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ECOSYSTEM APPROACH TO FLOOD DISASTER RISK REDUCTION

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Abstract

India is one of the ten worst disaster prone countries of the world. The country is prone to disasters due to number of factors; both natural and anthropogenic, including adverse geo-climatic conditions, topographical features, environmental degradation, population growth, urbanisation, industrlisation, non-scientific development practices etc. The factors either in original or by accelerating the intensity and frequency of disasters are responsible for heavy toll of human lives and disrupting the life support systems in the country. India has 40 million hectares of the flood-prone area, on an average, flood affect an area of around 7.5 million hectares per year. Knowledge of environmental systems and processes are key factors in the management of disasters, particularly the hydro-metrological ones. Management of flood risk and disaster is a multi-dimensional affair that calls for interdisciplinary approach. Ecosystem based disaster risk reduction builds on ecosystem management principles, strategies and tools in order to maximise ecosystem services for risk reduction. This perspective takes into account the integration of social and ecological systems, placing people at the centre of decision making. The present paper has been attempted to demonstrate how ecosystem-based approach can help in flood disaster risk reduction.

Keywords: Flood, Natural disaster, Disaster management, Ecosystem approach, Disaster risk reduction

Introduction

Disasters – (natural or man-made) are common throughout the world. Disasters continue to occur without warning, and are perceived to be on an increase in their magnitude, complexity, frequency and economic impact. Hazardous pose threats to people and assume serious proportions in the under developed countries with dense population. During the second half of the 20th century, more than 200 worst natural disasters occurred in the different parts of the world, which claimed lives of around 1.4 million people. Losses due to natural disasters are 20 times greater (as % GDP) in the developing countries than in an industrialised one. Asia tops the list of natural casualties due to natural disasters (Disaster Management in India, 2011).

India, due to its geo-climatic and socio-economic conditions, is prone to various disasters. During the last thirty years' time span, the country had been hit by 431 major disasters resulting into enormous loss of life and property. According to the Prevention Web statistics, 1,43,039 people were killed, and about 1500 million were affected by various disasters in the country during these three decades. The disasters caused huge loss to property and other infrastructure costing more than US$ 48,000 million. Floods, earthquake, cyclones, hailstorms, etc. are the most frequent disasters occurring in India (Disaster Management in India, 2011).

Flood destruction has always brought miseries to numerous people, especially in rural areas. Flood results in outbreak of serious epidemics, specially malaria and cholera. Simultaneously, scarcity of water also arises. It has a drastic effect on agriculture produce. Sometimes, water remains standing over large areas for long span of time hampering the Rabi crops (Disaster Management in India, 2011).

India is one of the most flood-prone countries in the world. The principal reason for flood lie in the very nature of natural ecological systems in the country *viz*., the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variations across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to be more than 2500 mm. Most of the floods occur during the monsoon period, and are usually associated with tropical storms or depressions, active monsoon conditions and break monsoon situations (Disaster Management in India, 2011).

Twenty three of the 35 states and union territories in the country are subjected to floods and 40 million hectare of land, roughly one- eighth of the countries geographical area is prone to floods. Table 1 represents the flood affected area and damages for the period 1953 to 2004 in India (Water Data Complete Book, 2005; Central Water Commission, 2007).

Table 1. Flood affected areas and damages in India (1953-2004) (Central Water Commission, FMP Directorate)

Particulars	**Unit**	**Average during (1953-2004)**	**Years**	**Maximum damage (Year)**
Area affected	Million hectare	7.63	1978	17.50
Population affected	Million	32.92	1978	70.45
Human lives lost	Number	1597	1977	11316
Cattle lost	Thousands	94	1979	618
Cropped area affected	Million hectare	3.56	1988	10.15
Value of damage crops	Rs. Crore	708.57	2000	4246.6
Houses damaged	Th. No.	1235.61	1978	3508
Values of damage houses	Rs. Crore	251.05	1995	1307.9
Values of damage public utilities	Rs. Crore	813.69	2001	5604
Value to total damage to houses, crops and public utilities	Rs. Crore	1817.07	2000	8864

Floods occur in almost all river basins in India. The main cause of floods are heavy rainfall, inadequate capacity of river to carry the high flood discharge, inadequate drainage to carry away the rain water quickly to streams or rivers. Ice-jams or landslides blocking streams; typhoons and cyclones also cause floods. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil. Areas with hardpan just below the surface of the soil are more prone to floods as water fails to seep down to the deeper layers (Disaster Management in India, 2011).

