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Disaster Risk Reduction through Flood Resilient Planning Strategies in Flood-Prone Areas of Rural Punjab

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***Abstract*:** *The incremental frequency of natural disaster alarmed the world over the last decade. The International Disaster Database further confirmed the scenario with last five years data showing highest frequency of natural disasters equivalent to previous whole decade records. The people in developing countries like Pakistan are the most affected due to the poor housing quality, inadequate levels of infrastructure and lack of emergency services in the country. The main focus of this study is to identify and explore the disaster resilient design strategies incorporated in the designs of Model Villages project initiative of Provincial Disaster Management Authority Pakistan for climate compatible constructions in flood affected areas. The application and integration of climate compatible layout, designs, construction techniques, materials and resources in addition to their interpretations aligned with rural constructions appreciably reduced the vulnerabilities and risks to natural hazards as observed during the following years episodes. The results further set future directions for the formulation of guidelines for building the Disaster Resilient Communities in Rural Punjab.*

Keywords: *disaster, risk, reduction, flood, Pakistan, strategies*

1. Introduction

The devastating floods caused by the summer monsoon rains in 2010 resulted in a disaster that was unprecedented in Pakistan. The flood affected 20% of the country, rendering almost 20 million people homeless, with around 2000 dead [1]. Unlike the earthquake of 2005 which was limited to the Northern areas, this was a disaster that rolled across the country, starting from the mountains of AJK[1], GB[2] and KPK[3] and swept down across the Punjab and Sindh – a process that took two months, from the end of July to the end of September 2010. The Districts of Bhakkar, Dera Ghazi Khan, Layyah, Mianwali, Muzaffargarh, Rahim Yar Khan and Rajanpur were completely swept over by the massive waters. The destruction of 498,000 houses in devastating flood 2010 provoked the Government of Punjab to plan for the rehabilitation of vulnerable distressed people [2]. The Government of Punjab determined for the provision of shelter with improved standard of living planned a scheme of Model Villages in flood affected districts of Punjab.

This flagship project for climate-compatible layouts and designs using the local construction techniques, materials and resources integrated/ aligned with rural construction was initiated. The Model Villages contemplation is not merely a project of provision of shelters but is furnished with all sophisticated amenities like School, Dispensary, Community Centres, skill development Centres, and Livestock Shed etc. The regular supply of Power and Fuel Energy is also ensured by installing the most cutting edge technology like Solar Panel and Bio Gas Plant [3]. The livelihoods also have been taken care of through provision of shops and trainings of

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[2] Gilgit & Baltistan
[3] Khyber Pakhtunkhwa

enterprise development. The community based integrated approach was adopted for the successful construction of the model villages.

2. Methodology

The design layouts of selected villages before and after reconstructions were studied analytically to identify the embedded flood resilient features in reconstructed models in addition to visual and condition surveys. The studied villages were compared for the traditional/ historic disaster mitigation measures and the modern solutions that are technically sound and culturally integrated preventive measures applied to reconstruction models.

3. Results and Discussions

3.1. Disaster Resilient Design Features

The main design and planning considerations to reduce and manage flood risks and to make climate compatible constructions are prioritization of site associated risk along with its assessment and substitution of land uses according to the vulnerability index, extrusion and intrusion strategies (Landscape Planning and Sustainable Drainage Systems), exceedance of flood management measures, floor Levels for each section of site (considering highest and lowest terrain), refuge areas strategic location, internal layouts, flood-resistant construction, emergency response planning, access and egress during flood events, proper signage and flood awareness measures [4]. All the analysed disaster resilient features are discussed in detail below for further understanding of their particular use while designing the disaster resilient communities.

