Cyclone

What is cyclone

Millions of people living in the coastal areas of the west Atlantic, east and south Pacific and north and south Indian Oceans, regularly face the hazards of cyclone, also known as *hurricane* in the Western Hemisphere, *typhoon* in the western Pacific, *willy willy* near Australia and *baguious* in the Philippines.

Every cyclone begins as tropical low-pressure depressions, created by oceanic temperature rising above 26 degrees Celsius, which rotates clockwise in the Southern Hemisphere and counterclockwise in the Northern Hemisphere, forming a gigantic and highly volatile atmospheric system - with an *eye* at the vortex (10 to 50 Km) which is a relatively calm area, an *eye wall* (10 to 15 km in height and 50 km in length) of gale winds and intense clouds and *spiral bands* of convective clouds with torrential rains (a few km wide and hundreds of km long) - that move above 34 knots (64 km per hour). The cyclones moving more than 90 km, 120 km and 225 km per hour respectively have been classified as severe, very severe and super cyclones. The hurricanes in the Atlantic and Northeast Pacific basins are classified in Categories I to V as per Saffir-Simpson Intensity Scale[1].

More often the cyclone blows over and dissipates by its own momentum without causing much damage due to reduction of moisture and increase in surface friction, but sometimes it landfalls on the coastal settlements with very high velocity of wind, torrential rain and massive storm surges, resulting in devastating damages to life and property.

Killer Cyclones

There are records of many killer cyclones that consumed tens of thousands of human lives, such as the Kyushu typhoon of Japan (1281) that killed more than 100,000 people, the Canton typhoon of China (1862) that took 37,000 lives, the Midnapore (1864) and the Backergunj (1876) cyclone of Bengal that claimed 75,000 and 200,000 lives respectively and the Galveston hurricane of Texas (1900) that left 12,000 dead [2].

Cyclones no longer kill such enormous numbers anymore in most of the countries due to various mitigation and preparatory measures; still people die in thousands at many places. The cyclones that killed more than 1000 lives since 1950 are listed below:

Table – I: Cyclones that Killed more than 1000 persons since 1950[3]

Basin	Cyclone	Year	Countries	Deaths
North Indian Ocean	Cyclone	1963	East Pakistan	22,000
	Cyclone	1965	East Pakistan	17,000
	Cyclone	1965	East Pakistan	30,000
	Cyclone	1965	Karachi, Pakistan	10,000
	Cyclone Bhola	1970	East Pakistan	300,000
	Cyclone	1985	Bangladesh	10,000
	Cyclone Gorky	1991	Bangladesh	131,000
	Cyclone	1971	Orissa, India	10,000
	Cyclone	1977	Andhra, India	20,000

	Cyclone	1996	Andhra, India	1,000
	Cyclone	1998	Gujarat, India	1,000
	Cyclone	1999	Orissa, India	9,500
West Atlantic	Hurricane Flora	1963	Cuba, Haiti	8,000
	Hurricane Inez	1966	Caribbean, Mexico	2,000
	Hurricane Fifi	1974	Central America	5,000
	Hurricane David	1969	Central America	2,608
	Hurricane Mitch	1998	Central America	11,000
	Hurricane Katrina	2005	New Orleans, USA	1,836
East and South Pacific	Typhoon Iris	1955	Fujian, China	2,334
	Typhoon Sarah	1959	Japan, South Korea	2,000
	Typhoon Vera	1959	Japan	4,466
	Baguious Thelma	1991	Philippines	3,000

