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Natural Disasters

Multifaceted Aspects in Management and Impact Assessment

Edited by Olga Petrucci

NATURAL DISASTERS - MULTIFACETED ASPECTS IN MANAGEMENT AND IMPACT ASSESSMENT

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http://dx.doi.org/10.5772/50134
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Contributors

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First published in Croatia, 2013 by INTECH d.o.o.
eBook (PDF) Published by IN TECH d.o.o.
Place and year of publication of eBook (PDF): Rijeka, 2019.
IntechOpen is the global imprint of IN TECH d.o.o.
Printed in Croatia

Legal deposit, Croatia: National and University Library in Zagreb

Additional hard and PDF copies can be obtained from orders@intechopen.com

Natural Disasters - Multifaceted Aspects in Management and Impact Assessment
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p. cm.

ISBN 978-953-51-1190-0

eBook (PDF) ISBN 978-953-51-5045-9

Meet the editor

Olga Petrucci is a Researcher of the Research Institute for Geo-Hydrological Protection (IRPI) working in Cosenza Section of the Institute (Italy). She works on both triggering conditions and effects caused by damaging hydrogeological phenomena as landslides and floods. She carried out several researches on the occurrence of these phenomena, thus realizing a database which currently is made of more than 11,000 records describing the occurrence, during the last two Centuries, of damaging landslides and floods in Calabria (Italy). The results of historical researches that have been published reveal the occurrence of not widely known hydrogeological phenomena, thus contributing to the dissemination of information on them. Moreover, she has been working on the impact of these phenomena, even elaborating damage assessment methodologies. She is currently in charge of the Historical Archive of IRPI Section of Cosenza and is author of several articles published on international journals and books also available on Google Books.

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Preface

This book is an overview of the complex and multifaceted topic of natural disasters impact. When a natural disaster affects an urbanized sector it can destroy or heavily damage physical elements laying in the area, causing loss, social and economic disruption, and environmental damage. At the same time, the unexpected alterations of the socio-economic environment can have several both short- and long-term effects on people health. A large number of possible approaches can be undertaken in order to assess economic, psychological, societal or environmental damage, aiming to reduce the effects of future disasters on the whole of these sectors. Moreover, the study approaches must be different according to the differences of grassroots characterizing social and cultural environments of the affected areas.

This book proposes a range of studies realized in different continents, showing various aspects from which natural disasters can be view, thus giving the measure of the complexity and multidisciplinary of the topic. It starts with a paper presenting a possible strategy to either avoid or reduce the vulnerability of concrete buildings during floods. Then, it continues with an insight into the communication during post-disaster emergency phase and with two chapters concerning the assessment of two different kinds of impact on people everyday life. The book ends with an analysis of the role of stakeholder participation in post-disaster reconstruction.

Chapter 1, by *Chidambarathanu and Retnam*, deals with prevention of damage related to floods, one of the most destructive type of natural disasters that every year cause huge economic damage and victims, especially in countries where urban settlements have been expanding dangerously near to rivers, without undertaking any kind of precautionary measure. The chapter focuses on the incorporation of flood loads during the design stage of reinforced concrete buildings and the assessment of flood vulnerability of these buildings. The study, carried out with reference to the Indian constructive standard code, aims to find out the flood vulnerability limit as a factor of ground floor height under flood forces, and to quantify flood load. Three different frame models are analyzed, and the results are plotted to compare the effects of flood forces in each type of frames. In a prevention perspective, aiming to recognize actions that can reduce vulnerability of reinforced concrete buildings before possible harm occurs, the importance of the outcome arises from the need of a strengthening solution to the new or existing structures in order to avoid their failure during flood.

Chapter 2, by *Fujiwara and Watanabe*, firstly reviews some networking technologies for disaster communications, and then discusses a scheme of multi-tier damage monitoring in a citywide area during natural disasters. It shows the scheme of the centralized hierarchical network and the experimental system designed for dedicated damage monitoring. The monitoring system is capable of collecting information within one minute from 256,000 terminals deployed in a whole city. Thereby, the system is useful and effective to collect data quickly and stably in conditions where the links could be maintained. Based on both the concept of the centralized hierarchical network and the experimental results, it is shown that the hybrid wireless monitoring system enhanced with ad hoc networks. The experiments by computer simulation show as the network is capable of improving reachability of packets, even in the damaged conditions of natural disasters. The chapter shows system configured with a centralized hierarchical network, which was developed to acquire damage information from lifeline facilities installed in residences. Some results of computer simulation for multi-tier networks enhanced with an ad hoc networking technique are also presented

In **Chapter 3**, *Robinson* analyses the impacts that were observed after Hurricane Katrina (23 August 2005) on the population and individuals who are living with or at risk for HIV/AIDS in Louisiana and the New Orleans area. These findings are also interpreted in the light of the Socio-Ecological Model of Health, in order to conceptualize how a major disaster like Katrina can have long reaching impacts on not just the individual but on entire communities and systems under which people live. The study highlights how a disaster can interfere with the large population living with HIV/AIDS or those who may be at risk for HIV in Louisiana. This numerous group of people can be seen as more vulnerable and may be disproportionately affected, thus it has been critical to examine the impact of the storm on the epidemic.

Chapter 4, by *Calkins and Win,* shows an attempt to measure the subjective, intangible impacts of the cyclone Nargis (Myanmar, 2 May, 2008) on the happiness and well-being of the inhabitants of the affected area. The goal is to infer, using two study areas differentially affected, its impacts on the level and distribution of well-being and social capital, and to make policy recommendations for the alleviation of some of the psychic effects. In fact, having no baseline of well-being of the heavily affected area, a slightly affected area was selected as a proxy benchmark for the "before" situation, against which the "after" situation, 27 months following Nargis, is then compared. The results show that the happiness of the heavily affected area is not significantly different from that of the slightly-affected area, suggesting that human beings rebound rapidly from disasters. For both areas, spiritual happiness is more than twice as important as emotional happiness, and physical happiness is less than one-third as important as spiritual happiness. The study demonstrated that the impacts of natural disasters tend to strengthen social capital, while assistance and aid, if poorly administered, can undermine it. Social capital can play a strategic role in rehabilitating organizational performance, farm productivity, and mental health following a disaster. Furthermore, the informal safety net during disasters plays a pivotal role in helping people to access the resources such as credit.

Finally, **Chapter 5**, by *Darabi et al.,* presents a detailed analysis of the post-disaster reconstructions management in the case of three earthquakes occurred in Iran, stressing a barely explored topic: the role of stakeholder participation to reconstruction. Starting from these cases study, the chapter presents a panoramic framework of the different and complex post disaster strategies used for reconstruction after major natural disasters, highlighting the multi-faceted, multi-scale and uncertain process which involve and affect multiple actors and agencies for long periods after the disaster strikes. The review of the reconstruction policies applied in the case of the three Iranian earthquakes analyzed shows that even though facing with both criticisms and obstacles, participation presents several advantages making it attractive for governments and reconstruction managers. Moreover, for the specific case of Iran, despite of limited participation, the attitudes have been changing over the time. One of the results of people participation is for example work division that leads to eliminate or strongly reduce conflicts between organizations, thus speeding reconstruction process and avoiding parallel or duplicated works.

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Chapter 1

Vulnerability of Reinforced Concrete Structures Subjected to Flood

Natarajan Chidambarathanu and Remya Retnan

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/53879

1. Introduction

Floods are one of the most widespread and destructive natural disasters occurring in the world (Singh and Sharma 2009), and with the increase in constructions along river courses and concentration of population around floodplain areas, flood-induced damages have been continuously increasing. The annual disaster record reveals that flood occurrence increased about ten folds over the past five decades (Scheuren et al. 2007). Thus, floods are posing a great threat and challenge to planers, design engineers, insurance industries, policy makers, and to the governments.

Structural and non-structural measures can be used to deal with floods (Sagala 2006). Structural measures include a set of works aiming to reduce one or more hydraulic parameters like runoff volume, peak discharge, rise in water level, duration of flood, flow velocity, etc. Non-structural measures involve a wide range of measures to reduce flood risk through flood forecasting and early warning systems, emergency plans, and posing land use regulations and policies. The futuristic reinforced concrete buildings can be considered as a symbol of modern civilization. These buildings are usually constructed based on the guide lines given by the standard code books (like IS:456:2000, for India). Unfortunately, the code provisions consider the seismic loads and wind effects alone, while accounting the dead and live design loads, and exclude the flood loads. This implies the necessity to bring out corrective measures that can be adopted to reduce vulnerability before harm occurrences.

This chapter focuses on both the incorporation of flood loads during the design stage and the assessment of flood vulnerability of reinforced concrete buildings. Vulnerability is expressed as a fraction of ground floor height and assumes that flood water at most immerse the building up to ground floor level. The importance of the outcome arises from the need of a strengthening solution to avoid failure of new or existing structures during floods.

1.1. Forces due to flood

The physical forces which act on the buildings include hydrostatic loads (Fig.1.), hydrodynamic loads (Fig.2.), and impact loads, and these loads can be exacerbated by the effects of water scouring soil from around and below the foundation (FEMA, 2001). The *hydrostatic loads* are both lateral (pressures) and vertical (buoyant) in nature. The lateral forces result from differences in interior and exterior water surface elevations. As the floodwaters rise, the higher water on the exterior of the building acts inward against the walls of the building. Sufficient lateral pressures may cause permanent deflections and damage to structural elements within the building. The buoyant forces are the vertical uplift of the structure due to the displacement of water, just as a boat displaces water causing it to float. These uplift forces may be the result of the actual building materials (the floating nature of wood products), or due to air on the interior of a tightly built structure. When the buoyant forces associated with the flood exceed the weight of the building components and the connections to the foundation system, the structure may float from its foundation.

The water flowing around the building during a flood creates *hydrodynamic loads* on the structure. These loads are the frontal impact loads from the upstream flow, the drag on the sides of the building, and the suction on the rear face of the building as the floodwaters flow around the structure. The magnitude of the hydrodynamic loads depends on both the velocity of water and the shape of the structure. Like the hydrostatic pressures, these lateral pressures may cause the collapsing of either structural walls or floors.

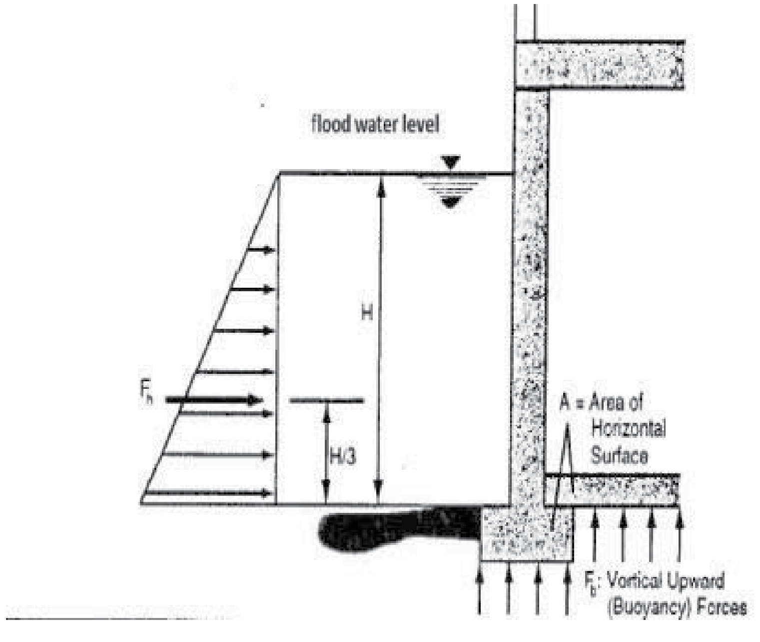

Figure 1. Schematic sketch of hydrostatic force (FEMA, 2001)

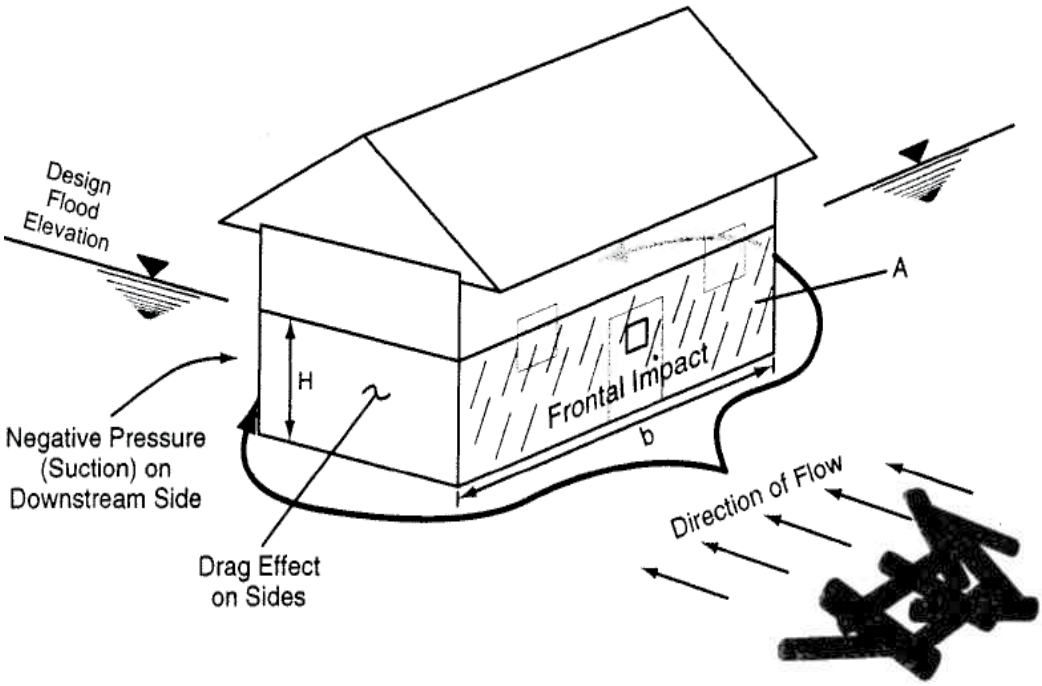

Figure 2. Schematic sketch of hydrodynamic force (FEMA, 2001)

Impact loads during floods may be the direct forces associated with waves, as typically encountered during coastal flooding, or the impact of debris floating in the waters, including logs, building components, and even vehicles. Impact loads can be destructive because the forces associated with them may be an order of magnitude higher than the hydrostatic and hydrodynamic. Floating debris can have devastating effects, as they apply large and/or concentrated loads to the structural elements of the building.

2. Literature review

FEMA (2001) published a manual focusing on the retrofitting of family residences subject to flooding without wave action. The measures include elevation of the structure in place, relocation of the structure, construction of barriers, dry flood proofing and wet flood proofing. The analyses necessary to determine flood-related hazard factors are also presented.

Kelman (2002), in a dissertation on Physical Flood Vulnerability of Residential Properties in Coastal Eastern England, examined the lateral pressure from flood differential depth between inside and outside a residence.

Kelman and Spenc (2004) categorised flood actions on buildings as energy transfers, forces, pressures, or the consequences of water or contaminant contact.

Messener and Meyer (2005) argued that the challenge consists in understanding the interrelations and social dynamics of flood risk perception, preparedness, vulnerability, flood damage and flood management, and to take this into account in a modern design of damage analysis and risk management.

Sagala (2006) examines the physical vulnerability to flood and people's coping mechanisms in flood prone residential areas in Naga city of Philippines. Six structural types of buildings were chosen and for each type of vulnerability curves (flood depth/damage) were plotted. Results indicate that buildings with plywood walls and wooden floors are the most vulnerable while the type with hollow block walls and concrete floors is the least vulnerable.

Arulselvan et al. (2007) conducted an experimental investigation on the influence of brick masonry infill in a reinforced cement concrete frame and validated outcomes by comparing them with theoretical results obtained by finite element analysis. Until the cracks developed in the infill, the contribution of infill to both stiffness and lateral stiffness was found to be very significant. The strains measured in infilled beams and columns were 20% less than bare frame beams up to failure of brick walls.

Haugen and Kaynia (2008) presented a method for prediction of damage in a structure impacted by a debris flow of known magnitude. The method uses the principles of dynamic response of structures to earthquake excitation, and fragility curves proposed in HAZUS for estimation of the structural vulnerability, by the damage state probability. The model was tested on a debris flow in Italy and it gave probabilities between 34% and 66% for reaching the damage levels which actually occurred for five out of six structures.

Kreibich et al. (2009) investigated the importance of flow velocity, water depth and combinations of these two parameters on various types of damages to buildings and roads. A significant influence of flow velocity on damage to roads was found, in contrast to a minor influence on monetary losses and business interruption. The energy head is suggested as a suitable flood impact parameter for reliable forecasting of structural damage to residential buildings.

Lopez et al. (2010) developed a methodology to estimate flood vulnerability to buildings, in either riverine or coastal settings, based on the aggregated damage to individual building components. Building vulnerability is modelled based on analytical representations of the failure mechanisms of individual building components.

3. Methodology

The present work focuses on the assessment of flood physical vulnerability of building expressed as a factor of ground floor height. The influence of design variation zones or boundary conditions has been also investigated. The methodology is schematized in Fig.3.

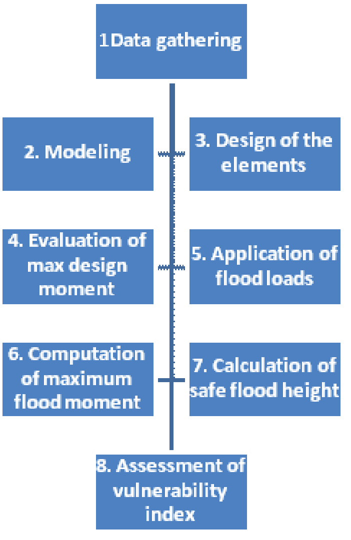

Figure 3. The steps of the methodology

3.1. Building details

The building configuration used for the study is regular, with plan dimensions 9m×18m. Table 1 lists the data associated with a four storey reinforced concrete building considered for the analysis, while the plan and elevation of the building are shown in Fig.4. and Fig.5., respectively. In Fig.4., the direction of interest refers the perpendicular direction of flood.

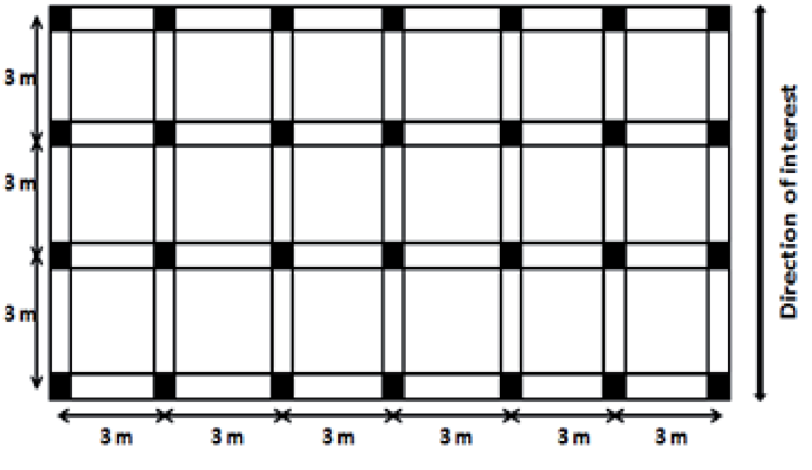

Figure 4. Plan of considered building

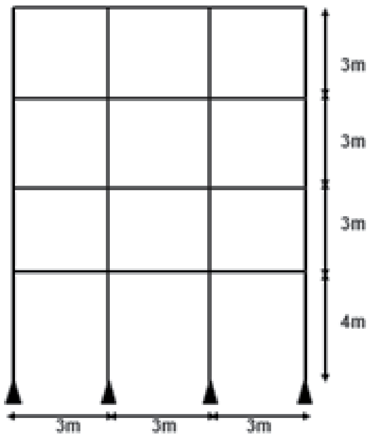

Figure 5. Elevation of frame

Ground floor height	4m
Remaining floors height	3m
No. of bays in X direction	6
No. of bays in Y direction	3
Bay width	3m in both X and Y directions
Column size	300mmx300mm
Beam size	250mmx300mm
Masonry wall thickness	230mm
Slab thickness	120mm
Unit weight of the concrete	25 kN/m^3
Unit weight of masonry	20 kN/m^3
Elastic modulus of steel	2×10^8 kN/m^2
Yield strength of steel	415 N/mm^2
Young's modulus of concrete	25×10^6 kN/m^2
Poisson ratio of concrete	0.2
Compressive strength of concrete	20 N/mm^2
Young's modulus of masonry	13.8×10^6 kN/m^2
Poisson ratio of masonry	0.25
Floor finish load	0.5kN/m^2
Terrace water proofing (TWF) load	1.5kN/m^2
Live load on roof	1.5kN/m^2
Live load on floor	3kN/m^2

Table 1. Reinforced concrete building details

3.2. Modelling

To compute the critical effect, the flood was assumed to act along the 18m side and an intermediate 2D frame along 9m side was considered for the study. Three frame models were used, a) bare frame model, without any partition walls (Fig. 6.); b) frame with light weight partition wall; c) frame with structural infill wall (Fig. 7.). The infill walls were modelled as a diagonal strut having width 230mm, very low moment of inertia, modulus of elasticity 13800 N/mm^2 and Poisson ratio 0.25. The weight of light weight partition walls were considered negligible. Hence, frame models for both bare frame and frame with light weight partition walls were similar but the difference will come in to the picture while applying flood load.

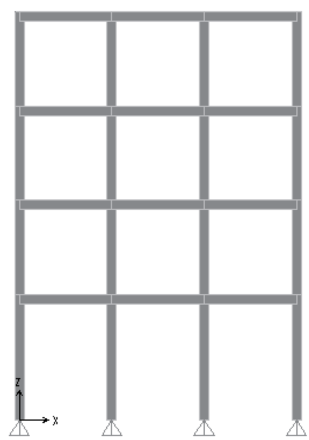

Figure 6. Bare frame SAP model

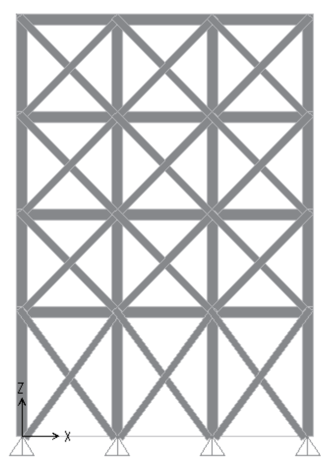

Figure 7. Frame with structural infill walls

3.3. Analysis

The procedure consists of linear static and linear dynamic analysis. When the linear static or dynamic procedures are used for seismic evaluation, the design seismic forces, the distribution of applied loads over the height of the buildings, and the corresponding displacements are determined using a linearly elastic analysis. The various steps involved in SAP model analysis are the following:

- Modelling of frame sections.
- Defining and assigning material properties and section properties.
- Assigning support conditions.
- Defining and assigning load patterns and load cases.
- Assigning load combinations.
- Setting up of analysis option.
- Running analysis.
- Inferring the results.

The load combinations considered for the study are:

a) 1.5 (DL + IL) b) 1.2 (DL + IL ± EL)

c) 1.5 (DL ± EL) d) 0.9 DL ± 1.5 EL

Analyses were carried out for six different conditions of seismic zones, flood duration, flood water height, flood forces, frame models, and support conditions, to obtain the maximum design moment, flood moment and lateral displacements.

3.4. Calculation of design moment

The earthquake load calculations were made for all the zones and all the models analysed, and designed for IS 456:2000. Here, the earthquake zones are considered to demonstrate the different structural variations but not the multi-hazard conditions (Table 2). The design moment is lower for fixed support condition than hinged condition.

Seismic zone	II	III	IV	V
Seismic intensity	Low	Moderate	Severe	Very severe
Z	0.1	0.16	0.24	0.36

Table 2. Zone factor (Ref. IS 1893-2002)

3.5. Calculation of flood loads

Flood loads are assumed to act as: a) hydrostatic loads; b) impact loads as equivalent static loads; c) impact loads as dynamic loads, considering the duration of flood. The hydrostatic loads consist of both lateral pressures and buoyancy forces. Lateral pressure is calculated using the formula $P_s = \gamma\ h_f$ (in kN/m^2), where γ = 9.81 kN/m^3 for water, and h_f is the water depth in meters. Since lateral hydrostatic loads are acting as triangular loads, the resultant hydrostatic load (F_f) acts at $h_f/3$ distance from ground level. Buoyancy force has a significant effect either if the building is surrounded by water or in submerged condition. Here, the flood is considered as slow moving; hence the effect of buoyancy is neglected. Impact loads are velocity dependent loads. As no codes or design books are available for incorporating the impact effects, the magnitude of these loads is arbitrarily considered as a factor of hydrostatic force acting laterally as UDL over the surface. Table 3 shows the magnitude of flood loads acting on the column for the frame models.

h_f (m)	F_f (kN)	Impact UDL (kN/m)	
		$0.1\gamma h_f$	$0.2\gamma h_f$
2	5.89	0.59	1.18
3	13.24	0.88	1.77
4	23.54	1.18	2.35

Table 3. Flood loads on frame models

The flood loads are assumed as dynamic loads by considering the duration of flood t_d. The dynamic displacement and dynamic flood moment are found using a deformation response factor (R). R is the ratio dynamic to static displacement caused by the flood force. The dynamic flood load is assumed as a rectangular pulse (Fig.8.).

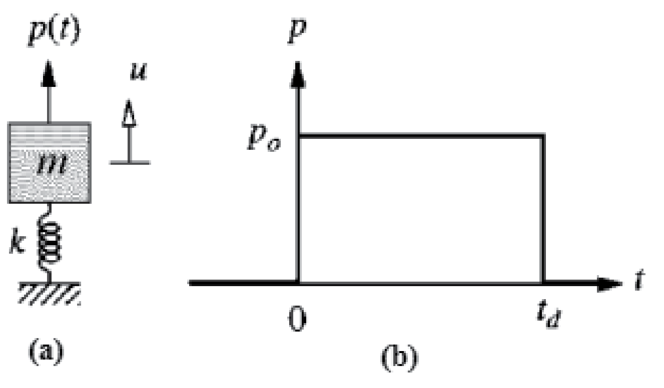

Figure 8. a) SDF system (b) Rectangular pulse load (Chopra, 2009)

The governing equation is:

$$m\ddot{u} + ku = p(t) = \begin{cases} p_0 & t \le t_d \\ 0 & t \ge t_d \end{cases} \tag{1}$$

The R value obtained after solving the equation 2 is (Chopra 2009):

$$R = \frac{u}{u_{st}} = \begin{cases} 2 \sin \pi \frac{t_d}{T_n} & \frac{t_d}{T_n} \le \frac{1}{2} \\ 2 & \frac{t_d}{T_n} \ge \frac{1}{2} \end{cases} \tag{2}$$

Where, u is the dynamic displacement, u_{st} is the static displacement, t_d is the flood duration and T_n is the fundamental natural time period of the structure. The t_d/T_n ratios and corresponding R values used are shown in Table 4. R = 1 indicates the flood as static while R = 2 indicates suddenly applied flood load. Since the flood assumed for the study is slow moving, R will always lies in between 1 and 2.

t_d/T_n	1/6	1/4	1/3	1/2
R	1.000	1.4142	1.7321	2.000

Table 4. Deformation response factor

3.6. Calculation of flood moment and height

Afterwards, analyses have to be carried out for different frame models in each zone with different boundary conditions, and the maximum flood moment in each case must be evaluated. The safe flood height is the height of flood up to which the structure is safe. It is obtained by plotting the moment due to hydrostatic force versus flood height: height corresponding to the design moment gives the safe flood height (h_f, safe).

The vulnerability index is assessed as a factor of ground floor height. It indicates the extent of damage that a flood can cause if the water reaches up to ground floor height. It is calculated using the equation (3).

$$Vulnerability\ index = \frac{ground\ \ floor\ height\ \text{-}\ safe\ \ flood\ height}{ground\ \ floor\ height} \tag{3}$$

4. Experimental results

The analysis was carried out for three frame models under different conditions of:

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- Flood loadings: static, equivalent static, and dynamic loads;
- Support conditions: hinged and fixed;
- Seismic zones;
- Flood water height: 2m, 3m and 4m;
- Flood duration: $T_n/6$, $T_n/4$, $T_n/3$ and $T_n/2$.

For each zone, earthquake loads were assessed for all the zones and all the models designed for IS 456:2000. The earthquake zones (Table 5) are considered to demonstrate the different structural variations but not the multi-hazard conditions. The maxima design moments for both the bare frame and the frame with light weight partition walls are similar, since the weight of partition wall is considered as negligible. The sizes of frame sections, selected according to these moments, are given in Table 6. For the frame with structural infill, the infill walls were modelled as diagonal structures. After applying flood loads, for different frame models and in each zone, for hinged support condition, the maximum flood moment in each case was evaluated. Assuming flood heights of 2m, 3m and 4m from ground level, maxima moments were also obtained (Table 7). Because of the free movement of water in between the columns of the bare frame, the flood moment for bare frame model is very low if compared to the other models.

