maharashtra.

The Normalised Difference Vegetation Index (NDVI), derived from red and near-infrared reflectances is a proven index for operational drought assessment because of its simplicity in calculation, easy interpret ability and its ability to partially compensate for the effects of atmosphere, illumination geometry etc. (Malingreau 1986, Tucker and Chowdhary 1987). The indices mainly used in NADAMS project are NDVI, Normalized Difference Water Index (NDWI) derived from Short wave infrared and near-infrared reflectances. NDVI or NDWI anomalies and NDVI-based Vegetation Condition Index form the basis to detect the agricultural drought intensity. District/sub district-level basic agricultural information on cropping pattern, irrigated areas, crop calendars, soils, rainfall, etc. form important base-level data for interpretation of satellite data. Institutional linkages with State departments of Agriculture and Relief are being established to provide needed ground data for the NADAMS project and to involve the departments in the drought assessment process. Thus methodology being adopted in NADAMS essentially reflects the harmonization of satellite-derived crop condition with ground information to characterize the intensity of agricultural drought situation. During June to August, drought warning information is issued in terms of 'Watch, Alert and Normal' categories. The 'Alert' warning calls for immediate external intervention, in terms of crop contingency plans. During the September and October months when the crops are in flowering to maturity phase, drought declaration is done in terms of 'Mild, Moderate and Severe' classes, reflecting the impact of drought on crop production. The operational frame work of drought assessment in the NADAMS project is shown in Figure 5.

Drought Vulnerability analysis and zonation from the point of view of response of agricultural situation and crop condition to rainfall variability and irrigation support is being done using the time series data on agricultural area NDVI. NDVI-based assessment of drought proneness takes in to account the actual condition of standing crops during the season and its comparison among different years of normal and abnormal years. The fluctuations of crop condition as triggered by weather and water supply conditions determine the drought-proneness of a given area.

Figure 5: Framework of agriculture drought assessment in NADAMS project



Long-term NDVI database consisting of extreme drought events and normal season facilitates quantification of NDVI variability, which directly indicates drought vulnerability.

Rainfall and Soil Moisture Estimation from Satellites

Observations from Meteorological Geostationary satellites are useful for indicating or forecasting an imminent drought rather than its monitoring. However, the prediction of such situations is still a major challenge for atmospheric scientists. In a recent significant study, Goswami and Xavier (2003) have shown that by analysis of past observations of rainfall and circulation it is possible to predict the monsoon breaks with a lead time of ~ 20 days. Fortunately, with the advent of high resolution microwave sensors onboard new generation satellites, it is now possible to make quantitative estimates of precipitation on global scales. Adler et al. (1998) suggested a method to merge the information from microwave sensors onboard polar orbiting satellites and that from the geostationary satellite to produce more frequent and regionally continuous maps of quantitative precipitation.

The availability of real-time rainfall observations may be useful for defining the indicators of drought. Other important meteorological observations are the global patterns of sea surface temperature (SST) and Outgoing long-wave radiation (OLR).

Recent studies have indicated that there is a relationship between equatorial convection patterns and the variations of Indian summer monsoon rainfall. The authors of this study found that the link of the Indian monsoon to events over the equatorial Indian Ocean is as important as the well-known link to the dramatic events over the Pacific (El Niño Southern Oscillation; ENSO). Over the equatorial Indian Ocean, enhancement of deep convection in the atmosphere over the western part is found to be associated with suppression over the eastern part and vice versa. The reliable drought prediction technique based on the analysis of global patterns of convection and other satellite observations is not available today, but the availability of high quality satellite observations can definitely boost the efforts in this direction.

Drought is a consequence of a prolonged period of dry soil due to lack of rainfall and could be inferred from soil moisture conditions over a long period of time. This, in turn, could be monitored regularly using microwave remote-sensing techniques. In recent years satellite-based microwave radiometers have been used widely to monitor soil moisture conditions (Schmugge et al. 1986, Chaudhury and Golus 1988, Owe et al. 1988, Jackson 1993, Njoku and Entekhabi 1996). Recently, Rao et al. (2001), Thapliyal (2003) and Thapliyal et al (2003, 2005) have demonstrated the potential of microwave radiometers for surface soil moisture estimation over India.

Lower microwave frequencies are preferred for soil moisture observation as they are least affected by vegetation, surface roughness and atmospheric cloud liquid water. Theoretically, 1.4 GHz is considered best for soil moisture observations. However, due to power constraints the lowest frequency used so far by satellite microwave radiometers is 6.6 GHz, e.g. Scanning Multi-frequency Microwave Radiometer (SMMR) onboard Nimbus (1978 to 1987) and Multi-frequency Scanning Microwave Radiometer (MSM R) onboard IRS-P4 (1999 to 2001). Currently, the TRMM Microwave Imager (TMI) launched in 1998 with lowest frequency at 10.7 GHz is providing observations at higher spatial resolution (~40 km as compared to ~100 km for a similar channel in SMMR and MSMR). Jackson and Hsu (2001) compared TMI 10.7 GHz brightness temperatures with observed soil moisture over the Southern Great Plains of USA and concluded that it has great potential for soil moisture estimation. Thapliyal (2003) showed that 10.7 GHz show high sensitivity to the surface soil moisture over India, which is comparable to that of 6.6 GHz of MSMR and SMMR.

Forest fires

Forest fire or wild land fire is considered to be one of the most important disasters causing adverse ecological, economic and social effects worldwide (Allan and Baker 1990; Stocks et el. 2001; Russell-Smith et al. 1997; Ginsberg 1998; Kinnaird and O'Brien

1998; Turner and Dale 1998; Butry et al. 2001). Fire is one of the most widespread and ancient ecological factors affecting many terrestrial ecosystems from tropical to temperate through fragmentation and loss of biodiversity (Rogers 1987). *Globally, forest fires are considered and Vint one of the major drivers of climate change, having* deleterious impacts on earth and environment, as studies reveal their significance in producing large amounts of trace gases and aerosol particles, which play a pivotal role in tropospheric chemistry and climate (Hao et al. 1996; Fearnside 2000; Crutzen and Andreae 1990). Fires strongly affect the distribution and abundance of plant species, habitats of animals and hence landscape properties (Robinson 1991). In India, out of 67.5 million ha of forests, about 55% of the forest cover is being subjected to fires each year, causing an economic loss of over 440 crores of rupees, apart from other ecological effects (Gubbi 2003). The National Forest Policy (1988) emphasizes the adoption of improved and modern management practices to deal with forest fires. The Disaster Management Act (2005) recognizes forest fires as a disaster.

To realize this, satellite remote sensing aided with Geographical Information (GIS) plays a significant role in monitoring, predicting and integrating various spatial and non-spatial factors effecting forest fires. Scientists world over have used satellite derived information in different regions of the electro-magnetic spectrum for active fire detection and monitoring (Dozier 1981; Matson et al. 1987; Robinson 1991; Chuvieco et al. 2003, 2008; Giglio et al., 2003). Forest fires in India are mostly anthropogenic, which include slash and burn agricultural practices, controlled burning, deforestation, firewood burning and others, which bear their cause to many tribal villages living in the proximity of forests. Almost all the fires in India are caused by humans.

Indian Forest Fire Response and Assessment System (INFFRAS)

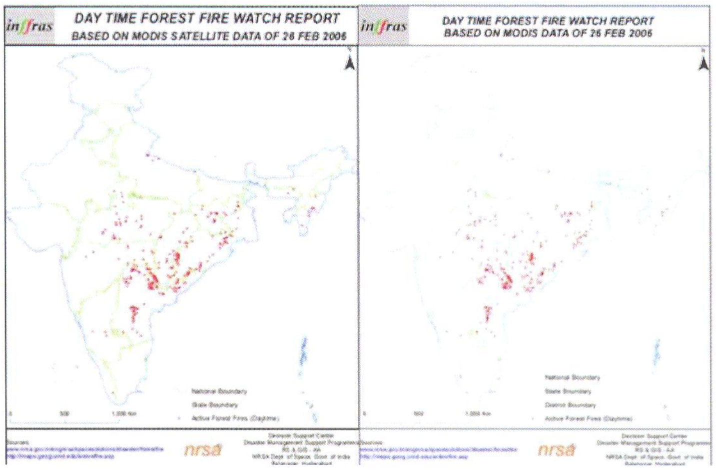
Under the Disaster Management Support Programme (DMSP), the Indian Forest Fire Response and Assessment System (INFFRAS) was established under the Decision Support Centre (DSC), as part of the Disaster Management Support Programme, to facilitate forest fire monitoring and management. The INFFRAS has been set up to preliminarily carry out (a) Active Forest Fire Monitoring and (b) Burnt Area Assessment using multi-temporal satellite data sets, (c) fire burnt area progression monitoring and (d) ecological damage assessment due to forest fires. INFFRAS has been providing the fire-related inputs to the user departments in terms of fire information overlaid with valueadded services such as forest administrative boundaries, vegetation type burnt, proximity to the villages etc. for the past four years. INFFRAS can be accessed on the web at http://www.nrsa.gov.in/rsgisweb/forestfires/dailyforestfires.html

Active fire location detection using MODIS /DMSP-OLS data

During fire season, daily fire alerts are generated using MODIS and DMSP-OLS satellite data on a daily basis. MODIS data is received at NRSA Earth Station at Shadnagar. The Moderate Resolution Imaging Spectro-radiometer (MODIS) onboard TERRA/AQUA platforms, operates in 36 channels (optical and thermal) with three variable spatial resolutions i.e. 250 m, 500 m and 1km. Active fire locations are detected using enhanced fire algorithm (Giglio et al. 2003), which is based on thermal anomaly between 4μm (channel 21 or 22) and 11μm (channel 31) along with other useful information from 0.645μm (Channel 1), 0.850μm (Channel 2) and 12μm (Channel 32).

As part of ISRO-NASA/NOAA collaborative effort, DMSP (Defence meteorological Satellite Program) Operational Line scan System (OLS) night time data is collected. I think it has already been done as the data is of 2006 through ftp in NRSA. The unique capability to detect low levels of visible and near-infrared (VNIR) radiance at night will be used to detect active fire locations and is further edited to reject the false alarms caused due to various factors. After generating the fire locations, value additions to the generated fire products such as masking with forest cover, overlaying of point vectors on infrastructure theme, etc. will be done (Figure 1). Time required for the whole process of generating active fire location will be around 2 hours after receiving satellite data and the products will be disseminated by email we updates to the concerned nodal officers. In addition to the fire alert products INFFRAS also provides forest departments with satellite remote sensing and GIS-based inputs for preparatory planning for fire control, damage and recovery assessment and mitigation planning.

Figure 1



Future Perspective

Earth Observation Systems

The limited number of EO satellites carrying moderate resolution sensors currently in operation, provide only infrequent coverage of tropical regions and always image at the same local time of day. Many tropical regions experience frequent cloud cover that is dependent upon the time of day. For effective and timely monitoring of any region on the Earth's surface, at least once each day from space is the requirement to react quickly and map the effects of the disasters like cyclone, floods, earthquake, typhoon, etc. The present EO satellites have been designed with general-purpose instruments to meet many wideranging user requirements and are not tailored to suit disaster prediction, monitoring and mitigation related requirements. It is being advocated that a composite EO satellite system comprising a network of optical and radar satellites to complement the existing EO satellites has the potential to address the observational gaps. However, it is important to examine the sensors and platforms especially the spectral bands, ground resolution and revisit period requirements necessary to address not only the existing observational gaps but also to work in synergy with the contemporary EO missions, particularly the planned/future EO missions.

There are some gaps in the existing earth observation capabilities in capturing certain disaster events due its temporal and spatial domains. Coarse resolution payloads (INSAT VHRR/CCD, METEOSAT, NOAA AVHRR) with higher repetitivity are ideal for continuous monitoring, but the limitation lies in poor spatial resolving capability. Disasters like earthquake, cyclone and floods need high-resolution sensors to map the effect for near real-time management. Of course, observations of attributes such as terrain features, ecological fragility and socio-economic status do provide the valuable information especially on vulnerability and the risk. Such observations support to a certain extent developing the scientific understanding and knowledge about the various aspects of the natural disasters, which help in disaster prediction, early warning and mitigation.

It has been part of the long-term EO strategy in the form of the New Millennium Programme (NMP) and Earth Science Enterprise (ESE) of NASA, and Living Planet Programme and Spectra mission, of ESA. Theses constellations are endowed with intelligent and autonomous missions. The missions like NEMO, CONCONUDS, BIRD and PROBA have been examined to identify their in-built intelligence and autonomy. The newer concepts like SensorWeb, Enhanced Formation Flying and event driven observation have been analyzed. The results of autonomous science craft experiment, NASA's NMP EO-1 mission pertaining to autonomously detect, assess and react to, and monitor dynamic events such as flooding, volcanoes, etc have shown great promise for constellation. The newer trends in SAR technology development, especially bi-and multistatic SAR and digital beam forming have been captured to develop small and low-cost SAR missions as a part of the constellation.

The success of EO in disaster management lies in harmonizing the mission parameters, such as spatial, spectral and temporal resolutions as well as the efficient turnaround time of the data acquisition and development of standardized data products, and acceptability and absorption of these products through appropriate service chains. The EO community has arrived at a set of wish list having highly diverse specifications for natural disaster management. The major feature of interests are spatial resolution, temporal resolution, spectral coverage, orbital altitude, revisit capability, width of swath, image size, stereo capability, imaging mode (sensor), data record, satellite owner and market requirements. A comprehensive investigation and analysis has been brought out by (Zhou, 2001) and CEOS proceedings [www.ceos.org]. The feedback to configure user's-centric EO missions should therefore come from the end-user requirements down the line. The feedback should also trigger the development of appropriate EO products and services.