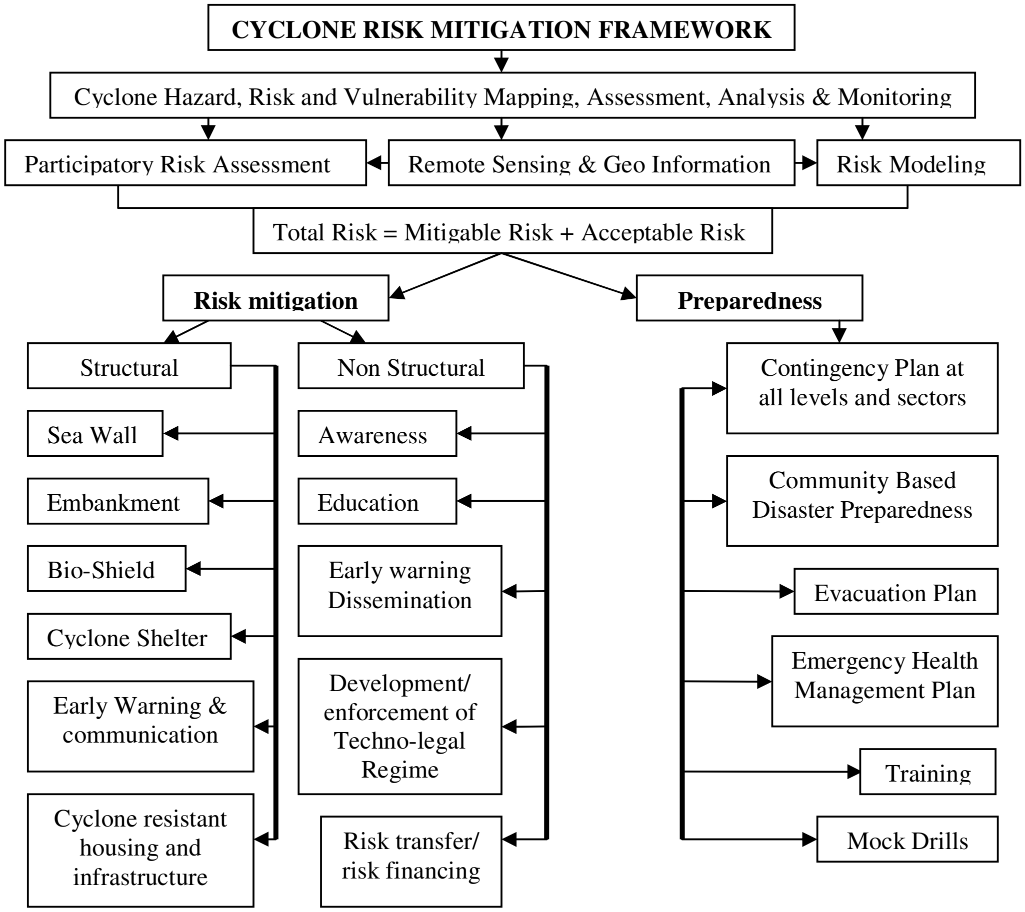
It would be seen that out of a total 602,908 deaths due to these 22 killer cyclones since 1950, North Indian Ocean accounted for 551,500 (93%), Bay of Bengal 540,500 (89.6%) and Bangladesh (erstwhile East Pakistan) 500,000 (83%). Most of these unfortunate deaths could have been prevented if basic and elementary measures for cyclone mitigation and preparedness were in place in these countries.

Analysis of the intensity of cyclones and the deaths and damages caused by them indicate very diverse co-relationship according to the level of economic and social development of the countries and the state of preparedness of the communities. The deadliest of all cyclones in recorded history – the cyclone Bhola of 1970 in East Pakistan – was classified only as Category III (maximum wind speed 205 km, lowest pressure 966 hPa and storm surge 4 m) [4] but it killed three hundred thousand people while the economic loss was estimated at only US$ 86.4 million. Contrarily hurricane Katrina of August 2005 in New Orleans was classified as Category IV (maximum wind speed 280 km, lowest pressure 902 hPa and storm surge 6 m) [5] but the casualties, despite the terrible mismanagement of the crisis, was limited to 1836, while the economic loss mounted to US$ 81.2 billion. Hurricane Mitch of 1998 in Central America, on the contrary, was classified Category V (maximum wind speed 285 km, lowest pressure 905 hPa and storm surge 8 m) [6] that killed 11,000 people and damaged assets worth US$ 4 billion.

