Towards a Sustainable World: Risk Management and Preventive Planning for Natural Disasters

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IMMEDIATE GLOBAL CONCERN

Although considerable progress has been made in past decades about the catastrophic losses in urban centres, particularly through the organization of the *International Decade for National Disaster Reduction* (IDNDR 1990-2000), the priority in most cities of developing nations is to cope with the immediate day-to-day challenge of biological and political survival. The commonality in the case of Kobe, Los Angeles, Medellin, Quito, Almaty, Latur, Bangladesh, and Philippines is that they all have been stricken recently by major natural disasters. But these cities and towns do have another common element: a new awareness and a political commitment to protect their communities from future disasters.

The number of people affected by disasters has been growing by 6% each year since 1960, out of which 90% have been affected by natural disasters. Rapid urbanization, upsetting the balance of the ecosystem, causes environmental degradation, thereby increasing vulnerability of the communities to disasters. Seventeen of the 20 largest cities in the world in developing countries compared to seven of 20 in 1950, are more or less vulnerable to some or other natural disasters like earthquakes, floods, and landslides, etc.

There exist successful examples of disaster mitigation, undertaking structural measures such as making buildings cyclone or earthquake resistant and non-structural measures such as land use planning or providing tax incentives to direct development away from hazard-prone areas. Warning systems installed in the Caribbean islands have reduced the number of lives lost each year in hurricanes. After new soil and grading regulations introduced in Los Angeles USA, losses from landslides have virtually been eliminated. In the earthquake at San Jose, Costa Rica in 1990, a retrofitted portion of a hospital survived intact. Making hospitals earthquake resistant increases construction cost only by 2 to 10 percent. Simple unsophisticated measures like appropriate tree plantation can shelter buildings from strong winds and eliminate hillside erosion. Thus what we need is awareness and a commitment to reduce disaster risk.

This paper highlights the lessons learned through major natural disasters of the world, viz, earthquakes, floods, and cyclones and their contributory efforts in construction of disaster-resistant settlements and to further a sustainable world. Disaster preparedness as a part of the development policies for the community are equally important as the policies for the phase of reconstruction and rehabilitation, which requires financial assistance, technical skills and the understanding the community. There is a need to build a system to fight disasters in cooperation with others to prevent these catastrophes and prepare ourselves for an emergency.

DISASTER MANAGEMENT: AN INTERSECTORAL APPROACH

Problems underlying our type of urbanization (poverty, unemployment) bring forth teams of professionals of various disciplines. Catastrophes are measured in terms of lives lost, death tolls, billion dollars lost and disruption of economic activities making primary stakeholders such as authorities for housing, health, land issues, development agencies and affected communities an integral part of the management committee. Community participation is the only long-term solution to ensure and prevent conversion of natural hazards to disasters. People – individuals and corporations – must participate in preventive plans to avert future disaster risk.

PHILIPPINES: MODEL OF INTERSECTORAL COORDINATION

Frequent natural hazards have made Philippines one of the most disaster-prone countries of the world. It provides an example of the evolving role of private sectors in urban disaster management. The *Interagency Network for Disaster Response* (IANDR) has identified several private sector organizations, viz., development and disaster management NGO's, community-based NGO's, religious organizations, business foundations, and private companies, that play a significant role in disaster management whether it is before, during or after the disaster. The evolution of partnerships for disaster and development explain the model of intersectoral coordination and efficient use of local resources.

NEED FOR DECENTRALIZATION

Medellin, Colombia's second-largest city, has a population of 1.8 million people and an 18 percent annual growth rate. Nearly all the city's slums, which house 200,000 people, are on the city's steep hillsides situated in a narrow valley 1,500 m above sea level. The city is surrounded by steep hillsides, river and a flood basin. Besides floods and landslides being the annual reality, Medellin is also in a high risk zone for earthquakes. Since 1987 landslides have killed more than 500 and left 3,500 homeless, city inhabitants have committed themselves to make Medellin safer from natural hazards. A new municipal system for prevention, response, and rehabilitation has been able to integrate risk management strategies with municipal, physical, social and economic planning. Community participation has changed the local attitudes about reducing risks.

