



## Study on Key Performance Indicators to Investigate Long-Term Performance of Post-Disaster Housing Reconstruction

L. J. Prasanna

*Human Settlements Planning and Training Division, NBRO*

E.E Wijegunaratne

*Human Settlements Planning and Training Division, NBRO*

Dr. G. Wedawatta

*School of Engineering and Applied Science, Aston University, UK*

**ABSTRACT:** Post disaster reconstruction is a vital phase in disaster management cycle. It aims to restore and improve pre-disaster living condition of affected communities. It is an opportunity to lay foundation for long-term risk reduction, also to contribute safer and sustainable development. Research has shown that permanent re-construction following a natural disaster is often inefficiently managed, uncoordinated, and importantly overlooks the long term requirements of the affected community. Adopting a long-term approach to re-construction however is required to ensure sustainable housing provisions and sustainability of local communities. Following the Tsunami devastation in 2004 in Sri Lanka, thousands of houses were damaged and destroyed and were rebuilt. Two approaches; “Donor Driven” approach and “Owner Driven” approaches have been employed to rebuild post disaster housing reconstruction. Studies revealed smooth flow of this construction process was disturbed by certain gaps that occurred throughout the above post disaster reconstruction programme. How these housing schemes perform in the long-term is seldom investigated. As the post tsunami housing schemes have now been in place for a reasonable period of time, it is timely to investigate how the schemes have performed up to now. A key step towards assessing long-term performance is to identify criteria to be used for assessment. In light of the above, this paper documents and suggest Key Performance Indicators (KPI) to be assessed in order to investigate the long-term performance of post-disaster housing reconstruction projects in Sri Lanka. An extensive literature review and expert interviews aided this task. Findings of this research will inform the policy-makers and practitioners to outline the KPIs to investigate how the post-disaster housing re-construction projects have performed in the long-term.

**Keywords:** *Key Performance Indicators (KPI), Post-disaster housing reconstruction, Long term performance*

### 1. BACKGROUND

Housing is usually the most valuable asset for people. It is one of the worst affected sectors in most of disasters. Particularly in rapid-onset events, housing is usually the element that is most extensively damaged or lost, and often represents the greatest share of loss in the total impact of a disaster on the national economy (Ahmed, 2011).

Destruction of housing can threaten the physical, social, emotional and economic fabric of affected households. The vulnerability of

housing and the built environment constitutes the primary risk factor for loss of life and for a significant portion of economic loss during any major disaster event in low-income and developing countries. Likewise, the housing sector constitutes the largest financial item in post-disaster recovery programmes (ADPC, 2015).

Landslides, floods and high winds are the hazards frequently occur in Sri Lanka. Such threaten human life, cause damage to life and properties, health, livelihoods and safety. This situation has been aggravated as the result of technological and socio-economic condition,



urban sprawl, haphazard development in hazard prone areas and impact of climate change.

Recent statistics shows over the past few decade disaster losses in Sri Lanka have increased substantially. Recently heavy and localized rains fell on several districts in Sri Lanka including Colombo, Gampaha, and Kegalle districts, caused heavy damages to properties and life of people. Loss of lives exceeded 400 whereas a number of fully-damaged houses exceeded 500. Disaster damages and losses take away the hard earned development gains. Records indicate that over the past 20 years, 23 million individuals and more than 5 million families were affected due to natural disasters. Besides human casualties, one of the most visible and striking effects of any major disaster is the destruction of houses. Construction of houses will be a major activity in the reconstruction phase of a disaster ([www.desinventar.lk](http://www.desinventar.lk)).

Fig. 1 shows the houses destroyed by various disasters from 1996 to 2016 in Sri Lanka. As illustrated in the diagram, of those total number houses destroyed, 46.3% of houses destroyed by extreme wind events, 36.3% of houses destroyed by floods, and 13.8% was due to Tsunami.