The lessons that can be drawn from these three catastrophic cyclonic in three representative poor, rich and middle income countries are that the more developed the countries the less casualties would take place but more economic losses are likely to be sustained. Conversely in poor countries the human losses would be more but economic losses would be less simply because the unit costs of damages are assessed lower in developing countries. In the middle income countries the damages to life and property would be somewhere in between. The poor countries can however make a big difference if the governments invest to mitigate the effects of cyclone in a cost effective manner and the communities prepare to face the cyclones in a participatory and sustainable manner.

Cyclone Risk Mitigation and Preparedness Framework

Based on the lessons learnt from the cyclones around the world and the advances made in various related sciences and disciplines on the subject a cyclone risk mitigation and preparedness framework can be presented in the shape of the following diagram:



Risk Mapping, Assessment and Analysis

The first and probably the most complex task of cyclone mitigation is to map the hazard, risks and vulnerabilities of cyclone at all levels, analyze and assess the levels of risks and monitor it continuously. It is only on the basis of such a knowledge base that a proper and effective strategy for cyclone risk mitigation and preparedness can be developed.

Atmospheric and remote sensing sciences have made a huge progress in the understanding of the phenomenon of cyclones. Satellite images can spot the development of low pressure zones, doppler radars can track them down and instrumented aircrafts can reach the cyclone eye, eye walls and spiral bands to transmit data on wind velocity, pressure and moisture contents of the low pressure zones. Powerful software tools are available to analyze the data to make fairly accurate forecasts on the intensity, direction and location of the landfall and the likely areas to be affected by winds, rain and storm surges.

The time series data on cyclones have been utilized to map and zone the areas prone to the hazards of cyclone. Such maps are now available at a regional, district and even sub-district levels in most of the countries. Such maps are also available in digital formats which enable integration of various spatial data with socio-economic, housing, infrastructure and other variables that can provide a quick assessment of the risks and vulnerabilities of cyclones based on which appropriate mitigation and preparedness strategies can be developed. But actual work on such data integration has been limited to a few areas only and therefore vulnerability analysis has still to be done on the basis of ground level data collection and analysis, which is yet a largely unattended task in most of the countries.

The satellite imageries are also supplemented with data regarding topography, vegetation, hydrology, land use- land cover, settlement pattern etc to develop numerical models of storm surge and the inundation levels based on which timely warnings can be issued and realistic evacuation plans can be drawn up to shift the people and cattle likely to be affected by the cyclone. However such theoretical advances on cyclone modeling have been confronted with constraints in practical applications which would require more sustained research for accurate forecasting and simpler application format that would enable transfer of the technology to the planners and emergency response managers. The constraints are further compounded by non-availability of accurate ground level data base and the costs involved in up-scaling such models from a pilot research phase to country wide application phase. Such works are still in progress even in advanced countries and therefore developing countries may not have the benefit of such accurate modeling in the very near future although this is well within the realm of possibility.

This only highlights the relevance and importance of community based Participatory Risk Assessment (PRA). Many such PRA tools have been developed in coastal areas which capture the intimate knowledge and perception that a community has about its own risks and vulnerabilities. Such perceptions have often been validated by scientific analysis, lending credence to the reliability, simplicity and cost effectiveness of such assessment. More importantly, it involves the communities in the entire process making it democratic, sustainable and proactive and definitely facilitates bridging the gap between assessment and preparedness or knowledge and action.

Historically the coastal communities have faced the furies of nature and have inherited an intuitive and holistic knowledge of the way the nature behaves and the impact it has on animals, plants and human lives and livelihood. Accordingly communities have learnt to develop indigenous coping mechanisms for survival, which were internalized as life style activities and transmitted from one generation to another. Many isolated communities in the coasts have survived through this process. Unfortunately the process of so-called modernization and globalization are resulting in changes in the life style of the coastal communities and many of the traditional wisdoms and practices are fast dying out. There is a need to document these practices, assess their relevance and adapt them according to the changing conditions.