3.2. Site Layout Criteria

The first and foremost step in the master planning of disaster resilient communities is the protection of the site which can immensely reduce the impacts of the hazard event [5]. The model villages were critically designed with the traditional principles of engineered protection bunds in form of the peripheral raised road (the modern technically sound transformation) with ditches network (for extrusion and intrusion of water) and thick plantations to control access and egress of water during flooding (Figure 1). The peripheral roads are connected with central refuge area (elevated platform with community buildings) to provide direct evacuation and access to external main roads (Figure 2). The villages were designed following the traditions, culture and environment of the rural Punjab and strengthened with the disaster resilient features of the modern era (Figure 2). The amalgamation of the both traditions and modern technology created the MODEL VILLAGES for the rehabilitation of vulnerable distressed people. The focus was to design environment friendly disaster resilient communities equipped with renewable energy technologies (biogas and solar) for power supply and water storage tanks, hand pumps, rainwater harvesting techniques for water supply schemes. The critical infrastructure was designed to operate independently so as to provide basic community needs in catastrophic events. The housing units were grouped in linear blocks (4-8 units in one block) with permeable parks and open areas that can withstand the flooding maintaining the integrity of the structures (Figure 3). This type of housing layout also provides sufficient time for evacuation and keeps delayed water inclusions. The big and thick plantations were designed along the periphery to stop water inclusion and small leaf plantations inside area for easy water exclusion. The proper drainage systems were also designed based on the natural slope, contours and topography (Figure 4). The organically planned green and permeable area has further enhanced the village traditional character (Figure 4). The provision of centrally located refuge area which is the transformation of traditional chopal concept was provided connected with the main roads to facilitate safe evacuation [6]. The village layouts have embedded evacuation strategy with marked evacuation points linked with the main access roads. While designing these villages the low carbon footprint construction model was adopted that includes local and abundantly available building materials with modified (based on disaster resilient methodology) rural construction style.

3.3. Community Building Design

The design of community buildings is the most difficult task to be accomplished. The design philosophy for these buildings (community hall, schools, health centres, mosques, learning centre) was based on traditional chopal concept so that they merge into the village cultural and traditional routes [7]. The modern chopal concept was finalized consisting of centrally located designated elevated platform with community buildings (which also act as a refuge in case of emergency) after community consultations along with the incorporated evacuation routes (Figure 5). All the model villages are provided with this modern chopal comprising of community buildings and fully equipped with disaster resilient features to offer a refuge place in case of emergency. The community buildings are designed on the elevated grounds bearing 2 feet above flood level plinths and an average clear height of 12 feet with a flat roof to operate as an evacuation landing space (Figure 6). The followed building geometry is basic linear and symmetrical to perform better during flooding events. The materials used for the construction of these buildings are concrete, fired bricks, cement sand mortar, steel reinforcement and a proper damp proof course in addition to impermeable materials for roofs.

3.4. Residential Building Design

The residential units were designed incorporating all disaster resilience features into the rural community lifestyle to ensure their cultural and traditional systems [7]. The three different categories of residential units were designed depending on the family sizes based on the number of bedrooms. The basic plan of the residential unit for a single family comprises of 2 bedrooms with a connecting verandah, kitchen, toilet and an open courtyard with hand pump and green area (Figure 7). These residential units were also equipped with the solar panel and biogas technologies to ensure the regular supply of energy and fuel. The linear rectangular geometry of the housing units was critically evolved by integrating the local perceptions, needs and culture into the flood resilient features that includes the raised plinth, flat roofs, open courtyards, street side kitchen and toilets etc. The strengthened foundations of fired bricks and cement sand mortar with steel reinforcement were designed to take differential settlements in case of flooding. Similarly the 9” thick walls with exterior cement sand plaster and clear height of 10 feet were adopted with the openings (doors and windows) not exceeding than 30% of the wall area [8]. The flat roof design was adopted with impermeable materials, perimeter guttering system, rainwater harvesting and insulation to also act as a refuge in emergency.

3.5. Emergency Response Design

The model village’s layout is strategically planned for emergency response activities during or following an extreme event of flooding. The embedded emergency response plan includes designated refuge area, refuge for livestock, and designated area for storage of goods, identified and marked evacuation routes, designated emergency landing area, fully equipped refuge with food, water, medical etc. engineering facilities along with the evacuation plan and marked access to the village (Figure 3) [9]. The villages are also equipped with the early warning systems to communicate with the national authorities and dissemination of emergency alerts throughout the vulnerable communities [10]. The designated refuge areas are planned on elevated grounds and are located in close proximity to the access roads for safe evacuation [11]. These refuge buildings are fully equipped with the village services to accommodate the community in emergency and are designed to provide shelter, food, water, clothing and medical supplies accordingly.