Strategic Development Plan of Medellin began as development of risk assessment maps for most neighborhoods analyzing risk levels and a disaster prevention Geographical Information System (GIS). There were special programs for landslides, flood and seismic monitoring, and regular meetings of administrators with the community representatives to determine and address prevailing issues of

vulnerability. This followed environmental programs, civic education and integrated programs to improve slum neighborhood in coordination with UNDP. Decentralization of disaster related issues to local government has integrated risk management practice in everyday activity motivating the local community to work for growing socio-economic vulnerability by frequent threats of landslides, floods and earthquakes.

DISASTER CONTINUUM: PREPAREDNESS FOR EMERGENCY RESPONSE

Disasters affecting vulnerable communities are perceived as extreme environmental conditions and external disturbances to the development process. It needs to be made part and parcel of development planning right from preparedness planning to emergency response. Activities of emergency response should lead to post-disaster recovery periods where rehabilitation that is an attempt by people and the community to establish a semblances of normalcy by economic restructuring, starting small enterprises and resumption of basic infrastructure such as water supply and sanitation system. Reconstruction phase is marked by large-scale efforts to replace the damaged buildings, revitalize economies, and restore agricultural systems to their full pre-disaster capacity.

Level of Risk: The first step in development of public policies for disaster mitigation is to evaluate the level of risk. It can be analyzed quantitatively in terms of its four components – hazard, exposure, vulnerability, and location. Vulnerability depicts a broader view to incorporate stress from environmental and human resources. The probabilistic method of evaluation, can be derived modular form as follows to evaluate the alternatives required for disaster mitigation:

RISK = VULNERABILITY X HAZARD X EXPOSURE X LOCATION

The Relief to Disaster Continuum: Disaster continuum relates activities of one phase to another, that is, building a damaged house in emergency to provide temporary shelter can be made with building materials which can be reused for making permanent houses. Human settlements need to be formulated through environmental policy and strategies for action in the continuum from relief to development. Vulnerability reduction should be recognized as the central principle in any activity on the continuum. Efforts need to be made to dissolve the administrative barriers between disaster management and development works.

PREREQUISITE FOR PREPAREDNESS PLANNING

1. Hazards, risk, and vulnerability – Identify the atural hazards of the regions, the degree of risk that the population is subjected to and their vulnerability to injury, loss of life and property which further give estimates for losses and the requirement of emergency response.
2. Making inventory of resources available to vulnerable communities of a region.
3. Policy formulation for disaster preparedness, response and reconstruction which can help the immediate implementation of programs.

Emergency Response Plan: In event of huge cyclones accompanied by flash floods, government networks generally collapse to provoke an emergency response in terms of food and shelter to victims. In the absence of a duly made frameworks to deal with such events, the almost proverbial NGO flexibility, ability to mobilize resources and personal agility and creativity act as the main forces for the rapid mobilization and beginning of mitigation activities. But an absence of preparedness for mitigation activities at all levels greatly exacerbates the impacts of cyclones. Previous instances of cyclonic disasters pointed to the need for a Disaster Mitigation Plan to ensure a prompt, effective response based on local capacity and skills. The lessons can be elaborated as follows:

Emergency response gets greatly hindered by collapse of significant bridges and roads getting washed away, due to lack of maintenance. Expensive rehabilitation programs are required if schools and hospitals are not maintained or constructed using cyclone-resistant standards. In fact the whole physical infrastructure must undergo a phase of reconstruction requiring gigantic expenditures. Absence of emergency response plans results in unnecessary delays in providing immediate response to the victims. Lack of adequate institutional framework and decentralization of responsibilities creates ambiguous circumstances of "who's to do what." Data of damage assessment is extremely difficult to collect in the absence of networks and by which significant time is lost in targeting emergency distribution.

SUSTAINABLE FUTURE: ISSUES AND DESIGN PROCESS

In the current scenario with diminishing resources and exploding population, strategies for a sustainable future call for management of our habitats to reduce their vulnerability to disasters. Environmental protection as a component of sustainable development consistent with poverty alleviation is imperative in prevention and mitigation of natural disasters.