Therefore the ideal tool for assessment of cyclone risks and vulnerabilities at the local level should be a combination of scientific and traditional knowledge, each supplementing the other in a manner that science corrects those superstitions and dogmas of traditional knowledge that are not substantiated and traditional knowledge enriches scientific truths with those time tested experiments and experience of centuries that can not be simulated. Such ideal solutions are not very common, but the two complementary processes – increasing spread of scientific education on the one hand and growing respect of traditional and indigenous knowledge on the other – are creating awareness of such solutions, highlighting need for increased collaboration among the physical and social scientists for cyclone risk assessment and analysis at the local level.

Total and Acceptable Risk

Any strategy for cyclone risk mitigation or for that matter mitigation of any disaster risk would depend on correct estimation of total and acceptable risks. The concept of 'total risk' connotes the sum total of all probable harmful consequences or expected losses from a disaster such as deaths, injuries, damages to movable or immovable property, livelihoods, infrastructure, disruption of economic activities or environment damages. It may not always be easy to project such damages, such as environmental or psycho-social damages would be difficult to be quantified, but based on correct risk assessment of disasters it should be possible to construct different scenarios of total risks according to the intensity, location or time of disasters. Once realistic assessment of total risks are available, the countries and communities should make strategic decisions on how much of these risks can be prevented outright, how much can be mitigated and to what extent by the various agencies.

The residual risks that can neither be prevented nor mitigated in a cost effective manner in the given social, economic, political, cultural, technical or environmental conditions can be regarded as 'acceptable risks'. Therefore the level of 'acceptable risk' would vary from place to place and also from time to time. Once the level of 'acceptable risk' is decided countries and communities must be prepared to face these risks so that the damages to life, livelihood and property from these risks can be reduced to their minimum. Ideally the level of preparedness should be equal to the level of 'acceptable risk'. Excess preparedness in any sector or level would be wasteful which should better be avoided. Similarly deficit in preparedness would be taking a chance with risks that may cause avoidable damages.

Structural and Non Structural Mitigation

Given the nature of the cyclonic hazards, it shall not be possible to prevent the risks of cyclone however advanced the country may be socially or economically, as has been well demonstrated during the aftermath of hurricane Katrina in the USA. On the contrary there are indications that the hazards of cyclone would increase due to the effects of global warming and the resultant climate changes. As the ocean surface temperature rises probability of atmospheric depressions on tropical seas would increase. Similarly as the glacial melts raises the level of ocean the impact of storm surges would be more severe and many sea wall or embankment modeling done in the past may undergo revisions necessitating redefinition of the design parameters of such constructions.

In the face of increasing menace of cyclonic hazards, mitigation would remain the key and the most effective strategy to reduce the risks of cyclone. Every country and community has to decide its own mitigation strategy according to its own risks, resources and capabilities. Broadly such strategies would be two fold: structural and non-structural. Structural mitigation measures generally refer to capital investment on physical constructions or other development works, which include engineering measures and construction of hazard-resistant and protective structures and other protective infrastructure. Non-structural measures refer to awareness and education, policies techno-legal systems and practices, training, capacity development etc.

Sea Wall and Embankments

Among the structural mitigation measures sea walls and saline water embankments are probably the most effective and capital intensive investment to mitigate the risks of cyclones. A seawall is a coastal defense constructed usually of reinforced concrete on the inland part of a coast to prevent the ingress of storm surges arising out of cyclones. Sometimes the sea wall is constructed with a multiple purpose of reclaiming low lying land or preventing coastal erosion. The height of sea walls is determined according to the maximum observed height of storm surges which may be as high as 10 meters. Therefore sea walls are usually massive structures which can be built only with a heavy investment. Maintenance of such structures further requires recurrent expenditure. Hence sea walls along the entire coast are never a practicable solution to prevent or mitigate storm surges, but such walls are recommended when valuable assets like a city or a harbor is to be protected.