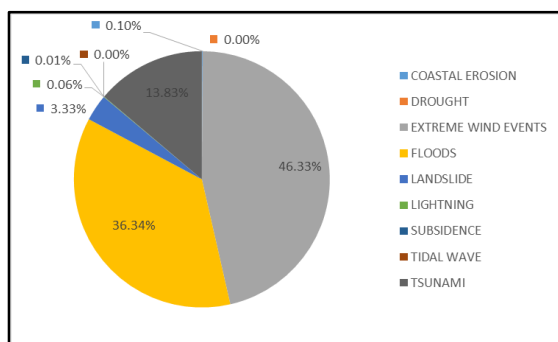


Figure 1: Houses Destroyed by disasters in Sri Lanka  
Source: DesInventar database of DMC  
([www.desinventar.lk](http://www.desinventar.lk))

These events necessitates rebuilding of houses, and affected communities. Accordingly, damaged and/or destroyed houses require re-construction. In some instances, communities need to be relocated in new housing schemes (Ex: New housing scheme for Meeriyabedda landslide victims). Housing reconstruction needs to adopt a more holistic approach, combining the rebuilding of houses with that of livelihoods and local markets. Under any of these situations, a long term view

needs to be undertaken in order to safeguard performance of such construction initiatives in the long term.

## 2. LONG TERM PERFORMANCE OF POST DISASTER HOUSING

Post-disaster reconstruction is an area that is gaining increased attention by many governments, environmental campaigners, scientists and various other stakeholders, both in the developing and the developed world. Along with the loss of life resulting from various disasters, loss of housing marks a major impact due to the multiple effects of psychological, physiological and economic damage that it creates.

Shanmugaratnam (2005) states post-disaster situation can be seen as one of new opportunities for reconciliation, investment and growth, sustainable resource utilization, human capital formation, employment generation and human development. Therefore proper planning should be made in order to obtain maximum benefits.

As Ingirige et al. (2008) argues, post-disaster reconstruction is a process that is both comprehensive and involves cross-disciplinary contributions of a wide variety of stakeholders. Reconstruction following a natural disaster is a complicated concerning social, economic and technological aspects. Therefore, rational decision-making is the key to accelerating the reconstruction process and to improve the human settlement environment.

There is a perceived gap in the understanding of the longer-term impacts of post disaster reconstruction. It has been demonstrated that more research is needed on the effectiveness of longer-term development in communities where international aid and expertise have been provided (Hayles, 2008).

Sustainability is an integrated approach considering economic, environmental, technical, institutional and social concerns at each stage of reconstruction to produce long term results. Planning and implementation of the post-disaster reconstruction projects should equally consider the social, economic and environmental aspects and many researchers have identified these factors as three main pillars of sustainability (Shafique, 2016).



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. Reconstruction programmes often fail to take in to account the desires of the disaster affected populations. If proper attention is not given to the needs of affected people there is a possibility that the newly constructed facilities become obsolete from the day the construction is complete. Proper planning is of utmost importance to reduce future vulnerabilities and to improve long-term sustainability. A good housing reconstruction strategy will take into account the social need together with long-term disaster mitigation and sustainability (Ratnayake & Rameezdeen, 2007).

Sri Lanka requires considerable post-disaster re-construction work on a continuing basis. It is essential that these housing re-construction work live up to their performance requirements in the long term, not just satisfying immediate settlement objectives. Under any of these circumstances, a long term view needs to be undertaken in order to safeguard performance of construction initiatives in the long term. In this background, revisiting the post-disaster permanent housing schemes that have been occupied by the recipients beyond the short to medium-term can suggest valuable lessons for future practices. To undertake this examination successfully, it is vital to determine the right Key Performance Indicators to be assessed in order to investigate the long-term performance of post-disaster housing re-construction projects.

### 3. METHOD OF STUDY

The study methodology comprise of a comprehensive literature review and expert interviews composed with engineers, urban planners, lecturers, sociologists and disaster managers, who engage in post disaster housing reconstruction projects. These interviews were mainly designed to capture and document KPIs to be assessed in order to investigate the long-term performance of post-disaster housing re-construction projects.