Disasters are still perceived as a negative to development. There continues to be focus on large scale disasters and an ignorance of small and medium scale ones. In Peru, recent research indicates that 1.5 small disasters occur each day and their cumulative impact has a significant effect on peoples' lives. There is an evident need for additional efforts to strengthen the resilience and self-reliance of communities to cope with natural disasters through the recognition of their traditional knowledge, practices and values as a part of their own development system. Traditional systems, amongst other things, offer a distinct advantage over most other modern technologies as they permit easy recycling of materials unless affected very badly. By conversion of earthen walls into mud and making necessary preparations, it can easily reused. Similarly stones, after cleaning and adequate wetting, and timber members can also be reused in construction. Sustainability is to preserve the quality of resources and environment for the next generation. Sustainable development brings together two basic principles underpinning management of human activities, one concentrating on development goals and secondly limiting harmful impacts of human activities on the natural environment. Disaster impact assessments should be made a regular part of the widely practised "environmental impact assessment" and needs to be undertaken as a routine before any finalization of development projects.

LEARNING FROM TRADITION

Development of non-engineered resistant housing, using indigenous technology and local materials are the only long-term solutions. In Latur, Maharashtra NGO's using geodesic domes, tarpaulin sheets, ferroconcrete technology and cabin-type houses using bison and panels received negative reactions from the local population.

Traditional Settlements of Andhra Pradesh

The igloo-type dwelling units require traditional building skills used by people in the coastal areas of Andhra Pradesh to build cyclone-resistant houses. They are circular in plan with low walls and a conical roof. It is found to be the best form resisting cyclones. The roof consists of palymarah thatch over a rough framework of bamboo which is supported over a central timber post. Sometimes creepers are grown over the roof to prevent it from being blown over. There is hardly any ventilation in the interior except through the small opening serving as an entry. Organization of functional spaces in the interior is very difficult and most activities take place outside the unit. Interiors are made more spacious by increasing the height of walls two meters. Mud infill walls, sometimes constructed by

wattle and daub method are plastered with cow dung and lime plaster.

In Bangladesh people have adopted techniques to resist surges. Here cement soil blocks of 90 percent non-saline soil and 10 percent cement are used instead of mud. These can be hard-pressed and require minimal skilled labor and construction methods. For roofing, reinforced concrete hyperbolic paraboloid shells are used in industrial and suburban housing. An A-frame modular housing system with bamboo as it primary component was developed. The inherent strength and of an A-frame is that it offers high wind resistance. Venting systems which offer pressure equalization, composite panels made from the core of jute plants and plaster resins for binders are widely used for walling and roofing.

OPTIMAL DISASTER-RESISTANT DESIGN

Tropical Cyclones

Cyclones occur in all tropical countries where the sea surface temperature is greater than 26 degrees centigrade. These tropical storms are called cyclones in the Indian Ocean, hurricanes in the Atlantic, and typhoons in the Pacific Ocean. India on an average faces one major cyclone on its east coast every year, and one every two years on its west coasts. In fact, it was in 1977 at Andhra Pradesh, when a cyclonic storm with the gale speed of 150 km/hr, accompanying heavy downpours of 400 mm, generated maximum awareness about their destructive forces and long-term effects. This cyclone completely washed away 2,302 villages and 86,650 huts within 6-7 hours. The global impact of tropical cyclones found addressing socio-economic aspects including densely populated river deltas isolated island groups, highly developed industrialized and residential coastal zones in higher latitudes.

Cyclone-Resistant Construction: Shelter and Settlement

The principal dangers of the cyclones are negative and positive pressures built up by strong winds depending on wind direction and location of openings. In order to resist wind forces, a building should have a strong anchorage, bracing and continuity to behave as one entity against airfoil dynamics.

1. Anchorage – All components of the building need to be anchored together from top to the ground by an adequate and continuous chain linkage.
2. Bracing – Additional bracings are required to resist lateral forces developed on the various building components due to horizontal wind load.
3. Continuity – Construction joints should increase the integrity of the structure for efficient transfer of load.

Together with this the use of hipped roofs in preference to gable roofs prevents suction of wind, thereby reducing direct impact forces. Use of flat roofs minimizes wind effect. Ventilation slots placed at the ridge are effective in reducing internal pressure and thereby decrease total uplift on roofs. Door and window frames need to be properly anchored to the wall. Properly secured openings prevent building of excessive internal pressure.

