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Post Disaster Reconstruction Strategy and Sustainable Reconstruction in Disaster Affected Area

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***Abstract**: A disaster is the occurrence of an extreme hazard event that impacts on vulnerable communities causing substantial damage, disruption and possible casualties, and leaving the affected communities unable to function normally without outside assistance. Natural disaster happened frequently around the world and caused great loss of lives and properties. Post-disaster reconstruction (PDR) is a complex and highly demanding process that involves a number of different and well-coordinated courses of action. Therefore, it is vital that these complex activities are well planned.*

Sustainable reconstruction offers the chance to improve the quality of buildings, the environment and living conditions in disaster-affected regions. Disasters due to natural hazards create enormous pressure to provide survivors with adequate permanent housing as rapidly as possible. The urgent need for housing normally leads to numerous or large-scale reconstruction programmes and huge demand for construction material, and the potential environmental impact of reconstruction can become considerable. Improperly managed resource exploitation for construction materials can result in deforestation, pollution of water resources, and depletion of locally available materials. The construction process in itself can result in waste generation, water and air pollution. The pressure to regain equilibrium as quickly as possible must be balanced with seizing opportunities for long-term risk reduction and community improvements through sustainable reconstruction.

Sustainable reconstruction is designed to address such challenges by providing an integrated framework for action.

1. Introduction

A natural disaster is a major adverse event resulting from natural processes of the Earth. Such as floods, hurricanes, tornadoes, volcaniceruptions, earthquakes, tsunamis, and other geologic processes. A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience, or ability to recover and also on the infrastructure available. Natural disasters have significantly increased for the last 40 to 50 years. In 1992, more than 368 natural disasters were reported, affecting 170,47,8,000 people. In 2001, this number more than doubled with 712 disasters reported and 344,87,3,000 people impacted.

Conventional reconstruction efforts often failed because of a one-sided approach, e.g., one that focuses only on technical or construction aspects. There were cases where houses were constructed but without the necessary infrastructure, water supply and sanitation, because of one-dimensional attitudes and, among other challenges, institutional constraints, bureaucracies, etc.

Compared to conventional reconstruction, sustainable reconstruction is an integrated approach to reconstruction based on the well-known definition of sustainable development. In contrast to conventional reconstruction, environmental, technical, economic, social and institutional concerns are considered at each stage and activity of a sustainable reconstruction programmed to ensure the best long-term result, not only in house design and construction activities, but also in the provision of related infrastructure such as water supply and sanitation systems.

2. . Objectives of Study

- To study the impact of disaster.
- To study the challenges of post disaster housing reconstruction programmes.
- To study the principle of sustainable reconstruction.
- To develop general framework for the management of post-disaster housing reconstruction programmes.
- To provide guidelines regarding the key aspects of sustainable reconstruction.

3. Impact of disaster

As noted earlier, disaster impacts comprise physical and social impact. The physical impacts of disasters include casualties (deaths and injuries) and property damage, and both vary substantially across hazard agents. The physical impacts of a disaster are usually the most obvious, easily measured, and first reported by the news media. Social impacts, which include psychosocial, economic, and political impacts, can develop over a long period of time and can be difficult to assess when they occur. (Lindell & Prater,2003)

3.1 Physical Impacts

According to the EM-DAT database (www. emdat.be/database), there were 25 geophysical, hydrological, or meteorological disasters that produced more than 50,000 deaths between 1900 and 2011. The developing countries in Asia, Africa, and South America accounted for approximately 3,000 deaths per disaster, whereas the corresponding figure for high-income countries was approximately 500 deaths per disaster. Losses of structures, animals, and crops also are important measures of physical impacts, and the EM-DAT database shows that these have been rising exponentially throughout the world since 1970. Moreover, the rate of increase is even greater in developing countries such as India and Kenya.

3.2 Social impacts

Social impacts include psychosocial, economic, and political impacts. As a concept, social vulnerability has been defined in terms of people's "capacity to anticipate, cope with, resist and recover from the impacts of a natural hazard" their social vulnerability refers to their susceptibility to behavioral changes. these consist of psychological, economic, and political impacts.

4. Concept of Post Disaster and Sustainable Reconstruction

4.1 Post Disaster Reconstruction (PDR)

Reconstruction process may be divided into two main programmes, first is building housing units and the second is restoring or building infrastructure: roads, electricity, lifelines, railways, water supply and sanitation. Housing projects seems to be first priority in most post disaster reconstructions in many countries, needed by disaster's victim and become first priority for the government. In developing countries where disaster victims have no home insurance or financial access for rebuild their home government must provide permanent houses to homeless disaster victim citizens.

