

Sustainable Infrastructure Re-construction Approaches for Flood Disaster Areas

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Abstract

Natural disasters bring about substantial damage to the built environment and lead to the perishing of many lives. Post disaster effects are highly variable resulting in social distraction, prevalence of diseases and reconstruction of infrastructure. The 2010 Pakistan Floods caused great infrastructural damage; buildings, facilities, roads, railways, hospitals, cultivated areas, etc were destroyed. There is need to address the reconstruction and rehabilitation of flood affected areas using a sustainability oriented approach. The study is focused on formulating technical and managerial approaches for construction of infrastructure such as feasibility criterion, design provisions, specifications, construction material procurement, construction methodology, construction technology, plan-outs, construction management etc. The research included the evaluation of the best practices in reconstruction that were adopted by countries affected by disaster. Case studies from USA, Germany, Indonesia, Bangladesh and India have been studied for this purpose. It is intended that the paper will be useful to government authorities, private sector entities and NGOs engaged in the reconstruction of facilities in Pakistan's flood affected areas.

Keywords

Flood disaster, disaster management, reconstruction, sustainability, Pakistan

1. Introduction

The onset of any disaster has a tendency to create chaotic situation whereby there is tremendous risk to the environment and the lives of people. It is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources (UNISDR, 2009). Disaster can result from natural and manmade agents whereby its intensity depends upon a region's vulnerability and exposure to hazards over a period of time. In attempt to develop the real definition of 'disaster' three main

constructs has been discussed by research scholars as *Vulnerability*; environmental threats which need long term recovery, destructive agents for population, *Hazard*; chronic or gradual concentration, epiphenomenon, dangerous events natural or manmade, *Social*; destabilizing social system, social situation precipitated by non routine destruction by forces of nature, impact at national, regional, segmental, local levels (Rodriguez et al, 2006). When hazards intersects with exposed vulnerable elements at risk will a disaster occur and cause humanitarian, economic and ecological effects as natural hazards are triggering disaster events. But, it is the elements at risk and their degree of vulnerability inherent in a social system that will define the final consequences. (Sundar et al. 2007)

Disaster management is the systematic process of using administrative decisions and organizational capacities as tools to implement strategies for enhancing capacities which are known to be key for lessening the impacts of natural hazards on the built environment. The strategies adopted comprises all forms of activities, including structural and non-structural measures which would in essence help avoid (prevention) or limit (mitigation and preparedness) the adverse effects of hazards (UNISDR, 2009). In terms of major phases of disaster management process described by Sundar et al., 2007 for natural disaster *mitigation* is attributed to be of strategic importance because it is an action taken to reduce both human suffering and property loss resulting from extreme natural phenomena. Mitigation includes land use planning, improved disaster-resistant building techniques, and better agricultural practices. Other disaster management phases include preparedness, response and refugee relief operations.

2. Catastrophic conditions in Pakistan

Developing countries suffer the greatest costs when a disaster strikes more than 95 percent of all deaths caused by disasters occur in developing countries, and the loss due to natural disasters is 20 times greater (as a percentage of GDP) in developing countries than in industrialized countries. (World Bank Disaster Management). Like other South Asian countries, Pakistan continues to suffer from a plethora of natural and human induced hazards that threaten to affect the lives and livelihood of its citizens – natural disasters include floods, earthquakes, landslides, and drought, human induced disasters are fires, civil unrest and terrorism, refugees and internally displaced people, health epidemics, transport accidents, industrial accidents and war. The human impact of natural disasters in Pakistan can be judged by the fact that 6,037 people were killed and 8,989,631 affected in the period between 1993 to 2002 (World Disasters Report, 2003). Geographically, Pakistan is situated in a hazard-prone region. It is exposed to erratic seasonal monsoons that bring heavy rain downpour which can result in violent flash floods inflicting heavy damages to property and land. Floods are the most recurrent natural calamity in Pakistan, and this is followed by earthquakes, cyclones and drought. (Haider, 2007). A comprehensive strategy overseeing the management of the effects of catastrophic natural disasters is evidently still in its infancy in Pakistan. There are no long-term, inclusive and coherent institutional arrangements to address disaster issues. Disasters are viewed in isolation from the process of mainstream development and poverty alleviation planning. For example, disaster management, development planning and environmental management institutions operate in isolation and integrated planning between these sectors is almost lacking. (Naseer et, al. 2010)