Sea walls can be vertical, sloping or curved. Modern concrete sea walls tend to be curved to deflect the wave energy back out to sea, reducing the force. There are instances of many sea walls which were constructed after devastating cyclones and which successfully prevented such disasters. The most important is the 12 Km long and 17 ft high seawall constructed in Texas after the Galveston Hurricane of 1900 which killed 8000 people. The seawall has never been overtopped by a storm surge from a hurricane, although maintenance of the wall has been beset with various engineering problems. The Gold Coast seawall in Australia was laid along the urban sections of the Gold Coast coastline following 11 cyclones in 1967. The massive stone seawall in Pondicherry constructed and maintained by the French engineers kept the historic city center dry even though tsunami waves of December 2004 had driven water 24 feet above the normal high-tide mark. Similarly 3.5 meter high sea wall in Maldives saved the city of Male from the tsunami. Such success stories are available from many coastal cities. There are also instances where absence of such protective structures near the beaches and resorts and breaches in sea walls near the cities and towns resulted in severe damages to life and property.

If sea walls are essential to protect coastal cities and harbors, saline water embankments are recommended to protect rural settlements and to prevent saline water ingress into agricultural and horticultural land. Such embankments are usually a ridge built with earth or rock to contain the storm surges. Cost benefit calculations usually do not permit very high specifications for such constructions and therefore effectiveness of such embankments in preventing or mitigating the impacts of cyclones have been rather limited. Further, saline embankments have the potential to kill the mangroves due to chocking of saline water. Therefore such embankments should be constructed in limited areas where vegetative protection would not be adequate to prevent the ingress of saline water into habitations.

Bio-Shields

Bio shields usually consist of mangroves, casuarinas salicornia, laucaena, atriplex, palms, bamboo and other tree species and halophytes and other shrub species that inhabit lower tidal zones. These can block or buffer wave action with their stems, which can measure upto 30 meter high and several meters in circumference. They trap sediment in their roots, thereby maintain a shallow slope on the seabed that absorbs the energy of tidal surges. They also break the high velocity of winds and thus protect agricultural crops and shelters besides providing shelter and grazing lands for the livestock and farms. They reduce evaporation from the soil, transpiration from the plants and moderate extreme temperatures. They protect fertile coastal agricultural land from erosion. They also serve as carbon sinks as they help enhance carbon sequestration which makes coastal communities eligible for carbon credit to earn additional income. Besides they promote sustainable fisheries by releasing nutrients in the water.

Unfortunately the multiple and long term environmental protection and economic functions of the bio-shields have not been adequately appreciated until very recently. Unabated anthropogenic pressures of coastal settlements and unchecked commercial exploitation of coastal resources have resulted in denudation of such natural buffers exposing large areas to the vagaries of cyclonic storms. In the Indian state of Orissa, where the low-lying coastline has been stripped of mangroves to make way for shrimp farms, the super cyclone of 1999 left more than 10,000 people dead and around 7.5 million homeless. Although the cyclone affected over 250 km of Orissa's coastline, it was only the highly denuded area of 100 km through which water surged. Other areas with intact mangrove forests were largely unaffected. Again the Indian Ocean tsunami of 2004 impacted those areas more severely where the bio-shields buffer were either not available or depleted considerably. In such areas tsunami waves made deep ingress into land, ruined crops, drowned livestock and poisoned arable land and water supplies with salt. Mangroves and other coastal habitats, where still in existence, met the tsunami head on. For instance, the Pichavaram mangrove forest, a tourist attraction in Cuddalore district, protected about 6,000 people living in six hamlets located between 100 meters and one kilometer from the mangroves. Seawater did not enter the village and hence there was no loss of property.

Therefore systematic regeneration of the bio-shields in the coastal belts wherever feasible is the most natural and cost effective method of protecting these areas from storm surges and erosion. This is not an easy task which can be achieved instantly since there is a time cycle for such plantations to grow and survive against fresh pressures of winds and waves. Therefore serious efforts are required in designing such bio-shields, selecting the appropriate fast growing species suitable to the agro-climatic zones and involving the coastal communities in the maintenance and protection of such buffer zone of plantations.