4.1.1 Reconstruction

There two common procurement methods of housing project. First, housing project relatively needs less construction skills, equipment's, and simple construction methods compare to infrastructure project, disaster victims or communities can build the houses by themselves. Second approach is government appointed private contractor to build the houses.

4.1.2 Nature of Post Disaster Reconstruction Project

The greater degree of coordination with policy and legislation required for large scale disaster, while routine construction processes have proved adequate for small-scale disasters. Existing legislation was not drafted to cope with an emergency situation and was not developed to operate under the conditions that will inevitably prevail in the aftermath of a severe disaster. The reconstruction projects are expected to have sustainability, implemented in order to raise level of development and to reduce vulnerability for future disasters. Disaster management as public project management, has aims to produce unique product in certain duration and to elevate living condition of people, not profit oriented which government as the client.

4.2 Sustainable Reconstruction

Conventional reconstruction efforts often failed because of a one-sided approach, e.g., one that focuses only on technical or construction aspects. There were cases where houses were constructed but without the necessary infrastructure, water supply and sanitation, because of one-dimensional attitudes and, among other challenges, institutional constraints, bureaucracies, etc. Often, conventional reconstruction neglects important social and livelihoods issues which result in a poorer economic situation for beneficiaries with interrupted social relations. Compared to conventional reconstruction, sustainable reconstruction is an integrated approach to reconstruction. In contrast to conventional reconstruction, environmental, technical, economic, social and institutional concerns are considered at each stage and activity of a sustainable reconstruction programme to ensure the best long-term result, not only in house design and construction activities, but also in the provision of related infrastructure such as water supply and sanitation systems. As a result of buildings enhanced performances during construction, use and demolition phases, sustainable reconstruction offers a variety of environmental, economic and social benefits.

4.2.1 Why Sustainable Reconstruction Necessary?

Sustainable reconstruction offers the chance to improve the quality of buildings, the environment and living conditions in disaster-affected regions. Disasters due to natural hazards create enormous pressure to provide survivors with adequate permanent housing as rapidly as possible. The urgent need for housing normally leads to numerous or large-scale reconstruction programmes and huge demand for construction material, and the potential environmental impact of reconstruction can become considerable. Improperly managed resource exploitation for construction materials can result in deforestation, pollution of water resources, and damage to coral reefs and depletion of locally available materials. The construction process in itself can result in waste generation, water and air pollution. The mitigation of natural disaster risks, however, requires building a culture of prevention. Disaster management should not be overlooked in the rush to restore life to pre-disaster conditions. The pressure to regain equilibrium as quickly as possible must be balanced with seizing opportunities for long-term risk reduction and community improvements through sustainable reconstruction. Sustainable reconstruction is designed to address such challenges by providing an integrated framework for action. High-quality well-constructed houses and safe and sustainable environments are human rights. Adequate housing is essential for human survival with dignity. Without secure housing, basic rights to family life and privacy, freedom of movement, health and development are compromised.

5. Study on Post Disaster Reconstruction (PDR) Strategy and Sustainable Reconstruction in Disaster Affected Area

5.1 Post Disaster Reconstruction (PDR) projects

Reconstruction projects are defined as the modification, conversion or phased complete replacement of an existing facility that involved expansions, additions, interior renovation, or upgrading the functional performance of a facility also reconstruction can be refer to restoring basic services and life support infrastructure to normal.

5.1.1 Challenges of PDR Hosing Programmes

Post Disaster reconstruction projects are considered slow, complex and expensive. Indeed, to recover disaster victims or communities back to pre-disaster standard life (or better) is very complex job and Reconstruction Projects Facing following challenges in reconstruction projects.

Disaster	Policies	Funding	Relocation	Land ownership	Construction material	Construction cost	Construction labour	Construction quality	Contract abandonment	local capacity	Aid Agency capacities	Coordination	communication	Temp. Facilities	Political environment
Friuli EQ		X						X							
Mexico City EQ		X													
Kalamata EQ	X				X			X		X	X				
Northridge EQ	V	V													
Kobe EQ			X	X	X			X						X	
Turkey EQ			X												
Armenia EQ			X												
Gujarat EQ								X							
Indian Ocean Tsunami (Indonesia)	X		X	X	X	X	X	X	X	X	X	X	X		
Indian Ocean Tsunami (Sri Lanka)	X		X				X			X		X	X		X
Katrina Hurricane					X		X							X	

Figure 5.1 Challenges of PDR

5.1.2 Strategy for Successful Post-Disaster Reconstruction

Disaster management as public project management and have following strategy that must be taking into consideration into post disaster reconstruction.