#### 3.1 Research Question

- What are the Key Performance Indicators (KPI) to be assessed in order to investigate the long-term performance of post-disaster housing re-construction projects?

#### 3.2 Research Objective

- To find Key Performance Indicators (KPI) to be assessed in order to investigate the long-term performance of post-disaster housing re-construction projects

## 4. KEY PERFORMANCE INDICATORS

### 4.1 Literature Review

Yilmaz et al. (2013) states, like other phases of post-disaster activity, evaluation also requires a structure for the conductor to follow. The creation of tools to be used during evaluation plays a vital role in achieving reliable results. Setting the correct indicators and their criteria is an essential step in developing evaluation tools. The indicators to be measure in a project are commonly identified as Key Performance Indicators (KPIs), Critical Success Indicators (CSFs), and Selected Success Factors (SSFs). These terms can be applied in any type of project, though they originally come from the area of business management. KPIs are the effects of a certain activity and briefly aims to find what can be done to increase the success of the activity. This section presents KPIs found through literature review and expert interviews of post disaster housing reconstruction. These KPIs to be assessed in order to investigate the long-term performance of post-disaster housing re-construction projects employed by both “Donor Driven” and “Owner Driven” approaches.

Shafique (2016) revealed affected community is an important stakeholder and consideration of their viewpoint and involving them in decision making process, especially in planning and implementation phase is very important for success and sustainability of post disaster reconstruction projects. It is very important that stakeholder’s consultation / participation should take place as soon as possible and they should be involved in decision making process from very first day of the project.

The design and implementation of any post-disaster housing reconstruction programme must find a balance between affordability, technical feasibility and quality of life. It must also recognise the end users as active stakeholders, aware and conscious of their own needs and wants, rather than as passive recipients, who need to be educated (Vatsa, 2001)

Ingirige et al (2008) conducted a user satisfaction survey on owner driven and donor driven post tsunami housing beneficiaries identified indicators; architecture/ aesthetic, quality/ strength and durability, functionality, space availability, availability to influence design and flexibility to future changes. Indicators used in previous studies to measure the success of the housing reconstruction programme is given in Table 01.

Table 01: Indicators used in measure the success of the housing reconstruction programme (Source: Authors)

Indicators	Sources
Quality/ strength/ durability	Ratnayake and Rameezdeen (2007), Ingirige et al (2008)
Functionality	Ratnayake and Rameezdeen (2007), Ingirige et al (2008)
Space availability	Ratnayake and Rameezdeen (2007), Ingirige et al (2008)
Aesthetics	Ratnayake and Rameezdeen (2007), Ingirige et al (2008)
Flexibility to make any changes in the future	Ratnayake and Rameezdeen (2007), Ingirige et al (2008)
Land size	Ratnayake and Rameezdeen (2007),
Location	Ratnayake and Rameezdeen (2007),
Overall facilities provided	Ratnayake and Rameezdeen (2007),

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recognize end users as active stakeholders and conscious of their own needs (Hayles, 2008).

Environmental Science for Social Change (2014) revealed a) disaster resilience b) participation of disaster affected families c) timeliness; d) affordability; e) project management and f) sustainability as assessment criteria, which were used to review the efficacy of post-disaster housing reconstruction in terms of the long-term or developmental contribution of the modality to the housing community. Table 02 shows the assessment Criteria and indicators for post-disaster housing reconstruction.

