

**ASPECTS OF POST-EVENT EARTHQUAKE MANAGEMENT**

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**Abstract**

Ever since human beings created shelters for living on Planet Earth, vulnerability to the perils of human-made shelters was a natural consequence. During a 30 year period,(1974-2003), the world faced 6,367 natural disasters, out of which 2,566 were in Asia, accounting for over 40 percent of all occurrences worldwide (Guha-Sapir, et al 2004, p 80). Out of 921 disasters that occurred during the same period in South-Central Asia, India shared 303 disasters or 33 percent of all events. This shows how vulnerable Indian people are to an array of natural calamities. Inquiry into pre- and post-earthquake risk management dimensions is needed to repel hazardous effects of natural disasters. The research focuses on pre- earthquake risk management dimensions with special attention to post earthquake risk management issues, important for participatory approaches.

**Keywords:** Earthquake Risk Management; Disaster; Gap Analysis

**Introduction**

Between 1974 and 2003, India experienced 303 disasters resulting in 1,832,098,717 victims (People killed and affected) and a loss of US \$ 43,378 million (Guha-Sapir, 2004). Earthquake prone regions cover about 60 percent landmass of India. This research, therefore, focuses on the two historically significant earthquake events at Latur and Bhuj. These happenings show that the past colossal loss of lives and property is demanding an in-depth study of its effects so that an effective mechanism can be put in place to address the needs of mitigation and response. Having realized its importance, the research traces the gaps observed for examining the effectiveness of earthquake risk management. Even though the research is based on the response received in the Indian context, its application is universal.

Pre-Earthquake Risk Management (Pre-EQRM) measures are a function of several parameters namely, Preparedness (pr), Human Measures (hm), Non-structural Measures (ns), Risk Analysis (ra) and Structural Measures (sm).

Similarly, Post-Earthquake Risk Management (Post-EQRM) measures are a function of several parameters namely, Efficacy (ef), Human Resource Response factor (hr), Planning (pl), Risk factor (rf) and Built Environment (be).

EQRM performance is based on the pre- and post-earthquake risk management measures. Thus,

$$\begin{aligned} \text{EQRM performance} &= f(\text{pr, hm, ns, ra, sm}) + f(\text{ef, hr, pl, rf, be}) \\ &= f(\text{pre-disaster variables}) + f(\text{post-disaster variables}) \end{aligned}$$

Developing a clear and practical understanding of the overall field of disaster management, deep insight into earthquake risk management and its factors of mitigation and response has done the literature search. The research focuses on pre- and post-earthquake measures in Latur and Bhuj regions, based on the perceptions of the affected community, Non-Governmental Organizations (NGOs), government officials and future professionals in four schools of Architecture in the region. The victims or affected people in two places in Latur and Bhuj regions have gone through

hardship from the effects of the earthquake. They have seen how the event causes damage, the way government and non-government organizations work and the response of buildings and their designers. Therefore, victims constitute the primary source of data collection for the study of variables of Pre-EQRM and Post-EQRM performance. On the other hand, the NGOs worked in the affected region have experienced the conditions in which humanitarian work has been carried out. Their perception of the variables is also important for the study. The government officials, during the events, had to work in different ways than the routine. They have their own perception ratings for the variables under study. Their input is important for the study. The ways in which the buildings are designed and constructed make them vulnerable to the effects of earthquakes, in turn affecting safety of people, who occupy them. Innovative ideas come from designers who design buildings. The students of architecture or future professionals are the ones who need to learn from the past and apply good practices in their designs for new projects to be more resilient to the earthquake shocks. Their perception of the variables under study is important for this research.

## **Research Method**

### **Research Question or Research Hypothesis:**

Is there a significant difference in the perception of EQRM with respect to pre- and post-disaster issues between service providers and affected community?

Based on the above question, eight subsidiary questions, that will lead answering the main question, were formulated. Structural models related to differences in the pre- and post-EQRM perception based on region-wise and sector-wise experience were set up. Four main hypotheses covering regions and sectors for pre- and post-EQRM dimensions were formulated.