Floods

Though the present space capabilities can provide certain information on extent of inundation and flood damages, it is difficult to address the degree of damage to the infrastructure and public utilities. To address these issues, large-scale maps are required and a mechanism for obtaining very high resolution data quickly along rapid analysis tools.

Estimation of the spatial extent of rainfall from the meteorological satellites on operational basis and incorporating the same in the flood forecasting models is a challenging task. Since most of our chronic flood-prone Himalayan river catchments are not equipped with field stations for data collection, space-based estimation of the meteorological parameters will have immense value. Further, spatial inundation simulations for a given flood forecast is one of the most wanted information which plays a vital role in preparedness and evacuation thus saving human lies. One of the most important information required for addressing the problem is generation of very high resolution DEM with sub- meter accuracy. Though the technology such as LIDAR is available for generation of close contour information, processing the data and converting the elevation data into MSL is a complex task. Since the flood-prone area in our country is quite large, the task has to be achieved in a phased manner.

Urban centres in India are being marketed as global magnets for international business and finance. Cities are already the locus of nearly all major economic, social, demographic and environmental transformations. The unplanned urbanisation with poor drainage characteristics has contributed to increased frequency/intensity of flooding causing human distress and damage to infrastructure facilities. . It may be mentioned that 10 cities were severely flooded in 2005, with Mumbai being the worst affected; while 22 cities were flooded in 2006 with Surat being the worst affected. The 2007 monsoon has also witnessed very severe flooding in Kolkata, Delhi, Bangalore, Mumbai, etc. There is a need to establish an intensive network of observatories such as Automatic Weather Stations, for obtaining the meteorological data at frequent intervals. Such data is of immense value in the development of hydrological models for estimating the surface runoff for further use in drainage management strategies.

Agricultural Drought

Cropped area progression using microwave data, soil moisture estimation through conventional and satellite-based approaches, integration of NDVI with soil moisture information, quantitative assessment of drought impact on crop production and drought early warning and multi-criteria decision support systems are some of the development activities most relevant to the management of drought disaster. Retrieval of additional information from currently available satellite sensor systems, offers immense scope for improving the drought assessment procedures. The important studies planned in this direction include: (a) exploitation of SWIR region to detect crop water stress, (b) analysis of crop area progression using microwave data, (c) improved vegetation indices using BRDFs, (d) improved temperature retrievals for quantification of ET to develop process based indicators, (e) exploration of soil moisture retrievals operationally at different canopy closures, (f) extended data support from geo-stationary satellites, (g) estimation of spatial rainfall, and (h) use of process based indicators through energy balance approach.

Development of a unified index for drought severity assessment by integrating the data from different sources is an important activity recently undertaken to enhance the scope of drought assessment. There is a need to arrive at a scientifically true measure cutting across various rainfall zones and socio economically acceptable indicator of drought for the country. The index should be complete and comprehensively explain the phenomenon of drought. The index should give appropriate weightages to the rainfall, soil moisture and crop condition. To make the criteria uniform irrespective of region or state, Standardized Precipitation Index will be used to assess the deficiency of rainfall, since it has been standardized with mean zero and variance one. The impact of rainfall can be measured in terms of soil moisture availability through Soil Moisture Index (SMI), retrievable through water balance procedures. This index allows incorporating variability of soil parameters, crops and weather, which lead to better assessment of drought over the growing season. Collection of precise weather data at local level and transmission on real time basis is vital for resource management as well as for improving currently available weather services. Under this back ground, ISRO has taken initiative to establish Automatic Weather Stations (AWS) through out the country in a phased manner. AWS is an affordable alternative to get detailed weather information in the area of interest. AWS records data on the meteorological parameters like rainfall, wind speed and direction, humidity, temperature etc. Special sensors of particular interest can also be included in AWS, to measure soil temperature, leaf wetness, etc. The AWS data finds extensive applications in agricultural monitoring – drought/crop condition assessment, crop management, disaster management – flood forecasting and in other fields like transport. Procedures have to be developed for early drought detection and assessing the quantitative impact of drought on agricultural production through the use of satellite data and assimilation of data from ground segments, routinely collected by various agricultural related departments of the country. Empirical models, process based models and ground surveys with sampling techniques need to be explored in this context.

Forest fires

Research is being carried out to extract the fire burnt area from the Indian Remote Sensing Satellite (IRS-P6) Advanced Wide Field Sensor (AWiFS) for the pilot areas in order to produce regional and national fire burnt maps on operational basis. It is planned to validate the AWiFS burnt area with the MODIS Burnt area products (MCD45) available through ftp from the MODIS website and also use it as supplement information to the AWiFS burnt area products. Keeping in view the potential of Indian satellite sensors onboard different platforms and with the experience of carrying out active fire detection and burnt area assessment on an operational basis, it is intended to extract fire-related information from an extended range of satellite sensors such as Indian Remote Sensing Satellite – (IRS-P3), which give a much broader coverage in terms of the total area covered. Preparatory work is already through to develop algorithms for extractin gactive fire locations from thermal sensors onboard upcoming INSAT satellites, in order to have a continuous monitoring of forest fires (almost every four hours).

Conclusion

With recurrence of natural disasters causing significant human distress and economic loss on the one hand and increasing emphasis on the adoption of holistic approach to minimize the disaster impact, application of space technology has attained a crucial position in the development of disaster management plans in India. Geospatial products customized to different natural disasters by blending remote-sensing-derived information with related ground data are being used for assessing the prevalence, intensity and persistence of disasters and the damage caused by these disasters in near real-time mode. Disaster preparedness is another important dimension of disaster management in which the geospatial products are playing equally important role by virtue of providing the information on vulnerability and risk aspects. Harmonizing the specifications of Earth Observation systems to the needs of disaster management, development and dissemination of standardized data products in reduced turnaround time, improved monitoring, impact assessments and predictive capabilitiesthrough institutional participation constitute the major challenges to strengthen the disaster management strategies in the country.

Acknowledgments

We express our sincere thanks to Dr. V. Jayaraman, Director, National Remote-Sensing Centre for his constant encouragement and guidance.

References

Agarwal, A., Sunita, N. (1991) Book on Floods, Flood Plains and Environmental Myths.

Allan, G. and Baker, L. (1990): Uluru (Ayers Rock-Mt Olga) National Park: an assessment of a fire management programme. Proceedings of the Ecological Society of Australia 16, 215–20.

Butry, D.T., Mercer, D.E., Prestemon, J.R., Pye, J.M. and Holmes, T.P. (2001): What is the price of catastrophic wildfire? *Journal of Forestry* 99, 9–17.

Chaudhury, B.J., and Golus, R.E. (1988), Estimating soil wetness using satellite data.*International Journal of Remote Sensing*, 9, 1251-1257.

E. Chuvieco, B. Allgower and J. Salas, Integration of physical and human factors in fire danger assessment. In: E. Chuvieco, (Ed), Wild land fire danger estimation and mapping. The role of remote sensing data, World Scientific, New Jersey (2003), pp. 197–217.

P.J. Crutzen and M.O. Andreae, Biomass burning in the Tropics: Impact on atmospheric chemistry and biogeochemical cycles, Science 250 (1990), pp. 1669–1678.

Disaster Management in India: A Status Report, Natural Disaster Management Division,Ministry of Home Affairs, Government of India, New Delhi, August 2004 (http://www.ndmindia.nic.in)

J. Dozier, A method for satellite identification of surface temperature fields of subpixel resolution, Remote Sensing of Environment 11 (1981), pp. 221–229

P.M. Fearnside, Global warming and tropical land-use change: Greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation, Climate Change 46 (2000), pp. 115–158.

L. Giglio, J. Descloitres, C.O. Justice and Y.J. Kaufman, An Enhanced contextual fire Detection Algorithm for MODIS, Remote Sensing of Environment 87 (2003), pp. 273–282.

Ginsberg, J.R. (1998): Perspectives on wildfire in the humid tropics. *Conservation Biology* 12, 942–43.

Gopalakrishnan, M., 2002, Central Water Commission The International Seminar on Disaster Preparedness and Mitigation 21 November 2002, New Delhi.

Gubbi, S. (2003). Fire, fire burning bright! *Deccan Herald*, Bangalore, India. Available from http://wildlifefirst.info/images/wordfiles/fire.doc

W.M. Hao, D.W. Ward, G. Olbu and S.P. Baker, Emissions of CO_2, CO, and hydrocarbons from fires in diverse African savanna ecosystems, *Journal of Geophysical Research 101* (1996), pp. 23577–23584.

ISRO Study Team Report, 2005, Constellation of Earth Observation (EO) Satellites forDisaster Management.

Jackson, T.J. (1993), Measuring surface soil moisture using passive microwave remote sensing. *Hydrological Processes*, 7, 139-152.

Jayaraman. V., D Gowrisankar. D., and Sanjay K. Srivastava. (2007), India's EO Pyramid for Holistic Development, *International Astronatical* 06-B1.5.05

Kinnarrd, M.F., and O' Brien, T.G. (1998). Ecological effects of wildfire on lowland rain forest in Sumatra. *Conservation Biology*, 12(5): 954 – 956.

Malingreau, J.P., 1986, Global vegetation dynamics: Satellite observations over Asia, *International Journal of Remote Sensing*, 7, 1121-1146.

Miranda, F.P., Fonseca, L.E.N., and Carr, J.R. (1988), Semivariogram textural classification of JERS-1 SAR data obtained over a flooded area of the Amazon rainforest. *International Journal of Remote Sensing*, 19, 549–556.

National Flood Control Commission Report (Rashtriya Barh Ayog), 1980.

Njoku, E.G., and Entekhabi, D. (1996), Passive microwave remote sensing of soil moisture, *Journal of Hydrology*, 184, 101-129.

Okamoto, K., Yamakawa, S., and Kawashima, H. (1998), Estimation of flood damage to rice production in North Korea in 1995. *International Journal of Remote Sensing*, 19, 365–371.

Owe, M., Chang, A., and Golus, R.E. (1988), Estimating surface soil moisture from satellite microwave measurements and satellite derived vegetation index, *Remote Sensing of Environment*, 24, 331-345.

Rao, B.M., Thapliyal, P.K., Pal, P.K., Manikiam, B., and Dwivedi, A. (2001), Large scale soil moisture estimation using microwave radiometer data, *Journal of Agrometeorology*, 3, 179-187.

Rathore, M.S. (2004), State-level analysis of drought policies and impacts in Rajasthan, India, Working paper 93, International Water Management Institute (IWMI), Colombo, Srilanka, p.40

Robinson, 1991 J.M. Robinson, Fire from space: Global evaluation using infrared remote sensing, *International Journal of Remote Sensing* 12 (1991), pp. 3–24.

Rogers, G.F. and Vint, M.K. (1987): Winter precipitation and fire in the Sonoran Desert. *Journal of Arid Environments* 13, 47–52.

Roy, P.S., Joshi, P.C., Murthy, C.S. and Kishtawal C.M., 2006, Geoinformatics for Drought Assessment, in Drought Management Strategies in India (Eds. J.S. Samra, Gurbachan Singh & J.C. Dagar), pp. 23-60. ICAR, NEW Delhi, India.

Russell-Smith, J., Ryan, P.G. and Durieu, R. (1997): A LANDSAT MSS-derived fire history of Kakadu National Park, monsoonal northern Australia, 1980–94: seasonal extent, frequency and patchiness. *Journal of Applied Ecology* 34, 748–66.

Schmugge, T.J., O'Neil, P.E., and Wang, J.R. (1986), Passive Microwave soil moisture research, IEEE Transaction on Geoscience and Remote Sensing, 24, 12-22.

Stocks, B.J., Wotton, B.M., Flannigan, M.D., Fosberg, M.A., Cahoon, D.R. and Goldammer, J.G. (2001): Boreal forest fire regimes and climate change. In Beniston, M. and Verstraete, M.M., editors, Remote sensing and climate modelling: synergies and limitations, Norwell, MA: Kluwer, 233–46.

Subbaiah, A.R. (2004), State of the Indian Farmer – A Millenium study, Natural Disaster Management, vol. 21, Published by Department of Agriculture and Coopearation, Ministry of Agriculture, Government of India, New Delhi. p.226.

Thapliyal, P.K. (2003), Estimation of soil moisture from satellite microwave radiometers and its impact on the simulation of Indian summer monsoon, Ph.D.Thesis, Department of Mechanical Engineering, Indian Institute of Science, Bangalore, INDIA.

Thapliyal, P.K., Rao, B.M., Pal, P.K., and Das, H.P, (2003), Potential of IRS-P4 Microwave Radiometer Data for Soil Moisture Estimation over India, *Mausam*, 54, 277- 286.

Thapliyal, P.K., Pal, P.K., Narayanan, M.S., and Srinivasan, J. (2005), Development of a time series based methodology for estimation of large area soil wetness over India using IRS-P4 microwave radiometer data, *Journal of Applied Meteorology*, 44, 127-143.

Tucker, C.J., and Chowdhary, B.J. (1987), Satellite remote sensing of drought conditions, Remote Sensing of Environment, 23, 243-251

Turner, M.G. and Dale, V.H. (1998)fc: Comparing large infrequent disturbances: What have we learned? Ecosystems 1, 493–96.