Table 02: Criteria and indicators for post-disaster housing reconstruction (Source: Authors)

Criteria	Indicators	
1. Disaster Resilience	1.1	Decreased exposure to natural hazards
	1.2	Ability of houses to withstand typhoons
	1.3	Measures to prevent/mitigate disasters
2. Participation	2.1	Level of community participation (H/M/L)
	2.2	Level of beneficiary satisfaction
3. Timeliness	3.1	Time between disaster and permanent relocation
	3.2	Adaptation to changing circumstances
4. Affordability	4.1	Access to basic services
	4.2	Access to employment/livelihood
	4.3	Collection efficiency rate
5. Sustainability	5.1	Development of local capabilities
	5.2	Use of local resources
6. Project Management	6.1	Coordination

Yilmaz et al. (2013) found indicators for social, economic, physical and overall evaluation of post-earthquake permanent housing projects. The indicator selection is based on measuring and evaluating the 'ability of adaptation' and 'success of transformation' from the perspective of rural dwellers living in the post-earthquake state-built permanent houses. Below Table 03 shows the group of indicators found.

Table 03: Group of indicators for social, economic, physical and overall evaluation of post disaster housing reconstruction (adapted from Yilmaz et al., 2013)

INDICATORS
Social evaluation
1. Training attendance
2. Temporary migration
3. Decision-making for migration
4. Knowing neighbours
5. Relationship with neighbours
6. Feeling of normalization
7. Changes and difficulties in post disaster life
8. Perception and aspiration of former and current environment



Economic evaluation
1. Financial help from the state
2. Completion level of house loan
3. Worthiness of the house received
4. Source of livelihood
5. Loss of animal stock and its recovery
6. Being unemployed
7. Comparison of income level (pre-and-post disaster)
8. Affording essential expenses
9. Increase in expenses
10. Spending on alterations
INDICATORS
Physical evaluation
1. Size of house and room
2. Size of private lot
3. Quality of interior materials
4. Direction of entrance and terrace
5. Level of privacy
6. Easy cleaning
7. Heating and ventilating during winter
8. Location of new settlement compared to former settlement
9. Distance to city centre and other services
10. Design of new settlement and outdoor facilities
11. Infrastructure and public services
12. Additional units owned
13. Any alterations done
14. Type of alterations
15. Reasons of alterations and anticipated alterations in future
Overall evaluation
1. Overall satisfaction from the house
2. Comparison between the old and the new houses
3. Preference of structural system and material
4. Level of expectations
5. Anticipated years to live in the same house
6. Relationship with the officials
7. Trust in the state
8. Participation in decision-making
9. Any issues to complain about

In certain cases, the constructed property does not satisfy the local requirements and is left abandoned or not utilized, mainly due to inappropriate design or lack of consultation with the community. It is important to consider the needs of all people and promote participative approaches in order to make the post disaster reconstruction sustainable (Thurairajah, 2013).

Perera et al. (2011) presented autonomy of designing own houses, appropriate counseling and facilitating the beneficiaries to adapt to new environments, proper linkage of socio cultural

aspects with real estate and economic aspects and availability of formal property rights are crucial factors for the success of the resettlement. Table 04 shows the indicators used to ascertain the success and failures of the Resettlement Program.

Table 04: Indicators used to ascertain the success and failures of the Resettlement Program (adapted from Perera et al., 2011)

CRITERIA
Improvement of physical environment of the resettlement ( <i>Real Estate aspects</i> )
Indicators
1. Choice of site for resettlement
2. Provision of services to the new location
3. Layout of the property
4. Housing design, construction and privacy Common property resources and community/public services provided to affected persons.
CRITERIA
Full economic rehabilitation of the affected persons ( <i>Economic Aspects</i> )
Indicators
1. New pattern of employment opportunities and motivation for other financial gain opportunities
2. Facilities to upgrade their present livelihood
3. Opportunities for future generation
4. Access to credit facilities
5. The capability of the community to develop itself.
CRITERIA
Full social rehabilitation of the affected person ( <i>Social Aspects</i> )
Indicators
1. Social status and relationships
2. Commitment for family
3. Education opportunities and facilities for younger generation
4. Facilitating for religion practices
5. Political empowerment
6. Crime rate in the area
7. Counseling services provided

Bouraoui et al (2010) examines the users' satisfaction based on qualitative analysis of several interviews with end users of a post flood reconstruction project. Below are the list of the indicators found.