Vulnerability to floods and other natural disasters is caused by the high population density, widespread poverty, unemployment, illiteracy, enormous pressure on rural land, and an economy traditionally dominated by agriculture. Children and women are particularly vulnerable. Eighty- five percent of deaths during disasters are of women and children (CRED, 2000) (Disaster Management in India, 2011).

Flood hazardous cannot be avoided and floods cannot be controlled fully by engineering measures. But the mitigation of the consequences can help significantly reduce the risk posed (Vogelbacher, 2013). Presently, there are inadequate levels of protection in the country against floods. Though non-structural measures improve the preparedness to floods and reduce losses, the necessity of structural measures would always remain to reduce the extent of physical damage caused by floods. An attempt has been carried out in this paper to explain how the ecosystem approach can reduce flood disaster risk reduction.

Ecosystem approach for disaster risk reduction

Ecosystem contributes to reducing disaster risk by two important ways. First, ecosystems, such as wetlands, forests and costal systems, can reduce physical exposure to natural hazardous by serving as natural protective barriers or buffers and thus mitigating hazard impacts. Well-managed ecosystems can provide natural protection against common natural hazardous, such as landslides, flooding, avalanches, storm surges, wildfires and drought (Dolidon *et al*., 2009).

The second way is by reducing socio-economic vulnerability to hazards impacts. While it is easy to focus primarily on ecosystems' protection and hazard regulatory functions, ecosystems also sustain human livelihoods and provide essential goods such as food, fibre, medicines and construction material, which are equally important for strengthening human security and resilience against disasters. For example, in addition to providing costal hazard protection, mangroves, coral reefs and sea grass beds are generally important resources for local livelihoods, as they support fishing and tourism activities (Hussain, 2008).

Moreover, in post-disaster context, affected communities especially in poor, rural areas often turn to their surrounding environment to meet immediate needs (food, water and shelter). Ecosystems and the resources they provide thus form an essential part of local coping and recovery strategies. In Negril, Jamaica, following a major storm, Little Bay, a local fishing community, relies heavily on groundwater springs when floodwater cut off their potable drinking water supply (UNEP, 2010). Well managed ecosystems are considered more resilient to the impacts of extreme events and are able to recover more effectively than degraded ecosystems (IPCC, 2011). However, it is important to recognise that ecosystems also limits in providing physical protection against hazardous. Other factors come into play that affects ecosystem performance, such as ecosystem composition (stand size, density, species) and health, and the type of intensity of the hazard event (IPCC, 2007).

Flood hazard mitigation function of ecosystems is depicted in Table 2. Protected areas provide space for floodwaters, absorb impacts of floods with natural vegetation and block sudden storm surges and sudden incursions of sea water (for coastal and marine ecosystem) thus reducing risk of floods.

Table 2. Flood hazard mitigation function of ecosystem

Ecosystem	Flood hazard mitigation
Mountain forests and other vegetation on hillsides	• Catchment forests, especially primary forests, reduce risk of floods by increasing infiltration of rainfall, and delaying peak floodwater flows, except when soils are fully saturated (Global Water Partnership, 2000).
Wetlands and floodplains	• Wetlands and floodplains control floods in coastal areas, inland river basins, and mountain areas subjects to glacial melt (Goldammer and de Ronde, 2004). • Peat-lands, wet grasslands and other wetlands store water and release it slowly, reducing the speed and volume of runoff after heavy rainfall or snowmelt in springtime. • Costal wetlands, tidal flats, deltas and estuaries reduce the height and speed of storm surges and tidal waves.
Coastal ecosystems, such as mangroves, salt-marshes, coral reefs, barriers islands and sand dunes	• Coastal ecosystems functions as a continuum of natural buffer systems protecting against hurricanes, storm surges, flooding and other coastal hazardous – a combined protection from coral reefs, sea-grass beads, and sand dunes/coastal wetlands/coastal forests is particularly effective (Gonzalez and Marques, 2008).