Zhou, G., (2001) Architecture of Earth Observing Satellites in Next 10 Years and Beyond, ISPRS Joint Workshop on High Resolution Mapping from Space 2001, Sept 19-21, University of Hanover, Germany.

Seismic Microzonation of Sylhet City

Mehedi Ahmed Ansary and Md.Rezaul Islam

Abstract

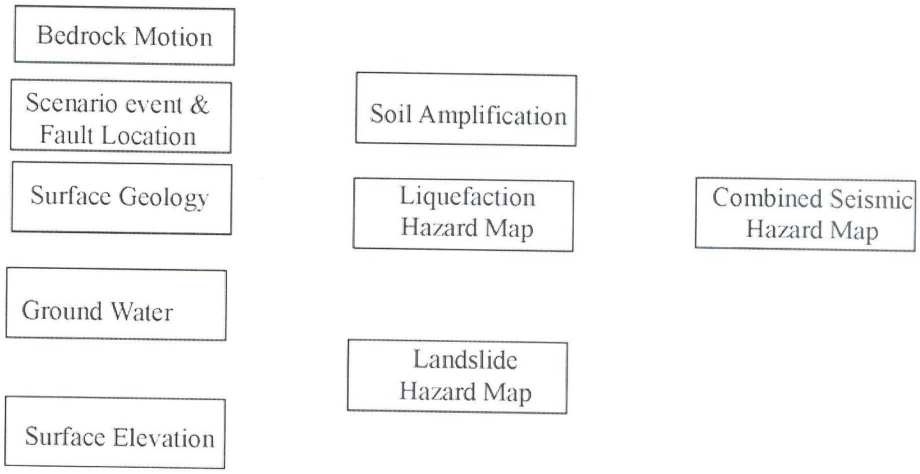
Seismic microzonation maps can play a significant role in mitigating the consequences of earthquakes. Geographic information system (GIS) provides an ideal environment for compiling and integrating regional databases of spatial geologic and geotechnical information for the development of seismic microzonation. The main goal of this study is to develop seismic microzonation map for Sylhet City based on secondary site attributes such as soil amplification, liquefaction and landslide. Vibration characteristics at different points of the study area were estimated by employing one dimensional wave propagation program SHAKE. The liquefaction resistance factor and the resulting liquefaction potential were estimated by a method suggested by Seed et al. (1983). The program used for landslide hazard analysis is XSTABL, which is a fully integrated slope stability analysis program, which evaluate the factor of safety for a layered slope using the simplified Bishop Method. The quantification of the secondary site effects and the weighting scheme for combining the various seismic hazards is heuristic, based on judgment and expert opinion.

Introduction

The 2001 Gujarat Earthquake in India and the 2005 Kashmir Earthquake in Pakistan and India revealed the vulnerability of "non-earthquake-proof" cities and villages in the Indian sub-continent. In 1897, an earthquake of magnitude 8.7 (recently modified by Ambraseys (2000) to be 8.0) caused serious damages to buildings in the northeastern part of India (including Bangladesh) and 1542 people were killed. Recently, Bilham et al. (2001) pointed out that there is high possibility that a huge earthquake will occur around the Himalayan region based on the difference between energy accumulation in this region and historical earthquake occurrence. The population increase around this region is at least 50 times than the population of 1897 and cities like Dhaka, Chittagong, Sylhet have population exceeding several millions. It is a cause for great concern that the next great earthquake may occur in this region at any time. Sylhet the most important northeastern district of Bangladesh, experienced earthquakes at regular intervals that had caused large destructions in the past.

Seismic hazard due to local site effects such as soil amplification, liquefaction, and landslide can be anticipated by combining the available soil parameter data with the current hazard models or by making use of existing maps showing estimated levels of these collateral hazards. Regional seismic hazard and risk analysis is used not only for estimation of potential damage and loss to existing facilities, but also for planning locations and construction of future facilities and for analyzing and comparing the regional effects of various retrofit schemes. The GIS-based analysis is useful to engineers, planners, emergency personnel, government officials, and anyone else who may be concerned with the potential consequences of seismic activity in a given region. The results of a regional seismic hazard and risk analysis are usually presented in the form of microzone maps that serve as an effective means of conveying information from the scientific community to the professional community of decision makers involved in hazard and risk mitigation. The mapping process for regional seismic microzonation through GIS is shown in Figure 1.

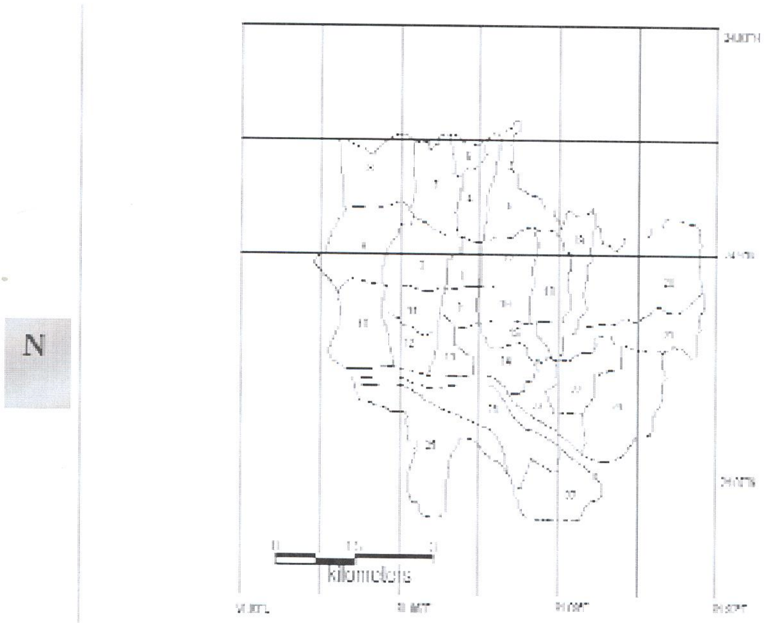
Figure 1: The mapping process for regional seismic



Admini strative Boundary of Sylhet City Corporation

Sylhet Municipality was established in 1878. During 1991, area of Sylhet Municipality was 10.49 sq.km and other urban area was 43.92 sq.km. Sylhet Municipality had 5 wards until 1991; in 1996 it had 13 wards. Recently, the Municipality is upgraded to City Corporation with 27 Wards and 210 Mahallas. Ward map was collected from Sylhet City Corporation where total area was divided into 13 wards .The Sylhet City Corporation authority did not prepare an updated map. So it was decided to prepare an updated ward map for this study. For this purpose, GPS value of different fringes site and core sites of the study area were collected. The existing city corporation map was scanned and converted into digital map. Using this digital map and 2001 Mauza data as well as consultation with the Sylhet City Corporation officials, a map containing 27 wards was developed. From updated map it was found that existing area of municipality is 26.50 sq km. Figure 2 shows the updated ward map of Sylhet City Corporation

Figure 2: Updated ward map of Sylhet City



Regional Tectonics

In accordance with Molnar and Tapponnier (1975), for the past 40 million years the Indian subcontinent has been pushing northward against the Eurasian plate at a rate of 5 cm/year, giving rise to the severest earthquakes and most diverse land forms. Bilham et al. (2001) has pointed out that there is high possibility that a large earthquake will occur around the Himalayan region based on the difference between energy accumulations in this region. There is a seismic gap that is accumulating stress, and that a large earthquake may occur someday when the stress is relieved. The major earthquakes that have affected Sylhet since the middle of the last century are presented in Table 1.

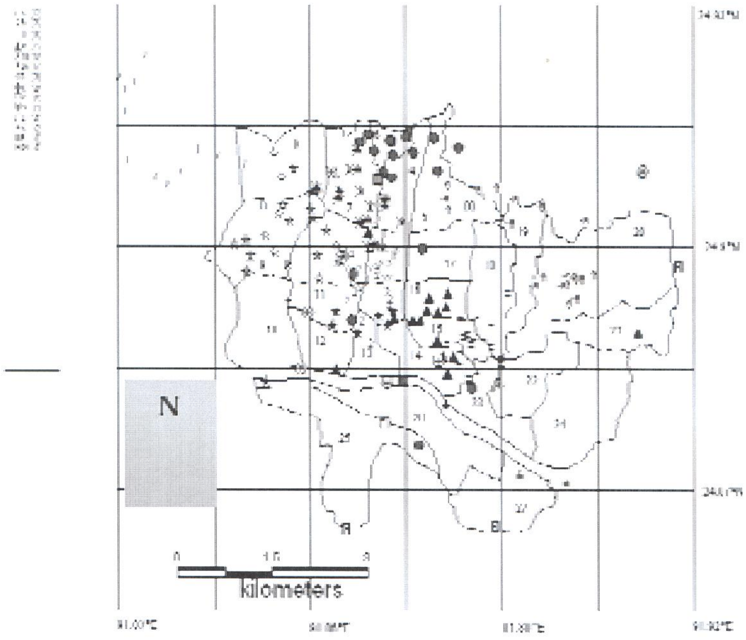
Table1: Some historical earthquakes with magnitude, intensities, epicentral distance and focal depth at Sylhet

Name of Earthquake	Fault	Magnitude	EMS Intensity	Distance (Km)	Focal Depth (Km)
1869 Cachar Earthquake	Tripura	7.5	VIII	92	56
1885 Bengal Earthquake	Bogura	7.0	V	234	72
1897 Great Indian Earthquake	Assam	8.1	IX	151	60
1918 Srimangal Earthquake	Sub-Dauki	7.6	IX	71	14

Soil Data

Necessary soil data was collected from different relevant sources of Sylhet City and accumulated in Microsoft Excel. For assessment of landslide potential Geological Map and Aerial Photograph is essential, however; these are not available. A total of 167 boreholes with SPT data were collected from different organizations and used to study site amplification and soil liquefaction potential characteristics of municipality area. Among these data, 9 boreholes with SPT-N data up to a depth of 100 ft. were directly collected by BUET for checking the authenticity of other collected data. The representative available boring is up to a depth of 50 ft. Figure 3 shows borehole locations.

Figure 3: Map showing Borehole locations



Landslide Estimation Data

The landscape is mostly formed by the hill ranges and hillocks (locally called tila) appearing in the north east and south of Greater Sylhet and surrounding the Sylhet town. These hill ranges attain a low elevation and have a gentle slope. Hillocks are scattered in Sylhet City. Figure 4 shows location of hill in Sylhet City. Hillocks of fringe area have moderate slope and possess vegetation, so less probable of slope failure. In the core area, tilas possess slopes about right angles due to rapid urbanization associated with hill cutting. These areas are more vulnerable to landslide.

Figure 4: Map showing location of hills

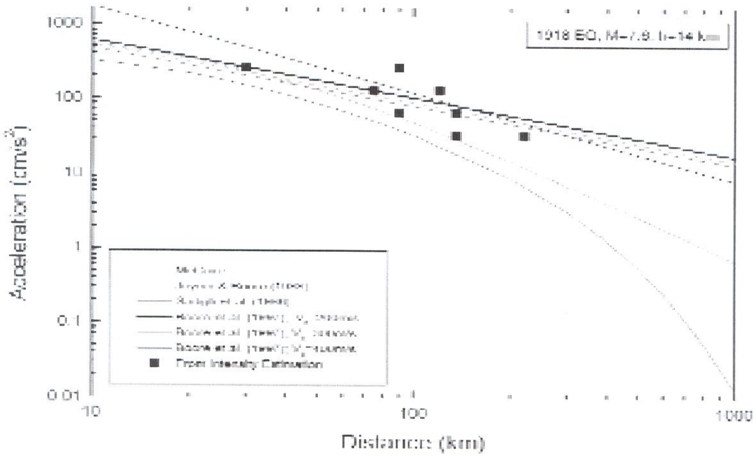
Assessment of seismic hazard

In the regional seismic loss estimation analysis it is considered necessary to determine the bedrock motion in the region. The most common method involves the use of an empirical attenuation relationship. These relationships communicate a given ground motion parameter in a region as function of the size and location of an earthquake event. Applying statistical regression analyses to recorded data, numerous relationships had been developed in the past. Often these relationships are developed with different functional forms and with different definitions of ground motion, magnitude, distance, and site conditions. To pick the most appropriate attenuation law for predicting rock motions, 1885 Bengal earthquake, 1897 Great Indian earthquake and 1918 Srimangal earthquake are considered. The requirements for selecting the attenuation law are as follows:

(i) Applicable to the ground condition of engineering bedrock in this study (Vs=250m/s).

(ii) Able to explain the observed or analyzed earthquake motion of 1885 Bengal earthquake, 1897 Great Indian Earthquake and 1918 Srimangal earthquake. In this study, the engineering bedrock is assumed to be the layer at which the shear wave velocity (Vs) exceeds 250 m/s, which exist almost 30 m deep from the surface of the study area. In this study, shear wave velocity is estimated from SPT-N value by using the equation of Tamura and Yamazaki (2002). Distance versus PGA values for earthquakes is plotted on log-log paper. From isoseismal maps, the epicentral distances of different locations and their intensities are found. These intensities were converted into PGA by using the correlation between PGA and intensity proposed by Trifunac and Brady (1975) and were plotted on Figure 5.

Figure 5: Distance versus PGA values for 1918 Srimangal Earthquake to compare several attenuation laws



From Figure 5, it is found that McGuire's (1978) equation follow the PGA trend of the study area. Finally, 1918 Srimangal Earthquake as the scenario event, PGA value 0.18g at bedrock level for study area was selected. Table 2 presents the PGA values at bedrock level from different attenuation laws for different scenario event.