3. Floods in Pakistan

Floods occur because of heavy rains, melting snow, unusually high tides and broken dams (Adimola, 1999) and caused immense damages to property and agriculture. Floods are the second most common disaster that can destroy roadways and devastate cities of any size (Weingarts et, al. 2002). Pakistan is one of the South Asian countries with the highest annual average number of people physically exposed to floods. These occur quite often due to storm systems that originate from the Bay of Bengal during the monsoon season from July to September every year. The storms originating in the Bay of Bengal pass over lower Central India and Rajputana, enter Pakistan and continue north into Kashmir. The mountain ranges in the extreme north of Pakistan provide a perennial source of inflow into the rivers. Punjab

generally susceptible to floods, while hill torrents tend to affect the hilly areas of Khyber Pakhtoonkhuwa, Baluchistan and the northern Gilgit-Baltistan areas. Flood events of 1950, 1992 and 1998 caused many deaths and huge losses to the national economy. According to official sources, floods in Pakistan during the decade 1991 to 2001 caused an estimated damage of over Pak Rs 78,000 million to property (WCDR, 2005).

The disastrous flash floods that occurred in 2010 have drawn the attention of entire world towards Pakistan, the results are; deaths (1,961), injured (2,907), damaged household (1,910,439), population affected (20,184,550), cropped areas (2,244,644 hectares) and districts affected (78) till October 07, 2010 (Pakistan flood 2010a). The major cause for flooding is monsoon with unprecedented abnormal rain generating flash floods on a large scale. Flash flooding in an arroyo (an arroyo is a water-carved gully or a normally dry creek found in arid or desert regions, when storms appear in these areas, the rain water cuts into the dry, dusty soil creating a small, fast-moving river) can occur in less than a minute, with enough power to wash away sections of pavement. Because of its rapid nature flash floods are difficult to forecast and give people little time to escape or to take food and other essential items with them. A natural disaster event is commonly defined as the impact of an extreme natural event on an exposed, and vulnerable society. If the impact exceeds an affected region's coping capacity thereby necessitating interregional or international help, a large disaster is said to have occurred (Sundar et al. 2007).

On comparison with major recent disasters, the 2010 Pakistan Floods scores high in the magnitude of population and land area affected, including the number of households that were damaged as result (NDMA1, 2010). The number of people suffering from the massive floods in Pakistan exceeded the combined total in three recent mega disasters - the 2004 Indian Ocean tsunami, the 2005 Kashmir earthquake and the 2010 Haiti earthquake (UN, 2010).

The infrastructure in the flood affected areas was completely destroyed: some of the notable components were roads (33 bridges), railways (4 sections), hospitals (38 completely and 14 partially), schools (12,516) (Pakistan floods, 2010b). The Prime Minister of Pakistan had said, "There is a need for huge investment on the reconstruction and rehabilitation of flood affected areas, to provide shelter and housing to the dislocated people, reconstruct damaged schools, hospitals, link again farms to market roads and restore damaged bridges and railway tracks in the affected areas" (Dawn, 2010).

4. Drivers for infrastructure failure

The lack of involvement of the private sector and civil society; unclear priorities for the development of facilities; lack of community participation and inadequate attention on issues pertaining to the environment and natural resources are some of the reasons why efforts towards recovery and reconstruction have been slow (ADB and WB, 2005). Buildings situated in unsafe locations; in addition to deficiencies in design, construction techniques and materials can potentially cause major building damages in natural disasters (Wisner, 2006). Disasters caused by floods are not accidental interruptions of ordinary life, but are characteristic features of the places and societies where they occur. Discrete disaster events are merely symptomatic of systemic failure, and not causes of it (Mustafa, 1999). The risks, inconveniences, and damages in disasters are caused by ordinary life, rather than by the rareness and scale of the hazards (Hewitt 1983). Arambepola et, al. evaluated the basis for infrastructure failure in Asia as; principles for safe construction has not been followed, building codes are not reviewed regularly, inadequate technical expert capacity, site selection without considering the risk aspects, no quality assurance regarding policies for post reconstruction, no training on safe construction methods, and the construction of buildings with inappropriate materials. Disaster recovery efforts are hence not planned, because the investment for reconstruction and recovery are sometimes the only investment made to assist stricken communities.