A metric was formulated based on the factor analysis conducted on pilot survey in two regions under study. The data was collected during September 2007-January 2008. The responses were grouped into five factors concerning pre-EQRM and five factors concerning post-EQRM. The instrument thus prepared was subjected to validity and reliability tests as per standard procedure. The method adopted in this research has been partly quantitative and partly qualitative. It follows a standard practice that relies on empirical evidence; utilizes relevant concepts; follows objective considerations; presupposes ethical neutrality and results into probabilistic predictions (Kothari 2006). The qualitative side of research is based on discussion guided to test in small groups (Groat and Wang 2002) in focused interviews.

### **Research Objectives**

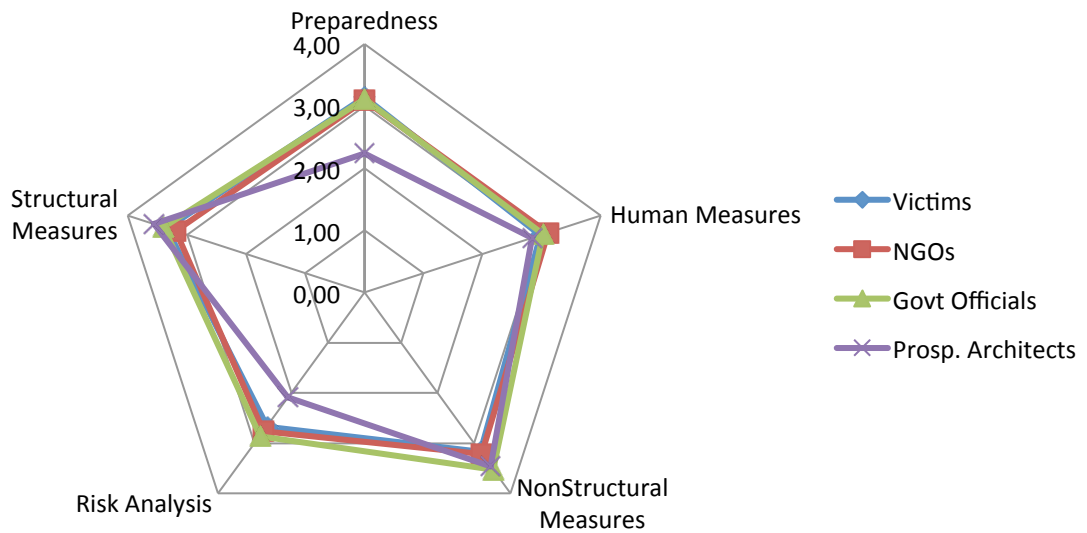
- To study existing models of disaster management / EQRM and prepare a metric for studying their effectiveness.
- Apply the metric to study the effectiveness of the EQRM processes in the two affected regions.
- To perform gap analysis, draw implications and develop a correlation matrix.