At settlement level, roads linear to prevailing direction of cyclonic winds help in channelizing wind flow. Clusters of three to four dwelling units are to be clubbed together in such a way to resist the direction of cyclonic winds. Efficient surface water drainage system prevent waterlogging in open spaces. Public areas and open spaces need to be finely paved and elevated from the ground level so as to act as a shelter during an emergency. Large-scale chlorination and inculcation of wells to make safe and potable water accessible to victims of the flood.

Flood-Resistant Construction: Shelter and Settlement

Flood control and mitigation strategies are broadly divided as structural and non-structural according to adoption of engineering or administrative methods. Non-structural approach involves adjustment of human activities to accommodate flood hazards while structural methods are based on flood abatement or making structures repel flood water methods such as by construction of walls with impervious materials, closure of lower level of windows, elevating building on stilts. Disaster preparedness is equally important, which is a short term measure to cover action required to organize relief and rehabilitation programs.

Design of Shelter: Houses on stilts need to have a rigid frame construction with diagonal braces. A sturdy base is advised to support superstructure up to plinth. Other structural measures are use of under reamed piles in areas of low bearing capacity, sand piling around existing structures to improve resistivity and cast iron rings set in precast concrete blocks for easy accessibility to roof tops.

Settlement Planning: Large scale forestation in catchment areas reduces surface run off and increases the time lag between onset of flood and flow, enabling people to move out of the danger zone. Other measures are zoning of areas according to the vulnerability of floods and framing development controls accordingly, development of an efficient surface drainage system. Flood proofing is essentially a combination of structural and emergency actions, concentrating on adoption of measures that can be put into action as soon as a flood warning is received.

Seismic-Resistant Construction: Shelter and Settlement

No other disasters, including famines and epidemics, kill as fast as earthquakes, except perhaps a nuclear explosion on a densely populated area. A short comparison earthquake with an atom bomb brings forth interesting data that the atom bomb dropped on Hiroshima in 1945, equivalent to an earthquake of magnitude 6, to a ten megaton H-bomb, equivalent to an earthquake of magnitude 8 on the Richter scale. An exact comparison is not feasible since tectonic energy is released 10-50 kms below ground and its effects on the surface could not match the destruction that an atomic bomb exploding on the surface would cause.

Earthquake prediction is still a distant dream because foolproof prediction has to be able to both locate the place and pinpoint the time of the quake. Ability to predict quake location has improved in the last few decades which has given us a better grasp of high risk areas. Predicting the time of a quake is still not reliable enough and teams through out the world are tapping several avenues of research. Engineers have used a technique placing special bases between foundation and superstructure for buildings belonging to special risk categories. Today, about one hundred buildings worldwide are based on these earthquake resistant bases. These have been utilized in hospitals, safety facilities and firehouses. These system now equip two nuclear power stations, one in Koeburg, South Africa and other in Cruas, Meysse near Montelimar in France, which is mounted on 1,800 earthquake resistant bases.

1. In a framed construction, non-symmetry of the structural system develops eccentricity, initiating torsional movements and finally leading to 45 degree cracks in the corners.
2. Load carrying wall areas – Earthquakes causes a vibratory motion on the ground, consequently each point of the structure gets a displacement, velocity and acceleration. The response of the structure is a function of ground motion and properties of structure itself viz., the period of vibration and dampening characteristics. By analysis of some of the prominent buildings in the world, it was found that where the gross wall area covers 10-50 percent of the total built up areas, their thick walls increase the period of vibration.
3. Though stones induce box action in masonry construction, reinforced concrete bins in the form of horizontal bands at levels of plinth, lintel and wall plates are recommended. Lack of through stones induces buckling and crushing failures of load bearing walls.
4. Rectangularity to minimize torsional effects – length of the rectangular blocks should be restricted to three times its width or

blocks and they must be separated by a 3-4 cms separation joint all through plinth to superstructure.
5. Materials used should be good in compression as well as tension. They should be adequately fire resistant, as fire generally follows an earthquake.

Earthquake-Resistant Mud Houses

In the use of soil as a building material, India has a highly developed traditional system of construction. These indigenous options produced houses which proved more resistant to tectonic forces due to it homogenous nature. "DHAJI - DIWARI" is an indigenous technique adopted in the state of Jammu-Kashmir, India which lies in a hazardous seismic zone.