Zone	Bare Frame	Light weight infill	Structural infill
II	33.56	33.56	64.90
III	45.00	45.00	92.66
IV	62.26	62.26	128.58
V	86.40	86.40	184.09

Table 5. Maximum design moments in kN-m

Frame model	Column size	Beam size
Bare Frame	300 x 300	250 x 300
Light weight infill	300 x 300	250 x 300
Structural infill	350 x 350	300 x 350

Table 6. Frame cross-sections in mm

h_f (m)	Bare Frame	Light weight infill	Structural infill
2	5.74	32.14	30.09
3	9.45	97.58	83.94
4	20.18	205.84	166.33

Table 7. Flood moment due to hydrostatic force (without impact factor) in kN-m

Impact force is assumed to act as UDL, and its value is arbitrarily taken as a factor of hydrostatic force. The impact factors considered are 0.1 and 0.2. For all the models, the moments are linearly increasing as impact load increases, because impact force is considered as a factor of hydrostatic load (Table 8). Non-linearity will come only while considering flood duration. Flood is assumed to act as dynamic rectangular load with flood duration t_d and the maximum flood moment obtained in each case is shown in Table 9.

h_f (m)	Bare Frame		Light weight infill		Structural infill	
	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$
2	5.74	5.74	36.67	41.20	33.62	37.16
3	10.69	11.92	109.92	122.27	92.5228	101.10
4	22.53	24.89	229.40	252.96	180.05	193.77

Table 8. Moment due to hydrostatic and equivalent static impact forces in kN-m

Zone	Bare frame				Frame with partitions			
	R=1	R=1.4142	R=1.7321	R=2	R=1	R=1.4142	R=1.7321	R=2
II	33.56	47.46	58.13	67.12	64.90	91.78	112.41	129.80
III	45.00	63.64	77.95	90.00	92.66	131.04	160.49	185.32
IV	62.26	88.05	107.84	124.52	128.58	181.84	222.71	257.16
V	86.40	122.18	149.65	172.80	184.09	260.35	318.87	368.19

Table 9. Flood moment due to dynamic flood forces in kN-m

Frame type	R=1	R=1.414	R=1.732	R=2
Bare frame and Frame with light weight infill	0.0448	0.0673	0.0897	0.1345
Frame with masonry infill	0.0092	0.0139	0.0185	0.0277

Table 10. Duration of flood (td) in sec

The fundamental frequency and duration of flood will be the same for both the frames. Also, the flood moment obtained is the same for frame with structural and non-structural partitions, because the contact area of flood water is the same for both frames. The safe flood height is obtained by plotting the moment due to hydrostatic force versus flood height. For example, for a frame with light weight partition wall in Zone II, design moment is 33.56 kN-m (Table 5) and its maximum moment due to hydrostatic loading is shown in Table 11. From the graph, the safe flood height corresponding to design moment 33.5596 is 2.0276 m.

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h_f (m)	Max flood moment (kN-m)
2	32.14
3	97.58
4	205.84

Table 11. Maximum flood moment for the frame with light weight partition wall in Zone II.

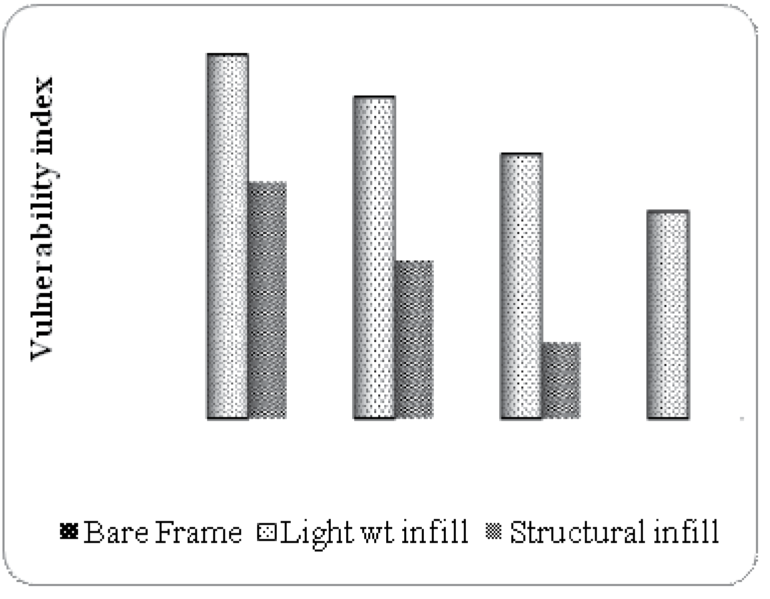

Figure 9. Variation of vulnerability in various zones

The vulnerability index of frame with light weight partition wall is high (49.3%) if compared to the other frames (Fig.8.). For frame with structural infill it only reaches a maximum of 32%, while it is zero for bare frame model. Vulnerability indexes obtained due to hydrostatic and equivalent static impact forces show that the highest values pertain to frame with light weight partition wall (Table 12). Vulnerability indexes obtained due to dynamic flood forces in various zones for different flood duration are shown in Table 13.

Zone	Bare Frame		Light weight infill		Structural infill	
	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$
II	0	0	0.518	0.539	0.347	0.371
III	0	0	0.461	0.484	0.244	0.27
IV	0	0	0.391	0.416	0.134	0.163
V	0	0	0.311	0.339	0	0.027

Table 12. Vulnerability due to hydrostatic and equivalent static impact forces

Bare frame				
R	1	1.414	1.732	2
Zone II	0	0.142	0.300	0.393
Zone III	0	0.061	0.233	0.336
Zone IV	0	0.000	0.160	0.272
Zone V	0	0.000	0.085	0.208
Frame with light weight infill				
Zone II	0.493	0.642	0.707	0.747
Zone III	0.435	0.600	0.674	0.717
Zone IV	0.362	0.549	0.632	0.681
Zone V	0.279	0.490	0.584	0.639
Frame with structural infill				
Zone II	0.320	0.519	0.607	0.660
Zone III	0.214	0.444	0.546	0.607
Zone IV	0.103	0.365	0.482	0.551
Zone V	0.000	0.266	0.401	0.481

Table 13. Vulnerability index due to dynamic flood forces

The storey drifts are evaluated from the lateral joint displacements. According to IS 1893-2002 Cl.7.11.1, the maximum storey drift is 0.004 H, where H is the height of the building. In this study, H = 13 m and hence the maximum allowable storey drift is 52 mm. The frame with structural infill wall has low storey drift if compared to bare frame, because infill walls have significant effect in resisting lateral storey drift (Table 14). For the frame with light weight partition wall, storey drift reaches 71.32mm, which is more than that specified for seismic resistant building (Table 15). Hence a frame with non-structural partitions with hinged support is not preferred in flood prone areas.

h_f (m)	Bare Frame	Light weight infill	Structural infill
2	0.634	5.939	0.084
3	2.017	19.696	0.205
4	4.665	46.242	0.466

Table 14. Storey drifts due to hydrostatic forces

h_f (m)	Bare Frame		Light weight infill		Structural infill	
	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$
2	0.807	0.98	7.666	9.393	0.1	0.116
3	2.578	3.138	25.372	30.975	0.264	0.324
4	5.918	7.172	58.78	71.317	0.616	0.766

Table 15. Storey drifts due to hydrostatic and equivalent static forces

The relative cost for any frame model is calculated with respect to the design moment of bare frame model in zone II (Eq. 4):

$$Cost\ relative_{zone\ III,IV,V} = \frac{DM_{zone\ III,IV,V} - DM_{zone\ II\ (bare)}}{DM_{zone\ II\ (bare)}} \tag{4}$$

Where $DM_{zoneIII,IV,V}$ are the design moments in zones III, IV and V for frame with partitions, and $DM_{zoneII(bare)}$ is the design bending moment of bare frame in zone II.

The relative costs for the three frame models are shown in Table 16. The graph of relative cost versus vulnerability index shows that for the frame with light weight partition wall the cost is increasing but the vulnerability is not reducing that much. Moreover, even though the initial cost is higher for frame with structural partitions, its vulnerability is lower if compared to frame with non-structural partitions (Fig.10.).

Zone	Bare Frame		Light weight infill		Structural infill	
	DM	cost relative	DM	cost relative	DM	cost relative
II	33.560	0	33.560	0	64.898	1
III	45.001	0.341	45.001	0.341	92.658	1.761
IV	62.259	0.855	62.259	0.855	128.579	2.831
V	86.398	1.574	86.398	1.574	184.094	4.486

Table 16. Relative cost as a factor of design moment for three frame models

The vulnerability obtained for different flood loadings is compared with partitions, zones and flood duration (Fig.11. and 12). Dynamic load with R = 1.4142 is used for comparing the results with static results. Frame with light weight infill wall is more vulnerable (64.2%) and bare frame is less vulnerable (14.2%). This is due to the free movement of water in between the columns of the bare frame, so that the contact area of flood water is very low if compared to the other frames. For the frame with masonry infill, vulnerability is less compared to light weight partition, even though the flood moment is the same for both the cases. It is due to the structural action of masonry infill against the lateral flood load.

Comparing vulnerability for different flood loadings to seismic zones (Fig.13.), for the frame with light weight infill, vulnerability is higher in Zone II (64.2%) and it reduces as zone increases (zone V: 49%). For frame with masonry infill, vulnerability is reaching zero as zone varies from II (51.9%) to V (Fig.14.). This is because the design moment of building in zone V is higher if compared to zone II and hence the building in zone V will be more resistive to flood.

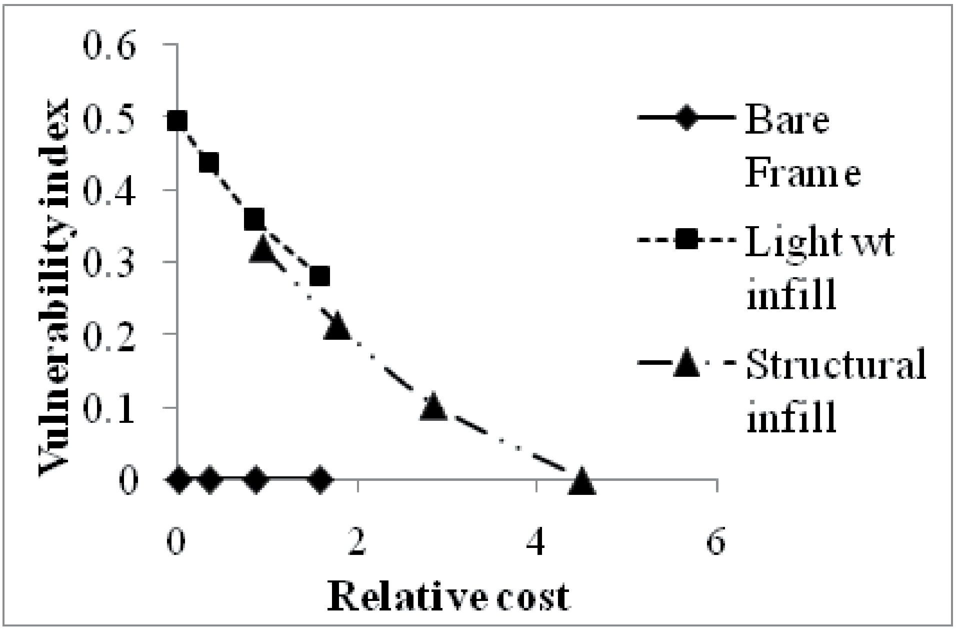

Figure 10. Variation of vulnerability against cost

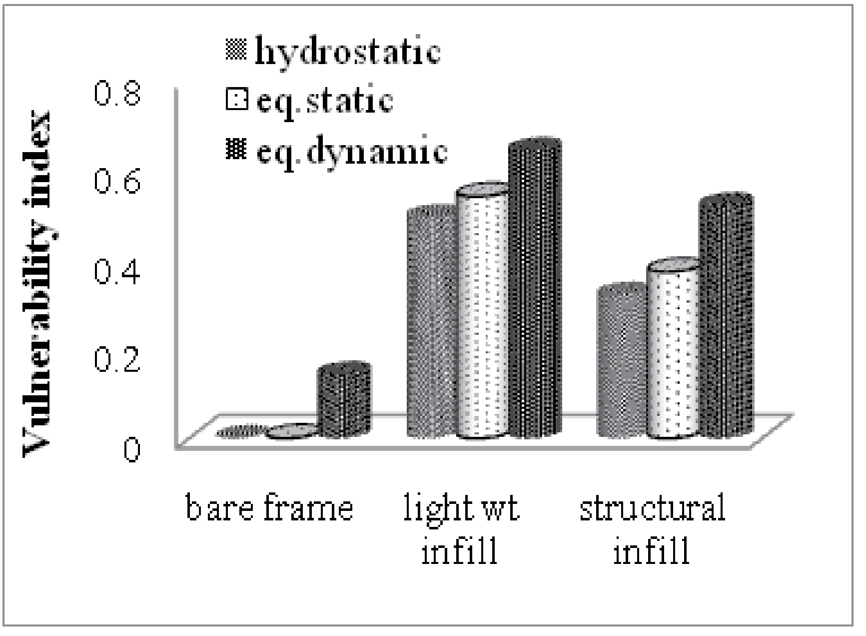

Figure 11. Vulnerability for different frame models in different flood loading conditions in Zone II

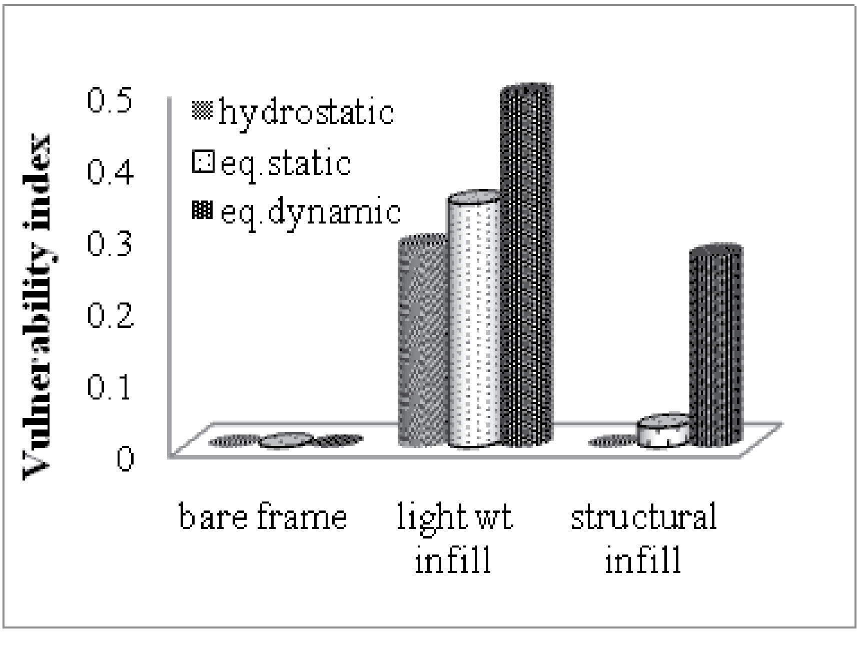

Figure 12. Vulnerability for different frame models in different flood loading conditions in Zone V

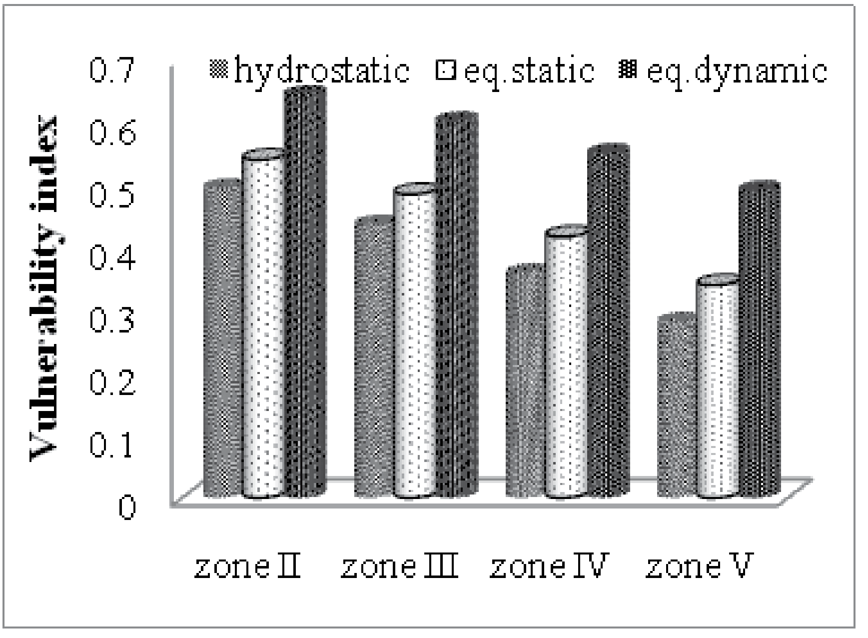

Figure 13. Vulnerability for light weight infill frame under different flood loading conditions in different zones

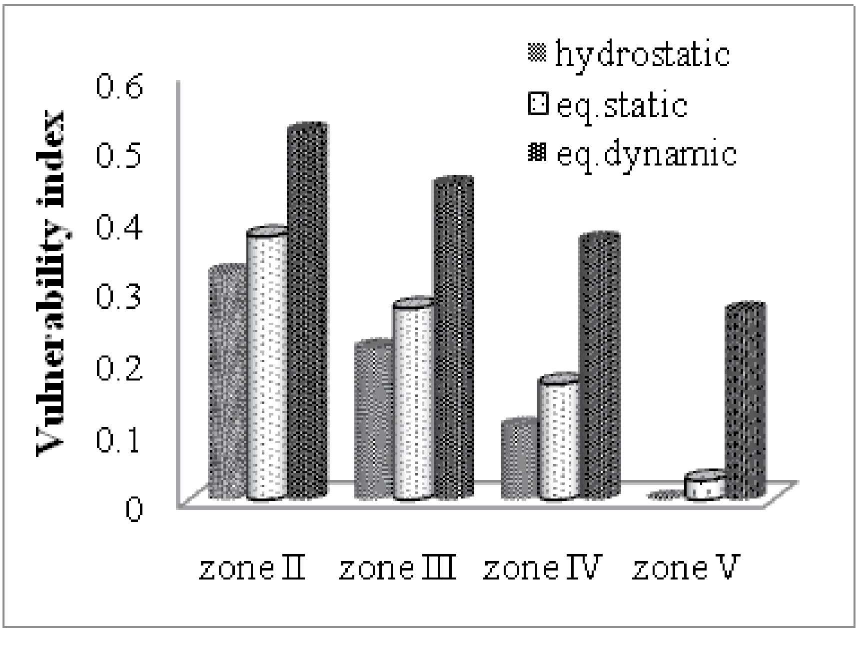

Figure 14. Vulnerability masonry infill frame under different flood loading conditions in different zones

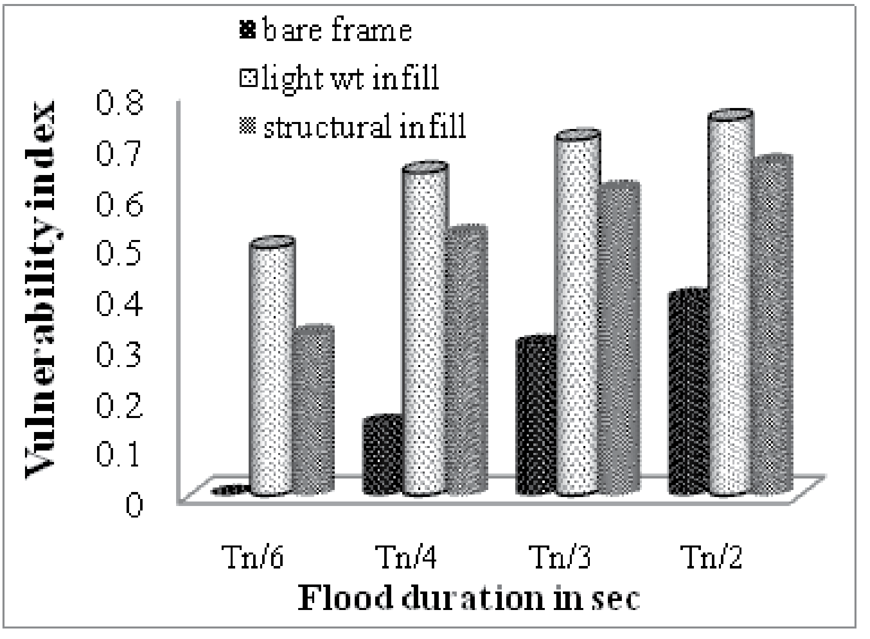

Figure 15. Vulnerability for different frame models under different flood duration in Zone II

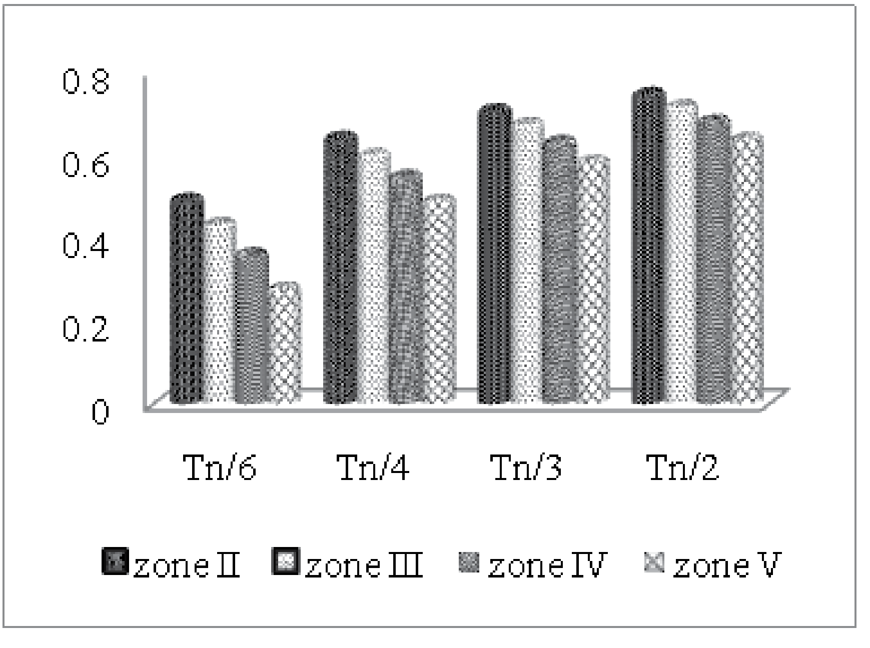

Figure 16. Vulnerability for the frame with light weight infill in different zones

Analysing different frame models under different flood duration in Zone II (Fig.15.), vulnerability increases with the duration of flood, but it is lower for bare frame (39.3%) if compared to frame with partitions (74.7% for light weight infill and 66% for frame with structural infill). It is due to the free movement of flood water between the columns of bare frame. The results of vulnerability for the frame with light weight infill (Fig. 16.), show that a building in zone V with flood duration $T_n/3$ is less vulnerable (58.4%) than a building in zone II with flood duration of $T_n/2$ (64.2%).

The analysis was carried out for all the cases, keeping the support of columns as fixed. The earthquake load calculations were made for all the zones and all the models analysed and designed as per IS 456:2000, for each zone and maximum design moments (Table 17). The maximum moment is lower for the fixed support condition, so the cross sections required is lower when compared to hinge support condition. The sizes of frame sections are given in Table 18. Fig. 18. shows the variation of flood moments for different frame models due to hydrostatic force. The flood moments parabolically increase as flood water height increases.

Zone	Bare Frame	Light weight infill	Structural infill
II	16.1389	16.1389	33.6639
III	25.3319	25.3319	49.3
IV	30.6598	30.6598	69.5349
V	42.6198	42.6198	100.8072

Table 17. Maximum design moment in kN-m

Frame model	Column size	Beam size
Bare Frame	250 x 250	250 x 300
Light wt infill	250 x 250	250 x 300
Structural infill	300 x 300	250 x 300

Table 18. Frame cross-sections in mm

The maximum moments obtained from the analysis for fixed support condition are shown in Table 19. For all frame models, the moments linearly increase as impact load increases. This is because, for the present case, impact force is considered as factor of hydrostatic load. Non-linearity will come only while considering flood duration. The duration of flood load (td) considered for various R values for hinged support condition are shown in Table 20 and the flood moments due to dynamic flood loads in various zones for fixed support condition are

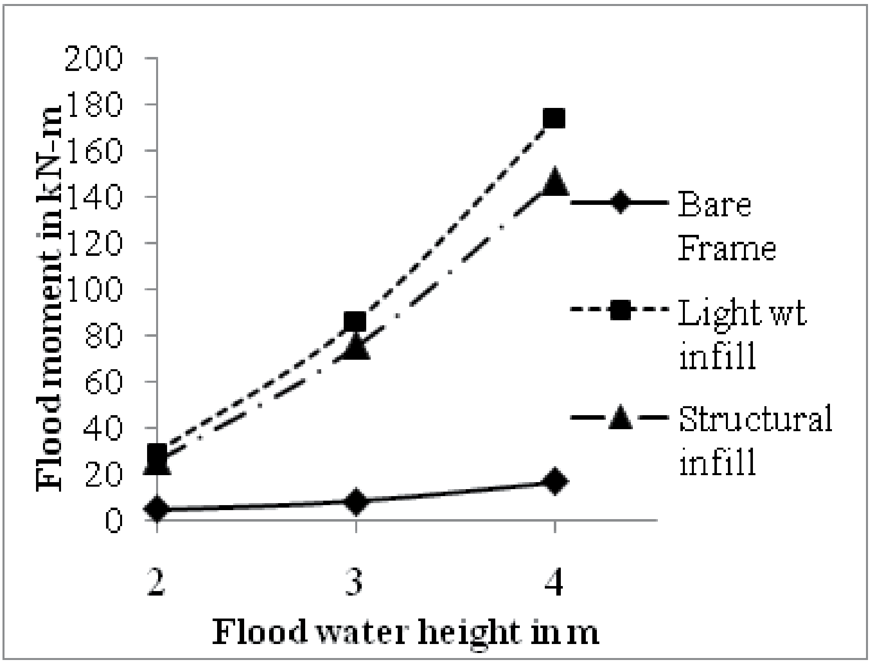

Figure 17. Variation of flood moment to hydrostatic force (without impact factor) with water height

shown in Table 21. Vulnerability for the bare frame is zero in all the seismic zones but it is non-zero for frame with partitions (Fig. 17.). This is due to the free movement of water in between the columns of the bare frame, so that the contact area of flood water will be low if compared the other frames. The vulnerability of frame with light weight partition wall is very high (60.3%), while for frame with structural infill it reaches 44.6% and it is not present for bare frame model.

Vulnerability indexes obtained due to hydrostatic and dynamic impact forces for fixed support condition are shown in Table 22 and 23, respectively.

hf (m)	Bare Frame		Light weight infill		Structural infill	
	0.1γhf	0.2γhf	0.1γhf	0.2γhf	0.1γhf	0.2γhf
2	4.4614	4.462	35.7516	42.4092	31.2512	36.9778
3	9.6472	11.2901	102.16	118.589	87.7618	100.1991
4	19.6866	22.5464	202.5541	231.1526	164.8106	182.9759

Table 19. Moment due to hydrostatic and impact forces in kN-m

Frame type	R=1	R=1.414	R=1.732	R=2
Bare frame	0.0401	0.0601	0.0801	0.1202
Frame with masonry infill	0.0098	0.0147	0.0196	0.0294

Table 20. Duration of flood (t_d) in sec

Zone	Bare frame				Frame with structural infill			
	R=1	R=1.4142	R=1.7321	R=2	R=1	R=1.4142	R=1.7321	R=2
II	16.14	22.82	27.95	32.28	33.66	47.61	58.31	67.33
III	25.33	35.82	43.88	50.66	49.30	69.72	85.39	98.60
IV	30.66	43.36	53.11	61.32	69.53	98.34	120.44	139.07
V	42.62	60.27	73.82	85.24	100.81	142.56	174.61	201.61

Table 21. Flood moment due to dynamic flood forces in kN-m

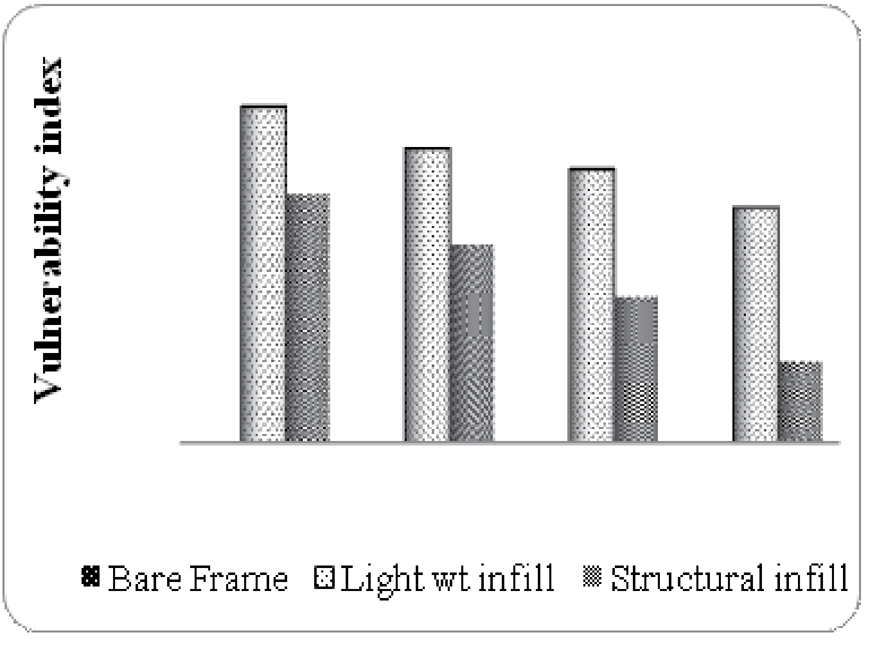

Figure 18. Variation of vulnerability in various zones

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Zone	Bare Frame		Light weight infill		Structural infill	
	$0.1\gamma h_f$	**$0.2\gamma h_f$**	**$0.1\gamma h_f$**	**$0.2\gamma h_f$**	**$0.1\gamma h_f$**	**$0.2\gamma h_f$**
II	0	0	0.638	0.663	0.488	0.523
III	0	0	0.566	0.596	0.400	0.438
IV	0	0	0.531	0.564	0.308	0.348
V	0	0	0.466	0.501	0.193	0.235

Table 22. Vulnerability index due to hydrostatic and impact forces

Bare frame				
R	**1**	**1.414**	**1.732**	**2**
Zone II	0.000	0.298	0.427	0.503
Zone III	0.000	0.178	0.329	0.419
Zone IV	0.000	0.128	0.288	0.383
Zone V	0.000	0.040	0.217	0.321
Frame with light weight infill				
Zone II	0.603	0.719	0.771	0.802
Zone III	0.528	0.666	0.727	0.764
Zone IV	0.491	0.640	0.706	0.746
Zone V	0.422	0.592	0.667	0.711
Frame with structural infill				
Zone II	0.445	0.608	0.680	0.723
Zone III	0.355	0.544	0.628	0.678
Zone IV	0.262	0.478	0.574	0.631
Zone V	0.145	0.396	0.507	0.573

Table 23. Vulnerability index due to dynamic flood forces

The storey drift is lower for fixed support condition and the maximum value concerns the frame with light weight partition walls (Fig. 19.). The frame with structural infill wall show the smallest storey drift: this indicates the significance of infill in resisting lateral storey drift. Storey drift reaches the maximum of 20.188 mm for the frame with light weight partition walls, which is less than that specified for seismic resistant building (Table 24).