## Research Results (Gap Analysis)

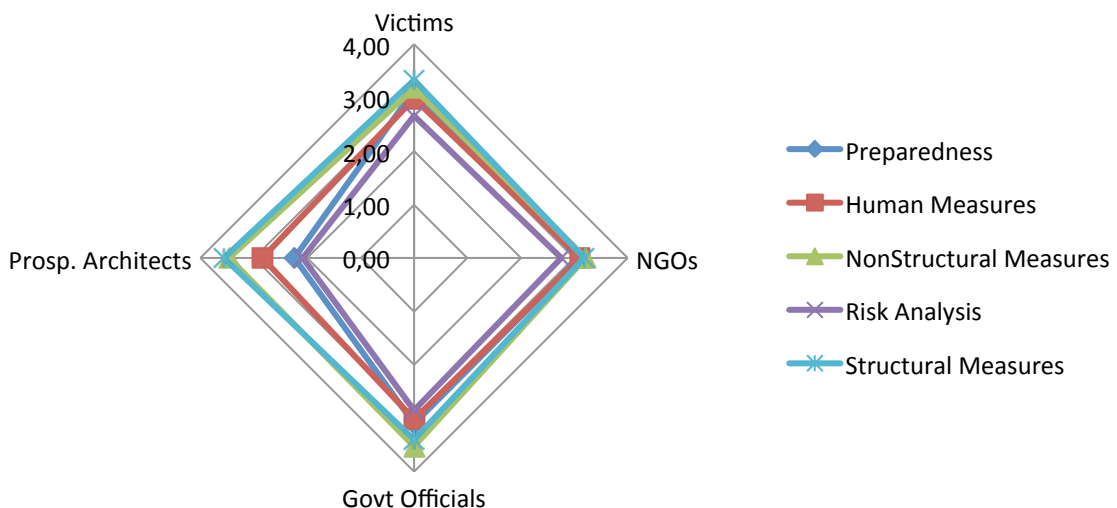
Hypotheses were tested and gap analysis of the responses received has been performed based on the mean sector-wise response rate with respect to each dimension under study. The results are shown in Tables 1 and 2, and corresponding radar diagrams are given in Figs. 1, 2, 3 and 4.

**Table 1.** Sector-wise Rating Averages (Pre-EQRM Dimensions)

Dimension	Victims	NGOs	Govt. Officials	Prospective Architects
1.Preparedness	3.14	3.09	3.11	2.24
2.Human Measures	2.99	3.11	3.02	2.84
3.Non-structural Measures	3.17	3.21	3.53	3.46
4.Risk Analysis	2.67	2.76	2.86	2.09
5.Structural Measures	3.34	3.19	3.40	3.56



**Fig. 1.** Sector-wise Radar Diagram of Gaps (Pre-EQRM Dimensions)



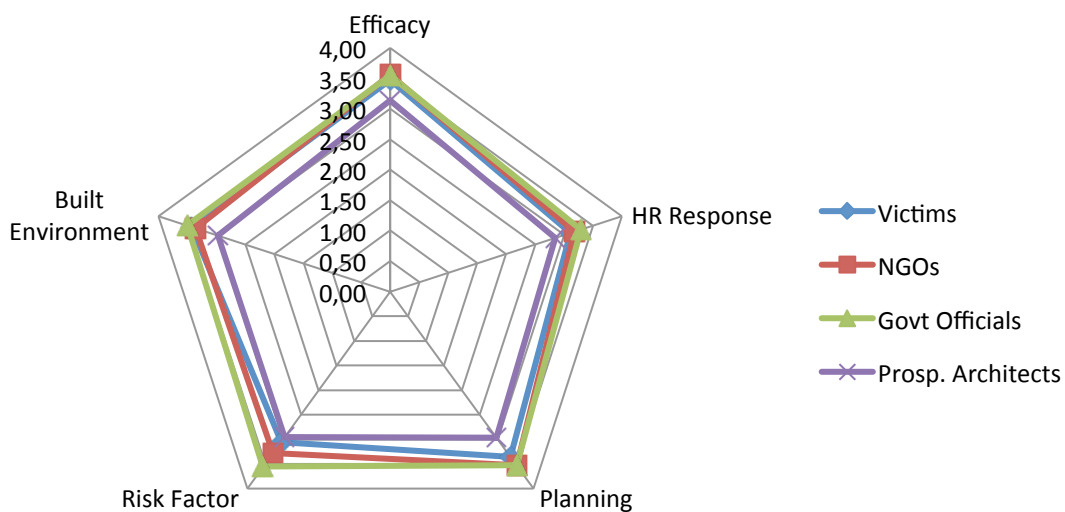
**Fig. 2.** Dimension-wise Radar Diagram of Gaps (Pre-EQRM Sectors)

Fig. 1 reveals that diversified opinion on some pre-EQRM issues exists between prospective architects and others. Prospective architects have rated 'preparedness' much lower than others; whereas victims, NGOs and government officials have reasonably unified opinion on the 'preparedness'. Further, diversified opinion can be observed between prospective architects and the rest of the respondents on 'Risk Analysis' dimension. This opinion is more diversified between prospective architects and government officials; however, it is, to a degree, unified between victims and NGOs. The rating of the victims, NGOs and govt. officials vary between 2.67 and 2.86 on a scale up to 5. The aspects of 'Structural Measures' and 'Non-structural Measures' show higher rating of prospective architects and govt. officials over NGOs and victims; whereas victims and NGOs have rated it lower.