1. Effective institutional arrangement- Clear responsible governmental unit and authority line will speed up decision making in recovery. In national level, specified governmental department and specific responsible unit must have fully authorization for disaster management.
2. Coordination and collaboration- Effective coordination and collaboration among stakeholders are the key factor in managing disaster management at international, regional, national, organizational, and project level.
3. Supportive laws and regulations.
4. Effective information management system- Sharing important information among key stakeholders and effective information management system are important for

successful outcomes of disaster management.

5. Competencies of managers and team members- Administrative, conceptual and technical skills are important for planning, implementing, and managing disaster project successfully.
6. Effective consultation with key stakeholders and target beneficiaries.
7. Effective communication mechanism- Effective communication will result to trust and cohesion among stakeholders in the project and therefore will lead to successful project.
8. Effective logistic management- People, expertise and technology are also logistics for disaster management. Using new technology such as GIS and remote sensing will enhance capacity to coordinate among organizations and more effective logistic management.
9. Sufficient mobilization and disbursement of resource- Inadequate of resource (people, equipment, and material) and poor or no risk analysis may result problems in the project and may lead to project termination or suspension.

5.2 Principle of Sustainable Reconstruction.

It is important to integrate the principles of sustainability strategically from the earliest stages of reconstruction in order to avoid major failures during reconstruction. The key principles, which should be kept in mind at all stages of reconstruction, are summarized below

a) Establish and maintain a well-functioning project-management process-
A well-functioning management process is the backbone for the success of any reconstruction project. Contracts and roles and responsibilities should be clarified as early as possible.

b) Ensure local participation in decision-making processes-
The active participation of local stakeholders in crucial decisions throughout the project process fosters a strong sense of ownership and acceptance for the project, and helps to facilitate care and maintenance of buildings following construction. This is especially true if the users are also the owners of the houses; rented-out dwellings tend to deteriorate more quickly than do owner occupied homes.

c) Anchor the project in the local context-
Projects should be anchored in the local context by taking any or all of the following measures-
    1. Exploring the availability of local know-how
    2. Working together with and not against the local authorities
    3. Cooperating with local service providers
    4. Using high-quality local materials when possible
    5. Building on and optimizing local construction technologies.

Anchoring reconstruction projects in the local context can contribute measurably to project's success and sustainability. Local institutions and organizations included in the project process are strengthened and improved.

d) Coordinate with other donors to identify potential synergies-
Responsible local authorities should coordinate all ongoing and planned reconstruction activities, at least at community level. In addition, however, project officials should contact other development organizations (international and national) to determine jointly the geographical and social distribution of reconstruction schemes based on local needs.

e) Conduct regular monitoring and evaluation (M&E)-
Regular self-monitoring and evaluation is critical for measuring the progress of reconstruction projects. M&E can be carried out in a rather simple fashion by selecting key indicators (amounts of money spent on different activities, amounts of materials used and timeliness of completion of activities) and then collecting measurements and summarizing them on a regular basis (weekly or fortnightly). If any indicator shows a deviation from the budget or from construction plans, then the cause for the deviation should be identified, so that remedial measures can be taken.

M&E can be complemented with, impact monitoring, which is used to assess the environmental and social impacts of project activities. Impact monitoring provides valuable information about whether the project is in conformance with best sustainability practices (and if not, how it can be improved). Impact monitoring is also very useful for building the project partners credibility with the local community, national authorities and international donors.

f) Choose the lifespan of houses to be built-
Selecting temporary or permanent shelter options has a huge influence on the house design as well as the project's implementation procedures, budget and time-frame. It is important to decide early in planning for how long the houses should last.

i. Provide adequate temporary shelters-
Reconstruction programmes that are seeking to produce quality results require time for realization. While housing projects are being developed, displaced residents need adequate temporary shelters that ensure humane living conditions and enable residents to re-establish life as quickly as possible. Programme budgets should anticipate this need.

j. Consider reusing and recycling temporary housing components for permanent houses to be built in the future-
Components such as well-maintained sanitary and kitchen facilities can be reused in new reconstructed houses; good-quality materials such as steel beams can be reused also.

5.3 Phases of Sustainable Reconstruction

The sustainable housing reconstruction process may be usefully considered a comprising three general phases:

a) The preparation phase of a reconstruction project is essential for the success of a sustainable reconstruction project. Preparations, such as defining the partners, approach, necessary assessments and planning, need to be carried out thoroughly.
b) Reconstruction planning phase where detailed plans and provisions are arranged and specific decisions are made
c) Reconstruction implementation phase where the actual reconstruction works are undertaken.

5.4 Preparation Phase

The preparation phase of a reconstruction project is essential for the success of a sustainable reconstruction project. Preparations, such as defining the partners, approach, necessary assessments and planning, need to be carried out thoroughly.