For the frame with structural infill wall, even though the initial relative cost is high, the vulnerability is lower if compared to frame with non-structural partition walls (Table 25).

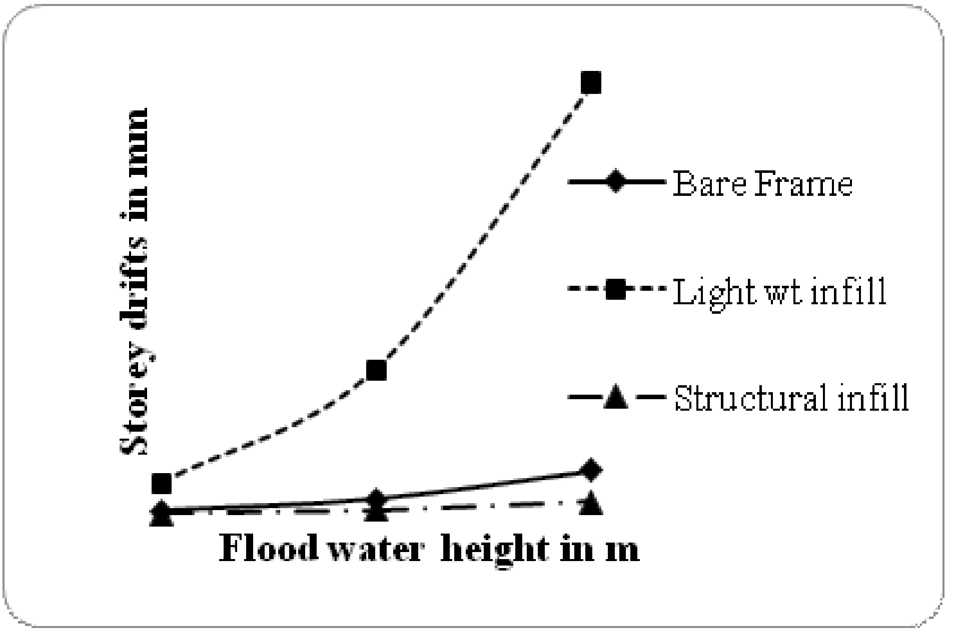

Figure 19. Variation of storey drift with flood water height

h_f (m)	Bare Frame		Light weight infill		Structural infill	
	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$	$0.1\gamma h_f$	$0.2\gamma h_f$
2	0.18	0.22	1.24	1.64	0.09	0.103
3	0.605	0.778	5.497	7.229	0.22	0.274
4	1.618	2.074	15.621	20.188	0.534	0.68

Table 24. Storey drifts due to hydrostatic and impact forces in mm

Zone	Bare Frame		Light weight infill		Structural infill	
	DM	cost relative	DM	cost relative	DM	cost relative
II	16.139	0.000	16.139	0.000	33.664	1.086
III	25.332	0.570	25.332	0.570	49.300	2.055
IV	30.660	0.900	30.660	0.900	69.535	3.309
V	42.620	1.641	42.620	1.641	100.807	5.246

Table 25. Relative cost as a factor of design moment for three frame models

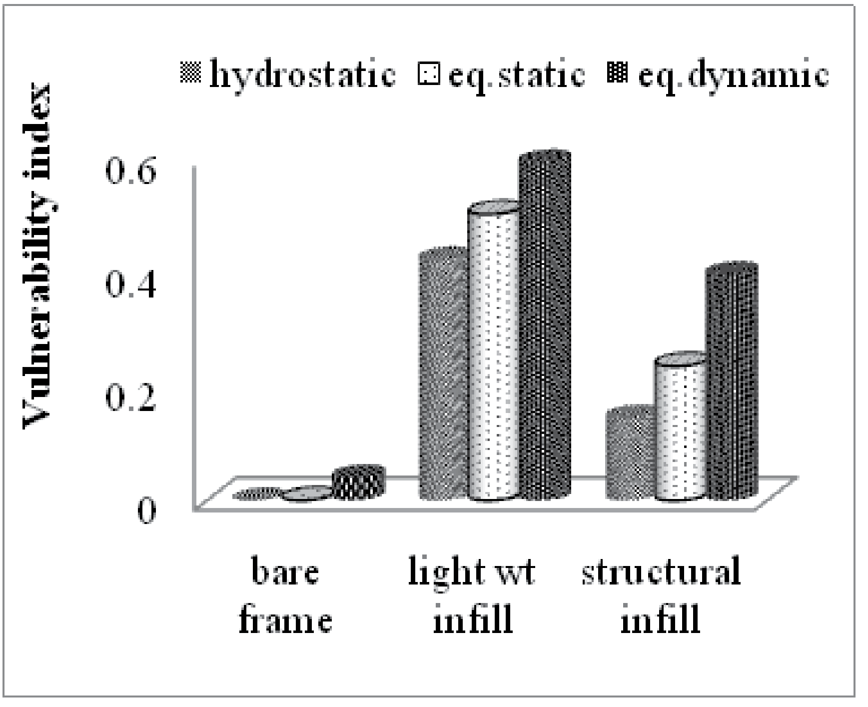

Figure 20. Vulnerability for different frame models under different flood loading conditions in Zone V

The vulnerability results obtained for different flood loadings are compared with respect to partitions (Fig. 20. and 21.). The frame with light weight infill wall is more vulnerable and bare frame is least vulnerable. This is due to the free movement of water in between the columns of the bare frame so that the contact area of flood water is lower if compared to the other frames. For the frame with masonry infill, vulnerability is lower if compared to light weight partition, even though the flood moment is the same for both the cases (Fig. 20.). It is due to the structural action of masonry infill against the lateral flood load.

The vulnerability reduces from zone II to zone V because the design moment in zone V is higher if compared to zone II and hence the building is more resistive to flood. The variation of vulnerability for the frame with light weight infill and with masonry infill under different flood loading conditions in different zones are shown in Fig. 22. and 23, respectively.

For the frame with light weight infill, vulnerability is higher in Zone II (71.9%) and it reduced as zone increases (Fig. 22.). For frame with masonry infill, vulnerability is higher in Zone II (60.8%) and it decreases as zone increases (Fig. 23.). This is because the design moment of building in zone V is higher if compared to zone II and hence the building in zone V will be more resistant to flood.

The vulnerability results obtained for different flood loadings are compared with respect to seismic zones (Fig. 24. and 25.). As the duration of flood increases, vulnerability increases (Fig. 24.); vulnerability is lower for bare frame than for frame with partitions. A building in zone V

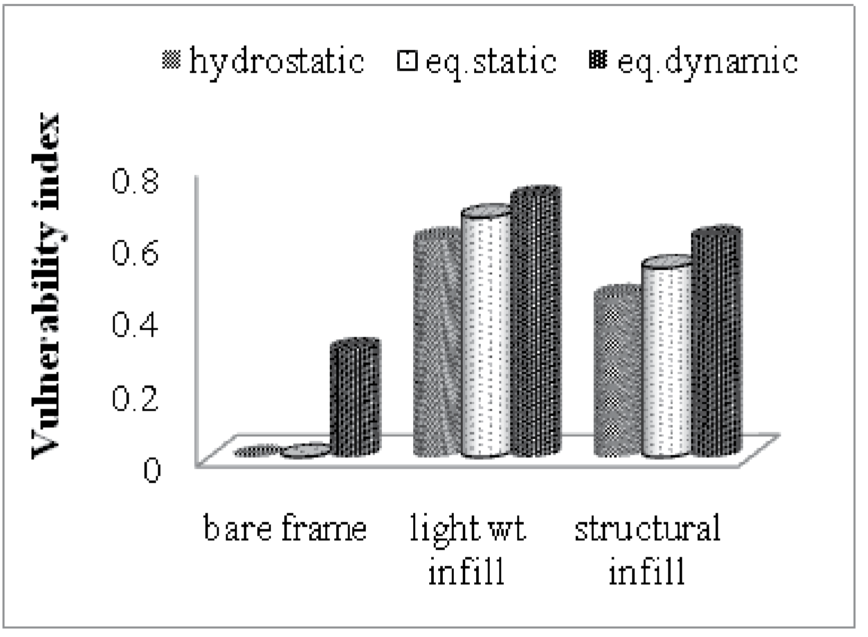

Figure 21. Vulnerability for different frame models under different flood loading conditions in Zone II

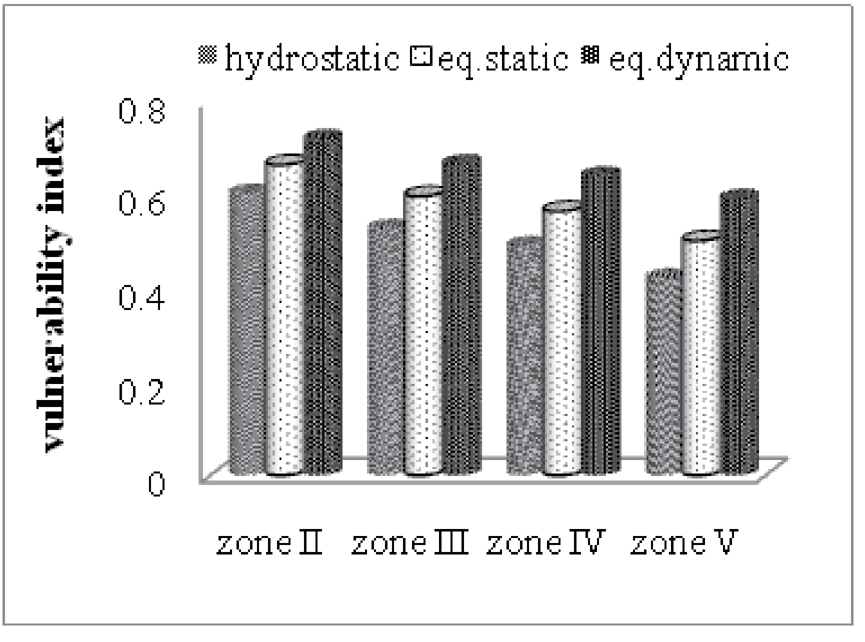

Figure 22. Vulnerability for the frame with light weight infill under different flood loading conditions in different zones

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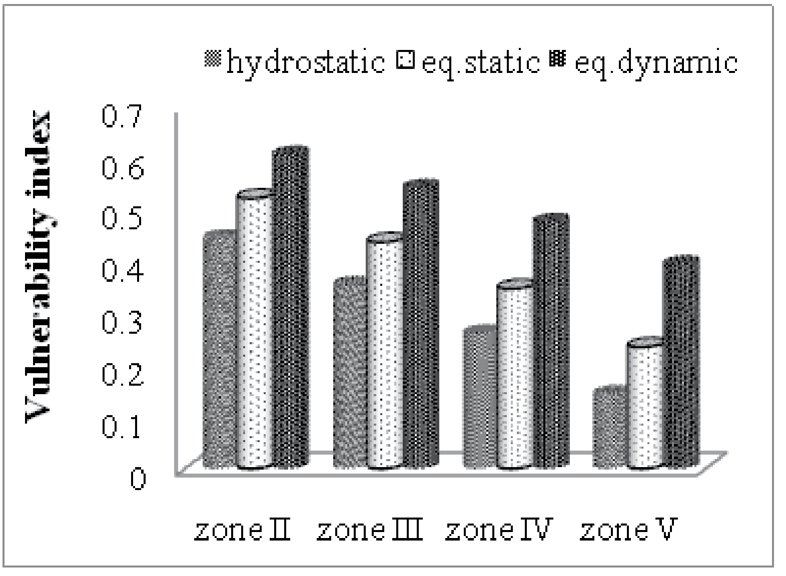

Figure 23. Vulnerability for the frame with masonry infill under different flood loading conditions in different zones

with flood duration $T_n/3$ is less vulnerable (66.7%) than a building in zone II with flood duration of $T_n/2$ (71.9%) (Fig. 25.), hence vulnerability is higher for building subjected to longer floods even if it also depends on the seismic zone.

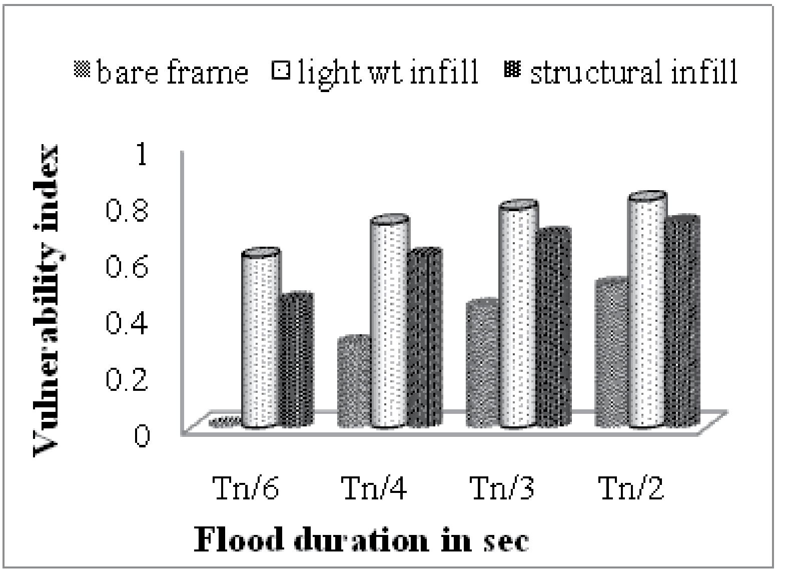

Figure 24. Vulnerability for different frame models under different flood duration in Zone II

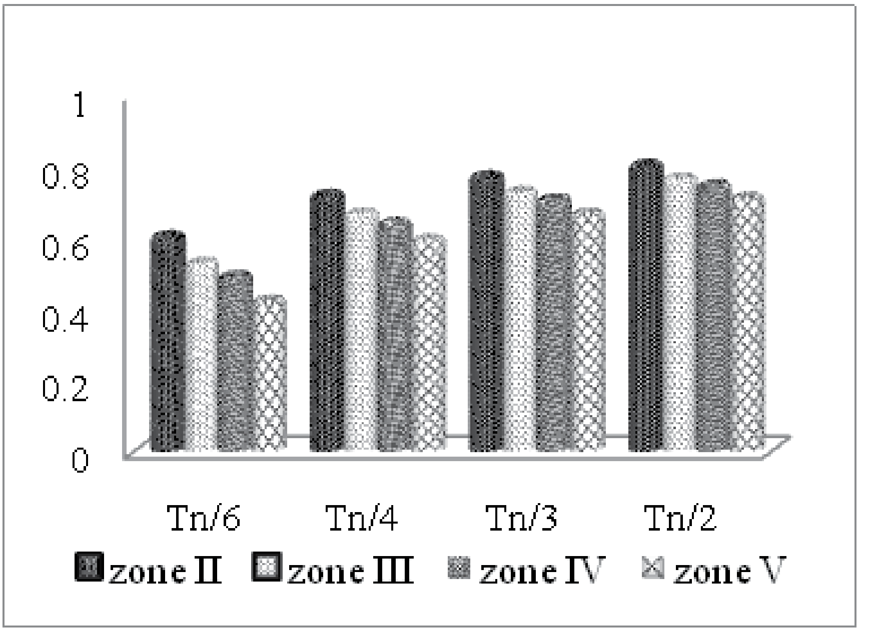

Figure 25. Vulnerability for the frame with light weight infill in different zones

5. Conclusions

Flood physical vulnerability deals with the level of loss that elements at risk or built environment suffer from the occurrence of flooding. This study aims to find out the flood vulnerability limit as a factor of ground floor height under flood forces and to quantify flood load. Three frame models were modelled and the effects of flood forces in each frame were analysed. The significance of infill walls in resisting lateral storey drift during flood is also investigated. The main conclusions of the analysis are:

- The flood moments parabolically increase as flood water height increases and linearly increase as impact load increases.
- The vulnerability of frame with light weight partition wall, for hinged support condition, reaches 64.2% for dynamic flood forces, that is very high if compared to the other frames.
- For frame with light weight partition wall in hinged support condition, storey drift reaches 71.32 mm, which is more than the value specified for seismic resistant building.
- The vulnerability of frame with light weight partition wall, for fixed support condition, is up to 60% in zone II which is very high if compared to the other frames.

- Storey drift for frame with light weight partition wall in fixed support condition is found to be less than hinged condition. The maximum value of storey drift for frame with light weight partition wall is 20.188mm.
- Even though the initial cost is more for frame with structural partitions, its vulnerability is very low if compared to frame with non-structural partitions.
- Buildings in zone II is most vulnerable and the vulnerability is reducing as zone increases. It reaches zero for frame with structural infill ass zone varies from zone II to zone V. This is because the design moment of building in zone V is higher if compared to zone II and hence the building in zone V is more resistive to flood.

Frame with light weight partition wall result as the most vulnerable and bare frame is least vulnerable. Hence frame with non-structural partitions like plywood are not preferred in flood prone areas. The storey drift for the frame with structural infill walls is very low if compared to the other frame models and this indicates the significance of infill in resisting lateral storey drift. Soft storied buildings are less vulnerable compared to ordinary buildings and this depends on the free movement of water in between the columns. Results also indicate the real need of considering the flood loads in the design procedure of reinforced concrete buildings.

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Multi-Tier Networks for Citywide Damage Monitoring in a Natural Disaster

Takahiro Fujiwara and Takashi Watanabe

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55513

1. Introduction

Progress of computer networks and mobile communications are leading to the environments capable of accessing networks anytime, anywhere. Furthermore, ubiquitous networks which are emerging in a smart city would awaken expectations to acquire any information with a hotspot panel in a whole city [1]. People expect to acquire information through the Internet with mobile devices or information appliances as usual, even in case of a large scale natural disaster. They also expect to contact with family and friends by mobile phones anytime. Though quick, accurate damage informationhas beenstrongly required for speedy and effective rescue operation, those communication systems did not work sufficientlyinthe previous large-scale disasters, due to both damage on facilitiesand communications congestion by heavy use or network overload [2, 3]. As a result, response efforts were delayed, causing further damage that could have been prevented with better communications.

To solve the issue on collecting damage information and personal safety information in a natural disaster, several studieshave been carried out,for example, to provide emergency services in Internet [4] and to maintain communications in evacuation shelters [5]. The Journal of IEICE introduced policy for acquiring damage information and maintaining communications in a disaster [6]. Moreover, regarding recovery from disaster damage in networks, telecommunication service companies have endeavored to mitigate aftermath of a disaster effectively [7]. However, in case of the Great East Japan Earthquake in 2011, telecommunication systems and networks could not maintained services after all [8, 9]. As a result, authorities could not comprehend the damage situations quickly, due to not only the scale of disaster-affected area but also to the loss of lines of communications [10].

This paper firstly reviews some networking technologies for disaster communications, and discusses a scheme on multi-tier damage monitoring in a citywide area. Then, an experimental system configured with a centralized hierarchical network, which was developed to acquire damage information from lifeline facilities installed in residences is shown. Finally, some results of computer simulation for multi-tier networks enhanced with an *ad hoc* networking technique are also presented.

2. Technologies for disaster communications

This section reviews some technologies that should be effective for disaster communications to acquire damage information in a large-scale natural or manmade disaster, including related studies on disaster communications.

2.1. A concept on damage monitoring in micro and micro perspectives

A concept of an integrated damage monitoring and assessment system was proposed [3], referred to as macro and micro perspectives (Fig. 1). The macro perspective performs comprehensive damage detection using image processing technique with satellite or aerial image. In addition, damage estimation in the aftermath of a disaster should be included in the perspective. The micro perspective, on the other hand, gathers individual damage information from a local site using several sensing devices, receiving emergency calls from suffers, and sharing information about rescue operations. Thus, the damage monitoring system needs to handle several types of information based on macro and micro perspectives. Multi-tier networks described in this paper play a critical role for the micro perspective.

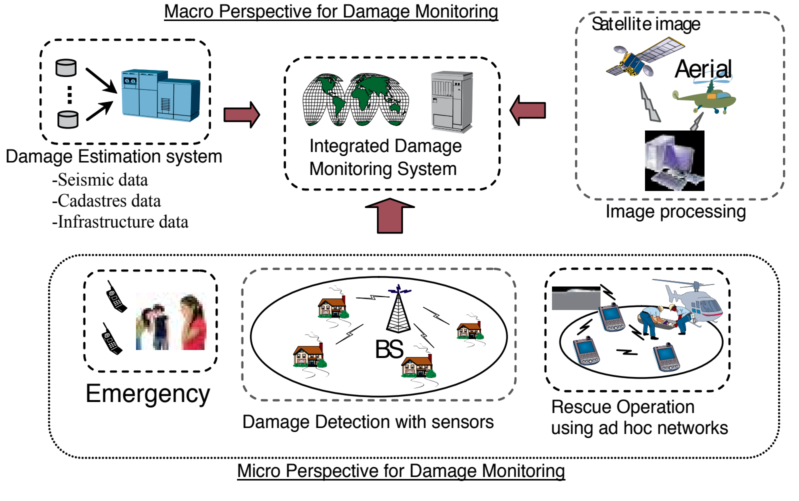

Figure 1. A concept of damage monitoring and assessment in a large-scale natural disaster based on macro and micro perspectives

2.2. Cellular networks in a disaster

The third-generation (3G) mobile systemshave provided the performance of up to 2 Mbps and various services in application systems [11]. Furthermore, current LTE (Long Term Evolution) and LTE-Advanced systems are providing a broadband mobile communications, leading to the fourth-generation (4G) cellular system, whichshould operate at the data rate of 100 Mbps or more [12, 13]. Since the latest mobile networks are challenging to provide a high data rate and a high capacity, those systems are required to operate at a higher carrier frequency and a large peak transmission power. A concept of virtual cellular system has been studiedand achieved to reduce the average transmission power compared with conventional cellular systems[14]. Thus, the current mobile systems have been developed focusing on high data rate and high capacity, under the policy of the best effort performance in ordinary conditions. However, in a disaster, it is strongly required for the communication systems to ensure connectivity even if difficult.

In the past,immediately after a large-scale natural disaster, massive access to communications systems occurred, and the systems lapsed into communications congestion, in the worst cases resulting in system failure. To both mitigate the congestion and prevent system failure, accessibilityingeneral channels for citizensis restricted into 1/n(Fig. 2). Since the regulation is mainly applied to the telephone call, data communications such as e-mail services might be maintained, even if taking a long delivery time. Meanwhile, prioritized channels have been set up in advance, to maintain connection in a disaster, but the number of the channels is not enough to transmit information from a large-scale damaged areas.

Multi-hopping is one solution to extend and maintain the coverage. A technical report of 3GPP (Third Generation Partnership Project) showeda scheme called ODMA (Opportunity Driven Multiple Access) to maintain high data rate in the edges of the coverage by relaying communications (Fig.3)[15]. Mobile stations located in the high data-rate can access the Base Station (BS) directly. On the other hand, stations outside of the high data-rate cannot maintain the rate. They request a terminal located in the high data-rate area to relay their packets.

Similar idea was proposed, referred to as MRAC (Multi-hop Radio Access Cellular), which aims high speed, high capacity and wide area coverage by multi-hopping [16]. In the system, dedicated Repeater Stations (RS) are set up in a good propagation area, and the stations relay packets between user terminals and BS. In the event that a mobile station detects high propagation loss in the single-hop conditions to BS, the station selects a neighboring RS to relay packets. Hereby, MRAC is capable of expanding the coverage. However, since MRAC premisesmulti-hoping via RS, the restriction of the arrangement of RS reduces flexibility of the system operation. One solution is *ad hoc* networking, to build a network flexibly.

2.3. Ad hoc networks

Ad hoc network is a scheme to flexibly build a network without infrastructure facilities [17]. The networkis expected to maintain communications and to collect information even in a disaster. Figure 4 shows a model ofad hoc networks, where terminals are deployed and connected each other flexibly with wireless communications. For example, in rescue opera-

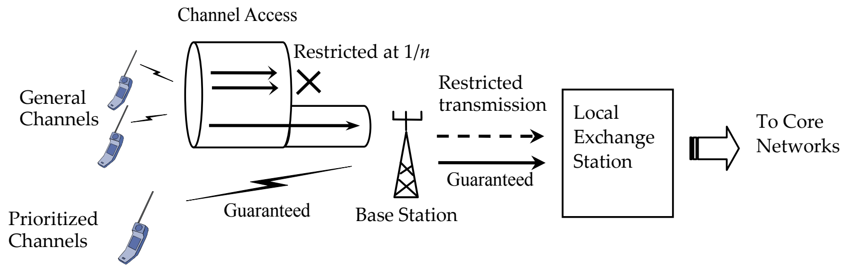

Figure 2. Traffic controlby reducing accessibility into 1/n in a disaster.

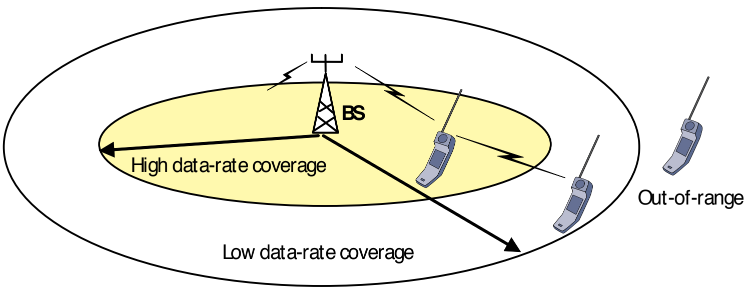

Figure 3. Opportunity Driven Multiple Access (ODMA).

tions, the rescue team should work, sharing damage information among the team in the afflicted site.Ad hoc networking technique enables the team to access each other and to share information without infrastructures. The information could be forwarded to an emergency operation center through the mobile base station.

Several protocols to build ad hoc networks flexibly and autonomously have been proposed based on the scheme ofon-demand driven routing protocols such as AODV (Adhoc On-demand Distance Vector routing protocol) [18] and DSR (Dynamic Source Routing protocol) [19], and proactive table-driven routing protocols such as DSDV (Destination Sequence Distance Vector routing protocol)[20] and OLSR (Optimized Link State Routing protocol) [21]. The network scheme may achieve flexible network. However, stable communications environment could not be provided immediately after a large-scale disaster, even in ad hoc networks. In addition, since the links of ad hoc networks are vulnerable, massive control packets such as either route request or route maintenance packets may be induced, resulting in heavy traffic congestion and communications failure.

2.4. Hybrid wireless networks

Hybrid wireless networking schemes combiningcellularand multi-hopping technique have been developedto aim high data rate, high capacity, wide area coverage and QoS control, not for disaster communications. The hybrid network named Sphinx [22] aims to achieve high throughput and low power consumption. Concurrently, it addresses fairness for resource allocation, and resilience for mobility. The mobile stations operate in two modes, one is a cellular mode, and the other is a peer-to-peer mode(Fig. 5). When a mobile station communicates with the others located in the same cell, all flows are served in the peer-to-peer mode in the initial state. In the event that a mobile station detects degradation of the throughput in the peer-to-peer mode, it requires BS to switch to the cellular mode.

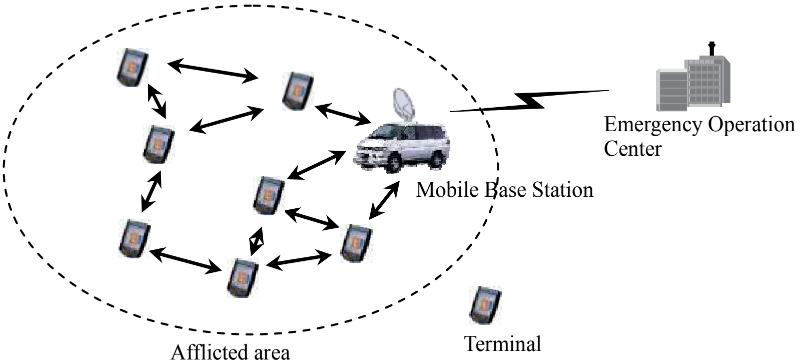

Figure 4. A concept of *ad hoc* networks forrescue operations.