Integrating ecosystem management and disaster risk management

Four previously separate institutional spheres that are ecosystem management, development planning, climate change adaptation and disaster risk management needs to converge to establish a new working arrangement that facilitate integrated disaster risk management. Ecosystem management provides the unifying base for promoting disaster risk reduction (DRR) and climate change adaptation with the overall goals of achieving sustainable development, human well being and livelihood security (Ming *et al*., 2007).

Flood Disaster Risk Reduction

Information

Proper and timely information to communities, related to various activities of disaster management are required to be ensured. The time of such information and related activities, if matches with the activities cycle of community, becomes highly successful. A plan of such information, according to management cycle is being provided in Table 3.

Table 3. Information cycle indicating time periodicity, activities and required information (Gupta *et al.*, 2013)

Time/Period	**Activities**	**Required information**
Oct-Nov	• Arrange credits • Repair of houses • Arranging agriculture inputs	• Depots/stores for agriculture inputs, varieties etc. • Availability/methods for availing credits • Employment opportunities/schemes
Sept-Oct	• Compensation/recovery information • Medicines • Repair of houses	• Reporting points for damages • Compensation schemes/methods of accessing it, point of reviving it
Aug-Sept	• Shifting to safer places • Care of vulnerable individuals • Staying at embankments	• Water situation/forecasts • Care points: Health, snake bites etc. • Flood availability
July-Aug	• Monitoring/protecting embankments • Boats, polythene etc.	• Forecast/warning and health • Nearest flood and health post and available services • Availability of boats • Availability of polythene/tarpaulin during emergency • Reporting points for breaches/cuts of embankments
June-July	• Arranging petromax/lanterns • Repair of drainage channels	• Availability of kerosene oil during flood • Nearest PDS depot for good grains/essential commodities
April-June	• Identification of places for temporary shelters • Storage of flood grains • Raising plinth of houses • Vaccination of livestock • Repair of embankments	• Places of temporary shelters • Vaccination requirements (cattle and people) availability • Do's and don'ts in emergency

As this cycle cannot be standardised, the information cycle may also vary for different area or districts (Gupta *et al.*, 2013).

The reliability of information, however, is crucial. Availability of services, personnel etc. as informed to community will have to be ensured. All care will have to be taken in this regard as the accessibility and communication during floods is extremely difficult and any information in such difficulties only enhances frustration of affected communities (Gupta *et al.*, 2013).

Time management

The manipulation in the timing of cropping cycle through advancement or postponement of crops was a successful strategy adopted by the farmers. Sowing the varieties which can sustain water inundation can be helpful in saving the crops from flood effects. This strategy is particularly helpful in a climate change situation where the rainfall (and hence the flood patterns) are un-predictable (early or late). The crops adopted in this regard and the timings of various crops combinations are shown in Figure 1.