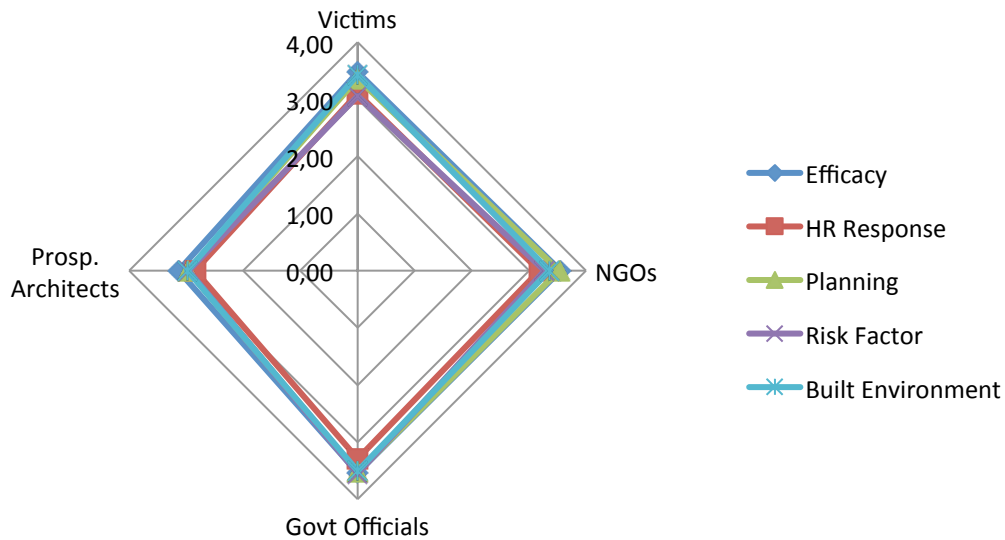
Fig. 2 provides the dimension-wise radar diagram to help identify gap of perception within a chosen dimension by a particular sector of respondents. The prospective architects display varied perception ratings having 'risk factor' rated the lowest and 'structural measures' being the highest rated with human measures being averagely rated. This shows they are diversified in their opinion on various dimensions under study. Other sectors like victims, NGOs and Government officials do not display as much diversified opinion on these dimensions. Within relatively small variation of ratings, 'structural measures' and 'non-structural measures' are rated higher over 'human measures' and 'risk analysis'. 'Human measures' are being rated in a mid-level rating by all sectors.

**Table 2.** Sector-wise Rating Averages (Post-EQRM Dimensions)

Dimension	Victims	NGOs	Govt Officials	Prosp. Architects
Efficacy	3.48	3.55	3.54	3.13
HR Response	3.11	3.18	3.29	2.85
Planning	3.36	3.53	3.53	2.97
Risk Factor	3.05	3.28	3.56	2.96
Built Environment	3.43	3.36	3.51	2.98