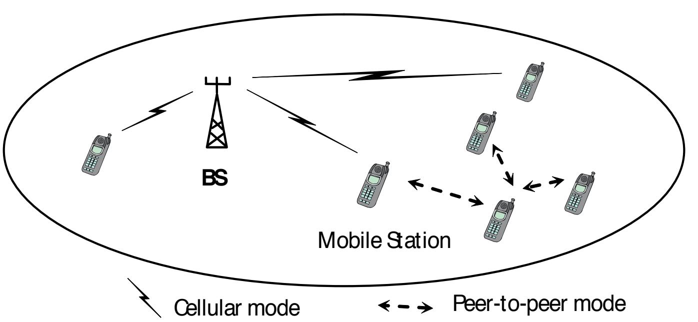

Figure 5. Hybrid network model for cellular packet data network (Sphinx).

Another scheme, named iCAR (Integrated Cellular and Ad hoc Relaying System), aims to avoid blocking and dropping communications due to localized congestion, and focuses on traffic load balancing [23]. The system installs ad hoc relay stations (ARS), which are placed at strategic locations to divert traffic in one (possibly congested) cell to another (non-congested) cell (Fig. 6). Terminals in a congested cell try to access a BS of a surrounding non-congested cell via an ARS. Those schemes are focusing on maintaining throughput and other features in ordinary conditions, and such hybrid networks might be effective even in extraordinary conditions, if the system could be resilient to maintain communications.

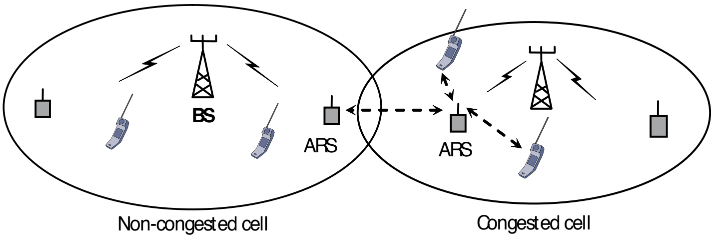

Figure 6. Integrated cellular and ad hoc relay system (iCAR).

2.5. Wireless sensor networks

Wireless sensor networks premise that massive sensor nodes are deployed in the field and build a network autonomously.The networks transmit data from sensors to a sink node by multi-hopping,which are expected to collect information in several application systems such as environmental monitoring, structural health monitoring and so on. Since the nodes are usually restricted in CPU power and are operating by batteries, it is strongly required to reduce energy consumption [24]. Though several protocols have been proposed, they do not sufficiently consider how to operate in the seismic monitoring.

Assumingseismic monitoring, multiple sensor nodes are placed in buildings, bridges, or structures to detect seismic motion, temperature, or distortion of the structures. Furthermore, the system might be expected to find persons who trapped in the building.The reference [25] describes a seismic acceleration observed in the University of California, Irvine, where the acceleration includes the bandwidth of around 30Hz on the ground and 5Hz on the fourth floor. Thereby, the monitoring system is operating at the sampling rate of 200Hz. Health monitoring of the Golden Gate Bridge was carried out with wireless sensor networks [26]. They achieved the monitoring of the vibration on the bridge by multi-hopping of 46 hops at a sampling rate of 1 KHz. Then, issues to be taken into account in monitoring system are to provide a long time operation and to extend the coverage of damage monitoring in a large-scale disaster.

As an example, Figure 7 shows an outline of the monitoring with a wireless sensor network in a building. The sensor network iscomposedof a number of sensor nodes (SNs), some relay nodes (RNs)and a sink node (SI) to gather data from SNs to SI. The network installs SI and RNs atstrategically designated positionsin advance on one hand. The SNs, on the other hand, are flexibly distributed in the building, and transmit data to RNs directly or via adjacent SNs by way of multi-hopping. The RN relays data to SI using a direct path or a multi-hopping path via RNs. Though, the SI is capable of collecting and storing the data, we have to study how to collect the information from a great number of sink nodes in a whole city.

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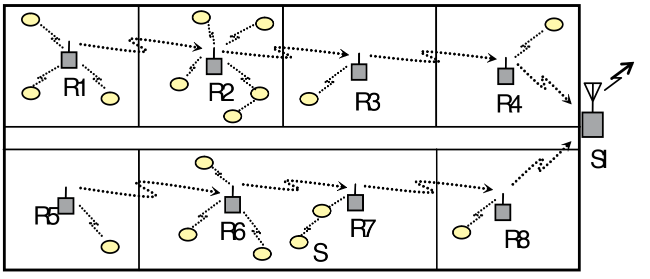


SI: Sink node, R: Relay node, S: Sensor node

Figure 7. Wireless sensor networks deployed in a building

3. Multi-tier networks for damage monitoring

Now, we discuss the network design of multi-tier networks to operate for damage monitoring. The architecture of the multi-tier networks is based on the hybrid network, which is configured with a centralized hierarchical network and *ad hoc* networks. In addition, to detect phenomena, wireless sensor networks are introduced and work with the hybrid network for damage monitoring.

In case of large-scale natural disaster, information required for damage assessment changes as time goes by.The authorities need to comprehend the circumstances of damage based on multidirectional aspects. They acquire damage information comprehensively,make a strategy for emergency response, and carry out rescue operation quickly. Though the concept of both the macro and micro perspectives shown in the previous section is nontrivial, we focus on a network model based on the micro perspective to comprehend the conditions of individual damages in an afflicted site.

Figure 8 shows a network model todetect extraordinary phenomenaand to collect the information.The sensors are placed in houses, buildings and structures in a whole city. Information detected by sensors is transmitted to a CS through a base station in the centralized network. The centralized network combines *ad hoc* networking operation to enhance the connectivity, referred to as a hybrid network. The emergency operation center accesses the information stored in the CS through the backbone network such as the Internet.

3.1. Damage detection with sensors

Damage detection in a disaster is performed with several sensors; seismic vibration is measured with accelerometers installed in a structure. Meanwhile, wireless sensor networks (WSN) draw attention to detect several phenomena, temperature, humidity, brightness etc. in low cost. As the nodes of WSN contain accelerometers, the networks are capable of detecting seismic acceleration to assess the damage. In addition, lifeline facilities such as gas meters,

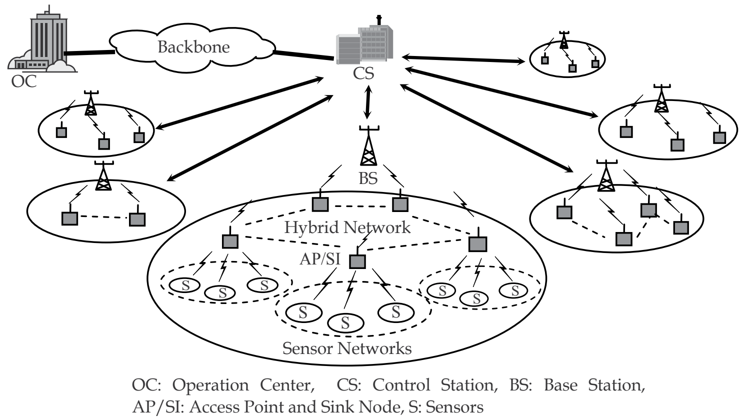


Figure 8. Network model for multi-tier damage monitoring in a natural disaster.

electricity meters and water meters include various kinds of sensors to detect conditions of facilities.

Since the communications range of a link in sensor networks is short, e.g., 20 m normally, or 100 m at most, multi-hopping technique is used to expand the coverage. Furthermore, each sensor node operates with a small battery, and the CPU power is restricted to control the operation including the calculation of a routing path. Provided that the scale of the network becomes larger, traffic to relay packets increases and induces large power consumption.

3.2. Centralized hierarchical network for damage monitoring

A centralized hierarchical network is composed of multiple terminals and a base station in a cell, and those BS access a CS to transmit the information gathered from terminals (Fig. 9). In ordinary conditions,the network is effective in transmitting packets quickly. If the network is available for quick accurate damage monitoring even in extraordinary conditions, the model would be employed in the monitoring system. However, such network has suffered from disconnection between terminals and BS, and lapsed into communications congestion in a previous large-scale disaster. In collecting damage information and emergency messages from terminals placed in a whole city, it is strongly required to transmit packets efficiently from distributed massive terminals to BS, and from BS to CS for swift rescue operations.

The network model is configured with two layers:the upper layer, composed of a CS and multiple BS connected by either wireless or wired channels, and the lower network,that contains a great number of terminals. Assuming that those terminals are placed in all residences and the collected information is restricted to emergency communications, the volume of the traffic in a cell is almost predictable, and we can design the channel capacity of the network. One concern is, however, those channels are vulnerable in a natural disaster. Especially, cables of wired networks may easily suffer damage. Thereby we should design

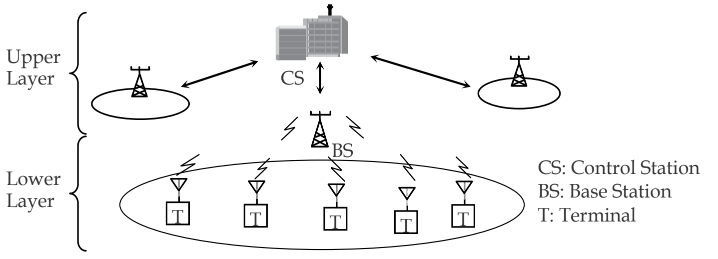


Figure 9. Centralized hierarchical network model.

the network to collect damage information quickly considering how to maintain connections in disaster circumstances.

The lower layer network, consists of the BS and multiple terminals in each cell, where the BS and terminals communicate in TD-CDMA (Time Division and Code Division Multiple Access) mode at 2.4 GHz, which is designed based on CDMA (Code Division Multiple Access) and TDMA (Time Division Multiple Access). The output power is 10 mW or less for the communications range of 300 m.

	Upperlayer	**Lowerlayer**
Frequency	2.1099GHz(Fw) 2.2899GHz(Rv)	2.402GHz(Fw) 2.482GHz(Rv)
Bandwidth	<200kHz	<1.5MHz
Outputpower	1W	10mW
Modulation	π/4-shiftQPSK	DBPSK(Fw),DQPSK(Rv)
Accesscontrol	Polling	TD-CDMA
Datarate	288kbps	19.2kbps(Fw) 9.6kbps(Rv)

Table 1. Air interface parameters of channels in the upper and lower layers (Fw: Forward-link; Rw: Reverse-link)

	Forward-link	**Reverse-link**
Chiprate	1.2288Mcps	1.2288Mcps
Datasize	156B	256B
Framelength	320ms	320ms
Datarate	19.2ksps	9.6ksps
Processinggain	64	128

Table 2. Data transmission parameters of the CDMA channels.

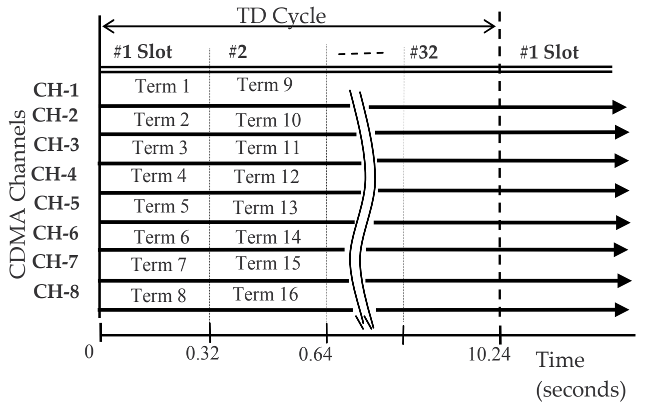


Figure 10. Channel operation in TD-CDMA

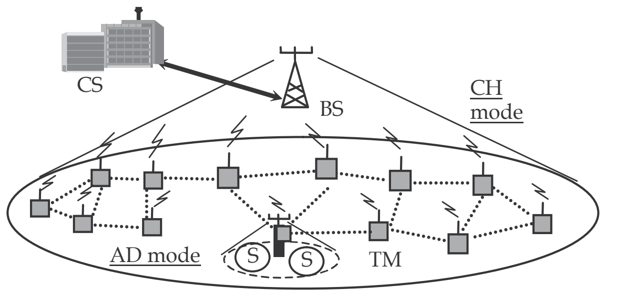
The experimental system was designed to contain 256 terminals in a cell. The communications system of the radio channels connecting terminals with BS in the lower layer employs CDMA technology operating at 2.4GHz. The communications system also introducesthe time division mode,hence, referred to as TD-CDMA. Figure 10shows the time chart ofthe TD-CDMA operation. The multiplexed CDMA channels are divided into 32 timeslots of 320ms, to operate in the time-division-multiple-access mode. A group of 8 terminals, e.g. terminals 1 through 8, is assigned to one timeslot. 8 terminals are invoked at the timing of the #1 slot, and transmit data to the BS via CDMA channels. Thus, the BS is capable of collecting data from 256 (8′32) terminals in one TD-cycle of 10.24 seconds. The parameters of CDMAchannelsand data transmission are shown in Table 1 and 2.

3.3. Hybrid wireless monitoring enhanced with *ad hoc* networks

A centralized network showsa good performance for damage monitoring in conditions where the links between a base station and terminals are maintained. *Ad hoc* networking, on the other hand, allows a node to rebuild a route by alternative links even if the connection of the links may not be maintained. However, the links of *ad hoc* networks are vulnerabledue to not only mobility or limited power but also interferences or deteriorated propagation conditions. Thereby, ahybrid wireless network combining *adhoc*networks and a centralized network has drawn attention for disaster communications [27].

The hybridnetwork(Fig. 11) combines both schemes of the centralized hierarchical network (CH mode) connecting BS and nodes directly, and the *ad hoc* networks (AD mode) connecting nodes each other. If the condition ofthe link between BS and a node is getting worse and the connection cannot maintain, the node shifts the operation to the *ad hoc* mode and accesses a neighboring node, where the node relay packets to BS.

In normal conditions, most of nodes access BS directly in Cellular mode. Ifa disaster occurs and several links between BS andnodesare disconnected due todamage or obstacles, those nodes switch to *ad hoc* mode, and attempt to build a route to BS by way of multi-hopping.



CS: Central Control Station, BS: Base Station, TM: Terminal, S: Sensor

Figure 11. Hybrid wireless network enhanced with *ad hoc* networks.

Provided that the node discovers a node which can access BS directly or other nodes which already found a route to BS, the node requests one of the neighboring nodes to forward damage data to BS.

To build a connection in AD mode of the hybrid network, each node, which cannot access BS directly, needs to discover a route to reach BS. Every node operating in either cellular or *ad hoc*mode (CH or AD mode) periodically transmits a control packet. The control packet includes the number of hops (Hop-CNT) to reach BS, the addresses of source, destination, sender and receiver nodes (Fig.12).

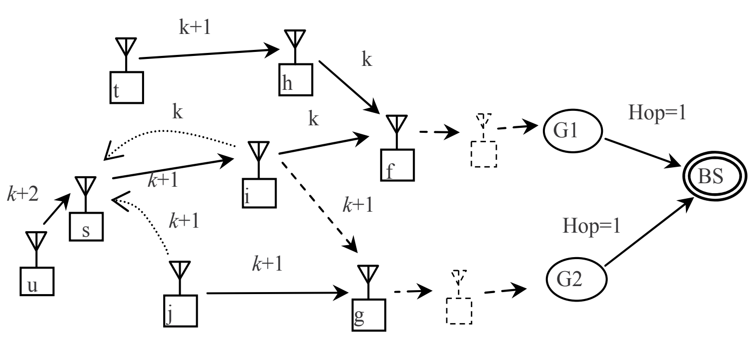


Figure 12. A scenario in route discovery.

Inthe route discovery, a node (node-s), which cannot access BS, monitors communication of neighboring nodes. Overhearing a packet, the node checks Hop-CNT of the received packet, and knows how many hops are required to reach BS. It selects a node (node-i) as the next hop node based on the received Hop-CNT. The node-s records the address and the Hop-CNT of node-I; receiving a packet from node-s, the node-i forwards the packet since it already knows a route to reach the BS in a multi-hoping.

Provided that node-s detects multiple nodes which can reach BS, it records the nodes' address and Hop-CNT, and selects a node which has the shortest hopping range. If multiple nodes are found whichhave the shortest route, it may select one of them randomly. Provided that node-s notices it cannot overhear the communicationsfromthe node recorded in its routing table during the time to live (TTL), node-s decides the node is not available and deletes the record of the node in the table. The value of TTL is designated as a system parameter in advance.

Provided that a certain node transmits a packet, its Hop-CNT is set up at the value incrementing the value of the next hop node. Thereby, the further neighboring nodes can overhear the communications and discover an available next hop node. Node-i is transmitting a packet to node-f at Hop-CNT=k. node-j is also transmitting at k+1. node-s overhears from node-i and -j at Hop-CNT=k and k+1, respectively. Then, node-s selects node-i, and transmits a packet to the node at Hop-CNT=k+1. Likewise, node-u discovers a route via node-s. Thus, nodes discover a route by overhearing neighbor communications, and establish a route via the neighboring nodes.

When an intermediate node (node-f) is required to relay a packet by a node (node-i), it forwards the packet to the next hop node according to the routing table. Concurrently, node-f records in its routing table the addresses of node-i and the source node (node-s) for the backward path. When a reply packet arrives at node-f to deliver to node-s, node-f recognizes to relay the packet to node-i according to the routing table. Likewise, node-i relays the packet to node-s.

In the event that an intermediate node (node-i) detects failure in forwarding a packet to the next hop node (node-f), node-i replies an error message to the backward node (node-s) according to the routing table, then deletes the data of node-f from the routing table of node-i. In conditions where node-i does not have another next hop node information in the table, it returns expiration as the error message to node-s. If node-i has an alternative path in the routing table, it returns route-error instead of expiration to its backward node. When the route-error arrives at the source node, the node retransmits the packet to the same next hop node as alternative path. Then, node-i forwards the packet to the alternative node, node-g. When the source node receives expiration, it must select another next hop node. If there is no entry in the table of the source node, the source node has to hold on until it detects a new entry node by overhearing.

4. Experimental system

4.1. Experimental centralized hierarchical network

A dedicated data collection system was developed based on centralized hierarchical networking scheme for damage monitoring. The experimental system was designed tocollect datafrom lifeline facilities such as gas pipelines, water pipelines and sensing devices [28, 29]. The systemwas configured with two layers, to monitor the state of city lifelines of about 256,000 residences in a whole city.

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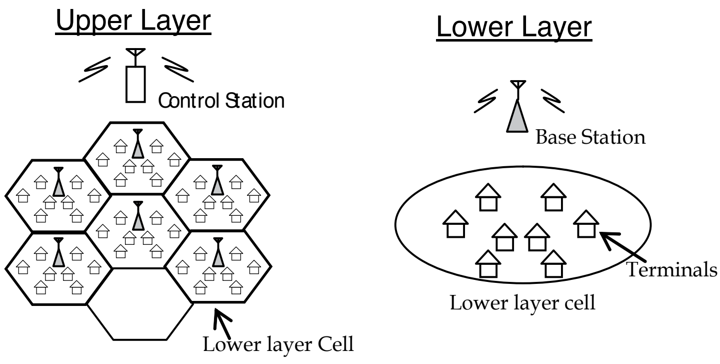

Figure 13. A model of acentralized hierarchical damage monitoring system.

The experimental system comprises two-tier networks to cover a total of 250k terminals in an urban area of about 260 km^2(Fig. 13). The system employs 2.1 GHz radio communications for the upper layer and 2.4GHz CDMA forthe lower layer, and gathers data from gas meters, water meters and extra signals installed in houses to comprehend the conditions of lifeline facilities.

The upper layer network was designed to covers a whole citywith1024 cells.The central control station accesses the BS of each cell with a TDM (Time Division Multiplexing) wireless system. The upper layer radio system employed a narrow-band radio communications of 2.1GHz to connect CS and multiple BS, where the output power is 1 W, to cover a long distance. The air interface parameters are listed in Table 1. CS and BS of the upper layer contain a database server (Fig. 14):data transmitted from terminals to BS are stored in the database, and the server of BS provides data according to the requirement of CS. The CS stores the data in the database and provides the data in an application system.

The lower layer network consists of BS and multiple terminals in a cell, where the BS and terminals communicate in TD-CDMA at 2.4 GHz, combining CDMA and TDMA technologies. The output power is 10 mW or less in the communications range of 300 m. Though the experimental system was designed to contain 256 terminals in a cell, 128 terminals were actually installed in a residential area. The interface unit contained ina terminal is connected to a liquefied petroleum gas (LPG) meter, natural gas (NG) meter, water meter and additional signals (Fig. 14). Figure 15 shows the experimental CDMA and interface units connecting with meters.

Frame error rate (FER) is defined as the rate of communications failure in two-way transmission. The experiment observed and recorded the number of communications failure in each of 128 terminals, as in Figure 16, where the FER is indicated on the average of 128 terminals. The average FER was approximately 1.5×10−3. Thereby, the experiment showed the CDMA system achieved a low FER on the order of 10−3 even in the output power of 10mW, where the communications range is within 300m.

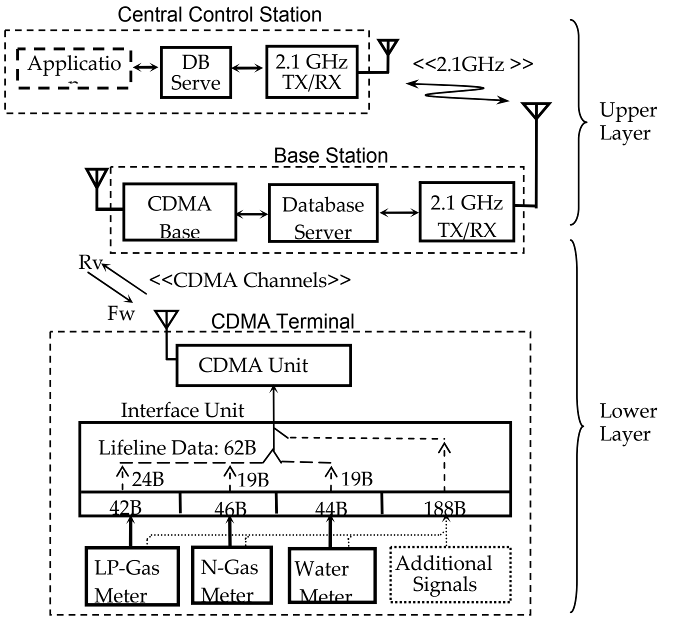

Figure 14. Experimental system for lifeline monitoring.

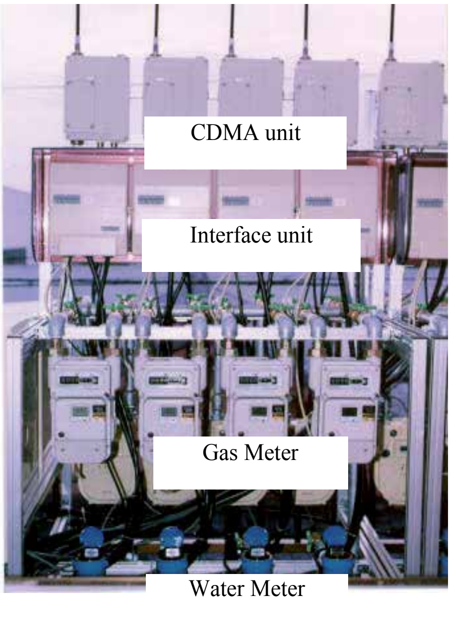

Figure 15. Experimental units.

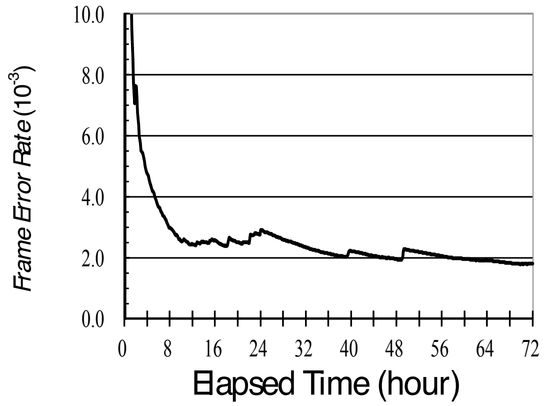

Figure 16. Time series behaviour of FER in CDMA channels.

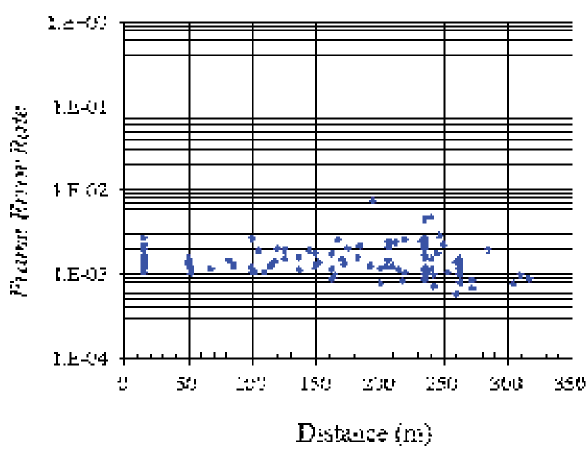

Figure 17. *FER*of each terminal

The experimental CDMA system in the lower layer was designed to access 256 terminals in the interval of 10.24 seconds. The experiments confirmed that the system operates in 10.24sec-ondsfor256 terminals (128 actual terminals and 128 dummy terminals). On the other hand, the data rate in the upper layer was designed to transmit data at 288 kbit/s from BS to CS in the polling mode. The experiments showed the data collection time from 1024 BS (three BS and 1021 dummy stations) to CS was 424 seconds in conditions where the data size from each BS is 5120 bytes, i.e. 20 bytes times 256 terminals. To acquire urgent information from every terminal immediately, the BS extracts the state information of two bytes from the data which was acquired in each terminal, and gathers the urgent data of 512 bytes in the cell. By transmitting 512-byte data to CS, the data collection time from 1024 BS was 51.7 seconds.

Thus, the system can collect a small data of two bytes from 256,000 terminals within 60 seconds though it takes about 7 minutes to collect a large size of data of 20 bytes from 256,000 terminals. Thereby, multi-tier centralized network is able tosurvey damage to lifeline in a whole city within one minute.

4.2. Hybrid wireless monitoring enhanced with *ad hoc* networks

The hybrid wireless network enhanced with *ad hoc* networks described in the previous section was evaluated by computer simulation, assuming a round shapecell the radius of which is denoted by r. BS is placed at the middle of the cell, and nodes are arranged in grid in a cell, where the grid interval is denoted by d.

Nodes for CH mode are selected randomly according to DCNR, which is defined later. Those nodes work as gateway nodes to relay packets from nodes. The rest of nodes operate in AD mode.

Assume that the communications range (l) of a node operating in AD mode is equal to the grid interval (d). Each node can access four adjacent nodes. This assumption is based on installing nodes in a residential area, which is arranged in grid. Assuming the distance between houses is 20m, the grid interval is 20m, and the communications range is also 20m.

Direct Connection Node Ratio (DCNR) is defined as the ratio of nodes, which can access BS directly, and is given by equation (1).

$$DCNR = \frac{\text{Number of direct connection nodes}}{\text{Total number of nodes in a cell}} = \frac{m_1}{N} \tag{1}$$

where m1 is the number of nodes which can reach BS at one hop, and N is the number of all nodes in a cell.

Reachability (γ) is defined as the ratio of the nodes that are able to reach BS directly or by multi-hopping. The maximum hopping range (MR) is the upper limit of multi-hopping count (n). Reachability within n hops (γ (n)) is given by equation (2).

$$\gamma(n) = \sum_{i=1}^{n} m_i \Big/ N = \gamma_1 + \gamma_3 + \cdots + \gamma_n \tag{2}$$

where m_i is the number of nodes reachable to BS at i hops, and γ_1, γ_2,,, γ_n are the reachability in each hop count from one to n.

Average of throughput within n hops ($\overline{\eta(n)}$) is the ratio of the number of transmitted packets during T (seconds) to the amount of packets that all nodes can transmit in the network, and is given by equation (3).

$$\overline{\eta(n)} = \sum_{i=1}^{n} q_i(T) \Big/ N \cdot T \tag{3}$$

where $q_i(T)$ is the number of packets arriving at BS by i hops during T seconds.

Results are shown in Figure 18, in conditions where the radius of the cell is 340m, and the number of nodes is 901. In conditions where DCNR is 60% or higher, reachability at MR=2 is up to 98%. Even if DCNR is only 20%, it maintains reachability of approximately 90% within three hops. Figure 19 shows the throughput as a function of DCNR, in conditions where the cell size is 340m. Even if increasing MR at 1, 2, 3 and unlimited hopping, throughput is not improved drastically like reachability.