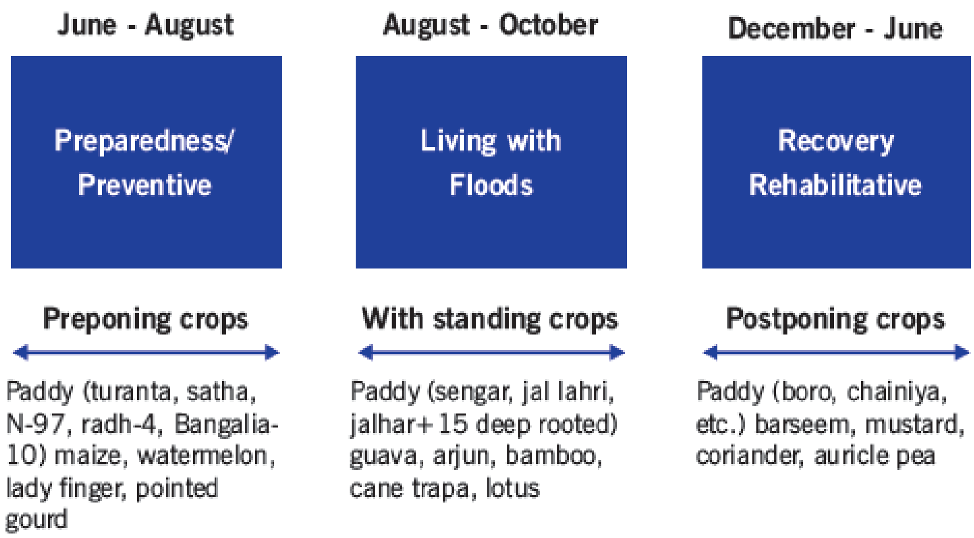

Figure 1. Crops adopted for climate change and their timings of sowing (Gupta *et al.*, 2013)

Appropriate crops and crop varieties can be identified with the help of local farmers. The traditional varieties in an area and other developed varieties by various research institutions can be identified through an exercise and adopted by the farmers (Gupta *et al.*, 2013).

Space management

Multi-tier cropping system is very effective in low land areas where water logging is the major problem. In flood prone areas where farmers grow vegetables, the entire crop gets washed away in floods and sowing of new crops is also hindered due to water stagnation in the fields. In such situations, experimentation of multi layered cropping can be effective. The layers of crops are able to deal with various water levels in case of flooding in an area. A seasonal and spatial combination of crops under multilayered system in an area is being presented in Table 4.

Table 4. Seasonal and spatial combination of crops under multilayered system (Gupta *et al.*, 2013)

	Kharif (June-Sept)	**Rabi (Oct-Mar)**	**Jayed (Mar-May)**
Upper layer (on machan)	Nenua, bitter gourd, stputia, bottle gourd, pumpkin, cucumber, kundru	Bottle gourd, bitter gourd, sem, nenua	Cucumber, bitter gourd, kundru
Standing crops (on the bunds)	Arhar, brinjal, chilli, spinach	Soya, brinjal, chillis	Ocra, maize, brinjal
Ground layer	Groundnut, elephant leg, spinach, kulthi, urad, turmeric	Garlic, onion, spinach, radish, carrot, methi, tomato, coriander	Onion, spinach, tomato, coriander

In this method two or three cropping is practiced with the highest crops being at a height of 5-6 feet. The higher crops get saved even if lower crops are fully or partially damaged due to flood and water lodging (Gupta *et al.*, 2013).

Flood sensitive extension system

It is important that the farmers get the information of adaptive agriculture and also the space for more of such innovations. At the same time it is important that the inputs (seed of appropriate varieties, composts, pesticides etc.) also made available to farmers. The linkage of relevant government schemes and departments can be helpful in this regard. More emphasis is required on developing appropriate extension systems using locally available knowledge. For all extension measures a synergy of traditional knowledge and technical & scientific know will play a vital role. The flood sensitive extension system is shown in Figure 2 (Gupta *et al.*, 2013).

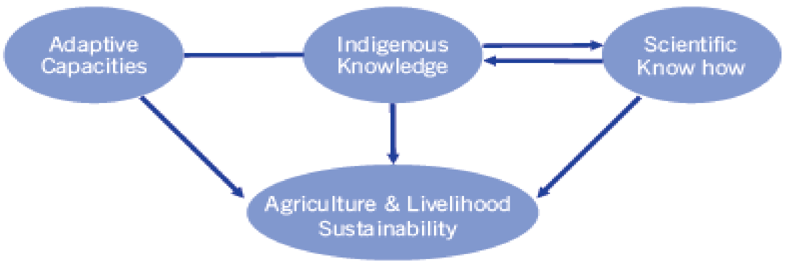

Figure 2. Flood sensitive extension system (Gupta *et al.*, 2013)

This flood sensitive extension system ensures the suitability of extension efforts as it also considers local knowledge and local resources. The community level institutions and processes involved in this regard in various villages can be farmer field school for sharing experiences amongst farmers, learning new knowledge, information-communication platform, etc.; agro-service centres for storing and availability of flood resilient seeds, compost, bio-pesticides, nurseries for flood resistant plants; master trainers on flood resilient farming; self help groups or community collectives for dissemination of information, organising community for collective actions etc. and nursery-raised seedlings to increase survival rate of seedlings (Gupta *et al.*, 2013).