5.4.1 Assessment

Housing reconstruction projects have various, often quite complex aspects. In order to ensure that reconstruction is sustainable and best reflects the needs of affected families, programmes should have included comprehensive assessment and analyses. Environmental Impact Assessment is undertaken in a post-disaster situation in order to minimize negative effects of reconstruction on people and the environment.

The following common types of assessments are considered:

- Household survey: assessment of the level of damage to the buildings, the type of buildings before the disaster, land ownership, income, livelihoods, infrastructure preferences, family sizes, gender issues, etc.
- Stakeholder analysis: preparation of a list, at least, of the relevant stakeholders and their priorities
- Analysis of available local construction materials, including their quality, supply chains, advantages, disadvantages, etc.
- Assessment of locally available skills and capacities for sustainable reconstruction
- Analysis of livelihoods
- Estimate the potential negative environmental effects (impact on freshwater supplies, generation of waste and waste water, noise and air pollution) from establishing housing in the selected area.
- Assessing the direct effects of the disaster on people (men and women, girls and boys)
- Assessing the indirect effects of the natural disaster on people and the goods and services which they use.

5.4.2 Set-up of a Reconstruction Project

A well-functioning management process is the backbone for the success of any reconstruction project.

The following key reconstruction project-management practices are recommended:

- Clarify expectations of partners and stakeholders (donor, national and local partners, implementers, etc.).
- Select reliable and skilled local partners.

- Clarify contracts and roles and responsibilities between the partners as early as possible in the process.
- Decide on the project's most important objectives.
- Agree on responsibilities and tasks, and enter a formal written agreement with partners.
- Set a time-frame according to the major milestones formulated in the objectives.
- Confirm available budget.
- Select the location and target group/community.
- Other preparation activities include the establishment of an office and management structure:
- Prepare office facilities and infrastructure.
- Establish the project team's professional staff, ensuring that they have adequate skills.
- Select a multidisciplinary team, according to the project's objectives, including qualified engineers (with technical background and substantial experience in housing construction), social workers (with experience in community mobilization and participatory decision making processes), economic specialists, etc.
- Formulate team members- job descriptions.
- Open a bank account.

5.4.3 Reconstruction at The Same Site or Relocation

There are a number of options available to victims looking for such alternatives, which include:

5.4.3.1 In-situ temporary shelter (on the site of the permanent reconstruction)

In certain instances, it is possible for residents of damaged or destroyed housing to remain on their own property through the provision of temporary shelter solutions. This is most commonly facilitated through the provision of tents; prefabricated or easily assembled robust structures can be used also. If the permanent structure is only moderately damaged, the affected family may return immediately through the provision of minor repairs, such as tarps to cover damaged roofs, with more permanent construction coming later. If the structure is more severely damaged, the family will have to find another location near to their property where their presence does not interfere with the demolition and reconstruction of the structure.

5.4.3.2 Renting a house or apartment

Rental assistance allows disaster-affected people to temporarily relocate outside the affected areas and may increase the likelihood that they return once recovery has occurred given that the rental property is not a viable long-term option. Rental assistance can allow for more immediate yet dignified shelter. The primary challenges associated with rental assistance include rapidly escalating costs that occur when long-term housing options are not available. Rental assistance that allows affected people to relocate into hotels and other available housing can be an effective solution in the short term, but rather costly. The question of who pays for it needs to be clarified.

5.4.4 Budget

Together with the time schedule the project budget is the key management tool for any cost-effective sustainable reconstruction project. The project manager prepares a budget which considers necessary financial allocations according to the time plan. Usually, the project manager establishes a cost calculation during the early planning phase so that he/she can calculate all project costs.

Project costs include: investment (plot, materials, transport, construction, labour, machines, fuel) operation (energy, electricity) maintenance (repairs, replacement) demolishing and recycling/disposal (labour, fuel, transport, machines, material).

5.4.5 Site Selection

In order to select a suitable construction site, project managers consider following key factors.

a) Analyze access to clean water, roads, shops and markets, schools and health facilities, and employment.
b) analyze conditions and technical requirements for water supply, sanitation, waste management and power supply.
c) Check for existing connections to municipal water mains. Assess their condition and the measures needed to connect the site to the municipal mains.
d) Check whether local reconstruction materials are available at the site or nearby in order to minimize transport costs.
e) Assess site topography: when possible, favor elevated (but flat) sites in order to avoid flooding and use shallow bedrock conditions for seismic protection.
f) Check the slope stability (angle, soil type, drainage, etc.).
g) Assess soil characteristics. This provides important information for determining: foundation type (strip or slab); depth for drilling water wells.

h) Assess impacts from nearby industries and airports (e.g., noise, pollution, etc.) and determine how to minimized disturbances.
i) Identify the groundwater table's depth. This will be important information for purposes of establishing foundation depth and size as well as the depth and distance required between latrine systems/septic tanks and water tanks.