1. The occupancy rate of rebuilt houses.
2. Beneficiaries' perception of the location of the rebuilt project in comparison with the original settlement.
3. The perception of the quality of the reconstructed houses in comparison with users' original dwellings.

4. The perception of the quality of the project infrastructure in comparison with the original settlement.
5. The perception of preventive measures in the project in comparison with those that existed in the original settlement.
6. The perception of community services in the project in comparison with the original settlement.
7. The availability of means of transport in comparison with the former dwelling area.
8. Land/house ownership.
9. Offered/lost jobs impacts of relocation on created or lost jobs.

#### 4.2 Experts' Perspectives on KPIs

Apart from indicators found from the literature review, following are the key performance indicators found with expert interviews;

1. Legal status.
2. Vulnerability level.
3. Types of changes victims done and its cost.
4. Short-term and long term livelihood opportunities.
5. Extent of the adaptive capacity improvement.
6. Whether the livelihood is permanent or temporary.
7. Capacity of the Local Authority.
8. Baseline for housing value.

## 5. FINDINGS

Indicators serve as road signs on the map, to guide the programme in assessing whether it is in fact achieving the greatest possible impact on the situation. Relevance of indicators chosen has direct impact on accuracy of the evaluation (UN-HABITAT, 2001).

As per the literature review, in most of the previous studies, indicators under physical, economic, social criteria have been commonly studied but not disaster resilience and overall evaluation criteria. However, as stress at the expert interviews, it is vital to assess indicators under disaster resilience and sustainability criteria as well. In light of literature review and expert interviews a model has been developed consisting physical, economic, social, disaster resilience, and overall evaluation. Indicators under each of these criteria to be assessed in

order to measure the long term performance of post-disaster housing re-construction projects. Below figure 2 shows the model developed based on previous studies and through the outcome of expert interviews.

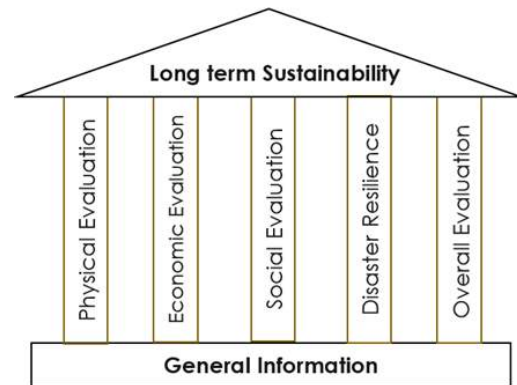


Figure 2: Model to measure the long term performance of post disaster housing reconstruction. (Source: Authors)

Indicators for physical evaluation refers to quality of interior spaces, psychological needs and technical characteristics of the house; plan layout, materials from a dwellers perspective.

Employability and level of income may appear as general indicators, but those are the basis for economic evaluation. When residence have limited sources of livelihood such as; fishing, agriculture and animal husbandry they lose their entire income source. In such scenario, indicators focus on house loans, livelihood and expenses.

Indicators under social evaluation aim to examine social relationship and its effect on individuals. Interaction between neighbours plays a vital role in long-term stay in the particular residence. Thus, it is important to understand level of relationships to each other.

Resilience needs to be systematically 'built in' to the planning and design process of housing reconstruction. It is crucial to ensure that every house reconstructed following a disaster is withstand future potential disasters.

Over all evaluation is about changes in daily life habits due to the layout of new house and the location of the settlement. As the residents start to compare their old and new environments, they may arrive at a conclusion to abandon their rebuilt dwelling. Thus, in the



development of indicators for investigation a separate section entitled ‘overall evaluation’ is designed to examine this issue. Table 05 group the indicators to be assessed under physical, economic, social, disaster resilience and overall evaluation.