Community level DRR

Community level interventions which are effective for disaster risk reduction in case of floods are important and depicted in Table 5.

Table 5. Matrix of pilot activities for community level interventions (Gupta *et al.*, 2013)

Livelihood and economic diversification	Ecosystem	Organisation	Education and skill development	Financial and risk spreading	Communication for adaptation (climate specific)	Adapted infrastructure
Risk and adaptation-specific interventions						
Creating livelihood opportunities outside affected areas	Forest as buffers	Formation of DRR and rescue committee	Training about food relief	Insurance	Flood warning system	Shelter during floods
Non-farm livelihoods	Pollution control measures	Establishment of DRR and relief organisations	Targeted strengthening of construction to increase resilience to floods	Catastrophe bonds	Strengthening communication towers	Wetlands conservation
Underlying systems for risk reduction and adaptation						
Increasing ability to access global labour and other markets	Developing productive inland fisheries and farming system	Increasing the number and diversity of civil society organisations-the right to organise	Skills such as global languages, that enable populations to access global labour and other markets	Strengthen banking system and improve access to it	Cell phones and other personal communication devices	Improving transport systems
General diversification within economic	Controlling pollution to enable long term	Incubating new forms of business organisations	Region-specific skill training (tourism,	Productive investment of remittance	Increasing access to and freedom of the media	Changing approaches to infrastructure design (houses,

and livelihood systems	productivity of ecosystems as they change	that can utilise and manage local resources	etc.)	flows	road, bridges etc.) to account for uncertainty

Some of the examples of community initiatives can be construction of roads with public participation, hand pumps and water chlorination, rehabilitation of link bridge, relief support during floods, grain banks etc.

From the communities' perspectives, it is proposed that relevant and accurate information should be with communities. The relevant information, modified and updated regularly, should be placed with the community/village. The village Disaster Management Group and Panchayat communities can be oriented for maintaining such information and sharing it with the villagers, especially women. A regular flow of information from and to village is important towards effective disaster management. The two way information flow and important areas of information is being presented in Figure 3.

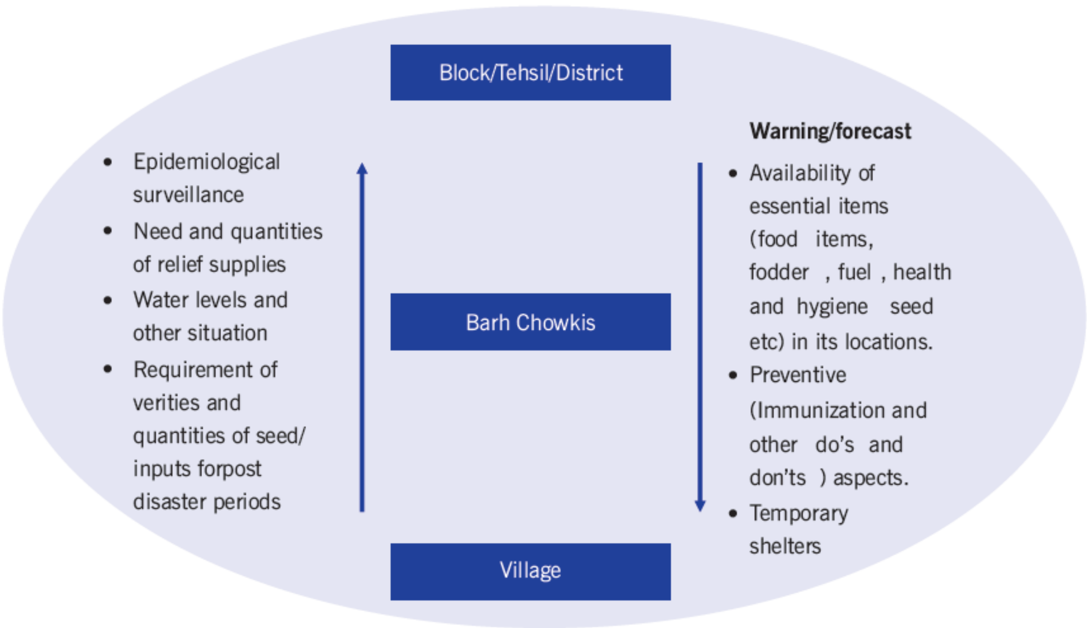

Figure 3. Information flow in a community (Gupta *et al.*, 2013)