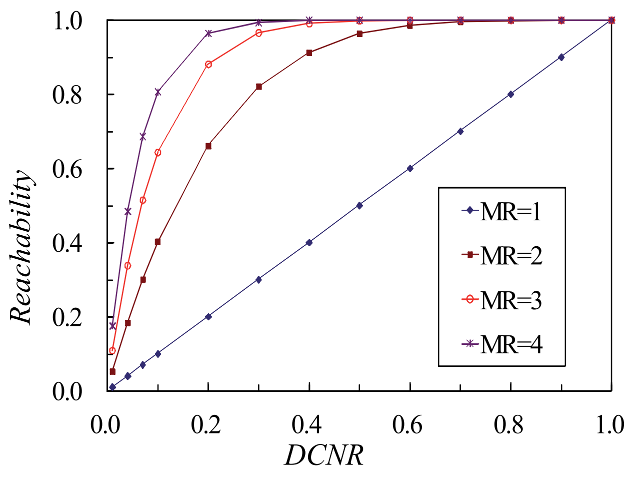

Figure 18. Reachability for DCNR.

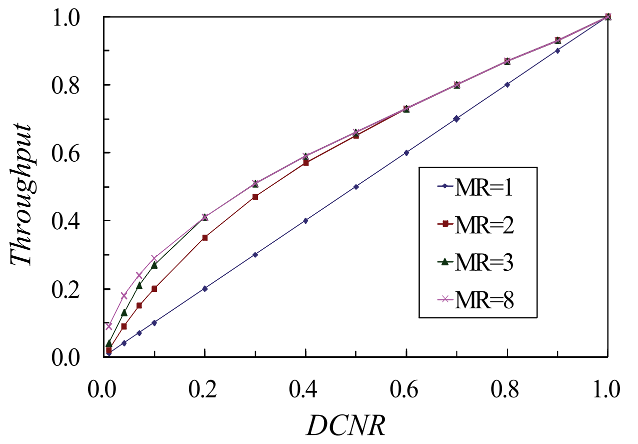

Figure 19. Throughput for DCNR.

5. Conclusion

We discussed a scheme of multi-tier networks for citywide damage monitoring in a natural disaster. We showed the scheme of the centralized hierarchical network and the experimental system designed for dedicated damage monitoring. The results showed the experimental TD-CDMA system achieved the frame error rate on the order of 10−3 even in the output power of 10mW, where the communications range is within 300m. The monitoring system is capable of collecting information within one minute from 256,000 terminals deployed in a whole city. Thereby, the system is useful and effective to collect data quickly and stably in conditions where the links could be maintained. Based on the concept of the centralized hierarchical network and the experimental results, we showed the hybrid wireless monitoring system enhanced with *ad hoc* networks. The experiments by computer simulation showed the network is capable of improving reachability of packets even in the damage conditions in a natural disaster.

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Chapter 3

Impact of Hurricane Katrina on the Louisiana HIV/AIDS Epidemic: A Socio-Ecological Perspective

William T. Robinson

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55472

1. Introduction

Emergency preparedness is an important issue and public health professionals seek to plan for and anticipate the effect of large scale disasters. The chief concern may be the impact of disasters on infection and infection control, or in some cases the impact of the public's health is a direct result of the disaster itself. For example cholera outbreaks such as seen in Haiti following the 2010 earthquake, or radiation sickness as a result of damage to the Fukushima plant. However, the effect of disasters on other epidemics, including more chronic diseases such as HIV/AIDS, may also be felt.

Hurricane Katrina and the failure of the federal levee system remains one of the largest and costliest natural or man-made disasters in U.S. record. In all Katrina is estimated to have cost over 100 billion dollars in damage and recovery costs [1] with nearly 2000 people dead or presumed dead [2]. While Katrina had impacts across the Gulf South, the city and metropolitan area of New Orleans Louisiana sustained the most devastation, which resulted in a near total evacuation of the city that continues to be felt seven years later. Crouse-Quinn [3] have remarked that Katrina was both a social as well as a public health disaster.

Like the rest of the South, Louisiana and New Orleans have high concentrations of people living with HIV/AIDS as well as high rates of newly infected cases. In 2005 there were 21,062 persons living with HIV/AIDS in the Alabama, Mississippi and Louisiana Gulf Coast area [4] and 7068 people living with HIV/AIDS in the New Orleans metropolitan area [5]. According to the CDC, the state ranked 5th and the metropolitan area ranked 7th in new AIDS cases in 2005, with 21.2 and 30.3 cases per 100,000 residents, respectively [6].

Thus the intersection of a disaster such as Katrina and the resultant long lasting effects of the storm and flood may have particular relevance to the large population living with HIV/AIDS or those who may be at risk for HIV in Louisiana. Given that in many ways this can be seen as a vulnerable population who may be disproportionately affected, it was critical to examine the impact of the storm on the epidemic.

One cannot, however, describe the impact of a single event such as Katrina on the entire epidemic without considering its effects on the individual as well as the various social and environmental contexts. It is increasingly recognized that explanations for determinants of health that operate solely on the individual level are inadequate [7]. Models of health and health behavior need to incorporate factors such as social and physical environments that nest individuals within these levels. The primary method of theorizing about health and health related behaviors from this multi-level framework has been the social-ecological approach [8, 9], that postulates a series of levels or strata at which these health-related risks and protective factors may operate. These strata often begin with the more proximal causes or moderators of disease, at the individual or intrapersonal level, and move towards the more distal interpersonal risks, social and cultural factors and ultimately societal, structural or environmental level factors. Several researchers have pointed to the importance of the ecological framework or inclusion of these multilevel factors in understanding the HIV/AIDS epidemic [8,10-12].

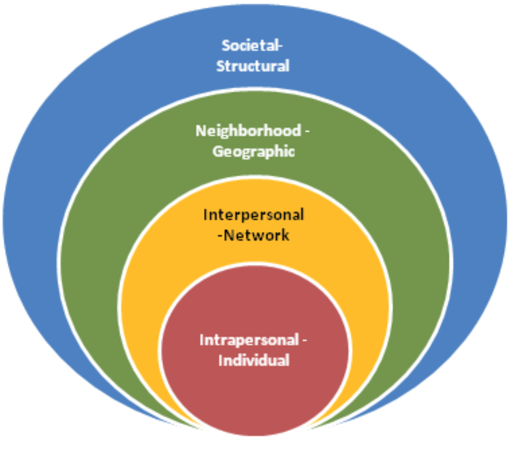

Figure 1. Socio Ecological Model of Health

Figure 1 presents an adaptation of the social-ecological model as one possible representation of levels of risk for HIV/AIDS. Following this model, Katrina might impact the way in which HIV acts at the individual level, such as influencing individual risk behaviors with unsafe sex or substance use practices. Social and interpersonal factors might be have been influenced by disruptions of networks or neighborhoods, and structural or policy level changes may have occurred at the system level such as the health care infrastructure.

Each of these levels embodies multiple research questions, often with multiple alternate hypothesized results. In order to best capture the possible ways in which the epidemic may have been affected by Katrina, the method of Strong Inference outlined by Platt [13] was used

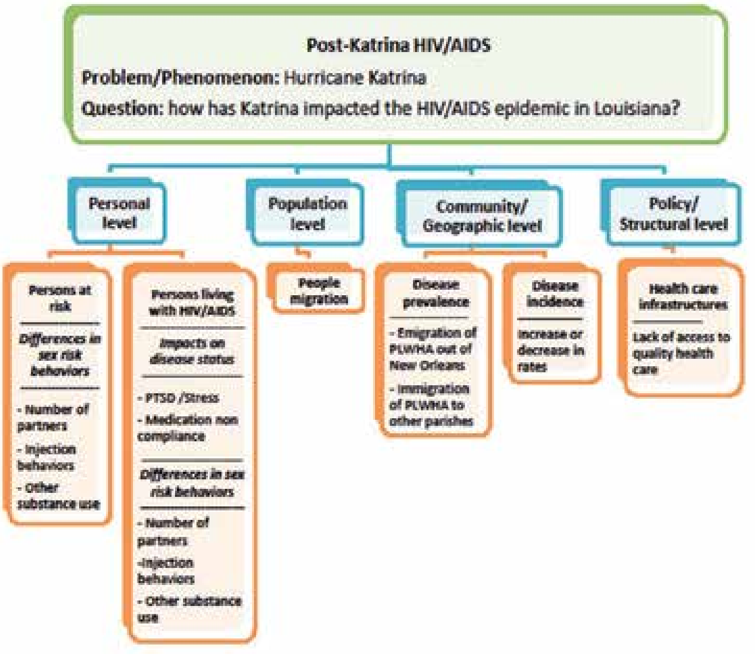

Figure 2. Logic tree conceptual diagram of potential Post Katina impact on the local HIV epidemic

to generate specific research questions and possible alternate hypotheses dealing with each of these levels.

Figure 2 represents the operationalization of these questions and the structure of their alternate hypotheses into a logic tree. These levels are explored in this chapter and the existing literature on HIV/AIDS and Hurricane Katrina is summarized and interpreted in this perspective.

2. Individual level

At the individual level, the primary changes that an event such as Katrina might have on the HIV epidemic are those of individual behaviors among those with or at risk for HIV/AIDS, and the impact that the disaster itself may have on the disease status of the individual living with HIV/AIDS.

2.1. Behavioral impact

The literature has pointed to changes in risk behaviors following natural and man-made disasters. While many of these changes may be moderated by the context of the event, increases in HIV specific risk behaviors, such as sexual or substance using practice, are common. Several studies specific to New Orleans have confirmed this effect after Katrina.

Morse [14] followed up with an existing cohort of New Orleans injection drug users 5 months after Katrina: 60% expressed that their risk behaviors had increased in the time since Katrina. Furthermore, among the injection drug users that had evacuated to other areas many had been incarcerated in other cities or had little or no difficulty in obtaining drugs. Kissinger [15] re-contacted a small sample of young women who had accessed clinical reproductive health services before the storm and found that many of them had stopped using birth control, contracted sexually transmitted infections or gotten pregnant after the storm. Similarly, she found high rates of risk behaviors among a sample of Latino migrant workers who had newly arrived after the storm [16].

Since 2003, New Orleans has participated in the *National HIV Behavioral Surveillance System* funded by the Centers for Disease Control and Prevention, an annual survey that assesses HIV risk behaviors and access to testing and prevention services among the three populations at highest risk for HIV a) men who have sex with men, b) injection drug users and c) heterosexuals living in areas at high risk for HIV and poverty. From 2006 to 2009, samples from over 500 respondents in each of these high risk groups were asked to self-report on their perceived change in HIV risk during the 12 month immediately after the storm. Overall, self-reports of increased risk - from 60% to 70% - were more commonly reported than reports of decreased risk (15%-20%). The most commonly reported reasons for why an individual's risk might have increased included increased or additional sexual partners, unsafe practices and increases in substance use or use of injection drugs and unprotected sexual practices. The most common reported reason for why a person's HIV risk might have decreases was a decreased number of sex partners.

These results cannot demonstrate a causal relationship between Katrina and change in risk. Furthermore they are self-report data and may be subject to recall or social desirability bias. However, they still do point to the fact that HIV risk behavior increased among many individuals in the time after Katrina.

2.2. Health status

The action of HIV is to compromise the human immune system by attacking the types of white blood cells (called CD4) that fight off many types of infection. Today, the primary disease management tool for HIV is the use of drugs including highly active antiretroviral therapy. Medication adherence, however, is critical in order to adequately manage the disease. Persons living with HIV on these regimens are able to live much longer and often control the disease to the point where its viral load is undetectable in the bloodstream. As a result the immune system may be less compromised and higher CD4 counts (a typical measure of the immune system t-helper cells) may be seen.

The impact of stress on the human immune response has been well documented [17]. Chronic stress can lead to reduction in the immune system's ability to fight off infection. Given that the mechanism for HIV is its effect on the immune system itself, it is no surprise that studies have demonstrated the relationship between stressful life events and the disease status of persons living with HIV/AIDS.

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Post-traumatic stress disorder (PTSD) is a chronic and long lasting stress related condition that is often triggered by specific psychological trauma. PTSD is common in post disaster environments and after Katrina, the entire population of New Orleans experienced trauma and levels of PTSD were shown to be highly prevalent in the city across many groups [18, 19] Wagner et al. [20] provide a synopsis of potential for PTSD, substance use, and HIV risk among youth subsequent to Katrina. Among persons living with HIV/AIDS, high levels of PTSD have been also shown following the experience of notification of a positive HIV diagnosis [21], and this has adverse impact on the disease progression.

In 2009, Reilly et al. [22] demonstrated high levels of PTSD (37%) in a sample of 145 persons living with HIV/AIDS in New Orleans one year after the storm. While high, these levels were consistent with other studies of the general population. By comparing the health status of those persons living with HIV/AIDS with PTSD to those who did not have clinical levels of stress, they found that persons living with HIV/AIDS with PTSD were less likely to have non-detectable viral load levels and were more likely to have weakened immune systems (CD4 counts) also two years after the storm. Thus, the disease status of the PTSD group was significantly worse than that of the group who showed low PTSD. It should be noted that this study was conducted on a clinic sample of persons living with HIV/AIDS who had already returned to and sought care in New Orleans, thus did not include people who were unable or unwilling to return.

Disease status of persons living with HIV/AIDS was examined to detect differences in the between Katrina evacuees who had returned to New Orleans and those who remained displaced outside the metropolitan area [23]. Laboratory records reported to the state Office of Public Health for 18 months prior to the storm and 18 months post storm were obtained and coded according to current residential status. It was found that those persons living with HIV/AIDS who had returned had overall CD4 counts comparable to residents from parts of the state unaffected by Katrina. Conversely, those persons living with HIV/AIDS who remained away from their homes showed both lower overall CD4 counts before and after the storm as well as showing a significantly greater decrease in CD4 in the time before to the time after the storm (Figure 3). While CD4 was used as the primary indicator of disease status in this study, similar results were found but not reported for increases in viral load laboratory results.

Other outstanding questions remain about the way in which an event such as Katrina might impact the disease progression of persons living with HIV/AIDS. While these increases in viral load and decreases in CD4 were found to be statistically significant 18 months out from the storm, studies are needed to examine the potential for longer term changes in these indicators. Furthermore, the extent to which these clinical indicators of disease status translate into other disease related outcomes is unknown. For example, do persons living with HIV/AIDS who were displaced or impacted by Katrina show shorter survival times from AIDS diagnoses to death? Similarly, reductions in time from HIV diagnosis to an AIDS diagnosis or AIDS diagnosing condition have not been established or investigated.

While stress, potentially in the form of PTSD, may be one explanation for these effects on disease status, other possible explanations are conceivable. For example, disruptions in medication regimen or adherence could also explain these results. This may be an intractable

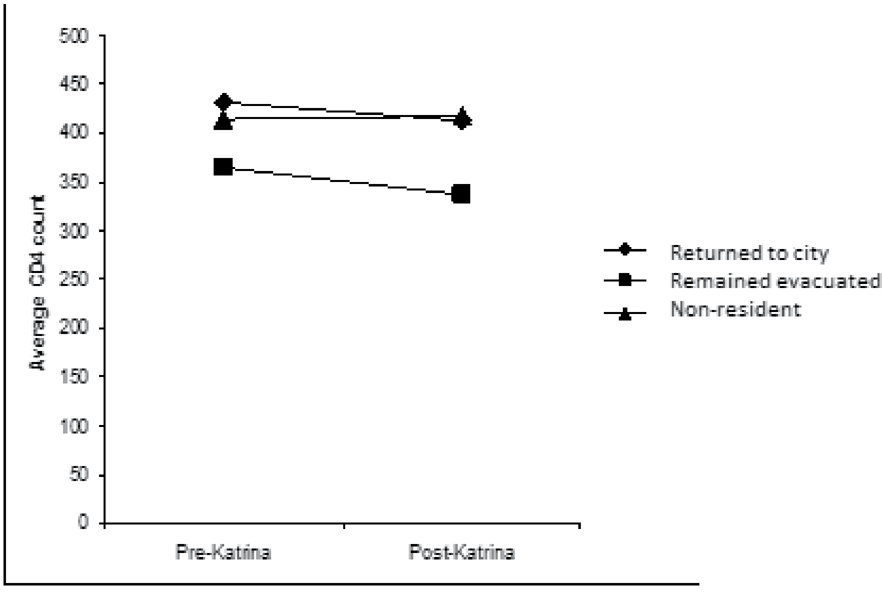

Figure 3. Average CD4 Counts Pre and Post Katrina for Evacuees, Returnees and Other state residents.

problem, however, given that PTSD itself has been shown to result in poor adherence [24,25]. Increases in viral load and decreased immune response at the individual level are certainly unfortunate, more problematic, however, may be the impact that this has on the epidemic itself. Recent studies have shown that individuals with high uncontrolled viral load, including those who are newly infected and may not know their status, are more likely to transmit the infection [26,27] and disruptions in medication can result in emergence of drug-resistant strains of the virus. Thus Katrina may have had a synergistic effect leading to increased risk behaviors and increased viral loads ultimately leading to increases in infections.

3. Social network and geographic levels

By far the most dramatic and long lasting effects of Katrina and the resulting failure of the federal levee systems was the widespread flooding and devastation of the city of New Orleans and surrounding communities. Many large areas of the city remained under over 10 feet of water for weeks after the storm. Furthermore, the city itself remained under a mandatory evacuation order with no critical services such as water or electricity for over a month until the New Orleans Mayor allowed a staged return to certain ZIP codes based on damage. Thus, people were unable to return to their, even undamaged, homes for long periods and those with significant damage were forced to relocate to other neighborhoods, cities or even states. Other large scale disasters may necessitate long or short term evacuation events. Flooding, radiation release, or damage, such as that observed in Katrina, Fukushima [28] or the 2010 Haiti

Earthquake, may lead to significant population migration. In these cases, accurate data on current population estimates are critical to conduct public health and other important planning efforts, however, these data are often invalid or not available, such as in the case with Katrina.

3.1. Population data

Because of the lack of availability of this important information in the absence of the traditional measures of population (e.g. the US Census), several attempts were made to calculate estimates of the return of the general population of New Orleans and the surrounding areas. One of the first comprehensive published results was the New Orleans Emergency Operations Center's Rapid Population Estimate Project, a survey realized by CDC and the Census [29]. Later survey estimates based on neighborhood enumerations [30] or made available from commercial sources or marketing research firms such as Claritas/Neilsen were released [31]. Eventually the U.S. Census was able to provide standard mid-year estimates of the city population, however, these figures have been regularly disputed by state and city officials and annually amended.

Several problems and caveats with these data sources exist that make it very difficult to plan and conduct regular public health activities. Clearly the results of these studies are extremely time dependent especially given the rapid and ever changing pace of the population migrations in the months and years since Katrina. The results also lack a needed level of geographic specificity or resolution, that is to say they are often only available at the level of the entire parish. This is problematic when assessing smaller areas such as ZIP codes, neighborhoods or census blocks. Given the differences in damage to neighborhoods may differentially influence a person's ability to return to their home. Related to this is the disparity and disproportionate impact of Katrina on different racial, ethnic and socioeconomic groups. Only with the release of the complete 2010 Census will true and accurate data be available at the level of detail that is needed to conduct public health and planning activities.

Because of the absence of reliable population data, planning efforts had to be based on non-empirical or proxy measures for traditional data. For example postal service measures based on the proportion of households within a ZIP code or neighborhood who were receiving mail were used in some cases. Greater New Orleans Data Center [32] conducted regular estimates using these sorts of methods. Other efforts included an ethnographic mixed methods approach that was conducted as part of the National HIV Behavioral Surveillance System. This project involved both qualitative and quantitative descriptions of neighborhoods that were identified as high risk for HIV prior to Katrina, which documented the potential viability of survey research within those areas. These efforts targeted neighborhoods of greatest HIV risk based on pre-storm data.

These investigations included systematic social observations or windshield surveys followed by brief street interviews, focus groups and semi structured interviews with neighborhood residents. In all staff rated neighborhoods in terms of the appropriateness for survey activities and overall recovery based on these measures, which included over 16,000 direct observations of individual residential units and over 100 interviews with neighborhood residents [32]. Many of these areas were among the most heavily damaged neighborhoods and some continued to be classified as non-livable months or years post-Katrina.

Figure 4. Katrina damage in Lower 9th Ward

Figure 4 and Figure 5 document damage to structures in the devastated Lower 9th Ward that was not atypical of the area. Other areas, however, such as the French Quarter and Uptown, remained relatively untouched and showed denser occupation than pre-Katrina levels.

Regardless of damage, the results of the qualitative and quantitative investigations showed clear disruption to peoples social and sexual network due to the changes in post-Katrina neighborhood level population. Interview results frequently referred to the splitting up of families, friends and social groups. In Brumsfa's Sociology of Katrina [33] the impact of the formal and informal social network is frequently mentioned. Under the socio-ecological model these are important potentially protective factors when one considers the potential roles of collective self-efficacy or the ability of a community to mobilize resources. When these ties are broken, the community suffers. These changes could represent possible risk factors as new, potentially HIV infected, partners enter fresh networks, or alternatively these disruptions could reduce the protective factors that social support has on decision making ability.

3.2. Prevalence

A more direct measure of community or geographic risk is the prevalence of disease within the areas that these networks are embedded within. Disease *prevalence* is often defined as the proportion of the population who have the disease or condition. While prevalence may be used

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Figure 5. Katrina damage in Lower 9th Ward

to assess the stage of an epidemic, it is also the key measure for planning for services to persons living with the disease or prevention interventions for those at risk.

For diseases such as HIV/AIDS, monitoring of local prevalence is often conducted by state or jurisdictional health departments through the use of registry or sentinel surveillance systems. Typical disease surveillance systems utilize either active or passive disease reporting of notifiable (legally reportable) conditions. In *active* systems the information usually is the result of field investigation conducted by epidemiologists or other trained staff. For example when an outbreak of foodborne illness triggers an active investigation of local restaurants. On the contrary, *passive* systems rely on information that is reported by medical providers or laboratories. In the U.S. HIV/AIDS, surveillance is conducted using the enhanced HIV/AIDS Reporting System, which is for the most part a passive system. Address at diagnosis is often initially reported and in many cases it is rarely updated. Because of this, calculation of geographic disease burden or local prevalence is based on this address at diagnosis, rather than last known address of the individual.

Under large scale migration or evacuation events, passive systems will *overestimate* the prevalence of the disease or condition because the system will not be updated: the address that was reported at the time of a person's HIV diagnosis will remain in place even after that person has evacuated. Two methods were developed to estimate the post-Katrina prevalence of persons living with HIV/AIDS [5] in the New Orleans region. One method, based on available population return data described above, applied the point estimates of the proportion of the general population to the number of pre-Katrina persons living with HIV/AIDS to compute estimated prevalence. A second method utilized available information from additional secondary active surveillance or reporting systems, such as laboratory reports, to document the return or relocation of persons living with HIV/AIDS. Cases with any available information were used as a sample of all cases to impute return of all persons living with HIV/AIDS. Both of these methods were recomputed at regular intervals in order to inform and direct the state and local health department during this critical period.

Figure 6 shows the estimated return of *persons living with HIV/AIDS* (PLWH/A) to Orleans Parish at time intervals consistent with the available population data. The rate of return of persons living with HIV/AIDS, using the secondary surveillance estimates, consistently matches the return of the general population. Not shown here, however, are the group specific estimates, which again point to disproportionate return based on race, sex, and geographic area of residence. Surprisingly, mode of transmission was an important factor in the ability to return, with men who have sex with men returning much earlier and at higher rates. However, this may be confounded with the geographic and socioeconomic characteristics of where many of them resided.

3.3. Incidence

Disease rate is often calculated as the number of disease cases divided by the number of persons in the population. However, more formal definitions would introduce time and replace the number of persons in the population with number of person-years at risk in the population.

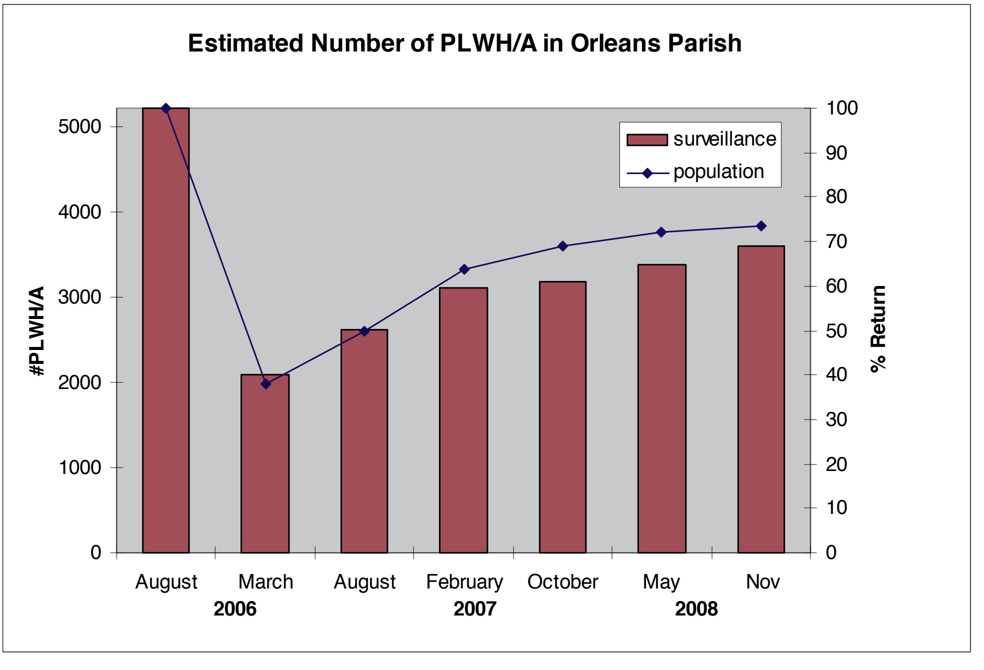

Figure 6. Estimated numbers of returning persons living with HIV/AIDS (PLWH/A)

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Under normal circumstances, these two numbers are equal and estimates of the # of persons living in an area at mid-year (as provided by the US Census) are equal to the actual number of person years at risk because any change over the course of the year is assumed to be consistent and therefore the midpoint reflects an average. However, in cases where the change in population is sudden this assumption is no longer valid and the mid-year no longer represents a true reflection of person years. It should be expected therefore that the mid-year estimate for New Orleans might violate this assumption since the entire city was under a mandatory evacuation order and only allowed a staggered and slow return to their homes.

Under large scale evacuation events, or other instances where the census does not accurately reflect the number of person years, disease rates will be drastically *underestimated*. Van Landingham [34,35] explained this phenomenon as applied to New Orleans murder rate. Due to the large population loss in the last months of 2005, there was an apparent drop in murders that was actually an artifact of calculations. After applying a corrected population estimate of the average person years at risk as a denominator the actual rate was similar to previous years.

Rates of HIV/AIDS calculated as those murder rates can produce incorrect estimates. In 2008 Robinson et al. [36] applied corrected estimates of the person years at risk to New Orleans HIV/AIDS diagnosis data and found that there was a dramatic spike in disease diagnosis rates in the year following Katrina (Figure 7).

4. Structural and policy level

We have already discussed how some persons living with HIV/AIDS and persons at risk may have had some difficulty in accessing needed programs services such as family planning or reproductive health needs [15] one year following the storm. Many of these interventions may have been traditionally sought at local public clinics, many of which remained closed until well after this time. This would be an example of one structural factor that could influence the epidemic as a result of Katrina. Thus, Katrina influenced the epidemic at a policy or structural level to the extent that clinic closures acted as a barrier to utilization of family planning services or other reproductive health needs that could've been used in the prevention of HIV or unplanned pregnancies.

Clearly one major concern following a natural disaster is in maintaining the infrastructure of the health care system. For those impacted with a disease such as HIV this is of vital importance and disruptions to the system can mean fluctuations in the delivery and availability of badly needed drugs or access to drug supplemental assistance programs. Several reports documented the recovery of the health care system and health care providers such as the Medical Center of Louisiana of New Orleans. One year after Katrina over 50% of professionals surveyed from the American College of Emergency Providers reported very little or no progress in the emergency care system [37]. Though improvements were marked and continue to improve to this day, a great deal of uncertainty existed well past that time [18] including the question of the future of the State's safety net health care system for indigent care.

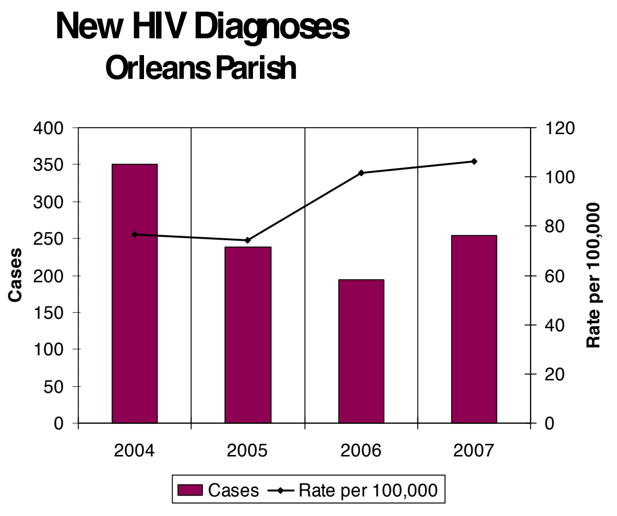

Figure 7. Corrected HIV rates in Orleans Parish 2004- 2007

Concerted efforts did take place to ensure quality care of persons living with HIV/AIDS. One example of that is the recovery of the Medical Center of Louisiana *HIV Outpatient* (HOP) clinic [38-41]. Approximately one month after the storm the New Orleans Mayor reopened areas of the city by selected ZIP codes. Immediately following this, HOP physicians and staff had established the means to provide medication and prescriptions to persons living with HIV/AIDS prior to reopening of their office space. Because of the importance of maintaining adherence, staff and social workers went so far as to advertise this service in local bars. By Summer 2006 staff had occupied a temporary space and restored many services, with some exceptions including laboratory testing.