Table 05: List of indicators to be assessed under physical, economic, social, disaster resilience and overall evaluation (Source: Authors)

Physical evaluation
Indicators
<ul style="list-style-type: none"> <li>• Plan layout</li> <li>• Size of house and rooms</li> <li>• Aesthetics</li> <li>• Space availability</li> <li>• Quality/ strength/ durability</li> <li>• Direction of entrance and terrace</li> <li>• Level of privacy</li> <li>• Easy cleaning</li> <li>• Baseline for housing value</li> <li>• Location of new settlement compared to former settlement</li> <li>• Comparison between the old and the new houses</li> <li>• Quality of the reconstructed houses in comparison with users’ original dwellings</li> <li>• Distance to city center and other services</li> <li>• Design of new settlement and outdoor facilities</li> <li>• Infrastructure and public services</li> <li>• Additional units owned</li> <li>• Any alterations done</li> <li>• Type of alterations</li> <li>• Reasons of alterations and anticipated alterations in future</li> </ul>
Economic evaluation
Indicators
<ul style="list-style-type: none"> <li>• Access to basic services</li> <li>• Access to employment/livelihood</li> <li>• Livelihood is permanent or temporary</li> <li>• Being unemployed</li> <li>• New pattern of employment opportunities</li> <li>• Motivation for other financial gain opportunities</li> <li>• Comparison of income level (pre and post disaster)</li> <li>• Payment terms</li> <li>• Opportunities for future generations</li> <li>• The capability of the community to develop itself</li> <li>• Land/housing ownership</li> <li>• Financial help from the state</li> <li>• Completion level of house loan</li> <li>• Duration and amount of house loan</li> <li>• Increase in expenses</li> </ul>

- Spending on alterations

Social evaluation
Indicators
<ul style="list-style-type: none"> <li>• Social status &amp; relationships</li> <li>• Commitment for family</li> <li>• Education opportunities</li> <li>• Facilitating for religion practices</li> <li>• Political empowerment</li> <li>• Crime rate in the area</li> <li>• Training attendance</li> <li>• Fear of disaster</li> <li>• Trust in disaster resistance of the house</li> <li>• Temporary migration</li> <li>• Decision making for migration</li> <li>• Feeling of normalization</li> <li>• Duration of disruption</li> <li>• Changes and difficulties in post disaster life</li> <li>• Perception and aspiration of former and current environment</li> </ul>

Disaster resilience
Indicators
<ul style="list-style-type: none"> <li>• Decreased exposure to natural hazards</li> <li>• Ability of houses to withstand hazards</li> <li>• Measures to prevent / mitigate disasters</li> </ul>

Overall evaluation
Indicators
<ul style="list-style-type: none"> <li>• Development of local capabilities</li> <li>• Use of local resources</li> <li>• Adaptation to changing circumstances</li> <li>• Occupancy rate of rebuilt houses</li> <li>• Overall satisfaction from the house</li> <li>• Overall facilities provided</li> <li>• Quality of the project infrastructure in comparison with the original settlement</li> <li>• Flexibility to make changes</li> <li>• Anticipated years to live in the same house</li> <li>• Relationship with the officials</li> <li>• Trust in the state</li> <li>• Capacity of the Local Authority</li> <li>• Participation in decision-making</li> <li>• Any issues to complain about</li> </ul>

## 6. CONCLUSIONS AND RECOMMENDATIONS

The ultimate goal of post disaster reconstruction processes shall be to attain a standard of living that is even better than what existed before the disaster. The prime aim of this paper is to document and present Key Performance Indicators (KPI) to be assessed in



order to investigate how the post-disaster housing re-construction projects have performed in the long-term. As identified in some of the previous studies, research findings revealed that some indicators have been more commonly studied under different aspect than other indicators.

Ultimately, this paper desire to present indicators under social, economic, physical, resilience and overall evaluation criteria as a starting point to investigate the long term performance of post disaster housing reconstruction projects. Indicators found in this study can be assessed through the viewpoints of dwellers.

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