**Fig. 3.** Sector-wise Radar Diagram of Gaps (Post-EQRM Dimensions)



**Fig. 4.** Dimension-wise Radar Diagram of Gaps (Post-EQRM Sectors)

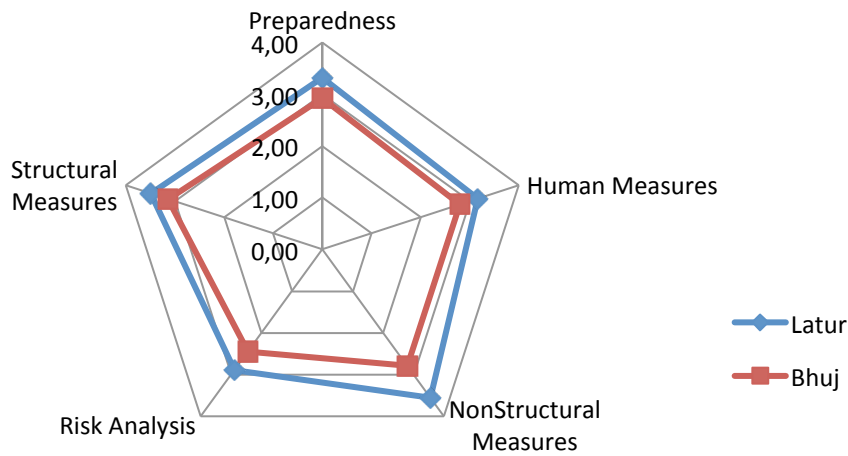
Fig. 3 provides the Sector-wise radar diagram of Rating Averages of Respondents indicating Post-EQRM gaps of perception ratings; whereas Fig. 4 provides Dimension-wise radar diagram of Rating Averages of Respondents showing Gaps of various sectors. Consistent difference of rating has been observed between Prospective architects and the rest of the sectors. 'Efficacy' has been rated the highest by all sectors, except Govt. officials, who, surprisingly, rated 'Risk factor' the highest. Interestingly, all other sectors have clearly rated the same the lowest. The Govt officials with respect to others' rating on the same dimensions have rated 'HR response' highest. 'Planning' has been averagely rated; except by prospective architects, who have retained some rating gap over others.

Fig. 4 provides dimension-wise radar diagram of rating responses of four sectors against five dimensions. 'Efficacy' has been rated high by all sectors, more so by the NGOs at 3.55. Generally, the diagram shows focused opinion of all sectors on the dimensions.

Gap analysis has also been performed based on the mean sector-wise response rate with respect to each dimension under study and for each region under study. Using SPSS software mean was calculated and based on it Region-wise radar diagrams were created. The results are shown in Tables 3 and 4, and corresponding radar diagrams are given in Figs. 5 and 6.

**Table 3.** Region-wise Rating Averages (Pre-EQRM)

Dimension	Latur	Bhuj
Preparedness	3.32	2.92
Human Measures	3.16	2.80
Non Structural Measures	3.55	2.79
Risk Analysis	2.89	2.45
Structural Measures	3.49	3.14

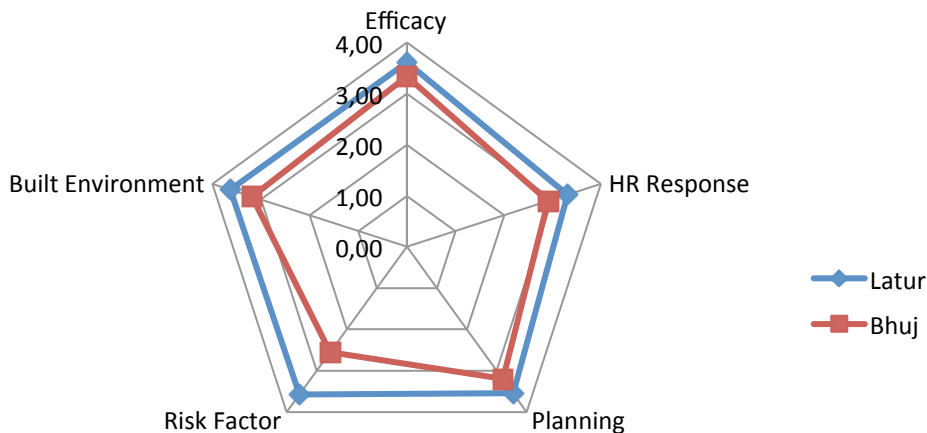


**Fig. 5.** Region-wise Radar Diagram of Gaps (Pre-EQRM Dimensions)

Fig. 5 provides Region-wise Pre-EQRM Rating Averages of Respondents in Latur and Bhuj. Here the comparison has been done between the responses of Latur and Bhuj. It is obvious from the diagram that respondents of Latur have rated all dimensions higher than the responses of Bhuj respondents. Especially, for 'Non-structural' measures the opinion is more diversified.