Cyclone Shelter

A large number of people in the coastal areas live in thatched houses which cannot withstand the high velocity of wind and storm surges resulting in extensive damages of such houses and deaths and injuries of a large number of poor people. The high rates of casualties in cyclones in Bangladesh and India are primarily due to unsafe buildings in the coastal areas. The poor economic conditions of the people may not permit them to rebuild their houses as per the cyclone resistant designs and specifications. Therefore, community cyclone shelters constructed at appropriate places within the easy access of the habitations of the vulnerable communities can provide an immediate protection from deaths and injuries due to the collapse of houses. Such shelters are usually built on pillars above the danger level of storm surges/inundation, are specious enough to accommodate a few hundred people of the neighboring hamlets and provide provisions of drinking water, sanitation, kitchen, etc. During the normal season such shelters can be utilized as schools, dispensaries or other community purposes.

A large number of such cyclone shelters were built in the coastal areas of Bangladesh and eastern and south India, which provided immediate shelters to the vulnerable communities. Drastic reduction in the number of deaths and injuries in the cyclones during the past 5-6 years can be partly attributed to these shelters. Therefore, the governments have placed a very high priority on the construction of such shelters in areas which have hitherto not been covered.

Cyclone Resistant Housing & Infrastructure

Super cyclones with wind velocity of 250 km per hour and above have caused damages to even engineered structures at many places around the world. This was largely due to the absence of appropriate design criteria for construction of buildings and infrastructure which can withstand the pressures of such strong winds. Bureau of Standards of various countries have developed revised design norms which are followed for new constructions. However, the compliance standards of such norms have not been very effective largely due to inadequacies of properly trained engineers and masons who can supervise and raise such constructions. The problem is further compounded by a week and ineffective system of enforcement of the guidelines.

The problem is even more complex for the large number of existing structures that have already been constructed without adherence to the revised norms. Such buildings can only be retrofitted with an additional cost which the house owners find reluctant to invest. Various advanced countries have passed legislations which has made retrofitting mandatory. In the developing countries the focus is confined more to strengthening the lifeline buildings which would play a critical role during emergency operations such as hospitals, emergency operation centers, police control rooms etc, leaving other unsafe structures and habitations as 'acceptable risks', for which adequate preparedness measures should be developed.

Early Warning and Communication

Early warning of cyclones and its dissemination to the coastal habitations is an important preparatory measure to reduce the losses of life and property during cyclones. Due to heavy investments involved in the installation, operation and management of modern early warning system, it is also considered as an essential component of structural mitigation.

With the rapid development of science and technology the early warning and communication system is undergoing changes. Powerful doppler radar systems can now track the movement of atmospheric depression and accurate early warnings can be issued 48-72 hours in advance about the probability of cyclone, its intensity and wind speed, direction and possible location of the land fall. Such warnings are broadcast through the radio and television network for the information of people in the coastal areas. Based on the data generated by the system numerical modeling on storm surge and flooding can forecast the inundation level from where the affected population can be evacuated to safer places. There are hundreds of such instances where early warning helped to save thousands of lives in the coastal areas. However, inaccuracies in the modeling exercises have some time led to exaggerated responses leading to unnecessary evacuation of hundreds of persons which could have been avoided. Such inaccurate predictions some time reduce the faith of coastal communities on the early warning system, which need to be avoided at any cost. It is expected that with further advances of early warning technology the predictions would be more and more accurate leading to better responses in emergency situations. It is also expected that increasing coverage of radio and television, more extensive use of ham radios and innovative use of mobile communication system would facilitate better dissemination of early warning to the isolated coastal communities particularly in the remote islands. The dissemination system can be made more effective with the active involvement of the communities and households in the preparation of their own cyclone contingency plans.