Extensive efforts by state Office of Public Health personnel and social workers also resulted in minimal disruption to the state Ryan White Title II funded *AIDS Drug Assistance Program* (ADAP). These efforts included agreements with other states in order to preserve services for those persons living with HIV/AIDS who were dislocated to other states [42]. This strategy was successful in that the results of a collaborative needs assessment New Orleans persons living with HIV/AIDS who utilized services such as ADAP, relatively few (15%) reported not being able to access these services in the six months following Katrina [43]. Also, while there was a reduction in the number of statewide unduplicated ADAP clients in the quarter following Katrina, that number of quarterly clients remained stable in the three years following the storm, potentially reflecting the fact that a number of clients may have not returned.

Clark et al. [41] made several recommendations for increasing emergency preparedness capacity. Physicians and other health workers should reinforce patient responsibility in knowing about their health indicators and their own medication need. Systems should move towards electronic health records and plan for storage and backup of needed data. Disaster plans should be developed by staff that is tailored towards their client base and explains the need for and how to access services such as getting assistance with medication needs during these crises. Finally, providers should be aware that different funding mechanisms may be impacted by these events differentially and anticipate the results of that potential fiscal disruption.

Other policy level factors could easily influence disease or the way in which Katrina impacts the epidemic. For example, how recovery money is allocated to rebuild neighborhoods, or to rebuild the health care system itself. Staffing and health department decisions or capacity to compete for funding also may be important.

5. Summary

This chapter presents a summary of the numerous impacts that were observed after Hurricane Katrina on the population and individuals who are living with or at risk for HIV/AIDS in Louisiana and the New Orleans area. These findings are furthermore interpreted in accordance with the Socio-Ecological Model of Health in order to conceptualize how a major disaster like Katrina can have long reaching impacts on not just the individual but on entire communities and systems under which people live. It is hoped that this model will allow future researchers to more fully understand the impact of disasters in a new light, as well as provide valuable insight into the experience of public health professionals working in disaster recovery conditions.

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Chapter 4

Impacts of Cyclone Nargis on Social Capital and Happiness in Slightly and Heavily Affected Areas of Myanmar

Peter H. Calkins and Ngu Wah Win

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/54140

1. Introduction

Over the past twelve years, natural disasters such as floods, tornadoes, cyclones, volcanic eruptions, earthquakes, *tsunamis* and landslides have intensified, violently terminating thousands of lives and leading to vast financial and environmental losses. The magnitude of those losses depends upon the vulnerability of the affected population, which is in turn influenced by the country's poverty level, social safety nets, inter-group inequalities, educational system, infrastructure, other institutions or policies, and prevention technologies. Still, many types of disasters brush mockingly aside even the most ingenious technologies perfected by humans.

Multiple causes explain the increased frequency and destructiveness of such events. Human abuse of the earth's resources, unrestrained pollution, and the release of greenhouse gases may not actually cause natural disasters, but they have clearly made them worse and more frequent [1]. Destruction could be eased through short-term early warning systems and long-term poverty reduction programs. Human cultures, beliefs, social interactions and happiness are deeply affected by disasters and constitute a set of human resources that can be used to rebuild society afterwards. Only if the physical and emotional impacts, as well as the successful and unsuccessful prevention and mitigation strategies, of such disasters are better understood may societies hope to reduce suffering from future disasters.

1.2. Case study of cyclone Nargis

One of the least analyzed natural disasters of the past 20 years is the cyclone -- deceptively named *daffodil* (Nargis) – that assailed the *Subjective Well-Being (SWB)* of small scale farm families in the Irrawaddy Delta, Myanmar. On May 2, 2008, this cyclone ripped away the ability of those farmers to feed even themselves, much less others. They lost their families, means of livelihood, and property. Flooding, rains and storms surges washed out almost everything and left behind only barren land. The government stopped reporting the official death toll when it reached 138,000 people, but this is surely an underestimate; especially since the figure did not include the 55,000 people still missing at that time. Thus, Nargis victims in Myanmar easily surpassed the entire human loss (170,000 fatalities) suffered from the much better-known nine-country (Indonesia, Sri Lanka, India, Thailand, the Maldives, Somalia, Myanmar, Malaysia, Seychelles) tsunami of 2004 [2].

A significant portion of the Nargis deaths could probably have been avoided. No system or programs of disaster relief or prevention were in place in Myanmar at the time of the disaster. Indeed, Nargis is the epitome of what can and does go wrong when humans disregard the delicate balance between nature and human consumption patterns, fail to anticipate or prepare for the consequences, and refuse aid in the hours and days following the disaster. It is true that throughout Myanmar, the involvement of government, non-governmental and economic development organizations in disaster recovery brought a certain level of needed support to the victims. Some organizations dedicated entire programs to disaster-related issues, whereas others administered recovery funding to only a limited extent. Unfortunately, however, each aiding country or organization brought its separate capacity and solutions, leading to coordination gaps and overlaps. Some international relief organizations even imposed conditions, such as religious conversion, which put victims into a no-win situation. Worse still, the government turned away or lethally delayed much of the shipments of food and medicine sent to the country [3].

1.3. Goal and specific objectives of the case study

The present study attempts to measure the subjective, intangible impacts of the Nargis cyclone on the happiness and well-being of the inhabitants of the Delta. The overall goal is thus to infer, using two study areas differentially affected by Nargis, its impacts on the level and distribution of *SWB* and social capital, and to make policy recommendations for the alleviation of some of the psychic effects. We used the word *infer* rather than *measure* because there had been no baseline study of subjective (or even monetary) well-being of the heavily affected area, Bogolay, before Nargis struck. A slightly affected area, Pyapon, was selected as a proxy benchmark for the *before* situation in Bogolay, against which the *after* situation, 27 months following Nargis, might be compared. To achieve this overall goal, this chapter is designed to meet four specific objectives:

1. Assess and compare relative poverty vs. relative happiness using the Gini, Thiel, and Lorenz curves [4], [5] for small farm households in heavily- vs. slightly-affected areas.

2. Assess and compare absolute poverty vs. absolute happiness using the Foster-Greer-Thorbecke indices [6] for small farm households in heavily- vs. slightly affected areas.

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3. Identify the physical, mental, emotional, social, and spiritual causes of subjective ill-being in areas differentially affected by Nargis.

4. Advance recommendations to local and national governments, NGOs, disaster researchers, and the affected communities concerning how to reduce absolute unhappiness; and anticipate, protect against, and reduce the psychological and social impacts of natural disasters.

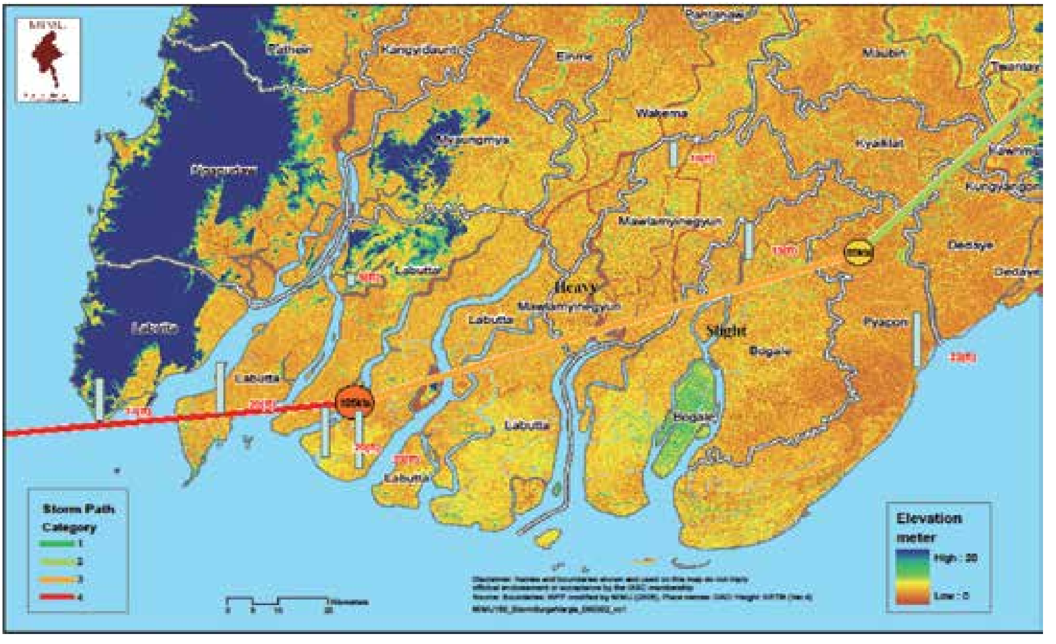

Figure 1. Path of cyclone Nargis and the loctions of the heavily and slightly affected areas. Source: MIMU _ Myanmar Information Management Unit

2. Literature review

The socio-economic research on natural disasters and their human consequences is fairly limited. Studies carried out among direct victims of disasters have demonstrated the persistence of at least one third of cases of trauma for more than two years after disaster exposure [7]. According to Galea et al. [8], most post disaster trauma will likely be resolved. Long term trauma on disasters continues to remain largely unexplored. Generally, post disaster stress subsides within one or two years in comparison to the immediate post-disaster situation.

To alleviate such trauma, Das [9] finds that the creation of a public space for sufferers may achieve to share voices for recounting their experience and a social acknowledgement of the events they have survived. Healing can be the end of suffering based on the way people use right understanding and life wisdom to interpret those events. The themes of wholeness and spirituality are harmonized with the origin of the term healing. Healing may be achieved through cognitive, emotional or behavioral reactions.

The individual stresses of a disaster have been found to be influenced by social networks. Disaster recovery is not only about building houses but the reconstruction of the whole community as a safer place [10]. To mobilize each member of the community in this community development, social capital is a crucial need. Indeed, in the post disaster situation the maintenance or increase of social capital seems crucial to enhanced disaster resilience. Social factors play a big role in the prevention of Post-Disaster Psychological Distress because of the strong correlation between the presence of social support and the mental health outcome following traumatic events.

Adler and Kwon [11] believe that social capital research is guided by the intuition that the goodwill borne to us by others us is a valuable resource. They define social capital as the goodwill available to individuals or social groups. Its source lies in the structure and content of the actor's relations. Its effects flow from the information, influence, and solidarity made available to the actor. Dekker and Uslaner [12] label external or out-group social capital as bridging [13] or communal social capital [14], while that focused on internal relations may be termed *bonding* or *linking*. Noy [15] has determined that countries with higher social capital, educational attainment, quality of institutions and governance, government spending and per capita income are better able to withstand the initial disaster shock and prevent further spillovers into the macro-economy. It is worth noting that Myanmar is lacking in most of these dimensions.

Social capital in turn is found to be positively correlated with subjective happiness since it provides support and opportunities for sharing at the individual level. Frey [16] explains that such trust and honesty improve social outcomes by increasing the levels of per capita income and SWB. If the people with whom one deals can be trusted rather than doubted, social capital is generally higher. Trustworthiness has both individual and societal dimensions; those who live in societies with high levels of trust are likely to have higher well-being, irrespective of individual views about trust. There are thus real well-being benefits from living in an environment where people can be trusted. Social capital is thus related to the value of social networks, bonding with similar people, and bridging between diverse people within the norms of reciprocity [17]. By providing networks of relationships, facilitating job search [18], and engendering the support from others, social capital is strongly related to a person's level of subjective happiness. This extends to the impact of democratic institutions on well-being through their positive influences on political, economic and individual freedoms [19].

Happiness is also dependent upon the level and distribution of income and its correlate, poverty. For this study, the Gini and Theil coefficients [4], [5] will be used to measure relative income inequality. The Gini coefficient is defined as the proportion of the area lying between the Lorenz curves of actual income distribution (red and green lines in Figure 2) and the blue 45-degree straight line of perfect equality. The range of the Gini coefficient is between 0 and 1, the smaller the better. In this study, we shall innovate by calculating the Gini coefficient not just for the distribution of monetary income, but also for of the distribution of happiness. The Theil coefficient is closely related to the Gini coefficient but avoids some of its mathematical shortcomings.

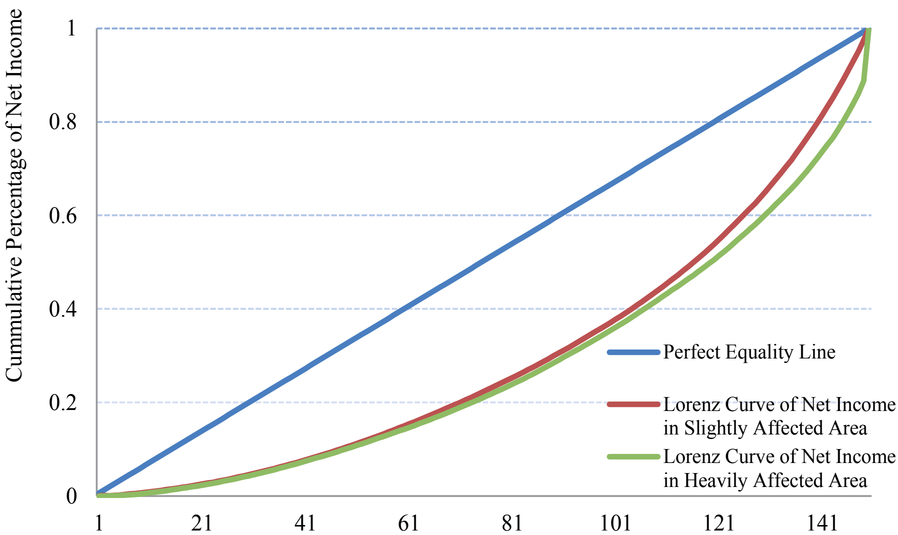

Figure 2. Illustrations of the Lorenz curves and Gini coefficients

But since the Gini coefficient is based upon the entire distribution of income, it is still inadequate to identify and help those households with absolute income below critical levels targeted by social and economic policies. The best-known absolute measures of poverty are the *Foster-Greer-Thorbecke (FGT)* measures of the *incidence*, *depth*, and *intensity* of poverty, to which we add the *urgency* of poverty (Eq. 1).

$$FGT_{\propto} = \sum_{i=1}^{H} \frac{\left[\left(z-y_i\right)/z\right]^{\propto}}{N} \tag{1}$$

Where: H = number of poor households; N = number of total households; z = poverty line in terms of the amount spent by the household per day; y_i = actual per capita expenditure; α= measure of the social aversion to inequality, such that, α=0 denotes the incidence of poverty; α=1 measures the depth of poverty; α=2 measures the intensity of poverty; α=3 measures the urgency of poverty.

Poverty is defined by monetary measures by the number of people living under the poverty line. The common international poverty line used today is \$1.25 at 2005 purchasing-power parity (PPP) [20]. Other subjective approaches to well-being assessment have been developed to measure the perceived poverty line, thus complementing or in some cases replacing income-based approaches [21], [22], [23]. In addition, purely subjective yardsticks have been developed to capture self-reported levels of happiness [24] [25].

In the present research, we calculate FGT measures to the incidence, depth, intensity and urgency of unhappiness with respect to mean self-reported happiness for the population. We employ the Lyubormisky questionnaire [24]. We shall also use some of the questions from Argyle and Hills' 29-statement Oxford Happiness Survey [25].

3. Conceptual framework

Based upon the literature, our conceptual framework is portrayed in Figure 3. The rhombus shows the structure of the dependent variable (well-being) that figures to the left of the equal sign in relation 2:

$$\begin{aligned}&\text{Well- being }(\omega_{\mathrm{p}}\text{ physical}, \omega_{\mathrm{m}}\text{ mental}, \varpi_{\mathrm{e}} && = && \beta_0\text{ basal happiness} + \beta_1\text{ personality} + \\ &\text{emotional}, \omega_{\mathrm{s}}\text{ social}, \omega_{\mathrm{sp}}\text{ spiritual}) && && \beta_2\text{ socio- demo factors} + \beta_3\text{ economic factors} + \beta_4\text{ interpersonal} \\ & && && \text{and work relations} + \beta_5\text{ institutional factors}\end{aligned} \tag{2}$$

The remaining boxes and arrows trace the direct and indirect influences that lead up to the final level of *SWB*; in other words the separate items and interactions among the arguments to the right of the equals sign in relation 2. These boxes portray the factors that potentially make some people happier or unhappier than others in the face of natural disasters or other external vicissitudes:

a. Income loss.

b. Non-income economic factors, such as perceptions of individual vs. aggregate income, unemployment, and inflation. Being unemployed or feeling that one is losing ground with respect to inflation or the neighbors' income, is a far more important drain on happiness than a low level of income itself.

c. Genetics and the make-up of the brain. This relates to the ambient levels of serotonin and other chemicals that physically create cheerfulness regardless of external circumstances.

d. Personality factors, such as self-esteem, personal control, optimism, extraversion, and neuroticism. Taken together, b and c constitute what psychologists term the set point. Previous research shows that each individual returns very rapidly to that set point even after major good luck (e.g., winning the lottery) or bad luck (being the victim of a natural disaster). It normally takes between six months and a year to return to one's normal happiness level [1].

e. Socio-demographic factors, such as age, gender, marital status, education, culture, and religion.

f. Contextual and situational factors, such as particular employment and working conditions; the stress involved in the work place; interpersonal relations with work colleagues, relatives and friends, and most importantly the marriage partner; as well as living conditions and health.

g. Institutional factors, such as the extent of political decentralization, perceived levels of corruption, and citizens' direct civil and political participation rights.

Yellow boxes portray the physical and logistical effects of natural disasters, especially as concern demography, both physical and wealth well-being. These elements, as well as social well-being and final SWB (light blue boxes) present great importance to the creation of happiness. The pink boxes represent negative impact on well-being (absolute poverty and relative inequality): they often have a powerful and immediate depressing impact upon *SWB*. Social well-being may act through both bridging and bonding social capital and rapid rebound to offset the effects of both yellow and pink boxes. If government and NGOs do not intervene, this system can operate internally to determine the level and distribution of SWB. When there is external intervention, however, it may take the various forms represented by the green boxes. These include education, training, and the attraction of better-educated residents, poverty reduction programs, the installation of early warning system, coordination among NGOs and with government agencies, rehabilitation of victims, loans to poor and female-headed households, and the creation of individual and social resilience.

Any or all of these may act perniciously, however. This is because institutional power, economic situation, aid distribution and pre-disaster relationships between and within societies may be harmful to the affected community, which can lead to both social problems and intensified human suffering. Unfortunately, previous research (e.g. [26], [27] and [25]) has often confused the internal anatomy of SWB (to the left of the equals sign in equation (2) with its exogenous determinants (to the right).

This research will estimate the endogenous weights (ω_i) of the components of well-being for each area, compare that structure between the two areas, and then explain and test for significant differences among the determinants β_i of the overall well-being score. Disasters and their direct effects (yellow boxes, Figure 3) have negative impacts on the emotional well-being, financial status, health and even life itself of individuals, families and communities.

3. Methodology

3.1. Testable research hypotheses

Based on the literature and conceptual framework, we shall empirically test five research hypotheses:

1. Average SWB (happiness) of the heavily affected area is not significantly different from that of the mildly-affected benchmark area, suggesting that human beings rebound rapidly from disasters.

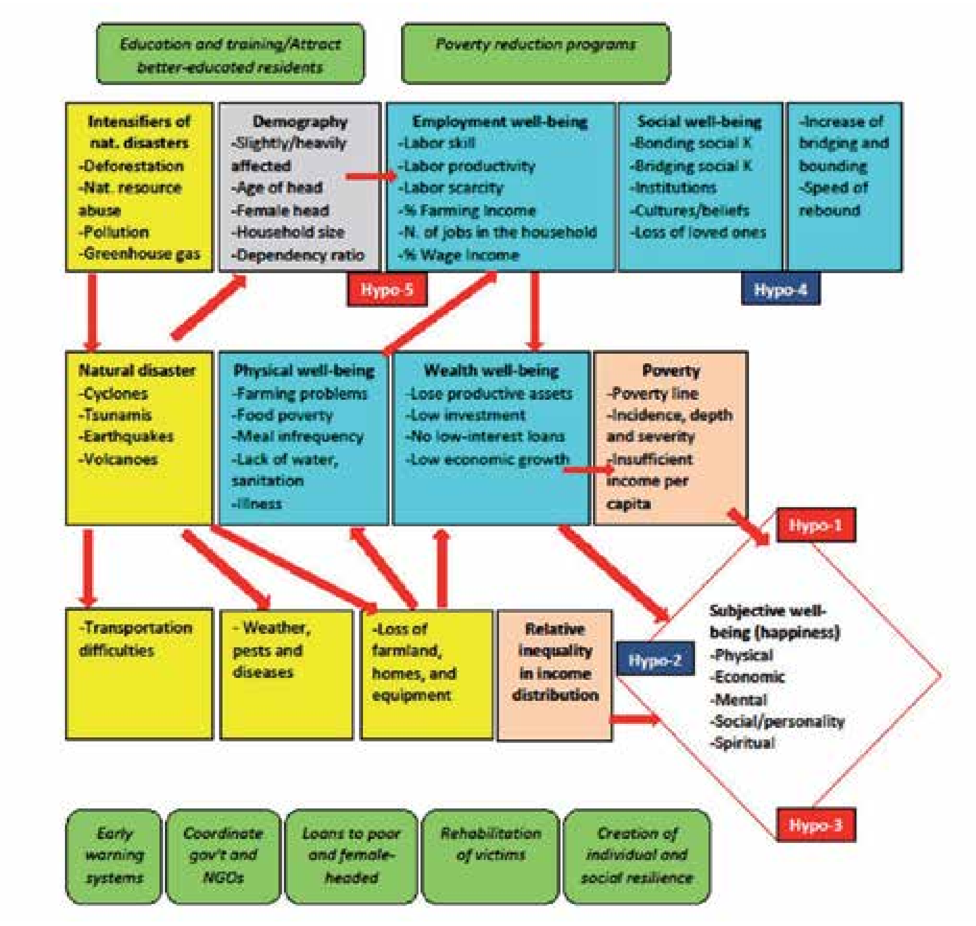

Figure 3. Conceptualization of the causes, pathways, well-being impacts, and corrective policies of a natural disaster

2. Around similar average happiness levels in the two areas, there are much more severe cases of unhappiness, and hence a much worse distribution of happiness, in heavily affected than in slightly affected areas.

3. The internal weighting of the sub-components of happiness differs significantly between the two areas.

4. The social capital of both types (bridging and bonding) in the Nargis heavily-affected area has increased significantly in comparison with the slightly affected area. This should give them higher protection from disasters in the future.

5. The determinants of SWB include income, social capital, education, employment, spiritual meditation, and male gender of household head regardless of the extent of Nargis damage.

3.2. Methods used for data analysis

The present research into the intangible consequences of a natural disaster upon subjective (un)happiness will be highly quantitative. We shall sequentially apply: a) the Foster-Greer-Thorbecke models of the absolute unhappiness, b) Gini and Theil estimations for relative happiness, c) tests for significance differences of means, d) correlation matrices with tests of significance and e) multiple linear regressions to determine the causes of absolute unhappiness. To best gauge the effects of a natural disaster, we have innovated on the three-part Foster-Greer-Thorbecke model of the a) incidence, 2) depth, and 3) intensity of monetary poverty by adding a fourth level 4) urgency. To calculate urgency, one simply takes the level of poverty or ill-being to the third power instead of just the 0th, 1st or 2nd powers. We also innovate in applying all four levels to unhappiness as well as poverty.

The cost-of-basic-needs approach will be used to measure poverty as it is perceived by a household. This should capture the psychological, demographic and social aspects that are taken into account in SWB approaches by considering an individual or household to be extremely, moderately, or not at all poor with respect to their consumption needs. In addition, two different scales to measure SWB or happiness were jointly used to analyze the impacts, if any, of cyclone Nargis on the level and components of happiness in the two areas.

We used Lyubomirsky scale [24], and the Chiang Mai University (CMU) scale, that It includes 28 questions taken or adapted from various sources, including the authors' field experience and the Oxford Happiness Survey [25] (Table 1). Even though the Lyubomirsky and Chiang Mai scales both seek to assess overall happiness, they are built up from quite different concepts.

The Chiang Mai scale is clearly broken down into social capital; as well as physical, mental, emotional, social and spiritual happiness. Each of these five dimensions implies a dominant time horizon, which may be hypothesized to lie on a continuum (Fig. 4).

For example, emotional happiness should logically be significantly correlated with the Lyubomirsky scale in the short run in that emotions are the immediate and often fleeting feelings in people's lives. At the other extreme, spiritual happiness is essentially a long- or eternal-term dimension expected to be positively correlated with Lyubomirsky's general happiness. This is because spiritual happiness is based on the satisfaction derived from inner mindfulness and mental strength regardless of, or even gained from, events in one's life. That strength can be a source of self-realization and inner pride.

Figure 4. Continuum of the sub-components of happiness by time horizon

Questions	Composite score
In general, consider myself a very happy person + Compare to most my peers, consider myself happier + Some people are generally very happy and what extent best describe the respondents + am not unhappy person	Lyubomirsky Subjective Happiness
Types of neighborhoods + agree or disagree that this neighborhood from different backgrounds get on well together + contact organization to solve the problem affecting people in the respondents' local area + share information to others if there is anyone the respondents could ask for help + involvement in the groups	Social Capital
Look attractive + feel fresh and full of energy + have great physical well-being at this time + will probably be free from diseases	Physical Happiness
Love to challenge my mind to create something new and different + often lose myself in the flow of my work or hobbies + feel secure + do have a happy memories + have no worries	Mental happiness
Don't regret the past + can easily/quickly calm down when feel bad/stressed + find myself smiling when no one else around + feel peace in my heart	Emotional Happiness
Can laugh even in the face of difficulty + know myself and exactly what want/need + respect myself + have clear faith or religion + feel great peace in my soul + willingly accept what happens to me + accept that others may have different beliefs + feel my life is very bright + can be myself however am or where go + am satisfied about everything in my live	Spiritual Happiness
Love to share with other people + feel harmony with others people + am not afraid of what others may think + My own freedom is more important than what others think	Social Happiness

Table 1. Component questions from the Lyubomirsky and Chiang Mai scales and the composite scores

3.3. Data collection

Sources of data were both local and national. We first amassed the secondary data on the Irrawaddy Division (Cyclone Nargis affected area). The major sources for secondary data were the Myanmar Agriculture Services, Settlement and Land Record Department, Central Statistical Organization, United Nation Development Program, Food and Agricultural Organization, World Food Program, United Nation Office for Coordination of Humanitarian Affair, United Nations International Children's Emergency Fund), Groupe de recherche et d'échanges technologiques and other non-governmental organizations. Secondary data of

http://dx.doi.org/10.5772/54140

the township, village profiles, maps, annual progress reports, project documents reports were also collected.

The questionnaire was designed to inquire about the socio-economic situation, use of economic infrastructures, social capital and happiness levels of individual households in the two research areas. The time frame of an interview was set at forty-five minutes to one hour. A pilot survey was conducted in May 2010 in Pyapon Township. The pilot survey data revealed the impact of local norms, gaps in information, and the degree to which data analysis would be feasible. Some assumptions and survey questions had to be adjusted before the main survey was undertaken. Final data collection involved 298 respondents: 148 from Pyapon and 150 from Bogalay.

4. Case study results

4.1. Hypothesis 1

Average SWB of the heavily affected area is not significantly different from the mildly-affected benchmark area, suggesting that human beings rebound rapidly from disasters.

The results shown in table 2 fail to invalidate hypothesis 1 as to the equality of average happiness levels in the two townships. The average score of heavily-affected Bogalay on the Chiang Mai scale (3.143) is not significantly different from the scale of slightly affected Pyapon (3.202). The level of significance (ie., the probability of committing an error in assuming a significant difference) is 12.8%, higher than the 10% cut-off point established for this study. In terms of the Lyubomirsky scale, the score of happiness in Bogalay is actually higher than in Pyapon (3.087 vs. 3.078), but this result is extremely insignificant (significance = 0.879).

The results further show that only average mental happiness is significantly lower in Bogalay (3.00) than in Pyapon (3.20). This is presumably because of the residual mental anguish associated with bad memories, nightmares, missed loved ones, and the karmic questionings noted above. We have also determined from a correlation matrix (not shown here) that all the components of happiness are very highly correlated with each other, except for emotional and social happiness. The former is individual; while the latter is collective, a reflection of social capital and human relations. Further research will have to be done to determine why this is so.

4.2. Hypothesis 2

Around similar average happiness levels in the two areas, there are much more severe cases of unhappiness, and hence a much worse distribution of happiness, in heavily affected than in slightly affected areas.