**Table 4.** Region-wise Rating Averages (Post-EQRM)

Dimension	Latur	Bhuj
Efficacy	3.62	3.33
HR Response	3.31	2.91
Planning	3.54	3.19
Risk Factor	3.58	2.56
Built Environment	3.64	3.18



**Fig. 6.** Dimension-wise Radar Diagram of Gaps (Post-EQRM Regions)

Fig. 6 provides Region-wise Post-EQRM Rating Averages of Respondents in Latur and Bhuj. Here the comparison is done between the respondents of Latur and Bhuj. Here too Latur ratings are higher than Bhuj ratings. Although, respondents of Latur and Bhuj are more or less unified on 'Planning', 'HR Response' and 'Efficacy' dimensions, they have more diversified opinion on 'Risk Factor'. However, none has given a maximum rating of 5.

## Discussion and Conclusions

Gap analysis has been performed (Tables 1 to 4) for pre- and post-EQRM dimensions. It has been done to reveal disparity between the perceptive ratings of various dimensions by service providers and service receivers.

### *Sector-wise Comparison (Pre-EQRM)*

Gap analysis in Fig. 1 reveals some important observations about various sectors regarding pre-EQRM dimensions. Diversified opinion has been found between prospective architects and others on the pre-EQRM issues. Prospective architects are found to be deficient in their understanding of preparedness, whereas victims, NGOs and government officials have a reasonably unified opinion on this dimension. Further, diversified opinion has been observed between prospective architects and the rest of the respondents on the Risk Analysis dimension. The opinion is more diversified between the prospective architects and government officials; however, it is to a degree, unified between victims and NGOs. This shows that prospective architects, being in the field of architecture, have less understanding about the risk analysis or they feel they need not know about it. The rating of the victims, NGOs and govt. officials vary between 2.67 and 2.86. There is a considerable opportunity to increase their level of perception on this dimension. The aspects of Structural Measures and Non-structural Measures show higher perception of prospective architects and govt. officials over NGOs and Victims. Technical professionals like architects and representatives of regulatory mechanism like govt. officials understand the importance of these measures; whereas the victims and NGOs are not aware of its technicality.

Fig 2 provides the dimension-wise radar diagram to help identify gaps of perception within dimensions by various sectors. The prospective architects display their varied perception ratings. They have rated Risk Factor the lowest and the Structural Measures the highest; Human Measures being averagely perceived. Other sectors display more or less unified perception ratings on all five dimensions with Non-structural and Structural Measures being of higher rating than Human Measures and Risk Analysis in that order. There is an opportunity to improve upon diversified opinions of prospective architects on various dimensions.

### *Sector-wise Comparison (Post-EQRM)*

Fig. 3 provides the radar diagram indicating Post-EQRM gaps of perception ratings of various sectors. Govt. officials and NGOs have nearly unified opinion of Efficacy, HR Response, Planning and Built Environment. These sectors being closely related to administration and management, and being associated with the regulatory aspect, it is obvious that they show their agreement. They differ on Risk Factor. Govt. officials understand various dimensions of risk in a post-disaster scenario, whereas prospective architects and victims are not sure about this. There is a scope for intervention in this area.

Comparative diversified opinion has been observed between prospective architects and all other sectors on all five dimensions, in the sense of prospective architects not being able to fully comprehend the dimensions, except for the built environment, which is part of their learning. They truly feel that a lot more can be done to improve response of settlements to future disasters. The government officials felt that service provided in planning related to relief camp and accommodation was satisfactory however; prospective architects felt that much more could have been done.