5. Reconstruction practices elsewhere

According to Kreibich et.al, (2009) who researched flood management discipline in Germany, it has been found out there is a strong link between preparedness and mitigation of flood effects. Preventative and precautionary measures help boost a community's defense against anticipated floods. If the populace is informed about appropriate measures, this can garner community involvement and participation. Therefore, in addition to overarching structural and non-structural mitigation, private precautionary measures help yield enormous economic benefit in the long run. Attention was paid on land use planning, particularly as regards flood plains that were not encroached by human settlements. Inundation channels were also built to transfer water away from the inner city during floods. Following the flooding event, a number of initiatives were launched. Flood zoning maps indicating the areas which would be affected by a hypothetical 20-year, 100-year and extreme event floods were introduced. This would serve to instill better preparedness about the imminence of flooding in the region. A new flood management concept was developed, which integrated a number of safety measures. Additional flood prevention measures that were installed are: flood retention areas upstream of settlement regions; updating stream profiles in the urban area; installation of sedimentation catches; installation of heating and other utilities in higher storey; using water barriers; flood-adapted building structure by a special stable building foundation or water proof sealed cellular walls.

In an effort to boost interdisciplinary action for flood mitigation (by Hayes, 2004) in USA flood proofing of residential structures have been considered plan (developing large hydraulic structure perceived as cost effective and implantable); wet flood-proofing structures (flood walls or new construction at higher platform); dry flood-proofing structures (application of sealants and enclosure around openings); and elevating structures.

It is necessitated that are designed according to safety guidelines, not whereby they can safeguard the inhabitants and their assets in times of natural disaster (Zou et.al, 2007). The design, construction, and material selection principles are defined as strong foundations to the resistance of the building to floods (under soil carry weight and no water logging, solid ground, using broken rock, concrete foundations); coherent and regular structure (integrated building elements, well assembled construction materials); join walls and roof to strengthen each other (reinforced columns, well bounded trusses); tying walls to building structure through column avoid falling; roof truss ties, flexible but strong roof trusses enhance safety; cross bracing of walls and roof, bracing against lateral movement; induction of drainage and sewerage plans, house elevation, safeguard house contents from flooding; appropriate sand and gravel for construction, conform to standards; use of well mixed concrete with good clean ingredients; making reinforced columns, adequate concrete and reinforcement areas; using deformed steel bars in concrete, without shape distraction; induction of well and septic tanks, according to household requirements.

According to Faisal et.al (1999) in a stance to mitigate the effects of flooding the non-structural practices by various groups in Bangladesh especially in the recovery and reconstruction dimension refer to the feeding of vulnerable groups, building materials, and soft or interest-free loans for business and agricultures with the participation of government, NGOs, banks and private initiatives. Generally, affected groups have very limited access to such help. It is noteworthy that pilferage of relief and rehabilitation funds is also rampant in many places. Ahmed (2005) developed approaches for design and construction; the options recommended were plinth protection brick and concrete (which is more durable but is expensive), reinforced concrete posts because they are resistant to deterioration by water (however, they are expensive), earthen walls option is recommended for walls strengthening due to cost saving and durability), galvanized iron sheet for roofing and, bracket with polyvinyl chloride drainage is recommended of durability. Innovative and alternative methods are evaluated as reinforced concrete (hollow concrete stump, hollow cylindrical reinforced post), ferro-cement, metal sections, timber and stilts. Aspects to the layout of a construction facility include a courtyard, grouping of buildings, extension provisions, toilets location outside of compounds and trees around construction facility or