We must reject hypothesis 2, however, because overall happiness and its five components do not mask significantly greater variations around the mean for Bogalay than for Pyapon. On the one hand, the coefficients of variation across households within the two samples

Happiness	Nargis damage	Means	Heavy minus slight	Std. Dev'n	Coeff var'n	t	Sig.
Average CMU score	Heavy	3.143	-0.059	0.339	11%	-1.53	0.128
	Slight	3.202		0.337	11%		
Average Lyubomirsky score	Heavy	3.087	0.009	0.447	14%	0.15	0.879
	Slight	3.078		0.500	16%		
Physical AHLS score	Heavy	3.122	0.044	0.614	20%	0.61	0.545
	Slight	3.078		0.625	20%		
Mental AHLS score	Heavy	3.004	-0.199	0.451	15%	-3.69	0.000
	Slight	3.203		0.482	15%		
Emotional AHLS score	Heavy	3.031	-0.024	0.372	12%	-0.51	0.608
	Slight	3.055		0.435	14%		
Social AHLS score	Heavy	3.205	0.108	0.671	21%	1.38	0.168
	Slight	3.097		0.688	22%		
Spiritual AHLS score	Heavy	3.271	0.128	0.469	14%	-1.40	0.163
	Slight	3.143		0.339	14%		

Table 2. Tests of significant differences in means between the two areas (Slight damage: Pyapon; Heavy damage: Bogalay).

(Table 2) are very similar for happiness and all its components, suggesting that -- like the means -- the distributions of happiness overall and by category are also roughly similar. On the other, Table 2 suggests extremely little difference in either the absolute incidence (four extended Foster-Greer-Thorbecke measures) or the relative distribution (Theil and Gini coefficient) of overall happiness and most of its subcomponents, either for the combined or the Pyapon and Bogalay samples. The differences would probably not be significant if appropriate statistical tests were available; except in the case of the incidence, depth, intensity, and urgency of mental unhappiness in Bogalay, for the reasons stated above. This single exception does not prevent us from clearly rejecting hypothesis 2.

What is more, the distribution of happiness is much more equal than the distribution of income per capita (as measured by the Gini and Theil coefficients) of the two samples (Table 4 and Figure 5). The incidence, depth, and intensity of unhappiness are not only radically less pronounced than the incidence, depth, and intensity of monetary poverty (cf. Figure 2); they are virtually identical for the heavily- and slightly-affected areas. As a corollary to the Easterlin paradox, we may posit that greater poverty does not make people proportionately less happy.

4.3. Hypothesis 3

The internal weighting of the sub-components of happiness differs significantly between the two areas.

	Regression	Absolute unhappiness				Relative happiness	
	Anatomy	Incidence	Depth	Intensity	Urgency	Quintile ratio	Gini coef.
CMU SWB score							
Combined sample		**35.9%**	**0.082**	**0.027**	**0.011**	**1.38**	**0.062**
Slight		*37.2%*	*0.084*	*0.028*	*0.012*	*1.39*	*0.063*
Heavy		*34.7%*	*0.080*	*0.027*	*0.010*	*1.36*	*0.056*
Physical happiness							
Combined sample	**.009*** **	**35.9%**	**0.189**	**0.129**	**0.108**	**1.76**	**0.119**
Slight	*0.204*	*37.8%*	*0.199*	*0.146*	*0.134*	*1.78*	*0.128*
Heavy	***0.072****	*34.0%*	*0.178*	*0.113*	*0.082*	*1.74*	*0.125*
Emotional happiness							
Combined sample	**.000*** **	**38.6%**	**0.193**	**0.130**	**0.109**	**1.65**	**0.108**
Slight	*0.178*	*39.2%*	*0.199*	*0.131*	*0.105*	*1.67*	*0.119*
Heavy	***0.000******	*38.0%*	*0.187*	*0.130*	*0.112*	*1.64*	*0.111*
Social happiness							
Combined sample	**0.19**	**37.6%**	**0.194**	**0.134**	**0.121**	**1.83**	**0.129**
Slight	*0.052**	*39.9%*	*0.221*	*0.173*	*0.175*	*1.86*	*0.139*
Heavy	*0.83*	*35.3%*	*0.167*	*0.097*	*0.067*	*1.8*	*0.134*
Mentalhappiness							
Combined sample	**0.186**	**34.6%**	**0.136**	**0.070**	**0.045**	**1.54**	**0.093**
Slight	*0.440*	*29.1%*	*0.097*	*0.043*	*0.025*	*1.5*	*0.099*
Heavy	*0.398*	*40.0%*	*0.173*	*0.097*	*0.065*	*1.52*	*0.099*
Spiritualhappiness							
Combined sample	**.000*** **	**24.8%**	**0.069**	**0.027**	**0.013**	**1.49**	**0.088**
Slight	*0.000****	*23.0%*	*0.061*	*0.025*	*0.013*	*1.48*	*0.095*
Heavy	*0.069**	*26.7%*	*0.077*	*0.028*	*0.012*	*1.49*	*0.096*

Table 3. Absolute unhappiness and the distribution of relative happiness in the two areas (Slight damage: Pyapon; Heavy damage: Bogalay).

The results shown in table 3 fail to invalidate hypothesis 3. The fact that the two Chiang Mai and Lyubomirsky scales contain very different components allows us to regress one on the other. In this case, we shall "explain" the Lyubomirsky score based on the five separate dimensions of the Chiang Mai scale to determine their relative importance to inhabitants of the two distinct areas of the Irrawaddy Delta. Three separate regressions were run for: a) the entire 2980 person sample and b-c) the 148 to 150 people in each area. The dependent variable for all three equations was the Lyubomirsky happiness score of the household, predicated to significantly increase as each dimension of short- or long-term happiness. The first three data columns of Table 5 indicate that for the overall sample, neither mental nor social happiness was a significant explanatory variable of the Lyubomirsky scale. In the mental dimension, two years after Nargis, people still had an indelible memory of this tragedy. Men-

	Monetary income/poverty		Happiness/unhappiness	
	Pyapon	**Bogalay**	**Pyapon**	**Bogalay**
	Slight	*Heavy*	*Slight*	*Heavy*
Gini coefficient	0.400	0.450	0.063	0.056
Theil Index or quintile ratio	0.250	0.380	0.012	0.010
Incidence	39.0%	67.0%	37%	35%
Depth	0.16	0.32	0.084	0.08
Intensity	0.08	0.20	0.028	0.027
Urgency	0.05	0.17	1.39	1.36

Table 4. The relative and absolute distribution of monetary income (Slight damage: Pyapon; Heavy damage: Bogalay).

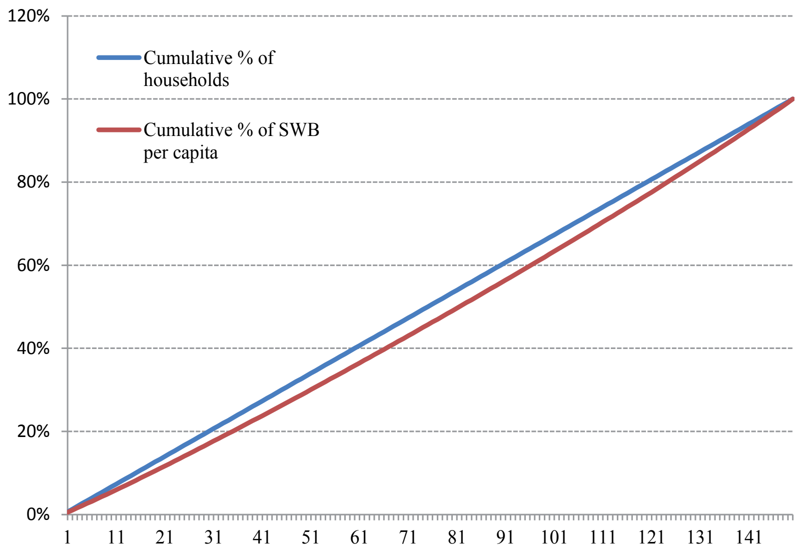

Figure 5. The Lorenz curves and Gini coefficients of unhappiness for both Bogalay and Pyapon.

tal unhappiness persists in the long-run, especially in Buddhist societies, because it is difficult to forget and even harder to forgive what people assume to have been their own errors in previous generations.

When people become victims of natural disasters, they ruminate on the horrible mistakes they must have made in their previous incarnation to merit the terrible fate of losing all one's family and possessions. At the time of the survey, it was also the monsoon season, with very stormy weather. When the children heard the thunder and saw the lightning, we

	Overall sample			Heavy damage: Bogalay			Slight damage: Pyapon		
Type of happiness	**B**	**t**	**Sig.**	**B**	**t**	**Sig.**	**B**	**t**	**Sig.**
Physical	**0.18**	**2.61**	**.009*** **	**0.17**	**1.81**	**0.072***	**0.12**	**1.28**	**0.204**
Mental	0.11	1.33	0.190	0.1	0.85	0.400	0.09	0.78	0.440
Emotional	**0.26**	**3.81**	**.000*** **	**0.4**	**3.57**	**.000*** **	**0.12**	**1.35**	**0.178**
Social	-0.12	-1.31	0.190	0	-0.2	0.830	-0.22	-1.96	0.052*
Spiritual	**0.57**	**4.11**	**.000*** **	**0.38**	**1.83**	**0.069***	**0.84**	**4.36**	**.000*** **

Table 5. Lyubomirsky happiness scale as determined by the five components of the Chiang Mai happiness scale. Dependent variable = Household-level Lyubormisky scores within the designated sample

observed them grab their toys and run into the house. To make matters worse, their parents were also facing problems of crop failure that season. This added to the mental stress and anguish of all households, taking away any significant connection with inter-household differences in overall happiness.

In terms of the social dimension, we would also have expected good relations with others to increase happiness. However, social happiness is non-significant in the combined and Bogalay regressions and significantly negative in the case of Pyapon (Table 5). This surprising result may partially be explained by resentment over how the aid after the cyclone was distributed. Based on the selection criteria for which areas and households were to receive relief, conflict arose between vulnerable households and community-based organizations. Because most of the NGOs knew little about Pyapon and which households were truly the most vulnerable, they sought direction from the community-based organizations. But these latter were corrupt and subject to favoritism, leading to injustice and unhappiness on the part of just about everyone.

The Bogalay regression (Table 4) indicates that physical, emotional, and spiritual dimensions are strongly correlated with happiness in the Lybomirsky sense, as predicted. However, both mental and social happiness are not significant for the same reasons as for the overall sample. Indeed, the people of Bogalay arguably suffered as much physical, livelihood, environmental, and human loss as almost anywhere in the Delta region. There is thus an enormous burden of karmic suffering from what has happened in their lives. This is consistent with the results of the t-tests for significant differences in means, under which only mental happiness was significantly different (and lower) in the heavily-affected area. It is not surprising, then, that happiness in Bogalay does not spring from the mental dimension.

The Pyapon regression (Table 4) is quite different. Spiritual happiness accounts for an astounding 84 percent of the overall score on the Lybomirsky scale. This reflects the overwhelming importance of individual karma in people's perceptions of happiness in the slightly affected area, in the sense that the people of Pyapon take strong comfort and satisfaction from the fact that their previous good deeds (kusula) saved them from the eye of the cyclone. This is also related to the fact that the social dimension in Pyapon is significantly negative. Social conflict arose in Pyapon because of both aid distribution problems, and high population density, and dependency ratios. An ugly social situation may therefore help to explain the strong spiritual retreat into interiorization, meditation, and solace-seeking in religion in Pyapon. Finally, the physical, mental, and emotional dimensions of happiness have nothing significant to do with the Lyubomirsky score, denoting a random distribution of these elements across happy and unhappy people in Pyapon.

These differences lead us to accept hypothesis 3. We further determined, in results not shown, that average scores of physical, mental, emotional, social and spiritual happiness of male-headed households were all higher than for their female-headed counterparts.

4.4. Hypothesis 4

The social capital of both types (bridging and bonding) in the Nargis heavily-affected area has increased significantly in comparison with the slightly affected area. This should give them higher protection from disasters in the future.

Various analyses lead us to reject hypothesis 4. As mentioned, Nargis affected status has no significant effect upon happiness. But this is not the case with social capital, which has a positive and significant correlation with happiness roughly equal to meditation at the temple. In the sustainable livelihood context, social capital is taken to mean the forms of mutual social assistance upon which people draw. These include networks such as caste, play groups, men's groups, women's associations, and religious groups. These networks can provide an informal safety net during difficult times and play a pivotal role in helping people access resources needed after a disaster. One of the most significant characteristics of resilient communities is the extent to which they work together towards a common aim, a function of their social cohesion. Groups that are homogeneous in terms of class, ethnicity, livelihood or wealth are more likely to cooperate in building resilience to disaster.

Village-level interviews determined that the relations between villagers and their formal and informal leaders were particularly strong. Indeed, one would expect that there would be an increase in joy as people banded together to help each other rebuild their lives. This is, as we have seen, an example of *bonding*. We would also expect that the villagers would be assisted by new NGOs and other organizations from outside, with whom they had had little or no contact in the past. This is an example of *bridging*. Where these positive conditions exist, they can offset the social unhappiness noted above from how aid is delivered.

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Thus, social capital does have a positive influence on happiness. However, the specific formulation of hypothesis 4 stipulates that "the social capital of both types (bridging and bonding) in the Nargis heavily-affected area has increased significantly in comparison with the non-heavily affected area." To test the hypothesis we conducted a t-test to compare the mean levels of social capital (and its bonding and bridging sub-components) between the two areas (Table 5).

In heavily-affected Bogalay, people feel discriminated against less often. The overwhelming reason for discrimination in both townships is the same: poverty. They are more religious than the people in Pyapon (but not significantly more than before Nargis). Indeed, there is no significant increase in temple-going, prayer, or meditation as a result of the cycle in either township. They also have been living longer together in Bogalay significantly longer, and have been confronted by a more fearsome external menace.

Based on these findings, one would logically expect their levels of social and bonding capital to be higher than in Pyapon. However, table 6 shows the exact opposite. The people of Bogalay have significantly lower scores for overall social capital and bonding capital within the community. Bridging capital with the outside world and organizations is also less, but not significantly so. While trustworthiness is higher within the community in Bogalay, people from different backgrounds get on less well together. Presumably because of the loss of family members, people in Bogalay have fewer people to ask for help when they are ill or financially strapped, resorting to strangers or NGOs (bridging) more often than the spouse or close family members (bonding).

People in Bogalay also get together in discussion-action groups less; when they do, they are more involved in NGO-type bridging than local bonding groups. It is equally striking that the main significant differences between the two areas are not in their means but in the variances around the means. This means that there are more persistent differences within communities than between the differentially affected areas, confirming that the social fabric has not been strengthened in the hard-hit area. There was undoubtedly less need for people in slightly-affected Pyapon Township to develop bonding or bridging social capital because individual households were largely able to put their lives back together again on their own. Indeed, there was competition between spending time building social capital and spending time meditating by oneself on the results of one's previous life.

We are thus in a position to clearly reject hypothesis 4. Although the people of heavily-affected, Bogalay trust each other more and are more active religiously, overall social and bonding capital are significantly lower. Bridging capital is also, lower, though not significantly so, because (a) people from differing backgrounds do not get along and (b) in the absence of close relatives; distant neighbors are presumably put upon to help in sickness and financial distress. Meanwhile, opportunities for compensation for the lack of social capital by building bonding capital, such as participating in local discussion-action groups, are not taken up as frequently as in Pyapon Township, the slightly affected area. Strengthening social capital in the future could overcome traditional barriers and promote working together for a common cause as the basis for more resilient responses to disaster in the future.

Social capital indicator	**Nargis damage**	**Mean**	**Heavy-slight**	**t**	**Sig. diff.**
Social capital score	Heavy	0.79	-0.01	-2.06	0.040
	Slight	0.80			
Bridging social capital score	Heavy	0.25	-0.01	-0.94	0.348
	Slight	0.26			
Bonding social capital score	Heavy	0.56	-0.03	-2.75	0.006
	Slight	0.59			
Seek bonding help from: *8 = spouse,7 = other family, 6 = relative, 5= friends, 4= neighbor*	Heavy	0.70	-0.10	-3.99	0.000
	Slight	0.80			
People from different backgrounds get on well together: *definitely agree= 6; definitely disagree= 3, don't know =2, too few people in neighborhood= 1, all same backgrounds= 0*	Heavy	0.76	-0.10	-4.26	0.000
	Slight	0.86			
If you are in financial straits for survival, seek bonding help: *husband / wife/ partner = 9, other hh member =8, relative s=7, friends =6, neighbor=5*	Heavy	0.07	-0.09	-2.87	0.004
	Slight	0.16			
During last year, participated in bonding discussion-action group: *7= others, 6= religious,5= sports, 4= social, 3= self-help*	Heavy	0.17	-0.11	-2.8	0.005
	Slight	0.28			
Trustworthiness in neighborhood: *most people = 4 …, no one is trust worthy=1*	Heavy	0.96	0.05	2.81	0.005
	Slight	0.92			
How long have you lived in this area? (years)	Heavy	6.94	0.16	2.54	0.012
	Slight	6.78			
Sought bridging help for community problems from: *2=GO NGO,3=NGO*	Heavy	0.08	0.02	1.25	0.214
	Slight	0.06			
Increase in trips to temple per month after Nargis	Heavy	0.36	0.31	1.18	0.240
	Slight	0.05			
Cause of discrimination: *race= 1, religion= 2, gender=3, economic= 4, health= 5, social = 6*	Heavy	0.67	-0.01	-1.1	0.273
	Slight	0.68			
Community spirit: *people help each other =3, go own way =2, mixture =1*	Heavy	0.95	0.02	0.99	0.322
	Slight	0.93			
Participated in a bridging discussion-action group: *1=GO NGO, 2= NGO*	Heavy	0.08	-0.01	-0.54	0.591
	Slight	0.09			
Seek bridging help from: *work colleague= 4, voluntary/ other org.= 3, other =2*	Heavy	0.11	0.01	0.46	0.644
	Slight	0.11			
Satisfaction of the neighborhood: *very satisfied =5… very dissatisfied =1*	Heavy	0.80	0.00	0.06	0.950
	Slight	0.80			
If you are ill in bed, seek bridging help: *3= colleague, 2= voluntary or other org*	Heavy	0.00	0.00	-0.01	0.992
	Slight	0.00			

Table 6. Tests of means and variances of overall, bonding, and bridging capital scores by Nargis-affected areas

4.5. Hypothesis 5

The determinants of SWB include income, social capital, education, employment, spiritual meditation, and male gender of household head regardless of the extent of Nargis damage.

The results reported in Table 7 support hypothesis 5. To assess the impact of demographic characteristics upon happiness with a view to better social targeting, we ran a regression to determine overall happiness [Equation 2] as measured by the Chiang Mai scale as a possible function of income, income squared (we expected a negative sign due to the Easterlin paradox), social capital, the employment rate/number of jobs, years of schooling of the household head, prayer/meditation, the quality of the diet, the regularity of meals over the previous week, and Nargis-affected area (Table 7). As expected, the sign on net income per capita was positive, while the sign on net income per capita squared was negative. This signals a decreasing rate of improvement of happiness as income increases, consistent with the Easterlin paradox. Similarly, education, total jobs in the household and the employment rate tended to increase happiness. This supports Lane's [28] contention that work is a source of self-realization in and of itself; rather than a necessary burden to be taken up in order to earn enough income for consumption, the view held by traditional neoclassical economics.

	B	Std. Error	Beta	t	Sig.
Constant	3.32	.16		20.42	.000
Physical					
Nargis affected status	-.06	.04	-.08	-1.35	.179
Average number of meals, past 7 days	-.09	.04	-.12	-2.19	.029
Level in food scarcity pyramid	-.02	.01	-.10	-1.68	.094
Economic					
Net income per capita	.00	.00	.37	3.27	.001
Net income per capita squared	.00	.00	-.33	-2.95	.003
Total no of jobs in household	.07	.03	.12	2.30	.022
Employment Rate	.16	.09	.10	1.82	.070
Social					
Schooling years of household head	.03	.01	.17	3.08	.002
Social capital score (the lower the better)	-.01	.01	-.11	-2.03	.044
Gender of household head (female)	-.11	.06	-.10	-1.86	.064
Spiritual					
Times pray per month after Nargis	-.003	.00	-.18	-3.27	.001
Time meditate in temple last year	.01	.00	.11	2.11	.035

Table 7. Regression of Chiang Mai Happiness Score upon a Complete set of Socio-Economic Factors (Adjusted R-squared=0.192; F-statistic= 6.867)

Furthermore, although long term meditation at the temple seems to increase happiness, the frequency of prayer decreases it (this is possibly because prayer often involves a mixture of noble and self-interested requests). Surprisingly, both the regularity and the diversity of the diet seem to decrease happiness. This result – which would support periodic fasting as an uplifting pursuit – certainly merits further research beyond the scope of this chapter.

Variable	**Aver. physical, mental, emotional, spiritual scores**		**Social capital score (the lower the better)**		**Interest rate for education and training (%)**		**Interest rate for health care and medicine (%)**		**Interest rate for food and drink (%)**	
Gender hh head	F	M	F	M	F	M	F	M	F	M
Sample size	41	257	41	257	41	256	41	257	41	257
Mean by gender	3.0	3.2	15	15	2	1.5	2.3	1.8	1.9	1.0
Standard dev'n	0.3	0.4	2.9	3.8	4.5	3.5	4.7	3.7	4.4	2.9
Mean difference	-0.17		0.08		0.52		0.54		0.87	
Levene's test for Equal variances	2.81		2.82		4.87		4.95		8.35	
Sig. variances	0.09		0.09		0.03		0.03		0.01	
t-test for equal means	-1.83		-3.27		2.34		2.35		-1.79	
Sig. means	0.07		0		0.02		0.02		0.09	

Table 8. T-tests for significant differences by gender of household head

A t-test was employed to detect significant differences between the 257 households with male and 41 female heads in terms of the likelihood to experience difficulty in terms of happiness, social capital, and interest rates for various types of loan. We found (Table 8) that the social capital of males is better than that of females in both types of Nargis- affected areas, since a man can spend his time in social activities after working hours. Most people use pawn shops for credit, since the interest rates from other sources are too high for them. However, social capital is very important if they want to borrow money from pawn shops. Since female headed households generally lack such social capital, the interest rates charged to female headed households are significantly higher than those charged to male headed households for food, drinks, and even health care.

The interest rate for education is also higher for female headed households, but much less so than for other categories of loan. However, the dummy variable Nargis-affected status is not significant the 0.10 level or better. We therefore cannot reject hypothesis 5.

http://dx.doi.org/10.5772/54140

5. Conclusions, limitations and recommendations

5.1. Conclusions

The comparison between two areas differentially affected by cyclone Nargis has led to the acceptance of hypotheses 1, 3, and 5 (Figure 3) and the rejection of hypotheses 2 and 4. We have demonstrated that the basic needs and economic possibilities for residents from the heavily affected area less sufficient and more arduous than in the slightly affected area. Nonetheless, Bogalay inhabitants are surprisingly happy living under the poverty line and trying their best to improve their future. The chapter has shown that the happiness of the heavily affected area is not significantly different from that of the slightly-affected area, suggesting that human beings rebound rapidly from disasters. Nor is there a greater tendency for the depth, intensity or urgency of unhappiness to be higher in the more heavily-affected area. For both areas, spiritual happiness is more than twice as important as emotional happiness, and physical happiness is less than one-third as important as spiritual happiness. Access to health care and education are no less good in the heavily-affected area.

The internal weighting of the sub-components of happiness does differ significantly between the two areas (hypothesis 3). In heavily affected Bogalay, a dark cloud of mental anguish lingered a full 27 months after the passage of Nargis; and overall social, bonding and bridging capital were significantly lower. People living in households with female heads were significantly more likely to experience difficulty meeting their needs than their male-headed counterparts, largely because of their lower social capital and the resulting exorbitant interest rates they must pay.

We have further determined that the impacts of a natural disaster tend to strengthen social capital; while assistance and aid, if poorly administered, can undermine it. Social capital has become more important than ever because of the critical significance of knowledge-sharing to organizations. The informal safety net during disasters plays a pivotal role in helping people to access the resources such as credit. Presentation, as we have done, of the nature of the social capital in Myanmar should help policy makers, researchers, community workers and non-government organization as they work to identify, and bring help to, the most vulnerable of the vulnerable. Thus, social capital can play a strategic role in rehabilitating organizational performance, farm productivity, and mental health following a disaster.

5.2. Limitations and strengths of the research

Due to limited statistical information on the pre-cyclone period, this research has had to resort to a contemporaneous comparison of two areas differentially affected by cyclone Nargis. Despite the similarity of the two areas in other ways, no two townships are perfectly comparable, so this study cannot be fully considered a "controlled experiment."

The study has presented new applications of several methods (the new Chiang Mai scale, Gini coefficient, Lorenz curve, and the extended Foster-Greer-Thorbecke indicators) to the study of the level and distribution of social capital and happiness. It is hoped that these methods can be applied to other studies in the future. This will provide comparisons over time and across space of the level and causes of subjective well-being, and contribute to the external validity of the findings.

5.3. Suggestions for further research and policy

The social and policy motivations of this study have been to provide a statistically assessment of the impacts of cyclone Nargis for use by regional councils and national planners, in the hope that such knowledge would help them to better define their role in post-disaster recovery. The results may also serve to inspire similar studies into the psychological and intangible effects of natural disasters in other countries for other periods.

Much more work on coordination among researchers and between researchers and key disaster response decision-makers is also needed to realize the full potential of post-disaster mental health research. Several levels of coordination are needed for successful post-disaster research: within inter-disciplinary teams of researchers; between researchers and administrative agencies that have access to data that can facilitate research; between researchers and service providers; and among the many different sets of individuals and organizations that provide services, often with inadequate coordination, to disaster victims.

In this, for example, since the two study areas differ substantially, and the determinants of income per capita are not the simple opposites of the determinants of the intensity of food poverty, policy implications must be targeted both geographically and in terms of the dimension of well-being. The government and non-governmental organizations should put into place new loans to help female-headed households. State and local economic development officials should focus their efforts on encouraging education and retaining and attracting better-educated residents. The resulting social capital will be the best gauge of the continued rehabilitation of the victims and the creation of individual and social resilience in case of future events.

Acknowledgements

The authors express their sincere gratitude to the Heinrich Boell Foundation for its generous financial support of the first author's Master's degree studies at Chiang Mai University, as well as the field research project that led to the findings reported in this chapter.

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Chapter 5

Participation in Natural Disaster Reconstruction, Lessons from Iran

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55004

1. Introduction

Post disaster reconstructions are naturally multifaceted, uncertain, multiscale and affect multiple actors and agencies. Some aspects in Post disaster reconstructions are more important like; cost of reconstructions, psychological problems of damaged area, need to social and economical recovery. To solve a part of these problems, stakeholder participation is progressively more being sought. This procedure has been changed into a paradigm in post disaster reconstructions and it has been found a spectrum in world wide. Participation is increasingly becoming regarded as a democratic right (Reed 2008), but execution methods and performance of participation follow different patterns. These differentiations are due to view points of governments to participation, political and economical condition of countries.

Participation is an especial experiment in any post disaster reconstructions that it could affect further reconstruction. Iran as a vulnerable country in the world experienced strong earthquakes in the past centuries, due to pressure of Arabian platform on country (Berberian and Yeats 2001). The Tabas (1978), Ghaen (1980), Golbaf (1981), Manjil (1990), Bou'in-Zahr (2002), Bam (2003), Zarand (2005), Mazandaran (2005), Borujerd (2006), Qeshem (2008), Damghan (2010), Hosseinabad (2010), Kahnooj (2011) and Varzeqan (2012) are examples of such earthquakes. Several different rehabilitate and reconstruction procedures have been adopted in disaster-affected areas. Participation provides an effective framework for natural disaster recovery. It decreases cost of reconstruction, helps to people psychological recovery and outsider affair acceptance. Therefore Participation is accepted as effective framework in disaster recovery and reconstruction.

It expected that new strategies will be adopted in further reconstructions. These strategies should provide a more effective framework in natural disaster management. Participation is an important feature in this procedure that makes disaster management effective. But this feature has occurred in Iran?

The article tries to examine this framework and answer following questions:

What participation strategies have been selected for reconstruction in Gilan-Zanjan, Bam and Lorestan earthquake?

What are the differences between these strategies and their outcomes?

2. Theoretical debate

'Participation' in social affairs and development dated back to the 1960s-70s (Ling, McGee et al. 2010). participation entered into planning domain in 70s (Reed 2008). Participatory techniques such as Rapid Rural Appraisal has been used especially by experts in development arena (Tsouvalis and Waterton 2012). From 90s term of participation has been overused. It led to ambiguous into means and ends. Ambiguity distinguishes between the efficiency, equality and empowerment arguments. (Cleaver 1999).

From 90s and afterward different facet of participation were discussed such as: Transparency in decision-making, Social integration (Lizarrald, Johnson et al. 2010), more partnerships; mobilization self-reliance, control and access to power, resources and basic services; (Victoria 2002), as a means leading to a precise end, comprehensive empowerment of poors (Sliwinski 2010), gender equity (Christoplos 2006), 'good governance' and democratic decentralization, accountability, (Ling, McGee et al. 2010) ensure the sustainability of the reconstruction, successful implementation (Mahfuzar and Chowdhury 2011), build a culture of safety, ascertaining sustainable development, enriched by social capital (Duxbury and Dickinson 2007).

The last period in participation referred to ''post-participation'' and learning from the mistakes and successes of this long history (Reed 2008). Critical view of point about participation rose simultaneously with participation growth (Cleaver 1999; Cooke and Kothari 2001; Edigheji 2004; Piffero 2009).