Fig. 4 provides dimension-wise radar diagram of rating responses of four sectors against five dimensions. Efficacy has been rated high by all sectors, more so by the govt. officials. It is quite obvious that officials understand the importance of being efficient in connection with a disaster event. The lowest rated dimension by all the sectors is the Risk Factor. This clearly underlines the inadequacy of their understanding of the potential risks, although many of them had earlier gone through or observed the trauma aspect of a disaster.

### *Region-wise Comparison (Pre-EQRM)*

Fig. 5 provides Region-wise Pre-EQRM Rating Averages of Respondents in Latur and Bhuj. The comparison shows that respondents of Latur have rated all dimensions higher than the Bhuj respondents. Especially, for 'Non-structural' measures the opinion is more diversified, in the sense that Latur respondents have rated it the highest amongst all five dimensions, whereas Bhuj has recorded it lower. The understanding of Latur respondents about Non-structural Measures is more than Bhuj. There is a scope to increase Bhuj region's awareness on all dimensions considerably to as to match with Latur region or higher. The awareness of Latur region can also be increased to the highest of 5 on the rating scale.

### *Region-wise Comparison (Post-EQRM)*

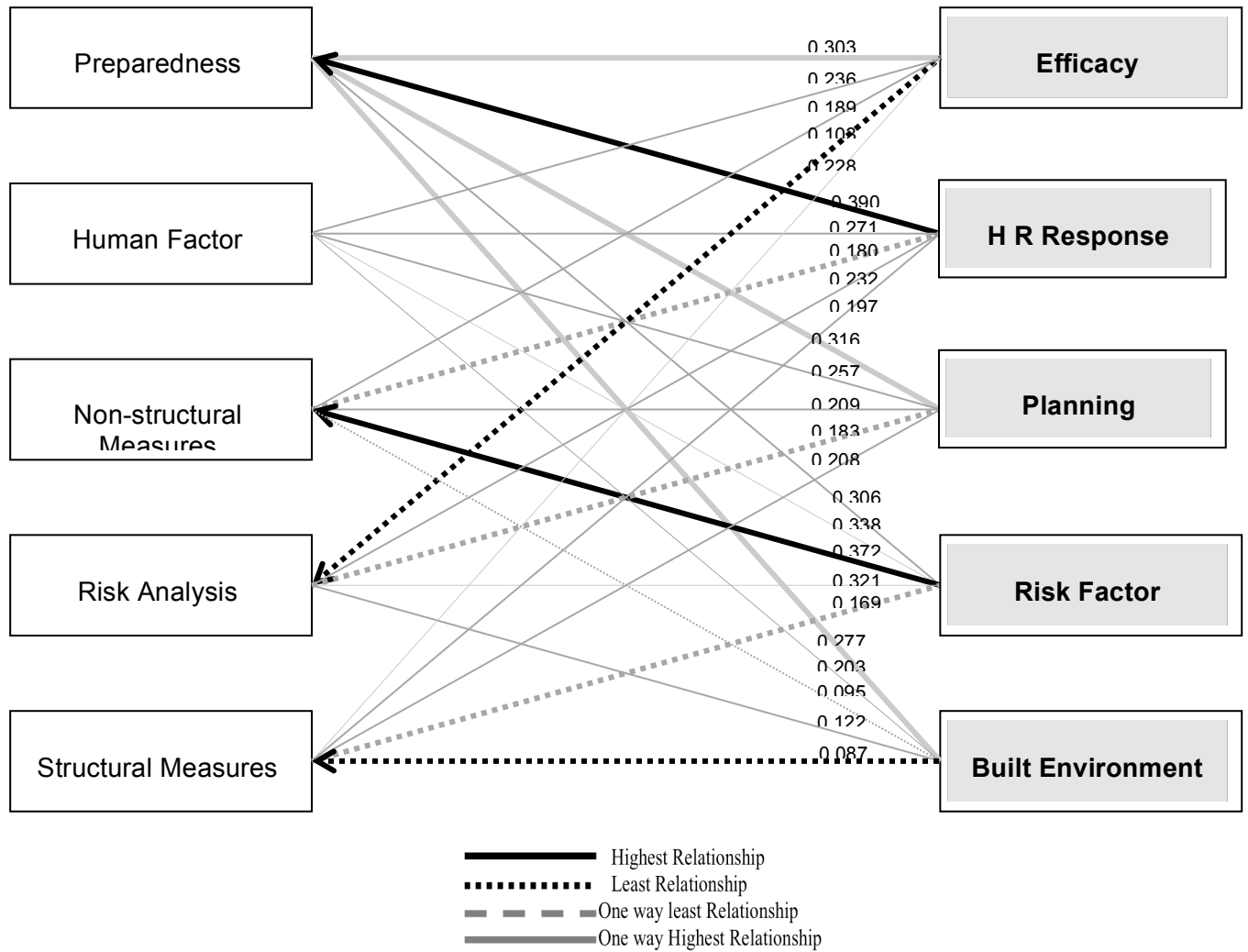
Fig. 6 provides Region-wise Post-EQRM Rating Averages of Respondents in Latur and Bhuj. Here the comparison is done between the respondents of Latur and Bhuj. The Latur ratings have been found higher than Bhuj ratings. Although, respondents of Latur and Bhuj are more or less unified on 'Planning', 'HR Response' and 'Efficacy' dimensions, they have more diversified opinion on 'Risk Factor'. However, none have given a maximum rating of 5. Hence, it can be concluded that Latur region needs efforts to increase their understanding on various post-disaster aspects. Efforts at governmental level are needed to gain service receivers' confidence by visible results in efficacy and planning during normal times. Bhuj region can aspire to elevate their understanding comparable to Latur or higher. The authorities need to show concerted efforts to gain people's confidence on appropriate systems being in place to counter damaging effects of future disasters. Fig. 7 provides these interrelationships in a graphical model.