Table 2. PGA values (% of g) at bedrock level from different attenuation laws for different for scenario event.

Attenuation Law	PGA for Cachar Earthquake (1869)	PGA for Great Indian Earthquake (1897)	PGA for Srimangal Earthquake (1918)
McGuire (1978)	0.12g	0.10g	0.18g
Sadigh et al. (1986)	0.0106g	0.0328g	0.0238g
Joyner and Boore (1988)	0.0078g	0.0108g	0.0163g
Boore et al. (1997)	0.030g	0.017g	0.055g

Site Amplification Analysis

It is well known that the surface ground motion of earthquakes is heavily influenced by the subsurface ground condition, especially in areas covered by thick sediments. It is important to evaluate the difference in subsurface amplification site by site to know the distribution of earthquake motion across a wide area. Vibration characteristics at different points of the study area were estimated by employing one dimensional wave propagation program SHAKE. An estimation of the fundamental frequency and the maximum value of the amplification are obtained at each site. Figure 6 shows the map of fundamental frequencies of Sylhet City. Figure 7 shows map of amplification at fundamental frequencies of Sylhet City

Figure 6: Fundamental frequencies at Sylhet City

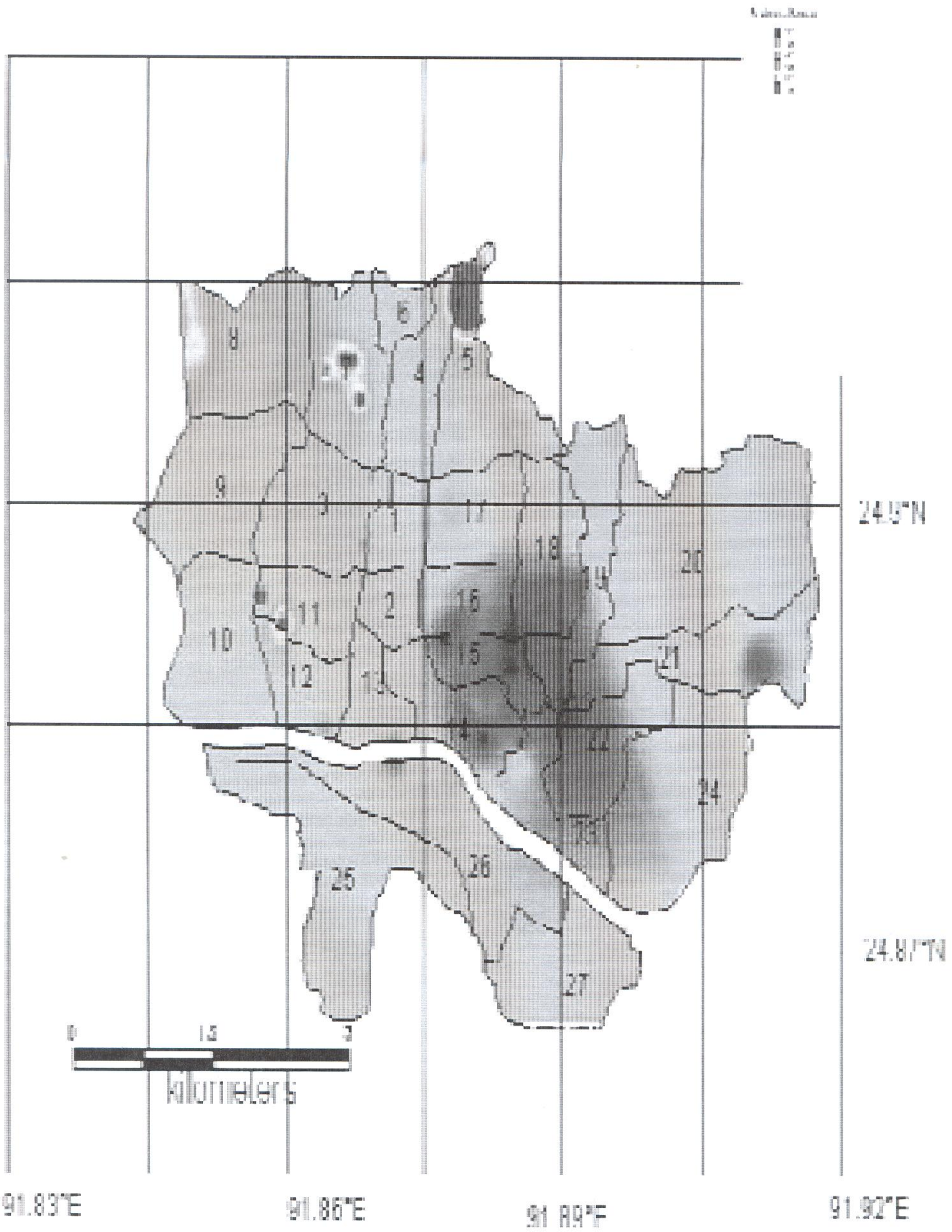
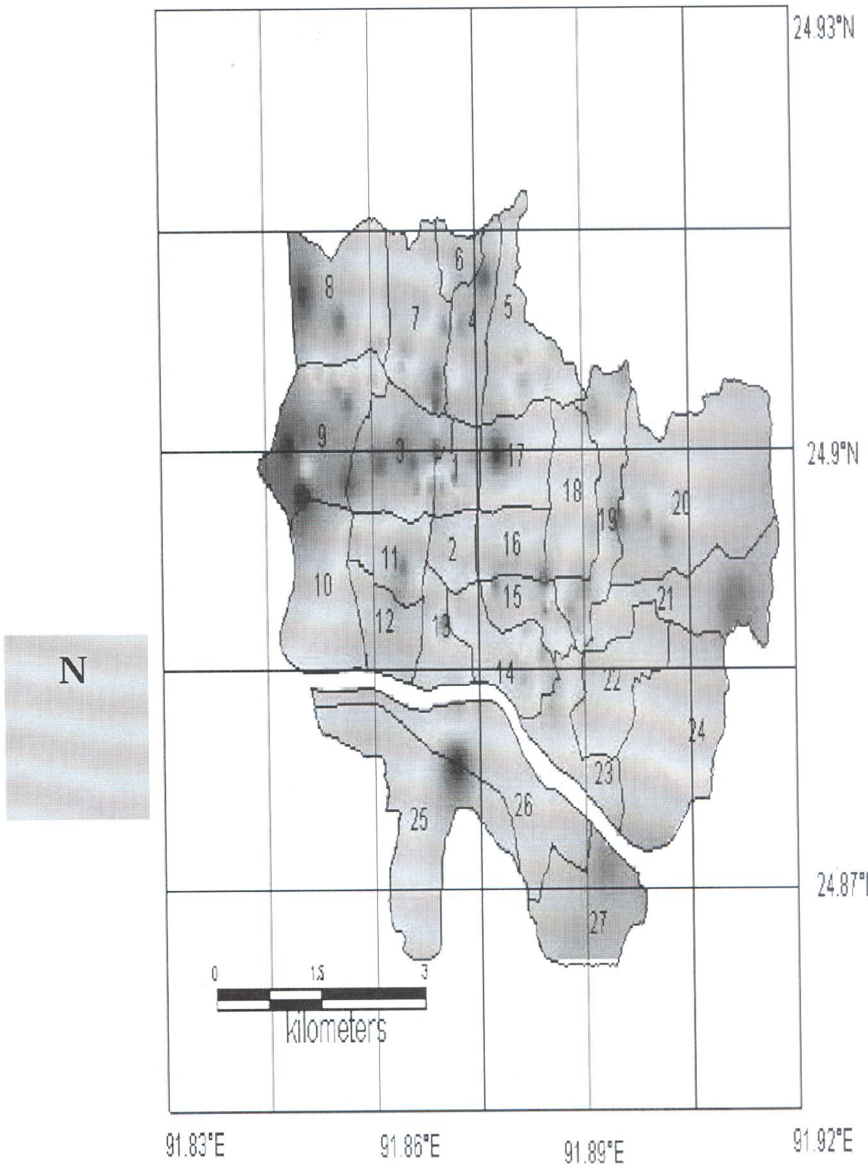


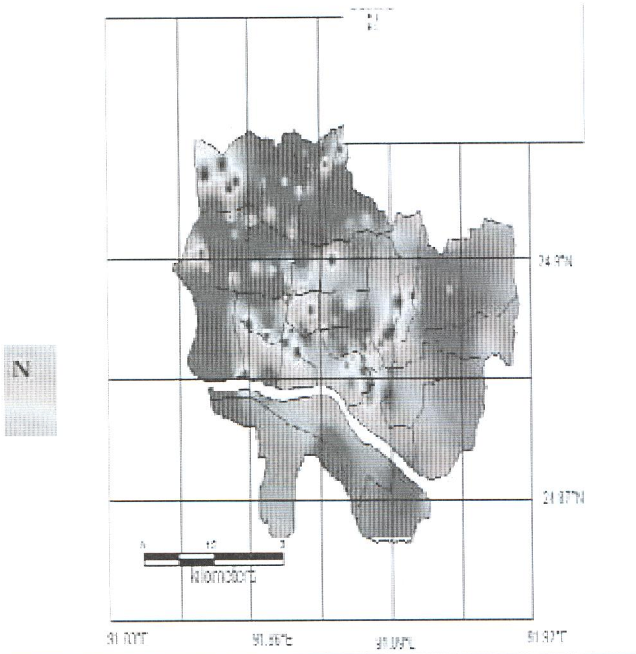
Figure 7: Amplification at fundamental frequencies at Sylhet City



Liquefaction Analysis

The ground water level changes with the season. For this study ground water table is considered to be at a depth of 1.5 m level. The liquefaction resistance factor, FL, for the top 20 m of soil, and the resulting liquefaction potential, PL for the 167 sites were estimated. Result of Liquefaction potential was presented in Figure 8 which shows that 3.35 Sq. Km. areas have low and very low Liquefaction potential, 13.70 Sq. Km. areas have moderate liquefaction potential and 10 Sq. Km. areas have high liquefaction potential. More than one third (37%) area will suffer high liquefaction if Srimongal Earthquake (1918) occurs again with same magnitude and same epicentral distance.

Figure 8: Map showing Microzonation based on liquefaction



Landslide Potential Analysis

Most of the recent research in this field has focused on determining the critical level of a given ground motion parameter that will trigger landslide. The program used for stability analysis is XSTABL, which is a fully integrated slope stability analysis program. XSTABL performs two dimensional limit equilibrium and analysis to evaluate the factor of safety for a layered slope using the simplified Bishop Method. Based on the static FS, the critical acceleration to begin the process of slope failure, a_C, is computed as

$$a_C = (FS-1)\ g\ \sin q \qquad (1)$$

Where

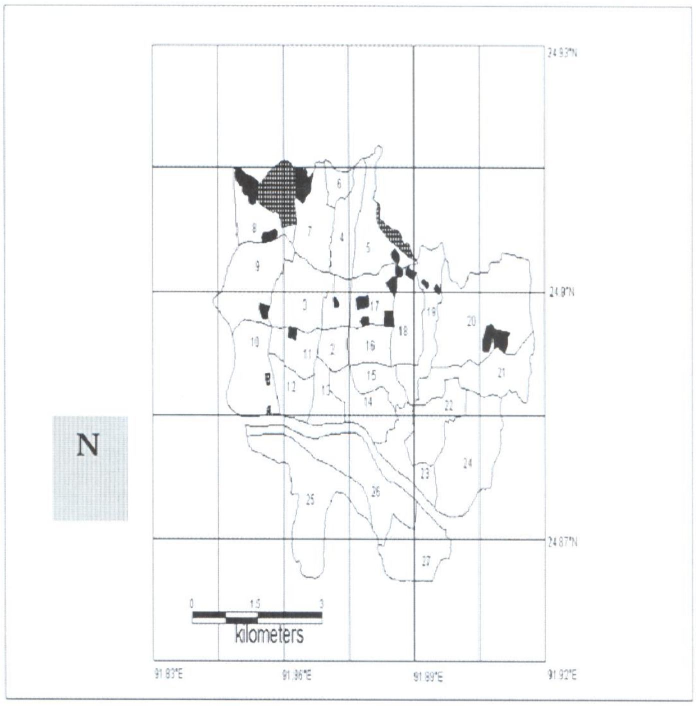
q = The slope angle

FS=the factor of safety determined from a static slope stability analysis

g= the acceleration of gravity

These a_C values are judged against the regional estimates of surface peak ground acceleration to give a prediction for the incidence of damaging earthquake-induced landslides in the area. There have been very few implementations of quantitative landslide hazard models in the GIS environment instead; a qualitative approach utilizing regional maps showing relative susceptibility of landslides in various geologic deposits will be used to depicted earthquake-induced landslide hazard. Figure 9 shows landslide potential in Sylhet City.

Figure 9: Map showing landslide potential in Integration of Site Effects in the GIS Environment



Integration Site Effects in the GIS Environment

Every analysis region is different; therefore the quantification of the secondary site effects and the weighting scheme for combining the various seismic hazards is heuristic, based on judgment and expert opinion about the influence of local site conditions in the region and the exactness of the available geologic and geotechnical information. However countries like Japan and the United States have long histories on instrumental seismicity and numerous models have been projected there to correlate the various hazards. However that is not the circumstances in Bangladesh. Heuristic rules for quantification and combination were used which were developed by Stephanie and Kiremidjian (1994).