Enhancing Seismic Performances: Principles and Examples

1. All elements of the building should be suitably linked together to obtain an integral action of the buildings
2. Adequate structural members, strong and ductile connections between the walls, roof elements and foundation should be ensured. During strengthening the effort should be made to increase both strength and ductility
3. Besides strengthening and increasing ductility, reduction in dead load may have to be recommended, like reduction in number of storeys.
4. Addition of new elements like shear walls, infill walls, wing walls and columns should ensure adequate connections between old and new construction by using shear keys and suitably designed dowels.

Retrofitting is done for strengthening of existing shelters according to the prevailing level of risk in a particular area. China has adopted an extensive plan of retrofitting the masonry buildings, so as to upgrade there seismic resistance to begin intensity VII to IX depending on location. Retrofitting can be achieved with concrete pilasters by shear keys going right to the top of the building, how many ever the number of storeys or adding bamboo posts in the frames of traditional houses.

1. Strengthening of foundation – Continuous footing for new structures and increasing the width of existing footings by adding load bearing elements of reinforced strips.
2. Strengthening of wall: Walls with small cracks can be repaired with thin fluid of epoxy resin, an excellent building material which is strong in tension.
3. Long load bearing walls should be avoided and supported with buttresses or partition walls.

Disasters are not single, but accompanied by secondary disasters and disaster threats like fire and landslides proclaim the need to plan for compound disasters. On January 17, 1995, in Kobe tremendous shaking of buildings and infrastructure led not only to their devastation but also triggered landslides. Within minutes 60 fires also blazed. More landslides threatened further devastation. Six months later typhoons affected the area, causing massive floods in the temporary housing.

COMMUNITY PARTICIPATION: TOOL FOR SUSTAINABILITY

A disaster shakes the confidence of the community in their own skills of house construction which in turn rob them of their ability and freedom to house themselves. Community participation is a tool by which their confidence in the traditional building skills can be improved.

It is evident from previous experiences that no program of rehabilitation, reconstruction, and disaster mitigation can be successful without the involvement of local communities. Most anthropologists agree that to understand a community properly, it is necessary to understand and work with local idioms. A project can not be sustainable unless understood by the community in their own terms and through their own idioms.

Community participation in mitigation programs enhance:

- Better preparedness of the community;
- Better feedback from the people;
- Learning from real life situations;
- Development of infrastructure for eventual mitigation programs;
- Better understanding of the socio-economic constraints.

Incompatibility between traditional methods and modern materials is the root of the problem which results in inappropriate constructions. If in the long run a local community is forced to utilize the locally available resources, then why shouldn't it be guided to a path they can presumptuously follow? Analyzing vulnerability and capacity to cope with natural hazards in the local level shows that communities have a comprehensive range of traditional techniques to help themselves resist and recover. Institutionalized responses to disasters are unlikely to be effective unless they are carefully tailored to match local vulnerability and capacities. Since the most effective disaster management plan always needs to be developed in a way so that it can be managed by local residents and be used by them as a basis for their own household, community and village level disaster planning. Thus local disaster mitigation planning is based on:

1. Integrating mitigation plans into existing development programs.
2. Building a culture of awareness amongst agencies to institutionalize a participatory approach for disaster mitigation.
3. Learning about indigenous techniques and local strategies to cope with disasters.

Working with community is not an easy task, emphasizing on the poorest of poor who are subjected to the maximum losses, or the donor community whose resources cannot be overlooked. It is pragmatically difficult to put the people first in programs of mitigation and rehabilitation unless they equip themselves with awareness of risk and are ready to design optimal resistant designs from their own indigenous systems and locally available materials.

LOOKING AHEAD: FOR A FUTURE

Dialectics and dynamics of development management prescribe planning as a process with clear goals and means. It is necessary to define our goals first and make development people oriented. Primacy must be given to environmentally propitious methodologies and not to technology in abstract.

Things have become far worse, as the previous Rio de Janeiro (1992 Earth Summit) deliberations have revealed a sunset of social justice and sunrise of private plunders that have devalued the life of many for the pleasure of few. Natural disasters are the loud warnings for every one of us to get ourselves aware of the increasing conflict of human happiness and human survival. Use of appropriate technology which can reduce dependency, counterbalance increasing vulnerability and build individual capacities of the communities is the urge of the **new world: A Sustainable World.**

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