Community Based Disaster Preparedness

Communities are the first real time responder to any disaster situation. However developed or efficient a response mechanism could be there would always be a time gap between the disaster and the actual response from the government and other agencies. In the case of Mumbai flood of July 2005 the response time was 12 hours while in the case of hurricane Katrina a month later it was more than 48 hours. During this critical period it is the community which has to look towards itself for self help. Therefore if the communities are mobilized and trained to assess their own risk through participatory risk assessment process, develop their own contingency plans and set up their own teams for evacuation, search and rescue, emergency shelter, first aid etc, the risks of cyclones can be managed with significant reduction in number of deaths and injuries.

The post 1991 cyclones in Bangladesh have demonstrated how a Community Based Disaster Preparedness (CBDP) programme could make a drastic reduction in the risks of cyclonic disasters. Therefore, more and more governments have adopted CBDP as an important strategy for disaster risk management particularly in the coastal areas. The Government of Philippines has in fact amended their laws to devolve certain emergency response functions to the communities. The Government of India is implementing the largest ever CBDP programme in 169 multi-hazard districts of 17 States covering nearly 300 million people.

Risk Transfer and Risk Financing

Mounting economic losses due to cyclones cannot be compensated by the Government whose role would be limited to providing ex-gratia relief to the next of kin of persons who have died or to those sustained injuries and to provide support for the reconstruction of houses and livelihood regeneration for the poor and lower middle class people. Government support would also be necessary for reconstruction of the damaged public assets. The risks of industrial, commercial and other infrastructure and assets in the private and household sector can only be secured through the mechanism of risk financing and risk insurance. As the country develops, the share of private sector in the GDP would increase and, therefore, risk financing would be assuming increasing importance. In the developed countries nearly ninety percent of the assets are covered by insurance against natural disasters which has encouraged collateral investment on disaster resistant housing and infrastructure so as to reduce the premium for insurance. This has been a win-win situation for the private and individual sector in transferring their risks to the insurance companies, for the insurance companies in generating business and for the government in reducing its expenditure on relief and reconstruction while at the same time encouraging private investments for better safety standards for buildings and infrastructure. The experiences gained in this regard need to be further adapted according to the conditions of low and middle income countries. Various innovative services and products like micro insurance, micro credit etc. have been developed in many countries for increasing the resilience of local communities. Micro credit is particularly playing an importance role in retrofitting the vulnerabilities of the poorer sections of the community, especially the women, in the developing countries.

Capacity Development and Training

Capacity development is the most cost effective method of reducing the vulnerabilities of the people living in the coastal areas. The coastal communities have a certain degree of capacities built into their social systems and practices acquired through inherited experiences of generations. But such indigenous capacities are often overwhelmed by the vagaries of nature due to various anthropogenic factors like the degradation of environment, changing land uses, pressures of population on settlements, climate change etc. Therefore, the local capacities have to be continuously upgraded and further developed according to the changing needs and the developments of science and technology and other improved practices in various sectors. The challenge of capacity development is to transfer the new horizons of knowledge into actionable modules at the local levels for the local people by the local community. Such capacities can be developed through meetings, interactions, discussions, exposure visits and trainings.

Training is particularly necessary for cutting edge functionaries within and outside the government at various levels in different sectors to impart them with necessary skill for cyclone risk reduction and management. Training programmes have to be practical, scenario based and exercise and problem solving oriented so that the functionaries are aware of their specific responsibilities and are able to discharge those responsibilities efficiently before, during and after the cyclonic disasters.

Training is also required for those community members who would be part of the community response teams for the initial critical hours and days till specialized assistance from the government and non-governmental agencies from the outside are organized. Such trainings may include maroon search and rescue, first aid, evacuation, temporary shelter management, arrangements of drinking water and sanitation, provision of cooked food etc. Such trainings can be better organized by a core group of community trainers who can be trained intensively by the specialized government and non-government agencies.