5.5 Planning Phase

The planning process is a crucial step towards sustainable reconstruction. It involves a variety of professionals and experts and includes the following steps:

5.5.1 Site Plan

The following key aspects need to be considered in the detailed site-planning process:

- Make the site plans flexible for future extensions, new accesses and necessary adjustments due to changes in the users' needs and habits
- Make sure that the site is accessible through a public transport system and material, labour transportation Consider plans to establish/improve the local public transport network.
- avoid any steep roads.
- Consider roads with sufficient drainage to avoid flooding and surface erosion.
- Ensure that space is provided along roads for pedestrians, bicycles and carts.
- Make sure that sufficient space is provided for utilities – water, sanitation and solid-waste services.
- Consider arranging the houses in clusters (rather than in rows) in areas at risk from cyclones.
- Plan for waste-collection locations and required waste separation and composting areas.

5.5.2 Building Design

Key sustainable house design recommendations are:

- Use house designs that are resistant to natural hazards, such as earthquakes and floods.
- Favor simple, low-cost, robust and practical solutions.
- Consider flexible designs that are easy to upgrade and expand.
- Consider the whole life cycle of a building when designing it
- Ensure easy maintenance through the use of modest and basic house styles. In many cases, maintenance and later renovation turn out to be technically complicated and, therefore, more expensive. Materials and tools needed to work the materials should also be locally available.
- Ensure cost-effectiveness in all construction activities.

5.5.3 Building Technologies

Sustainable construction practices should be low-cost, practical and environmentally appropriate. When selecting the most appropriate construction system, project managers should choose one that best suits local conditions, such as the availability of building material and skilled workers. Depending on local conditions, project managers may want to choose from among the following sustainable building systems:

1. Prefabrication- Entire walls, floors and roofs are ready-made in the factory and transported to the building site. Prefabrication allows for quicker and easier construction and can help to reduce labour costs and ensure quality control. Because construction with wall modules is rather complicated, good planning and organization are essential. Skilled staff and special equipment are often needed. It is also important to ensure that prefabricated houses are designed to suit local conditions, such as climate, subsoil, culture, etc.
2. On-site construction - All raw materials and construction products are transported to the construction site for assembly. Some elements, such as windows or doors, may be prefabricated. Concrete elements used for the foundation, columns and beams can be produced on site. Individual elements should not weigh more than 150kg so that three workers can move them safely. Concrete elements should be cast in wood or steel moulds. The on-site construction method is more labour intensive and it requires regular quality control on site. Raw materials should be available locally.

5.5.4 Building Elements

The main building elements are the foundation, supporting frames, floors, walls (with doors and windows), ceiling and roof. Simple building techniques help to ensure sustainable reconstruction. Local workers will need to have enough skill to ensure that the houses are built safely and with good-quality methods. If needed, additional training may be appropriate.

1. Foundation- The quality and lifespan of a house depends to a great extent on how the foundation is made. A poor foundation can soon lead to damage and deterioration that is difficult to repair. The type of foundation to be used should be selected early in the planning process, because it will influence the building's overall design. Key criteria for consideration when selecting a foundation include: ground quality, which can be determined through a soil investigation; the building's anticipated load, i.e., its weight when fully occupied; and the availability of equipment and skilled workers.

2. Walls- Walls play a crucial role in a house's resistance to earthquakes. Earthquakes affect buildings mainly with horizontal forces. The major danger due to the horizontal movements of the earth is that building walls and, consequently, roofs might collapse. The main aim of constructing earthquake-resistant houses is to avoid walls being able to collapse and to ensure that roofs are well secured to walls. In order to make houses as resistant to earthquakes, storms and floods as possible, the following measures are recommended:

- Ensure that walls are reinforced sufficiently. If possible, have a qualified engineer calculate the required reinforcement and control the quality of installation on site regularly.
- Make sure that ring beams are well connected in each corner and with the reinforcement of walls and columns.
- Experience has shown that walls made of cement or fired bricks resist floods much better than do mud walls.

3. Roof - The quality and state of the roof is extremely important. The roof protects against weather, wind, heat and cold. To some extent, roofs also protect external walls from sun and rain. Flat roofs are critical in areas with heavy rains. Highly skilled workers, excellent-quality building materials and regular maintenance are required to keep flat roofs watertight. In earthquake-prone areas, roofs should be as light as possible. To achieve the best earthquake resistance, roofs should be well connected to all walls and columns. The supporting frame and pillars, however, should always be able to support the roof without the walls, so that, even if a wall collapses, the roof does not fall down.