boundary wall. Provision of large drainage channels near the facility are recommended. Land suitability terms as land selection (flood level, no barriers, disposal area, ventilation, drainage system), land preparation (appropriate leveling, dressing, turfing and compaction), legal aspects (significant ownership and land protection). Homes can be built using the earth excavated from canals and ponds: however, this is not possible every time due to resource constraints. Basic infrastructure needs constituting of a water supply (tube-well should be located on raised ground), sanitation (the latrine should be located on raised ground or itself should be raised by having high lining walls built with concrete rings) and energy structures (Solar energy systems are advantageous in flood-prone areas because the panels are raised on a pole or on the rooftop and thus avoid damage by floodwater) needs to be looked into.

Flooding and fast moving water can cause structural damage, inundation and settlement of foundation due to scouring. Desai et, al (2008) investigated the impact of flood disasters and determined that they can cause severe cracking/collapse of a wall, settlement in foundation and scouring of the wall base. To cope with flood hazards the measures may adopted may be locating the building above an artificially raised ground. If a high level is unavailable; the plinth protection can be cementized; prevent dampening of mud mortar through capillary action by installing damp proof course at plinth level; prevent flooding of house by building plinth level higher than last high flood level Plinth band hazard, and soft soil, which is optional in case of hard soil. This is also serves as a damp proof course.

According to Berning et.al (2001) loss functions refer to the relationship between the extent of flood damage and the nature of the flood. The amount of damage inflicted is basically the costs incurred in repairing the infrastructure that has been damaged by a flood to pre-flood conditions. The extent of flood damage is governed by two important aspects: size of the flood i.e. the volume of the water flow and size of the area affected by the onset of the flood i.e. roads, bridges and drains within the periphery of the flood zone. The Cobb-Douglas functions can be used to demonstrate the link between flood peak and damage to infrastructure. There exists a high correlation between the extent of damage to the infrastructure by a flood and the size of the flood as opposed to damage to the infrastructure and the depth and duration of inundation.

6. Discussions

6.1. Feasibility and site selection

A number of government bodies, NGOs, foreign funded agencies etc are involved in the redevelopment and reconstruction of facilities in flood affected areas. There is, however, a need to stream line all the efforts expended in the construction of new houses, schools, roads etc. The selection of the site for construction should be far away from the river, in order to enhance evacuation time taken, in the event a warning system forecasts a looming flood. Furthermore, all construction needs to occur in areas which are less prone to flooding and are covered with trees, natural obstacles, etc. The ground level of these facilities must be raised such that they are higher than the previous flood level. If no natural ground is available, compacted soil can be used to artificially lift the elevation. Dams are particularly useful in controlling the flow of water and their construction needs to be expedited particularly at a time when the country is reeling with energy scarcity.

6.2. Design provisions

The transfer of load laterally and vertically can be achieved by adoption a regular building structure. The infrastructure needs to have a well developed sewerage system, drainage system, water supply system, air ventilation and energy system. The development would need to be planned according to the number of households that exist.

6.3 Construction technology

Reinforced concrete is the popular, least expensive and highly durable. Requirements of concrete are clean ingredients, well mixing, adequate transportation, timely setting, etc and must be considered. It is important to minimize the repair and maintenance of any construction to enhance the effective life while the properly addressing technical aspects. Although mud construction is common in Pakistan (remote areas) does not counter flood hazards. Because of this, reinforced construction is highly required.

6.4. Selection of construction materials

Natural soil, steel, cement, sand, crush, gravel, GI sheets (for roofing) etc are the recommended construction technology as bamboo is not readily available. These construction materials are easily available but sometimes monopoly of market share and can be scarce.

6.5 Construction Management

Reconstruction of facilities must be a joint venture of funding agency, government, and owners. Experienced teams with members from the local community and should perform the reconstruction and enhance participation form natives to promote best practices on long term basis.

7. Limitations

Current study provides an approach to develop understanding regarding measures against flood for reconstruction of facilities, but practical applications need to be researched.

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