Some of the community level DRR initiatives include information and warning system, weather advisory, public address system, self management community institutions, etc. Self managing community institutions can be of generally of two categories: formal and informal. The community institutions can be helpful in ensuring community ownership of the interventions and mobilisation of resources (Gupta *et al.*, 2013). Such institutions are self help groups, farmer field schools, agro service centres, master trainers, farmers' union and village federation as depicted in Figure 4.

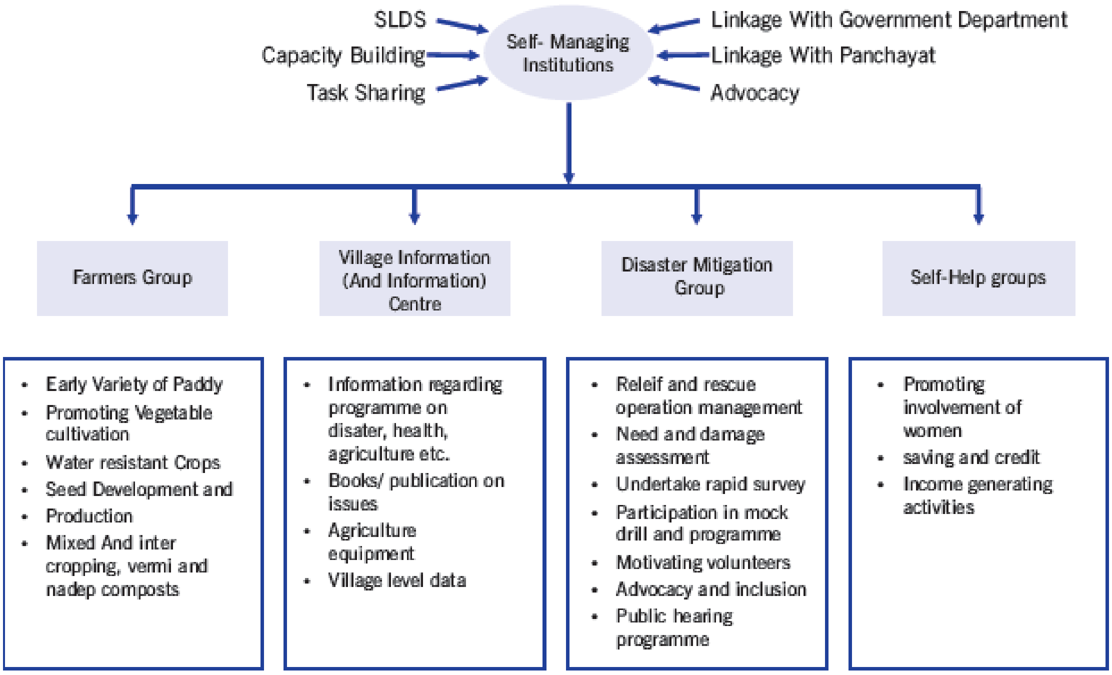

Figure 4. Role of community institutions and their linkages (Wajih, 2009)

Conclusion

Disasters are common throughout the world and are of various types. All disasters have wide ranges of impacts on environment and human beings. To control these disasters applications of engineering interventions can be to some extent avert them. However, to reduce risk of disaster, ecosystem-based approach will be more appropriate. Well managed ecosystems can provide natural protection against common natural hazardous, such as landslides, flooding, avalanches, storm surges, wildfires and drought. Eco DRR reduces physical exposure to natural hazardous and socio-economic vulnerability and at the same time it provides basic immediate needs aftermath of disaster. Ecosystems are more resilient to disaster than engineering measures. Flood DRR can be effectively achieved through Eco DRR by integrating different institutional spheres and at the same time through proper information, time and space management through cropping system, flood sensitive extension system and effective involvement of communities at each level. Eco DRR has a potential to be implemented throughout the world as an effective approach for mitigation of adverse effects of floods.

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