5.5.5 Construction Materials

Building materials are made either from naturally available sources like inorganic materials (e.g., clay, stone, steel) or from organic raw materials (e.g., wood, straw). Houses built with building materials of insufficient quality, low-quality concrete or inadequate steel reinforcement were usually badly damaged by natural disasters. Project managers should give special attention to using high-quality building materials. Try to ensure that the delivered material is of good quality by regularly material testing the aggregates (sand and stone), water and cement used.

To follow a more sustainable approach:

- Use only raw materials that are produced in an environmentally acceptable manner, and avoid using materials extracted from sensitive areas.
- Using locally produced materials can save transport costs, strengthen the local material production industry.
- Production of building materials at the construction site is often cheaper than is using prefabricated materials/elements and may also enable better quality control.

5.5.6 Procurement

Construction materials are often purchased through procurement because quantities are very large and might not be locally available. Another reason for going through a bidding process is that the donor and/or implementing organization has guidelines whereby bidding is obligatory. Procurement offers a very good opportunity to include sustainable and environmental aspects in the bidding process.

5.5.7 Repairs

In some instances, the cheapest and quickest method of providing adequate housing is to repair the damaged stock. In particular, this could be a good solution when the local population has not been significantly displaced. The scale of damage will vary; therefore, assessments will be necessary to determine the materials and levels of skill required for repairing the houses.

5.6 Construction

The construction phase is in many ways an important stage in the implementation process of reconstruction activities. Not only can many disturbances be generated from the construction itself, but also the housings long-term durability depends on whether the sustainable features of the housing design are implemented effectively during the construction stage. Therefore, functioning project management, quality control, environmentally friendly site management, careful handling of construction waste, material banks, controlled demolition and reuse of debris are essential.

6. Case Study

6.1 Tsunami, Which Hit Sri Lanka On The 26th Of December 2004.

On 26 December 2004 Sri Lanka was hit by the tsunami caused by a massive off shore earthquake some 1500 km away near northern Sumatra. The earthquake, measuring 9.0 on the Richter scale, was one of the largest ever recorded in the sea, and was produced by movements in tectonic plates at the interface between the India and Burma plates. The earthquake occurred on 26th December at 6.58 am Sri Lanka time. The first large wave hit the east coast at 8.35 am. Soon after waves several meters high battered many other parts of the coast. Within a very short time over 30,000 people were dead, and several hundred thousand had been displaced. In addition, massive damage had been inflicted on thousands of houses and other buildings, railways, bridges, communication networks and other infrastructure and capital assets.

6.1.1 Impact of Disaster

The immediate impact of the tsunami was unprecedented. The death toll is estimated at over 36,000 (30,957 people listed as dead with an additional 5644 listed as missing). The majority of victims were women and children. An estimated total of 8,00,000 people was displaced. The geographic impact of the tsunami was uneven. Much of the coastal belt of the Northern, Eastern and Southern Provinces and some parts of the Western Province were severely damaged. The Northern and Eastern Provinces were particularly hard hit accounting for two-thirds of deaths and almost 60 per cent of the displacement.

6.1.2 Response of Government

The Sri Lankan government launched an appeal to all friendly countries, the UN and relief agencies, through the Ministry of Foreign Affairs on 26 December 2004, seeking assistance in the immediate and medium term. Essential medical aid, emergency food and other relief supplies were mobilized within a day. Temporary shelter was provided to the displaced in schools, other public and religious buildings, and tents. Public and private sector organizations cooperated and organized relief efforts at many levels.

Once the immediate relief and rehabilitation measures for provision of food, shelter, clothing, clean water, and sanitary and medical facilities to affected families had been provided, it was necessary to address community needs to cope with the trauma and start rebuilding their lives. Relief efforts included provision of finances to meets immediate needs. Compensation of Rs 15,000 ($ 150) was offered for victims towards funeral expenses; livelihood support schemes included payment of Rs. 375 ($3.75) in cash and rations for each member of a family unit per week, a payment of Rs. 2,500 ($25) towards kitchen utensils. These initial measures were largely successful, though there were some problems with lack of coordination.

6.1.3. Impact Assessment

In order to develop a strategy for reconstruction it is necessary to have an assessment of damage. In this respect, Sri Lanka was fortunate to get an early assessment done by end January 2005 through a joint effort of the Asian Development Bank (ADB), the Japan Bank for International Cooperation (JIBC), and the World Bank (WB): "Sri Lanka 2005 Post-Tsunami Recovery Program – Preliminary Damage and Needs Assessment." This report provided a picture of the asset damage and economic losses in each affected sector and provided an estimate of the overall incremental financing needs.