Awareness and Education

While training and capacity development target specific groups according to their specific training needs, awareness generation is more of a general in nature which sensitizes common masses about the risks, vulnerabilities of cyclones and the preventive, mitigative and preparedness measures that can be taken at the government, community, household and individual level. Electronic, print and folk media can play important roles in awareness generation on a large scale.

Awareness and sensitization programme can also be organized for more specific and limited audience such as parliamentarians, policy makers, media and other selected audience.

Cyclone education programme, on the contrary, would be more formalized curriculum which can be institutionalized within the education system at various levels. Disaster management has already been included in the educational curriculum of the schools in many countries and cyclone risk mitigation can be a part of such curriculum. Various branches of science and technology can have course modules on Cyclone Risk Management. For example, civil engineering and architectural courses can have curriculum on cyclone resistant housing and infrastructure. Medical and mental health sciences can have course module on emergency health and trauma management for cyclone affected people, while IT and Communication sciences may have courses on Early Warning and Communication. Such curriculum at various levels of general and professional courses would help to develop necessary professional expertise to support the disaster risk mitigation and preparedness programmes of the government and other agencies at different levels.

Contingency Plans

In the not too distant past whenever a severe cyclone storm has struck the coastal areas in the developing countries the communities and government have mostly been caught unaware and often they have been so overwhelmed by the all round damages and destructions that it has taken quite some time for them to recover from the initial shocks and to plan and act in a coordinated manner, resulting in considerable chaos and confusion not only among the decision makers but also the emergency responders and other key stakeholders. Coordination among the agencies becomes a casualty in a crisis situation which affects the relief and reconstruction operations.

The disastrous consequences of an absence of a pre-disaster contingency plan has been demonstrated repeatedly in many countries on a number of occasions. Therefore, one of the most critical elements of cyclone risk management is to have a contingency plan in readiness, which would clearly delineate the roles and responsibilities of various agencies within and outside the government, define the exact functions to be performed by them, the process to be followed in the performance of these functions, the tools and equipments to be kept in readiness, procurements to be made, evacuation drills to be followed, the emergency medical plan to be put in place etc. Such a contingency plan should be prepared vertically at the national, provincial, district and sub-district and community level and horizontally for the different sectors – police, civil defence, health, fire services, food and civil supplies, agriculture, fisheries, water supply, roads and bridges and so on.

Standard operating procedure should be laid down for each activity to avoid any confusion and to ensure coordination among the various agencies involved in the response, relief, rehabilitation and reconstruction programmes after the disasters. Such contingency plan should be reviewed periodically to update them according to changing situations and also to create awareness among all the stakeholders. The best way to keep the contingency plan in readiness is to conduct mock drills at least once in a year before the cyclone season starts so that the operational difficulties in implementation of the plan are sorted out at the ground level and the various agencies within and outside the government can work together in a coordinated and efficient manner when the disaster would actually strike. Such mock drills again should be conducted at various levels to ensure operational readiness of the system.

Even with all these mitigation and preparatory measures in place the cyclones would continue to strike the coastal settlements and probably these would strike with more frequencies and greater intensities in future. Death, injuries and losses can no doubt be reduced with better preparedness and mitigation measures, but these can not be avoided altogether. The challenge would be how efficiently these damages are managed, how best the affected people are rescued and provided relief and rehabilitation assistance in a humane and transparent manner, how fast the damaged houses and infrastructure are reconstructed and how quickly the pre-disaster situations are restored and normal life bounces back to its rhythm. This would require a pre disaster recovery planning to be in place, ready for implementation, whenever a disaster strikes.

******

[1] *SSI scale is based on three parameters - maximum sustained wind speed, minimum central pressure and level of storm surge.*
[2] *NOAA Technical Memorandum, the Deadliest Tropical Cyclones, 1995.*
[3] *Compiled from NOAA and other sources.*
[4] *Bulletin of the American Meteorological Society, 1970*
[5] *Bulletin of the American Meteorological Society, 2005*
[6] *Bulletin of the American Meteorological Society, 1998*