The bedrock-level ground shaking in the region was ascertained. The shaking was depicted in terms of peak ground motion values. The regional distribution of bedrock-level shaking was estimated as 0.18g. Bedrock level PGA was measured as constant since the study area was relatively small. Figure 10 shows the flow diagram of integration of site effects. A map showing the distribution of the surface-level ground shaking in the region was developed first. Figure 11 shows the regional distribution of ground shaking hazard (MMIGS), which is, produced just by simple multiplication of the PGA at bedrock level with amplification factor shown in Figure 7.

Figure 10: Flow chart for Combined Seismic Hazard Map

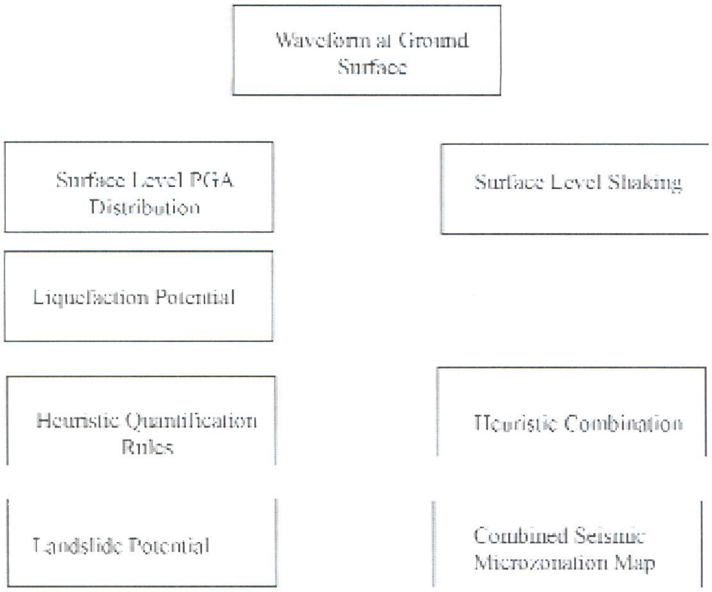
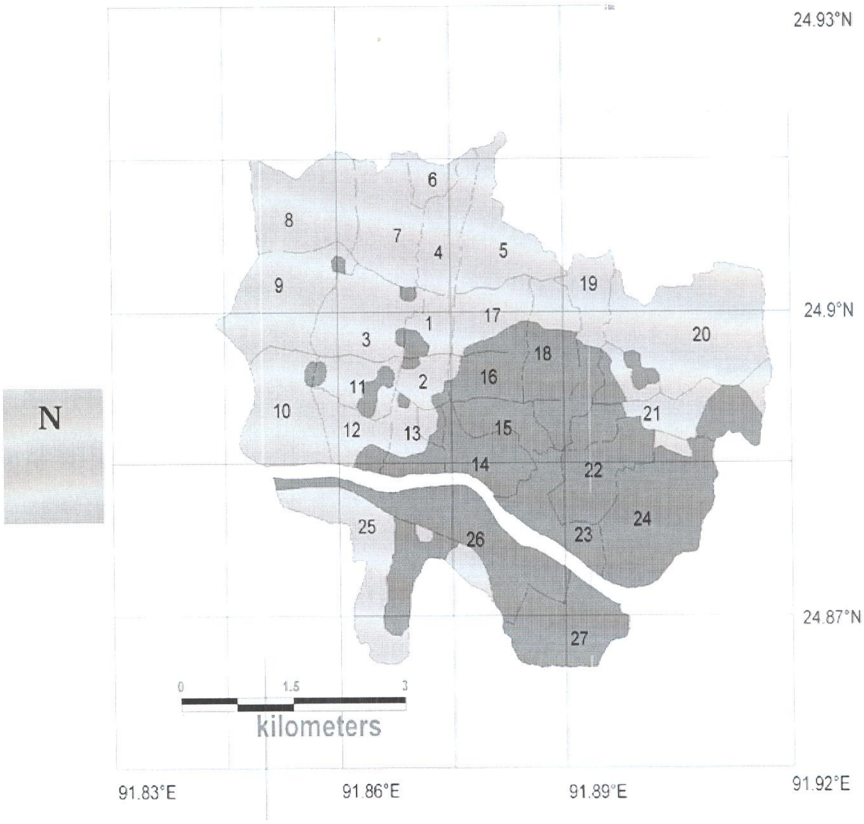


Figure 11: Map showing regional distribution of surface level peak ground acceleration in Sylhet City



It is decide d that the final combined seismic hazard would be quantified in terms of Modified Marcelli Intensity (MMI). There are several relationships for converting PGA to MMI. The equation used here was developed by Trifunac and Brady (1975). The following heuristic rules are used to quantify the seismic hazard attributable to liquefaction:

For regions with liquefiable soils with high liquefaction potential

MMILIQ= MMIGS+2

For regions with liquefiable soils with moderate liquefaction potential

MMILIQ= MMIGS+1 and otherwise:

MMILIQ= 0

To quantify the seismic hazard due to landslide (MMILAN), the following heuristic

rules are used. For region designated as "high"
MMILAN = MMIGS +2
For region designated as "moderate"
MMILAN = MMIGS +1 and otherwise
MMILAN = 0

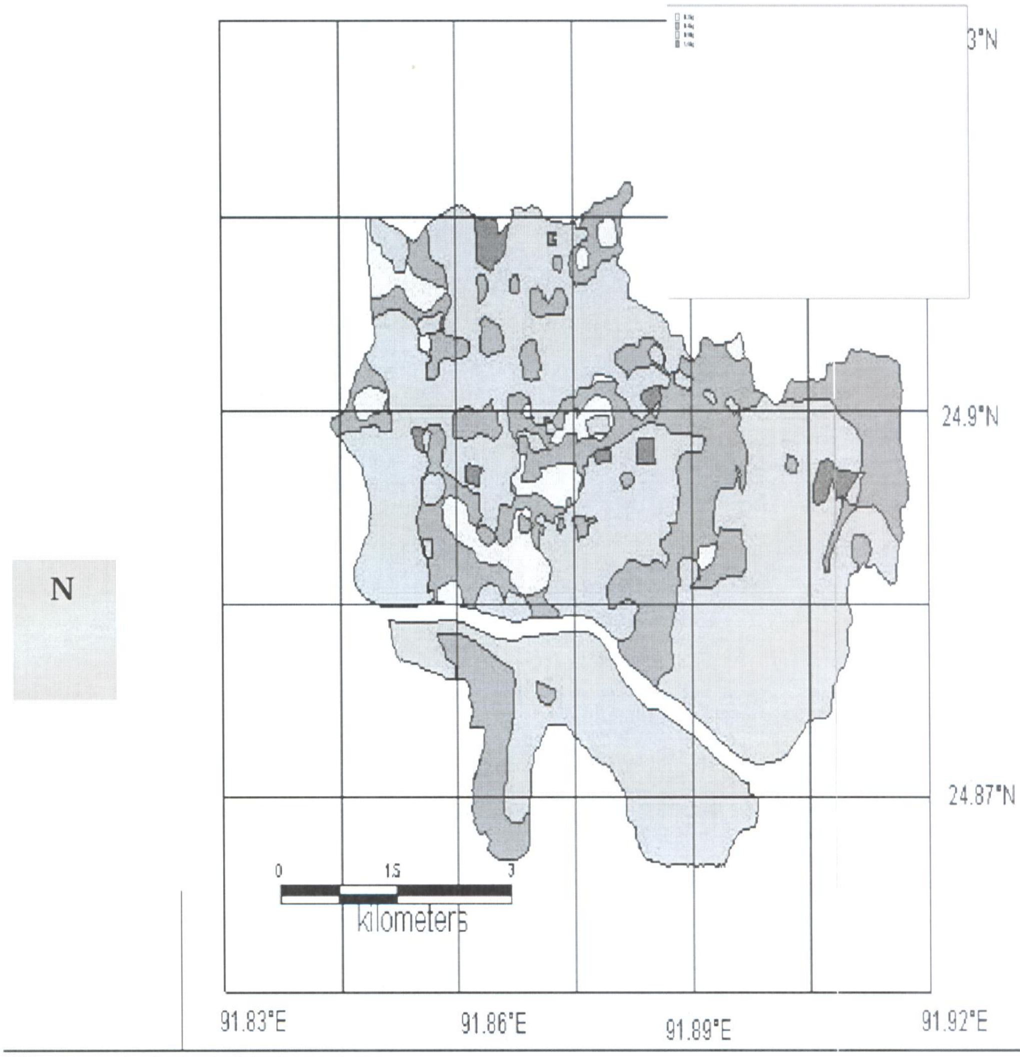
The rules for combining the assorted hazards are based on expert opinion (after Stephanie and Kiremidjian, 1994) about the comparative precision of the hazard information and the behavior of the local geology. For this study, four potential combinations were considered and their assumed weights are shown in Table 3.

1.9 times amplification plus liquefaction (high) plus landslide (moderate)	1.30g	0.32	1.25
1.9 times amplification plus liquefaction (moderate) plus landslide (moderate)	1.0g	0.26	1.0
2.5 times amplification plus liquefaction (moderate) plus landslide (high)	1.60g	0.068	0.25
Total		26.53	100%

Conclusions

In this study, GIS was used to carry out regional multi-hazard seismic microzonation for study area where reflection of ground shaking and the secondary site attributes of soil amplification, liquefaction and landslide are the salient features. The method to combine the different hazards is based on a weighted average approach. The GIS-based analysis is useful to engineers, planners, emergency personnel, insurance officials,

Figure 12: Map showing regional distribution of combined seismic peak ground acceleration in Sylhet City



government officials, and anyone else who may be concerned with the potential consequences of seismic activity in a given region. The results of a regional seismic hazard and risk analysis are usually presented in the form of microzone maps that serve as an effective means of transferring information from the scientific community to the professional community of decision makers involved in hazard and risk mitigation.

Acknowledgement

The author would like to express his sincere gratitude and appreciation to all those who extended their kind assistance and cooperation during the course of the study, in particular, officials of Sylhet City Corporation, Geological Survey of Bangladesh (GSB), Bangladesh Meteorological Department (BMD), Bangladesh Bureau of Statistics (BBS), Department of Civil Engineering (SUST), Department of Geology (DU), and all other agencies and organisations. Finally, the authors want to express their sincere thanks to Prof. J. R. Choudhury Vice-Chancellor, BRAC University for his constructive suggestions.

References

Ambraseys N.N. (2000). Reappraisal of North-Indian Earthquakes at the Turn of the 20th Century, Current Science, 79 (9-10), 1237-1250.

Bilham, R., V.K. Gaur and P. Molnar (2001). Himalayan Seismic Hazard, SCIENCE, 293.

Bolt, B.A. (1987). Site-specific study of seismic intensity and ground motion parameters for proposed Jamuna river bridge, Bangladesh, Report on Jamuna bridge study.

Boore D., W. Joyner and T. E. Fumal (1997). Equation for estimating horizontal response spectra and peak acceleration from Western North American Earthquakes: A summary of recent work, Seism. Res. Lett. Volume.68, No.1, pp.128-153.

Grunthal G, editor. (1998). European Macro seismic Scale, Luxembourg: Cahiers due Center European de Geodynamics et de Seismology, Volume 15.

McGuire, R. (1978). Seismic ground motion parameters relations, Journal of Geotechnical Division, ASCE, Volume 104, pp.461 – 490.

Islam, M.R. (2005) Seismic Loss Estimation for Sylhet City, M.Sc Engg. Thesis, Dept of Civil Engineering, BUET, Dhaka

Molnar, P. and P. Tapponier. (1975). Cenozoic tectonics of Asia, effects of a continental collision, Science, Volume 189(8), pp.419-426.

Oldham, R.D. (1899). Report on the Srimangal Earthquake of 12th June 1918, Memoir of Geological Survey of India, Volume 29, pp.1-349.

Rodríguez, C.E., J.J. Bommer and R.J. Chandler (1999). Earthquake-induced landslides: 1980–1997, Soil Dyn. Earthq. Eng. Volume 18, pp.325–346.

Stephanie, A. King, and Anne S. Kiremidjian, (1994). Regional Seismic Hazard and Risk Analysis through Geographic Information System.

Seed, H. B., I. M. Idriss and I. Arango (1983). Evaluation of liquefaction potential using field performance data, Journal of Geotechnical Engineering, Volume 109, No. 3, pp. 458-482.

Sharfuddin, M. (2001). Earthquake Hazard Analysis for Bangladesh. M.Sc. Engg. Thesis, BUET, Dhaka.

Tamura, I. And F. Yamazaki (2002. Estimation of S-wave velocity based on geological survey data for K-NET and Yokohama seismometer network. Journal of Structural Mechanics and Earthquake Engineering No. 696, Vol. I-58, 237-248 (in Japanese).

Trifunac, M. D. and A. G. Brady (1975). A study of the duration of strong earthquake ground motions, Bulletin of Seismological Society of America, Volume 65, pp. b581-626.