4. Conclusions

Therefore the main focus of the project was the integration of flood resilient design modifications in the local construction techniques with incorporated risk reduction plans at the time of construction to sustain in the time of emergency. The MODEL VILLAGES were designed as low cost, energy efficient and disaster resilient designs with low carbon footprint and environment friendly constructions. This project was found to be an appreciable effort and a contribution in the field of disaster resilient structures in rural areas of Punjab based on community consultation and monitoring/ evaluation criteria for future planning projects. The community based

integrated approach was well exploited with the following disaster resilient features to accommodate the social systems and practices in the rural settlements.

- Site Layout
- Land use Planning
- Infrastructure Design
- Community Building Design
- Residential Building Design
- Emergency Response Design

The above mentioned disaster resilient features for the designed villages will also serve as a model for climate compatible constructions to be also replicated in future for such development projects.

5. Acknowledgements

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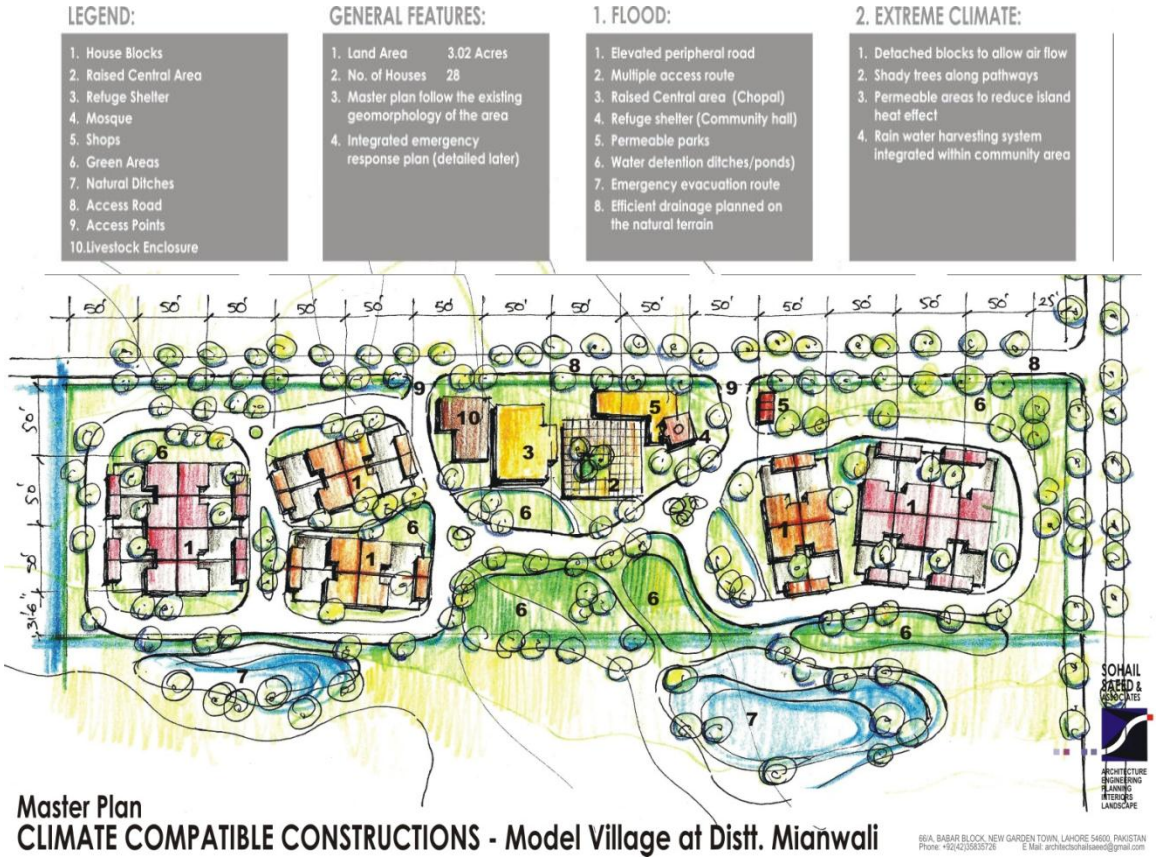

Fig. 1: Site Layout Plan depicting all climate change and disaster resilient features.