The ADB-JBIC-WB assessment estimated that Sri Lanka had suffered asset damages of around US$ 1 billion (4.5 per cent of GDP), and estimated that the medium-term financing needs (including immediate relief) would be around at US$ 1.5-1.6 billion. The destruction of private assets was substantial ($ 700 million), in addition to public infrastructure and other assets. Loss of current output in the fisheries and tourism sectors – which were severely affected – were estimated at $ 200 million and $ 130 million, respectively. Key industrial, agricultural and metropolitan centers were relatively unaffected and the damage to capital assets was primarily to tourism and fisheries sectors, each of which contributes only around 1.5-2 per cent of GDP.

6.1.4 Recovery

The task of recovery involves the rehabilitation and reconstruction of capital assets (both private and public) as well as the provision of the material and institutional assistance necessary for households to engage in gainful economic activities to rebuild their livelihoods. This involves not only the reconstruction of physical infrastructure and replacement of assets, but also the re-establishment of market and social networks. As indicated, domestic and international assistance enabled the country to cope successfully with the immediate relief tasks.

6.1.5 Housing Programme Progress

The housing situation for the tsunami-affected communities in Sri Lanka has made some progress. The number of displaced declined to 5,16,000 by mid-June 2005 from the 8,00,000 or so figure in the immediate aftermath of the tsunami as people returned to their homes (even if they are destroyed or damaged) and were removed from the statistics. An initial 1,69,000 people housed in schools and tents have largely been moved to transitional shelters (to bridge the gap between emergency accommodation and permanent housing). Transitional shelters were only being provided for the affected households in the buffer zone. By end August 2005, it was estimated by TAFREN (Task Force for Rebuilding the Nation) that approximately 52,383 transitional shelters, housing some 2,50,000 tsunami displaced people, have been constructed since February 2005 on 492 sites. A total of 55,000 such shelters are to be completed by end September 2005, thus completing the transitional house building programme, and this target appears likely to be met. The need for care and maintenance of such shelters becomes increasingly important as permanent housing reconstruction becomes delayed.

The government unit charged with this task is the Tsunami Housing Reconstruction Unit (THRU) based in the Urban Development Authority (UDA). The THRU has been signing Memoranda of Understanding (MOU) with donors who have offered to construct houses (international and national NGOs and some private companies). The MOU states that "the donor shall bear the cost of construction of the housing units which has been estimated to be around Rs. 4,00,000 per single storey detached type housing unit including the cost of basic amenities such as water, electricity and sewage within.

The MOU also states that the house must have a minimum of 500 square feet with two bedrooms, a living room, kitchen and toilet; and that construction must be in keeping with planning guidelines, design specification and standards given by the UDA. The donor must employ a contractor registered with the Institute for Construction Training and Development (ICTAD) or any other government construction agency.

6.2 Pakistan Straw Bale and Appropriate Building(PAKSBAB)

PAKSBAB offers creative green building solutions using local labour and renewable materials, such as straw, to provide affordable permanent housing especially suited for seismic and severe temperature regions of developing countries. The building methods used are about two times more energy efficient and almost one-half the cost of modern low-income housing.

In post-disaster reconstruction programmes and in building codes, there is an emphasis on conventional building materials and methods such as concrete and masonry construction. These methods are deadly when improperly constructed and require the use of high-cost, energy-intensive materials and skilled labour, usually unaffordable for the poor. Following an extensive natural disaster, the demand for these materials further increases the cost. Concrete and masonry construction also perform poorly in hot and cold climates, and their production, transportation and use are harmful to the environment.

Straw-bale construction uses straw, an agricultural by-product, compressed and tied into bales, as building blocks for walls. As currently practiced in many developed countries, straw-bale construction offers numerous benefits, including energy efficiency, the use of natural non-toxic materials, and resistance to earthquakes, fires and pests. Straw-bale buildings have proven to be durable. Since the 1980s the use of straw bale construction has steadily increased, and there are now straw bale buildings in all 50 U.S. states and more than 50 countries throughout the world. These buildings are durable, safe, energy and resource efficient, and have proven affordable compared with predominant building systems in developing countries. When detailed properly they are highly resistant to earthquakes (DUDBC,2015)

6.2.1 Construction Techniques of Straw Bale

In load bearing construction, the roof is placed directly on top of the straw bales. A roof bearing assembly resembling a ladder structure sits on top of the straw bale wall and distributes the roof load. The straw bale walls are compressed into place using cables, creating a more level surface for the roof placement. Sometimes, uneven distribution of loads can occur, causing the roof to settle irregularly. Using the straw bales as a load bearing identity eliminates the use of wood or steel as structural load bearing elements, saving construction material costs.