International Charter on 'Space and Major Disasters': An Assessment of Outreach in South Asia

N.K. Shrivastava, Sanjay K. Srivastava, P. Soma, O. Chiranjeevi, V.S. Hegde, S.K. Shivakumar and Darshana R. Dave

Abstract

The International Charter 'Space and Major Disasters' is a unique example of international cooperation to support disaster management authorities in terms of space information products of the disaster events. It is an operational arrangement wherein space-faring nations formally participate to pool their space and ground segment resources and deliver data in support of responding emergency situations. The signatories to the Charter, besides India's Indian Space Research Organization (ISRO), include space agencies of Canada (CSA), Europe (ESA, CNES, DMC), USA (USGS, NOAA), Argentina (CONAE), Japan (JAXA), and China (CNSA). The Charter has been in operation for the last eight years and has captured all the major disasters the world has faced during that period. It has demonstrated its effectiveness on almost all occasions. For example, the Asian earthquake and tsunami disaster event of December 26, 2004, a rare kind of event, brought to the fore several issues and challenges pertaining to the operational efficiency of the International Charter. The Charter was placed in a scenario where it had to perform and demonstrate what it could do for the wounded South East Asian subcontinent. The satellite images acquired under the Charter were distributed to a number of rescue and relief agencies, on request. The kind of response the Charter received from the user agencies all around the world once again established its significance and role in managing major disasters and its wider user base. In the context of South Asia, the Charter responded to the Muzaffarabad Earthquake, the South Asia Floods 2007 and more recently, the Kosi floods 2008. This paper brings out the objectives of the International Charter 'Space and Major Disasters', its operational organization, support mechanism and application for major disasters such as Flood, Cyclone or Hurricane, Forest-Fire, Volcano and Oil-spill. It also brings out some of the gaps that exist in the system and ways to improve it further, especially to support the South Asia region. ISRO plays an active role in the Charter's functioning by sharing secretariat, Emergency On-Call Officer and Project Manager Support services.

Introduction

The space-based disaster management system provides valuable inputs in disaster management. These inputs, when appropriately integrated with the conventional ground-based systems, provide valuable solutions to the problem during critical issues of various phases of disaster management. Interestingly, the space-based system is one that remains unaffected by the very disaster on ground and provides unbiased, synoptic and timely information on the nature and impact of the disasters. Space inputs are useful in taking appropriate preventive measures through hazard zoning and a priori risk assessment at local and regional levels. It is also well proven that space-based weather forecast and advance warnings of severe weather conditions facilitate timely and effective rescue, relief and rehabilitation of the affected population. Earth observation satellites facilitate imaging of the disaster-affected areas and help to assess the extent of damage to the affected areas. This vital information helps in initiating relief measures and allocation of suitable resources for rehabilitation.

As a part of promoting the use of space data systems, ISRO/Department of Space (DoS) has developed several tools/techniques in the past two decades to support disaster management for various disasters such as flood, cyclone, landslide, earthquake, forest fire and drought. ISRO, as a party to the International Charter 'Space and Major Disasters', is playing a key role in integrating space inputs for global disaster management. This paper provides a brief description of the Charter's functions, organization and operations. The performance of the Charter for over seven years of its operations is highlighted with case studies.

International Charter 'Space And Major Disasters'

During an emergency, the challenge is to obtain a quick and clear view of the situation. From their orbits, satellites provide images of wide areas in one pass, with a precision of a few metres for India's IRS and French's SPOT satellites. By virtue of having radar instruments on board, European's ENVISAT and Canadian's RADARSAT satellites have been imaging the surface of the earth in all weather conditions. Comparing images acquired after a disaster with earlier ones, when there was no disaster, allows for the detection of the areas where changes have occurred. This is vital information for the civil protection authorities, who have to rescue people and restore services. Today, the speed with which the Charter can deliver the products is limited by how quickly a satellite can be put in a vantage position to image the disaster.

Considering the potential contribution that space can provide in the case of major disasters, it was during the UNISPACE-III conference of July 1999 that the space agencies of France (CNES) and Europe (ESA) proposed the creation of a Charter for cooperation, which they later signed along with the Canadian Space Agency (CSA) on October 20, 2000. The International Charter was declared formally operational on November 1, 2000. Subsequently, ISRO and the National Oceanic and Atmospheric Administration (NOAA) joined the Charter in September 2001. The Argentina space agency CONAE joined the Charter in July 2003. In July 2003, UNOOSA also joined the Charter as a cooperating body, which would act as a gateway for submitting requests for assistance from UN agencies. Later, the United States Geographical Survey (USGS) and Space Agency of Japan (JAXA) joined the Charter in 2005. Recently, in 2007 the Chinese Space Agency joined the Charter.

The Charter requires the space member agencies to cooperate in providing data, information and services that will supplement/complement the needs of the states and communities in emergencies caused by disasters. The basis of such cooperation is voluntary, and the cooperating agencies of the Charter exercise their best efforts to fulfill the obligations towards the Charter and make available their space assets and associated ground resources for data acquisition and delivery. The partner agencies participate in the Charter without the need for obligation to expand their resources or incur any additional expenditure. Their participation does not prevent them from providing data on their own to the users.

The Charter is open to other space data and service providers for membership and contribution to the Charter's objectives. Requests for assistance in situations of emergency can be received from an Authorized User (AU) under the Charter. Other bodies, such as international organizations of humanitarian assistance and environmental management, can also request data through authorized users.

Primary Goals: International Charter

In promoting cooperation between space agencies and space system operators in the use of space facilities as a contribution to the management of crises arising from natural or technological disasters, the Charter seeks to pursue the following objectives:

- Supply, during periods of crisis, to states or communities whose population, activities or property are exposed to an imminent risk, or are already victims, of natural or technological disasters data, providing a basis for critical information for the anticipation and management of potential crises
- Participation, by means of this data and of the information and services resulting from the exploitation of space facilities, in the organization of emergency assistance or reconstruction and subsequent operations.

Charter Implementation and Operations

A Charter Board comprising representatives from all agencies oversees the functioning of the Charter and provides policy guidelines. The administrative, operational and technical coordination is provided by the Charter Executive Secretariat, formed with one representative per partner agency. The Secretariat functions on an email network, and one agency serves as 'primes pares' or nodal point (by rotation) coordinating the activities for a period of six months. Periodic teleconferences are held to discuss operational and technical problems and to resolve issues. This secretariat is also responsible for evolving the operations procedures, guidelines and documents as well as monitoring systems operations and performance.

In the event of a major disaster, an AU/Cooperating Body in the Charter list can activate the Charter by contacting a 24-hour operator, with functional designation as On-Duty Operator (ODO) in Frascati, Italy. Once a call is received accompanied by User Request Form (URF) and validated by the ODO, the latter notifies an Emergency On-Call Officer (ECO). The ECO develops a plan of action surrounding the event. The functions of an ECO are ensured by each of the Partner Agencies on a weekly rotational basis.

After completing the procedures for data acquisition for covering a disaster, the ECO passes on the plan of action to a designated Project Manager (PM), who is qualified in data handling, analysis and application, and assists the user throughout the process. The PM ensures data interpretation/analysis and prompt delivery of the data products and analysis reports to the users according to their requirements. Figure 1 represents the block schematic of Charter operations. The space resources committed by the Charter Partner Agencies (PAs) include optical and microwave sensors of different resolutions and swaths.

Charter Activation Criteria

A request for covering a disaster event is generally met by planning a new acquisition and/or ordering data from the archives. The following criteria will apply in accepting the request:

The request received from an AU is validated for compliance with the Charter's objectives and analyzed within the framework of the definitions provided and the scenarios established for various types of disasters. The Charter activation is approved only after a consensus agreement among secretariat members. The Charter is activated exclusively for an emergency involving major disaster. Data requests intended for research and development into disaster management or similar applications are not entertained. The sustained monitoring of disasters such as drought, tracking oil spill and epidemics does not constitute a case for Charter activation. The Charter can be activated against major disasters such as earthquakes, floods and landslides, storms or hurricanes, forest fires, volcanoes and oil spills.

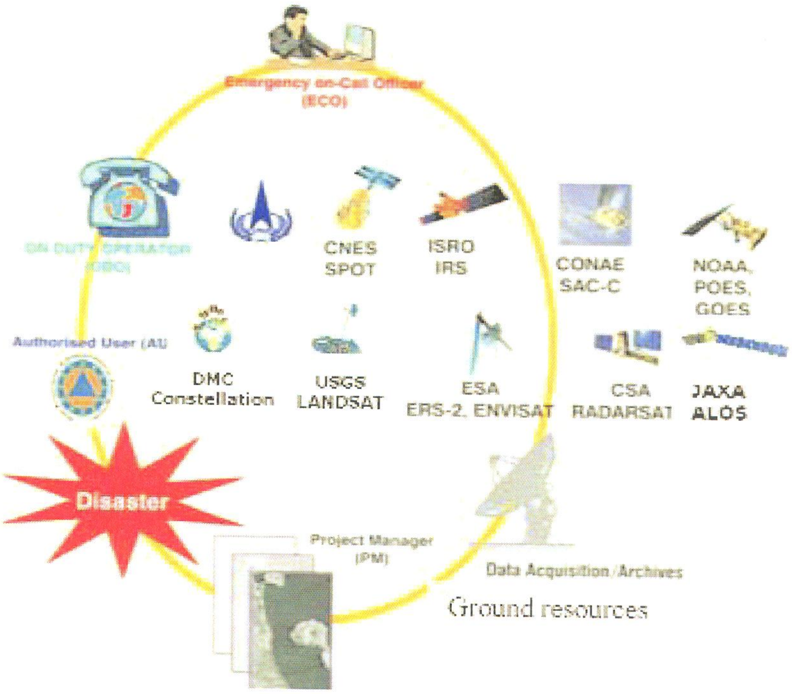


Figure 1: Charter Operations Cycle

ISRO's Participation In the Charter

ISRO, as a signatory to the International Charter has become an integral part of the global efforts in disaster management. ISRO offers imaging services through its operational Indian Remote Sensing fleet of IRS-1D, IRS-P4 and IRS-P6, employing all their sensors.

Towards supporting the International Charter by providing timely data and inputs as required, ISRO has organized an internal structure consisting of representatives of the Charter Board, a member of the Executive Secretariat, Emergency On-Call-Officer, Project Managers (PMs), and Communication representative in key themes.

ISRO as Authorized User for Charter Activation

Considering the active role played by ISRO in developing and establishing remote-sensing applications for disaster management, it was decided that in the initial phase of Charter operations, ISRO would take on the responsibility of being the AU for India and coordinate with the Central and State Governments to activate the Charter, whenever the need arises. ISRO as a part of the programme on disaster management support established a Decision Support Centre (DSC) that would be networked to the Central and State Government systems. Query-based services would be provided on various disaster-related aspects. This would lead to capacity building in the State Governments to use space-based information. Central and State authorities in India and outside may seek Charter support for disasters defined within the scope of the Charter, through ISRO.

International Charter For Rescue of Global Disasters

The Charter has been activated 162 times as on 4 October 2008, covering all the continents for all types of disasters. So far, the Charter has been activated for 95 cases of floods/hurricane/typhoon/Tornado; 25 times for earthquakes; 14 times for oil spill/accidents, 11 times for forest fires, 10 times for volcanic eruption, 5 times for landslides, and 1time each for cyclone and ice-jam. Presently, the Charter is activated, on an average, once in 3 weeks, and the frequency of activation has increased with UNOPS joining the Charter as a cooperative body.

The following are highlights of some of the Charter activations:

Bam Earthquake: The Bam earthquake in Iran was the most dramatic event in 2003, in which about 20,000 people were killed. A number of European rescue teams flew to Bam and for the first time some cooperation and briefing of activities took place under the European civil protection banner. France, Germany and Portugal activated the Charter simultaneously. Further, UNOPS and IRAN requested for the data. Two hazard zone maps of the Bam earthquake were derived from the fusion of IRS-1C, SPOT and Ikonos satellites data as given in Figure 13.2. These maps were widely used in the relief operations. Also, pre-event IRS-1C data from the archives was found to be very valuable.

Asian Tsunami: A high-magnitude earthquake, 9.0 on the Richter scale, struck southern Asia at 00:58 UTC, 6:58 a.m. local time on 26 December 2004. The epicentre was 320 km west of Medan, just off the west coast of the Indonesian Island of Sumatra. The earthquake was followed by tsunamis that killed nearly a quarter of a million people, mostly in Indonesia, Sri Lanka, and India. The coastal regions of India, Sri Lanka, Thailand, Indonesia, the Maldives, Malaysia, and Myanmar were all severely affected. Bangladesh, Seychelles, Somalia, Kenya, and Tanzania also suffered damage and loss of life. The Charter was activated by ISRO the same day. ISRO provided the first satellite images from IRS system giving assessment of the damage and areas affected by the tsunami waves (Figure 13.3). Later, the imageries received from all Charter agency satellites were analyzed and a complete report was provided on damage assessment. The satellite images were very useful in rescuing the people and providing relief material to the affected areas during relief and rescue operations undertaken by the respective governments and NGOs.

Hurricane Katrina: Levees were breached and floodwaters submerged the city of New Orleans after Hurricane Katrina made a landfall just south of the city on 29 August 2005. as much as Eighty per cent of the city was under six metre of water on 31 August 2005. Along the Gulf coast and the Mississippi, flooding was extensive. Authorities put the estimated death toll possibly in thousands, as rescue efforts were under way. The Charter provided very useful satellite images during relief and rescue operations (Figure 13.4).