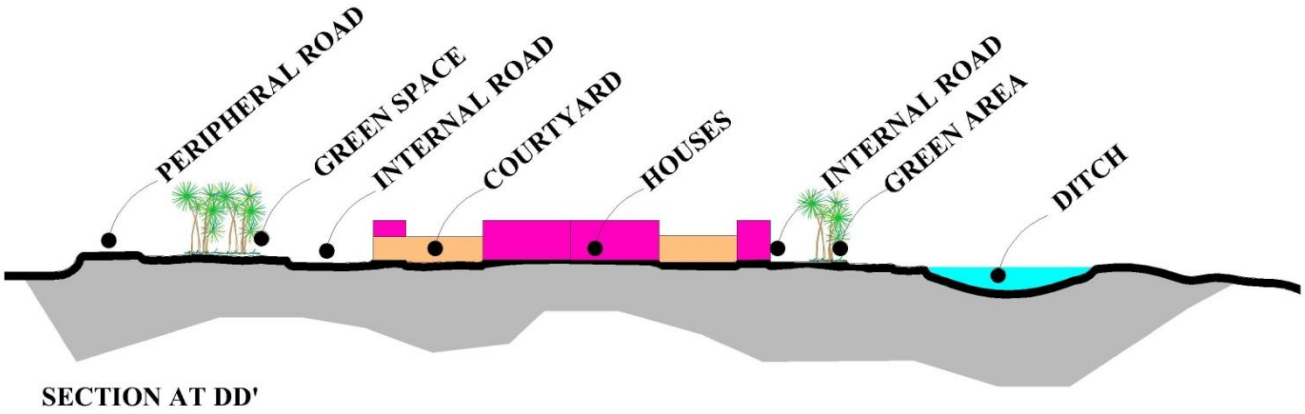

Fig. 2: Sectional Details of Site Layout depicting disaster resilient features.

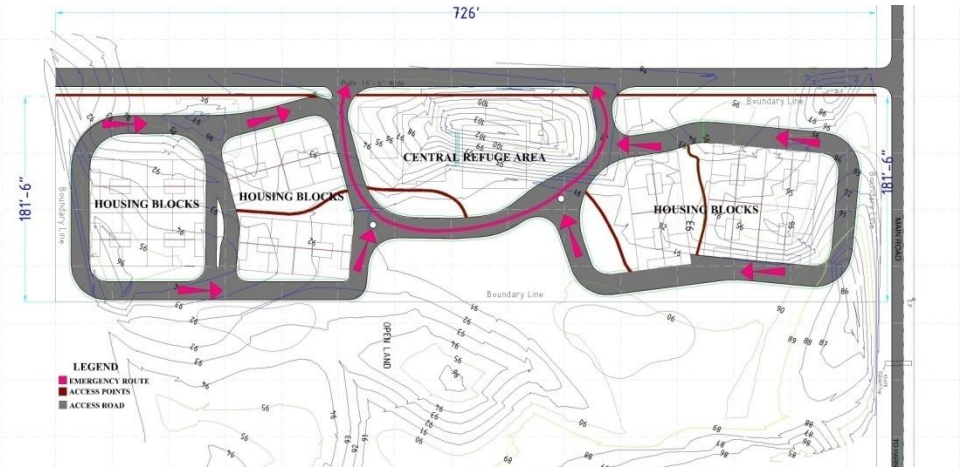

Fig. 3: Emergency response plans showing the emergency routing and evacuation strategy

Fig. 4: Integrated Landscape planning and drainage to reduce flood impacts

Fig. 5: Plan of Central Refuge Area evolved from traditional chopal concept

Fig. 6: 3-Dimensional Model of Central Refuge Area evolved from traditional chopal concept

Fig. 7: Housing Blocks with brick exterior finish