Participation trickled into the different discipline. It narrowed down and many classifications elaborated by different approaches and divers terminology (White. 1996; CHoguill 1996 ; Tosun 2006; Lizarralde and Massyn 2008; Reed 2008; Becker, Saunders et al. 2011; Tsouvalis and Waterton 2012). Arnstein's (1969) presented the first typology of participation as ''ladder of participation'' based on power redistribution in eight class (Arnstein 1969). Fiorino (1990) presents three category for participation: 'normative', 'instrumental', and 'substantive' (Tsouvalis and Waterton 2012). White (1996) classified it into four category as: nominal, instrumental, representative and transformative (White. 1996). In the reconstruction Da Silva (1980) suggested five levels of participation as: management, financing, design, construction of components and assembly of components (Lizarralde and Massyn 2008).

The meaning given to participation varies significantly from case to case (Barenstein 2011). Participation has been seen as an approach, as a method, a set of guidelines for involving communities in specific planning activities within bodies of knowledge. But we understand participation as: "Capacity building and empowerment process of people or local community in manner that enable them to control the causes which affects their lives." The origin of definition refers to democratic theories and human right based approaches. According to these approaches citizens have a right to influence decisions that affect their lives and is based on principles of citizen empowerment, equity, and social justice (Pomeroy, Ratner et al. 2006). We try to go beyond short term outcomes such as: reducing conflicts, acceptable and particular ends, more cost-effective, get access to additional resources, create sense of ownership. It tries vice versa to emphasis on institutional development and continuation of participatory institution in area.

Some researchers criticize the empowerment concept. They believe empowerment is unclear and it does not obvious who will be empowered (Cleaver 1999). Empowerment and capacity building in reconstruction process does not perceive merely as tool for empower marginalize people or other special groups. Empowerment is not redistribution of power but also it is as democratic practice and making institutional foundation of socio-cultural wisdom for future development. Thus it looks at unwanted circumstance as opportunity to strengthen social capital as a base for not only reconstruction, but also for sustainable continuum development. Thus it tries to empower all people and group, social integration.

The ideal empower process is allowing community members to make their own decisions and having authorities to help implement what they decide (Becker, Saunders et al. 2011). But always it faced with obstacles in operation. There are some gaps between presumption and action (Davidson, Johnson et al. 2007). Obstacles driving forces divided in four main sub-groups: a) general barriers, b) obstacles related to developer agencies, c) barriers related to government and d) barriers related to local community.

a. General obstacles could be summarized as:1) Different perception of participation by verity of stockholder, 2) participation appeared as ‘tyrannical’ (Sliwinski 2010), 3) Information deficiency, 4) Lack of resources, 5) Lack of motivation, interest, or time (Kruahongs 2008), 6) Unrealistic levels of expectation(Holdar, Zakharchenko et al. 2002), 7) Difficulty or deficit in comprehensive community needs assessment.

b. Obstacles related to developer agencies obstacles could be précised as: 1) Lack of awareness of the need (Holdar, Zakharchenko et al. 2002), 2) Lack of skills, culture of participation and experience in this field (Holdar, Zakharchenko et al. 2002), 3) fear from delay or revise projects (Adomokai and Sheate 2004), 4) difficulties in building up mutual trust between agencies and communities (Ishmail, 2005; adopted from Lizarralde and Massyn 2008), 5) time and political pressure (Jha, Barenstein et al. 2010), 6) Improper behavior by local community, 7) Local culture misunderstanding.

c. Some barriers relate to government and its deputies such as: 1) the decision-making process (Duxbury and Dickinson 2007), 2) inappropriate policies (Duxbury and Dickinson 2007), 3) Focus on short term issue rather than development and long term issues, 4) government structure and their perception and wants from participation, 5) difficulties to integrate the community in the design and management of the project (Ishmail, 2005;

adopted from Lizarralde and Massyn 2008), 6) political pressure (Jha, Barenstein et al. 2010), 7) bureaucratic and institutional problems (Ophiyandri, Amaratunga et al. 2008).

d. Last group of barriers refer to local community. it include as: 1)conflicts and tensions between the residents (Sliwinski 2010; Yung and Chan 2011), 2) disbelief and distrust, 3) lack of confidence (Kruahongs 2008), Lack of cooperation between the stockholders, 4) Limited access to information (Kruahongs 2008), 5) Lack of skills, participation culture weakness (Holdar, Zakharchenko et al. 2002; Jha, Barenstein et al. 2010), 6) diversity of stockholders interests (Jha, Barenstein et al. 2010), 7) power inequalities within groups (Reed 2008).

Despite all difficulties in performing participatory in damaged area, participation encounter with some critics too. many would agree that participation has, become almost a dogma, a belief or an act of faith that has not delivered on its promises and bit is excessive standardization and missing its' objective while being instrumentalized (Sliwinski 2010). In another view of point participation has been change into over-simplistic evolutionism models. It is blind to historical and social context and the importance of path dependency. It means that participation function is 'incorporating' rather than empower participants (Jupp 2008). Despite these critiques, main critic are presented by Christians and Speer Cooke and Kothari (2001) Christians and Speer (2007),Tsouvalis and Waterton (2012).

Cooke and Kothari (2001) belive that first, decision-making control held by agencies and funders. Second, the emphasis on participatory practices obscures many limitations and manipulations that suppress local power differentials. The third form of tyranny addresses the dominance of the participatory method, noting that the overwhelming acceptance of participation, particularly the goals and values expressed, has limited dialogue and even consideration of other methods for cultivating development (Christians and Speer 2007). According to Christians and Speer the theoretical ideal of participation is not functioning as the tool for liberation and distribution of power but participation are described as largely maintaining existing power relationships, though masking this power behind the rhetoric and techniques of participation (Christians and Speer 2007).

Even though participation critiques and obstacles, gap between subjectivity and objectivity, it has too positive impacts that encourage practitioners to apply it in reconstruction. Impacts such as emphasis was placed on earthquake-safe knowledge at the grassroots level (Jigyasu 2010), a sense of ownership, reinforce their local capacities and resilience and empower their community (Sliwinski 2010), improve the community and the respective government agencies relationships, understand each other, trust to each other (Buchy and Hoverman 2000), mobilizing marginalized groups, ensuring that grassroots voices have access to higher levels of decision-making, strengthening existing processes and creating new ones, creating networks of nested organizations and institutions, and nested deliberation processes (Robinson and Berkes 2011), emergence of a vibrant, heterogeneous, agonistic and lively group, create and critique relevant knowledge (Tsouvalis and Waterton 2012), to operational cost and time reduction, and reduce the negative psychological impact of earthquakes (Ophiyandri, Amaratunga et al. 2008).

3. Research methodology

The systems approach and life cycle has been applied simultaneity in this study in order to present participation in post disaster reconstruction. The systems approach allows a comprehensive and cross-disciplinary view of the many apparently separate facets of a complex process such as post-disaster reconstruction.(Johnson, Lizarralde et al. 2006). The life cycle development process seen as holistic view of point that pay attention to all aspects of the life cycle of a product. "life cycle development' is defined as the sequence of activities needed to completely define a product life cycle" (Umeda, Takata et al. 2012, p.682.)

In the systems approach according to Johnson, Lizarralde et al. (2006) two main sub-systems identified in the systems approach and the reconstruction process: (i) organizational sub-system that includes elements regarding 'who is to do what' and (ii) technical sub-system that includes elements regarding 'how' to consume the resources.

In the life cycle process, disaster assumed as a product that effective disaster management required participation of all stockholders. The life cycle of a managed disaster divided into phases, start at the same time the disaster begins. The life cycle includes restoration and reconstruction of facilities, services, and human resources to a quality, reliability, security, and survivability level equivalent to at least the same risk level as that of the pre-disaster situation. The life cycle ends with a process and vulnerability improvement phase intended to prevent or reduce the impact of a similar disaster and improve the management process for use in future disasters. (Houck, Kim et al. 2004). Post-disaster reconstruction is a complex process involving a number of interrelated activities. The level of complexity will vary, depending on the scale and nature of the disaster and the corresponding response of the population and the institutions involved. Different project cycles are likely to be occurring simultaneously at different levels and for different purposes wherever people are organizing some element of the response. (Jha, Barenstein et al. 2010).

Due to nature of disaster and local condition different managed disaster life-cycle model is presented (Alexander 2002; Sharma 2004; Moe and Pathranarakul 2006; Huggins 2007; Shaluf 2008; Collins 2009; Diwan 2010; Coppola 2011; Paul 2011). For example Moe and Pathranarakul state: "Disaster management includes generic five phases, namely :(1) prediction; (2) warning; (3) emergency relief; (4) rehabilitation; and (5) reconstruction. (Moe and Pathranarakul 2006). Coppola identified comprehensive four-phase approach disaster management. This approach contains four distinct components: mitigation, preparedness, response, and recovery (Coppola 2011). The necessary stages of reconstruction distinguished by Lizarralde, Johnson et al. (2010) as: project organization, project financing, project design and project construction/ implementation (Lizarralde, Johnson et al. 2010b). But complete actions and activities commonly performed in the recovery period of a disaster include:

- Ongoing communication with the public
- Provision of temporary housing or long-term shelter
- Assessment of damages and needs

- Demolition of damaged structures
- Clearance, removal, and disposal of debris
- Rehabilitation of infrastructure
- Inspection of damaged structures
- Repair of damaged structures
- New construction
- Social rehabilitation programs
- Creation of employment opportunities
- Reimbursement for property losses
- Rehabilitation of the injured
- Reassessment of hazard risk (Coppola 2011).

Life cycle of disaster in Iran is a little different from. First of all reconstruction focus is on reconstruction of houses and secondly the life cycle of disaster differs from one disaster to another, but mainly process are:

a. Organizational subsystem that include:

   - Shaping Steering Committee
   - Establish organizational and administer branches in area
   - Establish technical supervisor office
   - Establish financial and construction material distribution network

b. Operational and technical subsystem Includes:

   - Communication with the local community
   - Damage assessment
   - Provision of temporary housing in some cases
   - Demolition of damaged structures and disposal of debris
   - Rehabilitation of infrastructure
   - Design house plans in participatory manner
   - Choose technical supervisor for any building
   - Pay financial and construction material aids Construction

http://dx.doi.org/10.5772/55004

4. Case studies

Iran has been experienced devastated earthquake in recent years. Gilan & Zanjan 1991, Bam and Baravat 2003 and Lorestan 2006 seismic activity were more wreckers among others (Fig. 1). Therefore the most important reconstruction project allocated to these areas in Iran. Participation in any area will discussed separately.

4.1. Gilan and Zanjan earthquake (June 1991)

On 20th June, 1991 at 00:30 AM (local time) a disastrous 7.3 Richter earthquake jolted an area of over 600000 square kilometers. The epicenter was near the city of Rasht -center of Gilan province- leaving more than half a million people homeless, over 3000 villages devastated and about 15 cities damaged. Three cities and 700 villages were ruined. Estimated 40,000 to 50,000 people killed more than 60,000 injured 400,000 or more homeless remained, the Rasht-Qazvin-Zanjan area damaged extensively. Nearly all buildings were destroyed in the Rudbar-Manjil area(USGS 2010). Damages were incurred in three provinces, and some whole villages were completely buried in the huge landslides which happened as a side effect. Some towns also witnessed liquefaction and thus, sustained great damages.

4.2. Bam earthquake (2003)

At dawn on Friday, December 26, 2003, at 5:26:57 local time, a devastating earthquake with a focal depth of 10 km from the earth's surface and a magnitude of 6.5, hit the 2,000-year-old historical city of Bam and the town of Baravat as well as their surrounding villages (Ghafory-Ashtiany and Hosseini 2008). According to the official reports, more than 30,000 were killed and about 25,000 injured. More than 80% of the town's buildings were also destroyed. A total of 39,361 urban residential and commercial buildings in Bam and Baravat, and 32,400 rural units in over 250 villages suffered damage (HFIR 2009). The earthquake left 70,000 people homeless (Eshghi and Asheri 2005). Although the Bam earthquake had a devastating effect on the country's economy.

After the disaster, Bam's reconstruction management process was faced a lot of challenges and fundamental questions. The number of casualty and related social issues, extensive destruction of the historical town, and also the lack of good experience in the reconstruction of a city made the reconstruction project of Bam more complicated. The reconstruction of Bam was the most important post-disaster reconstruction project among recent reconstructions in Iran. Many factors, such as concern over the government and international agencies, the new managerial approaches, and the application of appropriate reconstruction methods, made it different from the other reconstruction programs.

It provided useful experience and lessons about post-disaster reconstruction programs. The reconstruction of Bam was the first experience for Iran in the reconstruction of an extensively damaged middle-sized city with a high rate of human loss and destruction.

4.3. Lorestan earthquake 2006

On 30 and 31 March 2006, a series of earthquakes ranging from 2.8 to 6 on the Richter scale hit different parts of the southwestern province of Lorestan. The strongest ones hit Doroud and Borujerd districts which incurred some 2000 injuries and 72 casualties as well as serious damage to over 35 000 houses and physical infra-structures in the area. This earthquake led to relatively small number of casualties and deaths. Because the community's positively response to the alert system, utilizing loud speakers and pick-ups, which was triggered by local authorities following the early strikes of the quake in order to evacuate the residences prior to the major shock of 31 March. At least 60 villages were completely destroyed and nearly 320 villages experienced damages from 10% to100%. Although the loss of life was less than similar disasters like the earthquake in Bam 2003 and Gilan and Zanjan 1990, the building and infrastructure damages were assessed high.

In the recovery process, the government didn't support from the intermediate phase of "temporary settlement". This was due to the favorable weather conditions and because most of the residents of Lorestan province participated well in reconstruction process. Consequently, people moved directly from emergency shelters into the permanent ones.

Figure 1. location of study areas in Iran

5. Gilan and Zanjan reconstruction

The reconstruction had a pyramid structure in Gilan and Zanjan. A headquarter was established as central office and destructed area has been divided into 17 subarea. Any part had its especial corresponding that ware called Setad Moin (SM). They were HFI branches throughout the country. HFI has been chosen as main executive of reconstruction but other organizations, NGOs and individual participated in reconstruction. Main participation policy was adopted as follow:

House owners are construction manager and they are responsible for design and implementation of their houses. The role of government is participation in affairs that house owner couldn't carry out their duties.

SMs divided damaged villages into four categories:

1. Villages that should be replaced due to geological instability.

2. Villages with relatively high destruction, they need to prepare rural physical guide plan. Reconstruction should be started after approval rural physical guide plan.

3. Villages with relatively medium destruction, house reconstruction permission issued based on rural physical guide plan.

4. Villages with partial destruction, some houses need to repair and limited rural houses need to rebuilt.

Reconstruction began after the establishment of Representatives Headquarters on Rural area. The first step was the removal of debris that people were involved. Simultaneity small unit as contemporary shelter were built. It changed to core unite of residential house for further development in some area. Small rooms that called "Fabian" distributed among damaged people. But most important once was the financial help to any family to build their building. Concurrent some basic material of construction distributed between households. It helps people built their own house based on their wants and needs.

People were dividing in to three groups including: farmers, ranchers and tenants based on their livelihood. The housing units were designed and built that it emphasized on the residential function. The socio and economical function of house were ignored in rural areas. Therefore majority of residential units that were designed and built by HFI with original plans were different. They looked at houses as one dimensional factor. Base on this approach they had a pre assumption that house is only as a dormitory. But the traditional houses were a part of socio-economy life. This assumption led to abandon the proposal plans by people. The main point was that villager livelihood was too important, but it was ignored by architects.

In first category of villages' classification, some of villages were displaced. Some of villages were mixed to gather in this procedure. This was done without people participation or limited participation and enough studies. It led to some conflicts and problems over the time in result. The second step villages' plans have been designed on pressures of time limitation and cold season. Local people didn't play critical role in this phase too. Therefore village plans was too simplified and it did not adopt with socio-economic and spatio-locational needs. Unadjusted plans led to other problems again.

The traditional houses were made of mud brick and wooden roof in north stricken areas of Zajnan province. HFI proposed a kind of construction using concrete frames and brick walls. This model had serious differences with the traditional model. Thus it needed a capacity building movement. The following methods were used for training villager:

- Classic training for related organization employee
- Villager training by Show Maquette, Pictures and posters, slide shows and maps in rural areas.
- Pattern building by construct a sample house in target villages.

In this project the HFI tried to organize some groups in some area as facilitators, calling "rural councils" in addition. In this region, the people transmitted their problems in each phase of the reconstruction to the rural council, who conveyed these problems to reconstruction authorities. This trend helped to accelerate the reconstruction process. The rural council was so useful in order to make effective relationships between authorities, designers and peoples.

The first method, due to: unknown result for volunteers; duration of courses in long time; voluntary refusal; lack of facilities for organizing their effort; was not effective. Second method was not successful too based on the lack of a common language among the educated elite and rural people. Final method HFI needed technical team that did not exist. The technical team was formed by HFI. These groups were sent to rural areas. HFI was responsible for the construction of housing units for households with orphans at same time. Therefore HFI constructed houses with new structure and form with technical assistance team. The houses were converted into sample units. This final method was more successful than previous two methods. Temporary housing units were made in sizes of 15 and 35 meters in Tarom Sofla area. These units as temporary accommodation units changed into the core unite for further development of residential units. This was an innovation in construction that presented by Esfahan branch of HFI. Over 190000 residential units were constructed, reconstructed, or repaired on area.

Various building materials were distributed with discounted, subsidized prices. Building materials were subsidized by the government in order to cope with rising prices due to increasing demand. Materials production was promoted too based on enabling approach. Long term, low interest loans were distributed through mobile or permanent banks. About 700 houses were built as a sample of safe construction and were donated to poor families. As a further contribution, over 50 schools and 17 health houses were built in various rural centers on behalf of national or international donating bodies.

6. Bam earthquake (2003) reconstruction

Bam reconstruction needs a new reconstruction strategy and efforts based on the previous experience and greatness of event in Bam earthquake. Shaping Steering Committee is the first

http://dx.doi.org/10.5772/55004

action in order to start reconstruction process for first time in Iran. Bam's reconstruction Steering Committee established as the singular leading and policymaking association. Bam's reconstruction Steering Committee and policy making was responsible for the planning, provision of financial resources, policymaking, executive operations, and supervision. The Steering Committee determined the responsibilities of each administration and commanded the organizations duties clearly, thereby preventing the likelihood of a duplication of effort relating to the Bam reconstruction. On the other hands, each organization and ministry continued to fulfill the responsibility that it had before the occurrence of the earthquake, and a supervisory association was responsible for the inter-organizational cooperation.

The committee was headed by the Minister of Housing and Urban Development and the head of the Housing Foundation of Iran (HFI) was also in charge of executive affairs (Omidvar, Zafari et al. 2009). Bam and Baravat were divided into 11 zones and rural area into 9 zones based on previous experience, and to use the maximum available potential in reconstruction. In each zone, an executive quarter was organized and mobilized.

Up to 97% debris of the destroyed units in Bam and Baravat were removed by March 18, 2006. The operation of removing debris was started after the confirmation of the unit's ownership. In this phase participation was manifested. People were participated in debris removal by separation and restore usable materials like bricks iron profiles and etc. They received about 80 us $ per family for their participation. This amount was paied in order to attract and encourage people participation. This policy had useful advantages that could be counted as:

Due to psychological condition of people (due to the loss of their family members), any physical activities could be cause psychological rehabilitation;

Recycling of materials and reuse of materials and reduce need to new construction material;

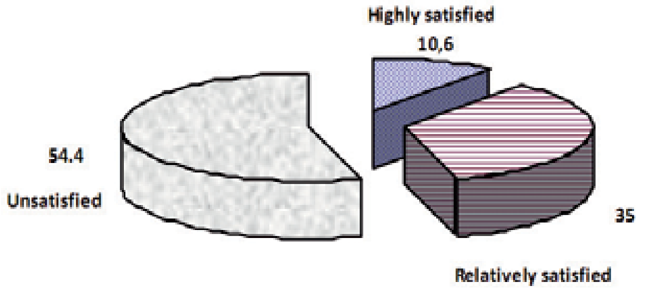
Owners Presence in demolish structures helped them to get out their goods and equipment especially valuable commodities like gold. It helps to reduce legal conflicts between residents;

Finally financial helps, empowered family economically, especially in post disaster condition.

Field survey shows that only 10.6 percent of people were satisfied from this kind of helps. 35 percent relatively were satisfied and 54.4 percent thought that the amount of financial helps were less than their needs (Fig. 2) (Zafari and Darabi 2012).

In this project, choose a proper design has been seen as a people right. House owner were able to choose appropriate style of architecture, structural system, construction materials. They choose their primary layout and they refer to an architecture council. Council was provided a complete detail of plans based on residents' opinion. During the reconstruction process up to 136 comprehensive plans covering 29,964 rural units were prepared. They were able to choose a technical executer contractor.

The Bam Reconstruction Steering Committee and Policymaking formed a council called ''Bam's architectural and urbanization council'' to preserve the identity and character of Bam and monitor construction process. The council regulated the architectural regulations. For this reason, some of the country's best consultants were selected for controlling the architectural regulations in every phase.



Source:(Zafari and Darabi 2012)

Figure 2. people satisfaction of financial aids

In case of retrofitting and also structural controlling, the government signed a contract with construction engineering organization, as a Non Governmental Organisation. This increased the participation of local organizations. Furthermore, the participation of contractors and executive teams were increased by providing educational opportunities to prevent the use of improper construction materials in the buildings, and also some contracts were signed to build soil mechanics laboratories(Omidvar, Zafari et al. 2009).

The government provided construction materials for the owners. Owners were received low interest loans for reconstruction. They received this loan in three parts according to physical building progress. People were constructing manager and they decide for themselves in construction method. All these activities were carried out after the building permit was issued. Finally, based on a survey conducted in 2008 by Omidvar and et al., it was found that the maximum of public satisfaction was occurred in the architecture design plan preference and construction contractor selection process. (Table 1) (Omidvar, Zafari et al. 2009).

Subject	high	moderate	low
Construction Contractor selection	45	34	22
Building Material selection	34	57	9
Architecture design plan preference	45	30	25
Debris Removal	10.6	35	54
Reconstruction Operation	37	45	19

Source: (Omidvar, Zafari et al. 2009)

Table 1. People satisfaction from Participation in reconstruction process (Percent)

7. Reconstruction of Lorestan

The HFI was the responsible of residential sector reconstruction like other reconstructions. Damaged area was divided into 8 parts that one SM was responsible for any subarea. Also, numbers of expertise were invited from HFI branches to help the SM. The reconstruction was started in Brojerd city and in villages simultaneously. The procedures in two areas were completely different.

Urban reconstruction was assigned to the municipality of Broujerd. Municipality had enough information about ownership and it could help prevent a potential further conflicts. All reconstruction affairs were did by house owners from debris removal to build houses. In many cases, damaged houses were in old structure of city that organic access network. Organic networks limited car access. Another problem referred to neighborhood. According neighbors safty, debris removal must be performed more accurately and without creating problems like dust and noise for neighbors. Only house owners could do it with care. Thus their participation was vital in reconstruction procedures. In some cases people look at disaster as opportunity for development. Earthquake was a chance to renew old urban context. A residential unit that was resisting for the opening of narrow street, was destroyed by the people. An important work that the municipality was unable to do for six years.

All other works have been done by people and their participation. Government and HFI provided the necessary funds for the reconstruction. The loans were paid to people after municipality approval and assistance of the banking system. In other aspect HFI was acted as council and assistant for solve peoples' problems. It was for first time that all works done by people.

In rural area reconstruction followed traditional method. But in Lorestan earth quake role of reconstruction responsibility was limited to management in compare with previous ones. Therefore main role in this subsystem referred to local people. According to previous experiences, the most important factor to participate people is the right of people to choose their houses layout. In this case people could choose the plan that was prepared by consultants. In order to improve the quality of houses planning, diversity of plans was prepared based on local residential needs. On the other hand, it was possible to people to design a new layout. About 12 consultant groups have been added to existing expert teams in Lorestan to expedite the designing, retrofitting and reinforcement of damaged units. Rural Engineering System (RES) formed after Bam earthquake. Presence of RES was most important point in Loerstan reconstruction. RES main job was monitoring the construction process by technical assistants and offered technical consultation to house owners in building process. Naturally in design process people took main decisions but it came to truth by RES members and HFI experts that were at villagers access.

The HFI was responsible for distribution low interest loan. It delivered building materials too. The local potentials for production of standard building material were identified and activated in the early days of the disaster. Several quality control systems have been created. This system tested samples of building material regularly. To increase accessibility, representative offices were set up in villages that also provided workstations to banks, which facilitates the administrative process (Zafari & Jodi, 2009).

It was clarified that the reconstruction scheme offered two options, the affected individuals could either take monetary compensation and acquire building material independently or HFI made it by providing low cost building material in lieu of the monetary Loans.

Financials polices changed after bam earthquake. In suitable reconstruction condition, limit financial aids change to complete finical loans to reconstruct permanent buildings. The main task of reconstruction return to home owners and HFI presented housing materials and construction management. RES offered technical supports to the people and constructers.

Local people roles were changed to main responsive of reconstruction based on mentioned policies. New polices emphasized on employment of local people beside the reconstruction. Therefore 15,261 units were repaired that home owners were main participants in repairs. More than 37,000 residential units were constructed by contribute of home owners. About 17000 residential units in the urban areas were reconstructed based on this view of point.

People participation was divided into two steps in Lorestan reconstruction including: the first step was decision making, decision taking, and planning. HFI tried to use public participation in all phases, such as through policy making, operating assessment and revision. Then, they held meetings with the public before preparing files and tasks. In some conditions in which it was necessary to relocate some villages. The area's mangers held meetings with the people after doing initial studies. The second step was reconstruction management. People participated in important tasks effectively like material distribution, removing debris, putting walls up, and roofing. The reconstructing management delivered directly to people and HFI and other authorities acted as a conductor and supervisor.

Quick review of reconstruction and participation role in three earthquake show: Participation has been a lot of volatility in reconstruction. General point is that participation in reconstruction has become more and more acceptable issue. But a kind of especial view of point dominated on it.

In first earthquake participation was a minor issue. Participation is visible in deferent step of reconstruction. There are neutral or negative image of participation in reconstruction authorities attitudes. In Gilan and Zanjan reconstruction people in many step of reconstruction acted as bystander in some cases they tried to modify reconstruction decisions. In some part they were as supervisor of reconstruction authorities. Participation is visible but partial and it completely depended on SM managers' attitude. In some cases participation has been occurred but it was an attempt to solve conflicts.

In bam participation is as main issue in reconstruction. People found a significant role in reconstruction. Foreign efforts like United Nation Development Program, other organization, people and NGOs intervention were effective to figure new form of participation. In Bam reconstruction for first time participation found new meaning in Iran. People found a good opportunity to reflect their wants in reconstruction practice. It shaped a triangle from government, people and technical assistants. It created the idea of RES for rural areas and made tasks of government lighter. People found their responsibility for this homes and building from debris removal up to construction.

In Lorestan reconstruction participation cycle were completed. In this cycle in all related phases people found their roles. Participation change into accepted issue and RES worked properly. In this reconstruction temporary shelter and small financial aids were omitted and long term loans were replaced instead. Reconstruction of residential houses was a task of normal people. Distribution of loans have been helped to empower local society. Distribution of construction materials have been done by some of local dealers. In this construction role of any side of triangle divided professionally and participation found the proper shape in all reconstruction efforts. More important point was the time of reconstruction in Lorestan. Reconstruction has been finished in about 6 month. But all efforts were limited to the reconstruction cycle and with ending the reconstruction and exit the reconstruction authorities from area, participation stopped and all structures collapsed. Unfortunately all efforts were done for reconstruction and it did not become institutionalized in area as an opportunity for further development.

8. Conclusion

Even though participation faces with some critiques and obstacles, but advantages of participation make it attractive for governments and reconstruction managers. A short review in three earthquake reconstruction policies in Iran shows that despite of compliance limited participation, the attitudes have been change over the time. Factors such as greatness of damaged area and budget limitation, local people actively involve in reconstruction, reduce responsibility of reconstruction authority, increase the reconstruction speed, Work division and less conflicts between organization, and less parallel or duplicated works are the result of people participation.

Although participation was not a main reconstruction policy today it has major affect on reconstruction policy. People participation led to new configuration in reconstruction management in Iran. New reconstruction management changed role of government from self reliant to a local community protective. But it is too far from real community participation in post disaster reconstruction. Although people play relative good role in construction but it need to change a process of capacity building and empowerment that is durable over the time. Unfortunately participation imposed due to deficit that will create by disaster. Based on origin of life it does not change into an institutional structure and it its continuity completely related to political structure of governmental organization. Therefore it can evolve quickly by managers' decision in different level. The main challenge arises here is: How can we institutionalize participation which is not affected by individual decisions and political change?

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Edited by Olga Petrucci

This book is an overview of the complex and multifaceted topic of natural disasters impact. Several possible approaches can be undertaken to assess economic, psychological, societal or environmental damage caused by natural disasters, aiming to reduce the effects of future events on the whole of these sectors. This book proposes a range of studies realized in different continents, showing various aspects from which natural disasters can be view, thus giving a measure of the complexity and multidisciplinary of the topic. It starts with a paper presenting a possible strategy to either avoid or reduce the vulnerability of concrete buildings during floods. Then, it continues with an insight into the communication during post-disaster emergency phase and with two chapters concerning the assessment of two different kinds of impact on people everyday life. The book ends with an analysis of the role of stakeholder participation in post-disaster reconstruction.

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ISBN 978-953-51-5045-9