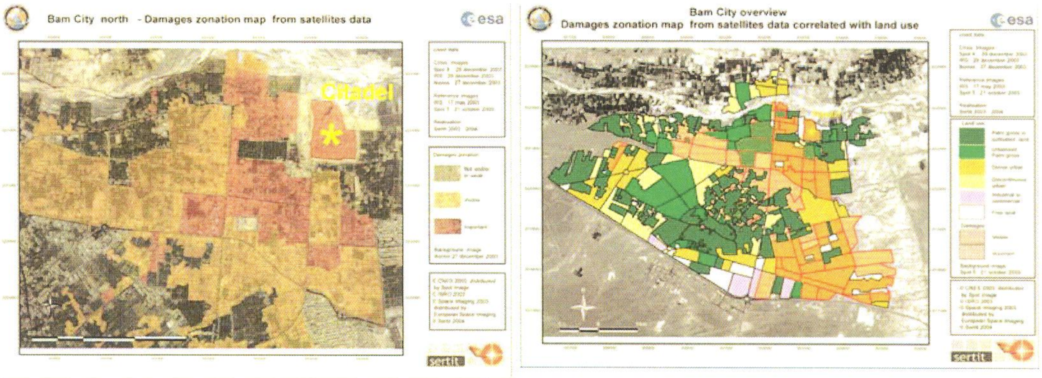


Figure 15.2: BAM (Iran) Earthquake Damage Zonation provided by Charter

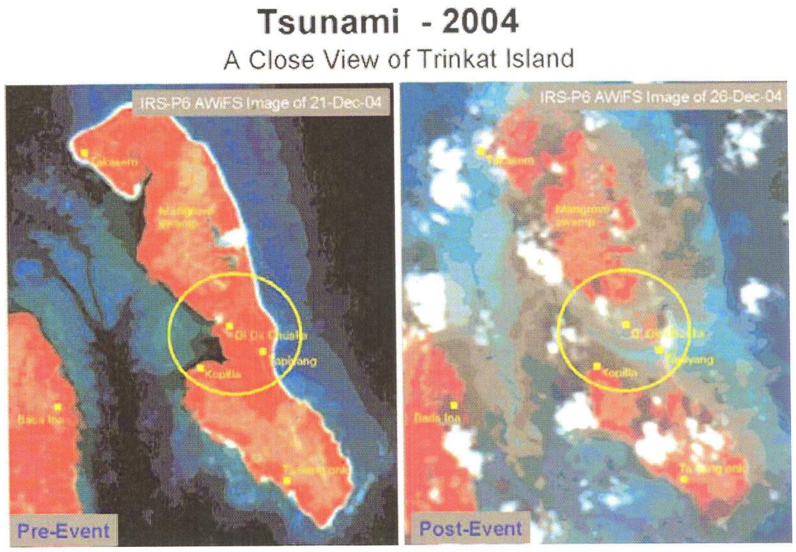


Figure 15.3: Tsunami Damage Zonation (Andaman & Nicobar Island-India) provided by Charter

21/12/2004-26/12/2004, before and after tsunami provided by IRS satellites

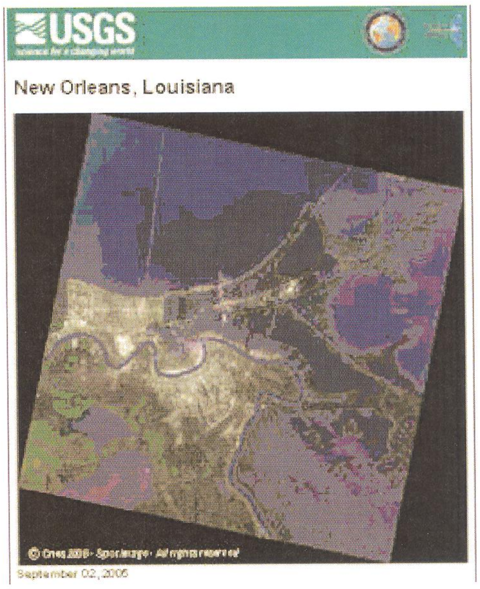
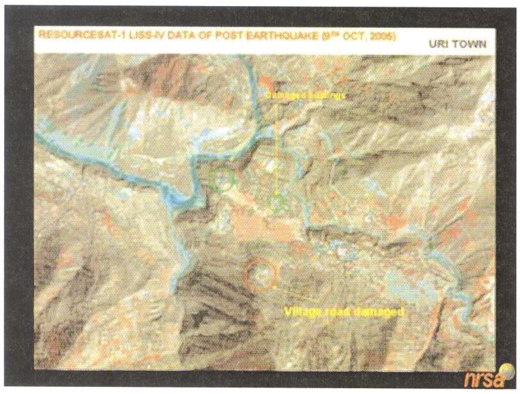


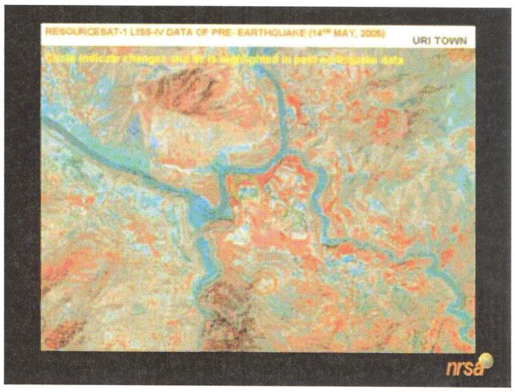
Figure 15.4: New Orleans, Spot satellite image

Earthquake in J&K (India): An earthquake of magnitude 7.6 struck western India at 03:50:38 UTC (8:50:38 local time) on 9 October 2005. The epicentre was located on the India-Pakistan border in the Kashmir region, about 95 km to the north-east of Islamabad. Shocks were felt over a radius of some 300-400 km, in north-west India, northern Pakistan, and Afghanistan. Indian authorities estimated that about 1,200 people died in the regions of Jammu, Baramulla, Kupwara, Srinagar, Poonch, and Udhampur. ISRO activated the Charter and provided satellite images, giving areas affected by the earthquake (Figure 13.5).

Floods in Bihar (India) – August 2007: The worst floods in 30 years hit Uttar Pradesh and Bihar as unusually intense rains in Nepal persisted, swelling rivers coming out of the Himalayas and causing extensive damage to dams and infrastructure. Estimates are of 200 dead and 12 million people affected. Figure 13.6 shows the flood-affected areas.

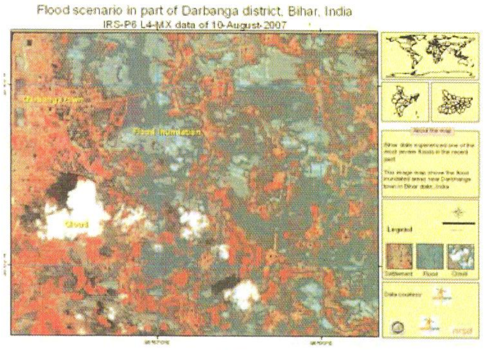


Jammu and Kashmir prov in a, Uri Resourcesat-1 LISS-IV Post-quake, *Source:* Resourcesat-1, Acquired: 09/10/2005



Jammu and Kashmir prov in a., Uri Resourcesat-1 LISS-IV Pre-quake, *Source:* Resourcesat-1, Acquired: 14/05/2005.

Figure15.5: The Jammu & Kashmir Earthquake Damage Zonation provided by Charter



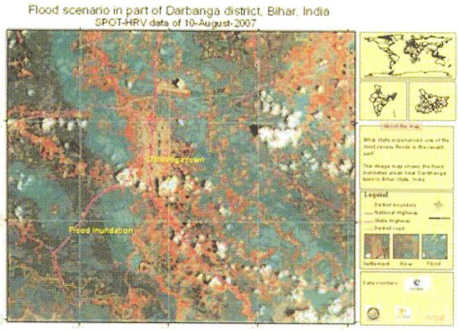


Figure15.6: Bihar Floods - Affected Areas provided by Charter

Kosi River Breach–Floods in India/Nepal–August 2008: The Kosi river breached an embankment on 18 August 2008, causing displacement of large number of people in India and also in Nepal. Deteriorating weather in the days following the break worsened the situation as flooding spread to the state of Bihar in India, where media reported 46 dead on 27 August. According to the Red Cross, as many as 1.5 million people may be affected by the violent flooding of the Kosi. Figures 13.7 and 13.8 show the satellite imageries provided under the Charter.

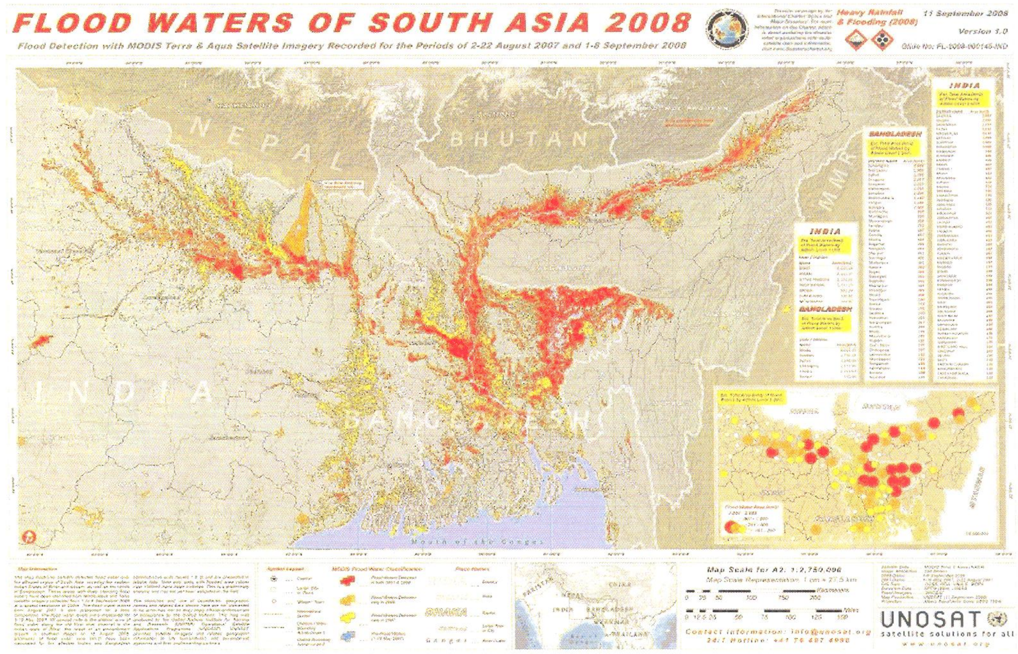


Figure 15.7: Flood Waters in South Asia, 2008

Source: MODIS Terra and Aqua, 250 m/pixel resolution.
Acquired: 1-8/09/2008; 1-10/05/2007, 2-22/08/2007

Satellite detected floodwater over South Asia, covering the eastern Indian States of Bihar and Assam and the whole of Bangladesh. Areas with likely standing floodwaters have been identified from Modis Aqua and Terra satellite imagery collected from 1 to 8 September 2008. The floodwater extent from August 2007 is also presented for a time comparison. Pre-floodwater levels were measured for 1-10 May 2007. Of special note is the distinct area of floodwater along the old Kosi river channel in the Indian state of Bihar, the result of an embankment breach in southern Nepal on 18 August 2008. Estimates of floodwater area (km^2) have been calculated for the affected Indian and Bangladesh administrative units (levels 1 and 2) and are presented in tabular lists. Note: only units with flooded area values over 100 km^2 have been included. Preliminary analysis not yet validated in the field.

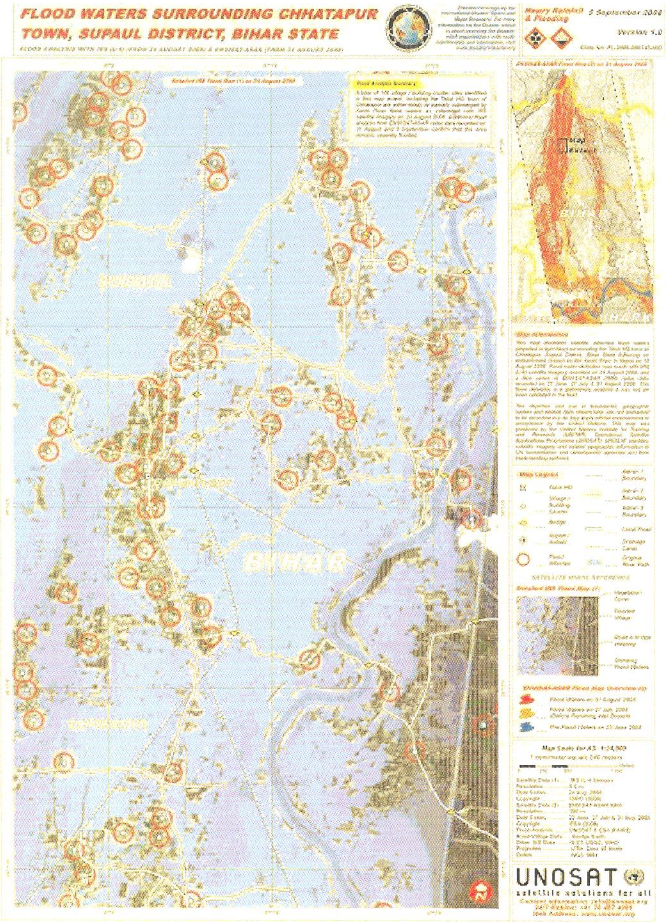


Figure 15..8: Flood waters in Chhatapur Town, Supaul District, Bihar State, 24/08/2008

Source: ENVISAT-ASAR IMM and IRS L-4, 150 m/pixel (Envisat ASAR); 5.0 m/pixel (IRS L-4) resolution.
Acquired: 22/06/2008, 27/07/2008, 31/08/2008 (Envisat); 24/08/2008 (IRS L-4)
Satellite-detected floodwaters surrounding the Taluk HQ town of Chhatapur, Supaul District, Bihar State following an embankment breach on the Kosi River in Nepal on 18 August 2008. Floodwater detection was made with IRS (L-4) satellite imagery recorded on 24 August 2008, and a time series of ENVISAT-ASAR (IMM) radar data recorded on 22 June, 27 July and 31 August 2008. A total of 108 village/building cluster sites identified in this map extent, including the Taluk HQ town of Chhatapur are either totally or partially submerged by Koshi River floodwaters as indentified with IRS satellite imagery on 24 August 2008. Additional flood analysis from ENVISAT-ASAR radar data recorded on 31 August and 5 September confirm that this area remains severely flooded. Preliminary analysis not yet validated in the field.
Credit: Copyright ESA 2008, ISRO 2008
Image processing, map created 05/09/2008 by UNOSAT

Feedbacks in South Asia Context

South Asian countries have experienced some of the major disasters in last five-six years.The Indian Ocean Tsunami 2004, which affected India, the Maldives and Sri Lanka was responded to well by Charter mechanisms. There were 3+1 different calls (India and France 26/12; UN 28/12; Germany for copy 29/12) in support of Charter Activation and more than 100 products generated over 150 images provided in a global effort by several institutions, which generated better response to Tsunami. Mr K. Kadiman, Indonesian State Minister for Research and Technology, during Earth Observation Summit in Brussels (2005) – made the following observations about the support from Charter - "Overwhelmed by (..) near-real time satellite imagery provided through the Charter on Space and Major Disasters, which enabled the government to swiftly grasp the full scope of the tragedy" . Charter products thus created awareness about the extent of impact and damage from the South Asian disasters at the global level. It helped relief agencies and also international donors to respond to the disaster emergencies in the respective countries.