Straw bale able to accomplish with simple load-bearing designs, in which the straw-bale walls support the roof load and resist earthquake and wind loads. It also utilizes renewable and locally available materials such as straw, bamboo, wood, clay soil, sand, gravel and rock, as well as local labour. The site-fabricated bales are smaller than those used in typical straw bale buildings, with reductions in foundation footprint and cost. Other unique features include the use of stone foundations encased in soil cement, and nylon fishing net that provides plaster reinforcement and ties the foundation, straw-bale walls and roof together.

Compared to conventional building methods, PAKSBAB approach is unique in that the primary materials of straw, timber and bamboo used in our home-building process sequester CO2. Straw-bale construction is extremely energy efficient and comfortable, with an excellent balance of insulation and mass, reducing the amount of fuel required for heating and cooling. This construction method significantly also reduces the use of building materials with high-embodied energy such as cement and steel, as well as the fossil fuels required for their manufacture and transportation.

7. Conclusion

Post-disaster reconstruction (PDR) is a complex and highly demanding process that involves a number of different and well-coordinated courses of action. Therefore, it is vital that these complex activities are well planned; subject to thorough consultation. Reconstruction process should be considered as development opportunities and should open the access of different types of innovative solutions. These innovations should lead to vulnerability reduction, and should enhance human and other activities security in long term.

By evaluating the overall information on the post disaster sustainable reconstruction programme and developing the general framework for management of post disaster reconstruction the successfulness of the process is raise awareness of sustainable reconstruction and to improve resilience to natural hazards in the future. This study encourages project managers as well as planners to adapt this approach wherever possible in their projects. Implementing agencies, where possible, are asked to support the reconstruction of buildings and structures that are as energy efficient and low greenhouse gas emitting as possible.

Drawing on experiences in Sri Lanka this thesis focused on two aspects of the large relief and reconstruction program that followed the Asian tsunami in December 2004, a result of which, almost 36,000 people died. First, various aspects of the effectiveness and financing of aid delivery activities following the tsunami are considered. Second, the challenges of designing significant reconstruction programs in the wake of the tsunami were discussed with reference to the well-known literature. Through the case study of the 2004 tsunami this thesis has also observed the reconstruction process of housing, land transport infrastructure and accommodation for victims. Aspects of the rebuilding process have been explored such as the policies adopted for each sector, the agencies involved for recovery process and the impact of disaster.

In second case study; If the growth of straw bale construction continues, the amount of money and energy that can be saved could reach millions, even billions. If cities began using straw bale as affordable housing, their energy consumption could be reduced by 60-70%. Moreover, if straw bale construction is used, costs of building could be greatly reduced. Money saved by using straw bale construction could be applied towards other initiatives in cities. We saw in the Pakistan example how straw bale has been used to provide housing for the homeless while at the same time stimulating local economies.

This study encourages project managers as well as planners to adapt this approach wherever possible in their projects. This study serves as a reference for Implementing agencies, project managers for the reconstruction of buildings and structures that are as energy efficient and low greenhouse gas emitting as possible.

Following are the Guidelines for the Key Aspects of Sustainable Reconstruction.

- Select reliable and skilled local partners.
- Decide project’s most important objectives.
- Confirm available budget.
- Select a multidisciplinary team, according to the project’s objectives, including qualified engineers (with technical background and substantial experience in housing construction), social workers (with experience in community mobilization and participatory decision-making processes), economic specialists, etc.
- Formulate team member’s job descriptions.
- Analyze access to clean water, roads, shops and markets, schools and health facilities, and employment.
- Analyze conditions and technical requirements for water supply, sanitation, waste management and power supply.
- Check whether local reconstruction materials are available at the site or nearby in order to minimize transport costs.
- Determine the priorities for sustainable development in the affected region.
- Use natural topography: place new houses at higher levels than previous, destroyed ones.
- Experience has shown that walls made of cement or fired bricks resist floods much better than do mud walls.

- Use house designs those are resistant to natural hazards, such as earthquakes and floods.
- For better resistance to floods, consider elevating the ground floor and building an extra floor or using a flat roof that residents could flee to, if necessary. Flat roofs offer the added advantage of providing storage space for the residents‟ assets (e.g., grain, farming tools). A temporary or permanent protective structure (e.g., light roof construction made of wood or bamboo) can be built on top of the roof.
- Tie the structure together firmly and use diagonal bracing.
- Select building elements that are easy to disconnect, when possible, in order to enable future recycling and reuse.
- Avoid building in areas with soft clays and loose-to-medium-density sand, which is waterlogged and may liquefy during an earthquake. Seek expert advice on piled foundations and structural design.

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