The Post-EQRM dimensions of efficacy at management level, desired human resource response by various agencies, planning to deal with future disasters, risk factor to be taken in to account for on and off the job risks and built environment that faces a critical balance today are important to contain the adverse effects of a disaster, Disaster preparedness and mitigation, especially related to the earthquake risk, should be integrated with development in which construction is one of its factors. It goes without saying that – 'Construction and destruction are two sides of the same coin of human development – one initiate development and the other counters it' (Deshmukh & Krishnamurthy 2006).

#### **Key Lessons Learned:**

- Prospective architects are deficient in their understanding of earthquake risk preparedness and risk analysis and as such, they need to be exposed to on-site and participatory issues dealt by NGOs and government officials.
- Victims and NGOs better perceive risk analysis.
- Understanding of structural measures is weak in NGOs and victims; as such, they need training in understanding architectural and structural issues better.
- The regions under study do not exhibit full understanding (rating 5) of any of the pre- or post-EQRM dimension, so general awareness and enhanced sensitization efforts in public awareness programs with participation from various sectors of expertise are the present day need.





**Fig. 7. Correlation Matrix of Relationship (Post-EQRM to Pre-EQRM)**

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## Author's Biography



**Ravindra Deshmukh** has 34 years of experience in profession, teaching and research. He served in North and South India, and in Africa. Professor Deshmukh has been with MIT for the last 20 years. He graduated in architecture from the Visvevsarayya National Institute of Technology, Nagpur in 1971 and did further post graduate studies at the Indian Institute of Technology, Roorkee in 1973. He completed his PhD on 'Development of Earthquake Risk Management Effectiveness Model with an Architectural Perspective' at Manipal University in 2009. He was the UGC Fellow at the University of Chile in South America in 1998. He was selected as the Fulbright Scholar by the United State's Educational Foundation in India (USEFI) to teach at the North Dakota State University, USA during the fall of 2005. He served on the Indian Society for Technical Education (ISTE) as National Visiting Professor during 2006-07. Specialized in Design, he now pursues his research in disaster management and is associated with the National Resource Institute for the National Program for Capacity Building of Architects in Earthquake Risk Management (NPCBAERM). He is currently professor at BN College of Architecture for Women at Pune. Cell: +91 9423201570