While the Charter did capture major disasters in South Asia, it also helped the civil defence authorities to integrate Charter inputs to enhance the quality of response. Some of the case studies, taken up by UNOSAT on the utilization of Charter products by the end-users, especially in the context of South Asia, are highlighted in Figures 13.9 and 13.10:

Figure 13.9:

Figure 13.10:

Hindu Kush region earthquake, Afghanistan – April 2004

Background:

The Charter was triggered on 31 March 2004 by UNOSAT on behalf of the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) in Geneva , to respond to severe floods in Namibia. International Federation of Red Cross and Red Crescent Societies have also expressed their interest.
UNOSAT triggered the Charter through the UN Office for Outer Space Affairs (UN OOSA).

UNOSAT services provided :

AIMS, end user for this event, has got all the facilities to process EO data in its premises. UNOSAT role, as PM for that activation, was only to deliver raw EO data requested as soon as possible to the end user

User feedback :

"Please find attached the Technical report (from our Technical Team) of the images provided as a result of the 6 April 2004 earthquake in Afghanistan that prompted the triggering of the Charter. We are pleased to inform you these products were distributed to the humanitarian community immediately the image processing was completed and they found it very useful. We are sorry sending the report late, we will definitely improve our turn around time next time. These products will be posted on our website in the coming days. We thank you for the support received and we hope it will continue as we continue to serve vulnerable communities. Regards"
Joseph Maada Korsu Kandeh
Field Coordinator, NE Afghanistan

Users: UN OCHA - AIMS
Sensors: SPOT 1 & 2, IRS-P6, SAC-C

NEPAL floods – August 2003

Background:

In August 2003, flooding and landslides due to the heaviest monsoon rains in 30 years, hit 54 of Nepal's 75 districts. Thousands of people were forced from their homes and thousands of acres of crops were washed away. The UN Office for the Coordination of Humanitarian Affairs (UN OCHA) and the UN Development Programme (UNDP) in Nepal were among those who responded to this disaster.

UNOSAT services provided :

In support of their need for updated geographical information, UNOSAT through the International Charter on Space and Major Disasters prepared customised up-to-date maps of the flooded areas using several types of satellite imagery (Spot 5, Envisat and Radarsat).
The maps were provided directly to UNDP Kathmandu and used by the local emergency response teams.

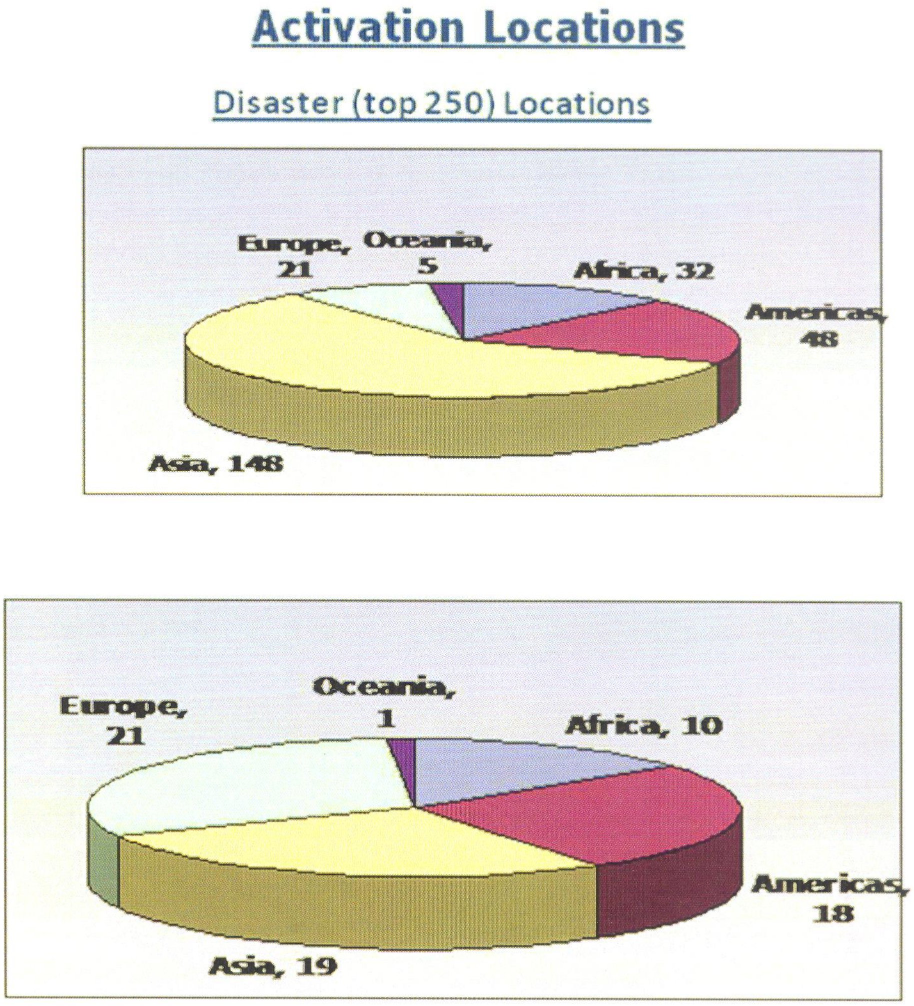
User feedback :

"The maps were very useful in locating the present floods and landslide areas and also to see how the rivers are changing their courses. We strongly believe that such information is very useful in future planning for designing development and disaster mitigation activities"
"Many thanks for your offer. We are extremely pleased by your pro active approach."

Users: UN OCHA and UNDP
Sensors: SPOT5, ENVISAT, RADARSAT

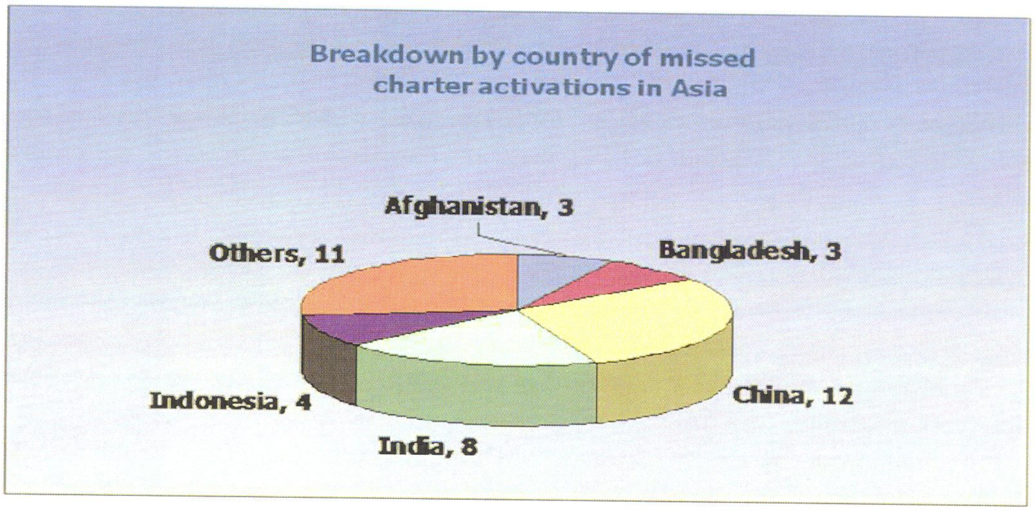
Using the Charter Activation data from 2000-05, UNOSAT assessment highlights that there were 148 incidences of disasters in Asia but Charter was activated only for 19 locations. In the case of Europe, it is 100% activation to all the major disasters. Further, there were 54 calls out of 87 (62%) in developing countries and 16 out of 54 were activated through UN agency. Asia, particularly South Asia, experiences maximum disasters, is yet to attract Charter activation as per its vulnerability.

Figure 13.11: Charter Activation Scenario from 2000 to 2005 (Source: UNOSAT)



Charter activation trends have been analyzed in the context of South Asia (Figure 13.12). Charter activation was missed out on 8 occasions in India, 3 and 2 each in the case of Bangladesh and Afghanistan, which shows lack of awareness and appropriate institutional mechanism in South Asia to harness the benefits of International Charter. This is where an institution like SAARC Disaster Management Centre has a role to play and it is expected that Charter provisions would be utilized for risk reduction in the high-risk South Asian region.

Figure 13.12: Missing statistics of Charter Activation in the case of South Asia.



Cooperation with other Frameworks

International cooperation has been recognized as one of the important strategies towards providing the access of Earth Observation (EO) products to the civil protection authorities/disaster management agencies in support of the emergency management. International Charter 'Space and Major Disasters' is a major step in this direction. The main features include an operational mechanism, which delivers EO products to civil protection agencies, and emergency and rescue services, and to signatories during emergency situations. The United Nation (UN) is a cooperating body since July 1st, 2003 and therefore UN agencies such as UNOSAT can request activations of the Charter through UNOOSA as the nodal agency.

Towards a Global Earth Observing System of Systems (GEOSS), the GEO initiative is an important step in putting in place a global system of systems for improved coordination of observations (space and in situ). In the GEOSS framework, an intergovernmental Group on Earth Observations (GEO) has already been set up with a secretariat for monitoring a 10-year implementation plan. The central focus is on observing and understanding the Earth system more comprehensively to expand worldwide capacity to achieve sustainable development with enhanced socio-economic benefits. Reducing loss of life and property from natural and human-induced disasters has been one of the core areas of GEOSS.[11]

Global Monitoring for Environment and Security (GMES), jointly led by the European Commission and ESA, has been established as a European capacity to produce and disseminate timely and reliable information in support to policy sectors concerning Environment and Security. GMES focuses on providing large-scale operational end-to-end services, primarily looking at EU policy sectors. GMES services are relevant to humanitarian aid and disaster risk reduction. There are initiatives by commercial agencies as well. A private company-SERTIT Service, for example, which operates through ESA and CNES, has been providing value-added products in support of the International Charter. It is a good example of public-private partnership.

Sentinel-Asia is another 'voluntary and best-efforts-basis initiative' led by the APRSAF (Asia-Pacific Regional Space Agency Forum) to share disaster information in the Asia-Pacific region on the Digital Asia (Web-GIS) platform and to make the best use of Earth observation satellites data for disaster management in the Asia-Pacific region.

The framework, as already discussed, helped in promoting EO products towards disaster reduction in the framework of cooperation. However, most of the EO products have been used during the response phase without the participation of stakeholders and also capacity building at the user's end. In the pre- and post-disaster phase, combining EO products with socio-economic and other in situ data adds substantial knowledge and provides structured solutions to the demands at international, national and local-level users. Thus, there is a need to have an arrangement that inspires the participation of stakeholders, enables capacity building and establishes stronger linkages to the end-users.

Future Developments

In the course of time, with closer international cooperation, Charter space resources will increase and it will be possible to provide space inputs to disaster managers very quickly to make disaster assessment in near real-time. With rapid growth in information and communication technology, faster modes of data transfer will be available in areas where such connectivity is not possible at present. With the participation and interest shown by different international organizations, regional historical databases on various disasters that play a key role in providing assessment of the disaster will get organized

Regional Cooperative Mechanisms on Space Technology Applications for Disaster Management, Publication of Information, Communication and Space Technology Division (ICSTD), United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Bangkok (http://www.unescap/org/tcstd/stas/publication).

CEOS (2001). Committee on Earth Observation Satellites, The Use of Earth Observing Satellites for Hazard Support: Assessment and Scenario, Final Report of Disaster Management Support Group, 220 pp, Published by NOAA (http://disaster.ceos.org/pdf/CEOSDMSG.pdf).

19th Board Meeting, International Charter, Montreal, Canada (April 2008).

ISSN 0974 – 6463

SAARC

JOURNAL OF SOUTH ASIAN DISASTER STUDIES
SAARC Disaster Management Centre
IIPA Campus, I.P. Estate,
Mahatma Gandhi Road, New Delhi 110002
Phone: 91-11-23702445, Fax: 91-11-23702446
Email: director.sdmc@gmail.com, dharc@nic.in

Printed by: Celluloid # 98737 98727