MEASURING RESILIENCE AND RECOVERY

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ABSTRACT

This paper reports attempts to measure and assess resilience and recovery after various recent earthquakes that had huge impacts in their respective countries. The examples are both quantitative and qualitative. The concept of resilience as used in disaster literature has, until recently, been imprecise (Bruneau et al., 2003). This papers reports the latest thinking on what the concept means and how to measure it. It also links resilience to the speed and quality of recovery. Recovery is variously referred to as recovery, reconstruction and long-term development. The research reported here makes no distinction between these. Recovery may involve reinstating things to the same state they were in before the disaster or 'building back better'. The focus of this paper is to measure the speed of recovery with reference to a 'base state' immediately prior to the onset of the disaster.

We used satellite imagery and ground surveys to measure and compare the speed of recovery in Thailand and Pakistan. People were rehoused significantly faster in Thailand than in Pakistan. We used household surveys and key informant interviews in Pakistan to measure recovery of a range of 10 indicators, including access, housing, education, health, administration, environment etc. Finally, we used building control and insurance data in Northridge California to suggest that insured households got rehoused on average 12 months faster than uninsured households. The paper concludes that it is possible to measure speed of recovery, but queries whether speed should be the sole measure of resilience?

INTRODUCTION

Like sustainability, resilience is both important and imprecise; an amorphous concept that encompasses a society's capacity to bounce back after a disaster, its level of preparedness to confront or deal with a disaster and its ability to recover quickly and successfully.

Resilience is an engineering analogy meaning the ability to spring back and resume an original form after being distorted. In psychology it is defined as an individual's ability to adapt to stress and adversity – that ineffable quality that allows some people to be knocked down by life and come back stronger than ever. (Psychology Today, 2014).

As Zolli and Healy (2012) define it, resilience is the increasingly critical ability to anticipate change, heal when breached, and have the ability to reorganize … to maintain [a] core purpose, even under radically changed circumstances. Zhou el al. (2010) similarly define disaster resilience as the capacity of hazard-affected bodies to **resist** loss during disaster and to **recover** after disaster in a specific area in a given period. It can be conceived as both the loss potential and the biophysical/social response.

This ability to resist and recovery from loss in disasters has been adopted by this paper in terms of two measures: **robustness** and **resilience**. Imagine a cumulative frequency graph of some indicator such as 'households in permanent accommodation'. Immediately after a catastrophic event people are displaced. How many, or what proportion of an indicator that remains 'undamaged' and functioning, the survival rate, is a measure of robustness, R1. Slowly at first people are rehoused. This process speeds up, perhaps in steps, until the majority are rehoused and the s-shaped curve flattens. Resilience can be measured by the speed of recovery, T2 and the resilience imparted by a given mitigation action can, theoretically, be measured by the area between the two curves in Figure 1.

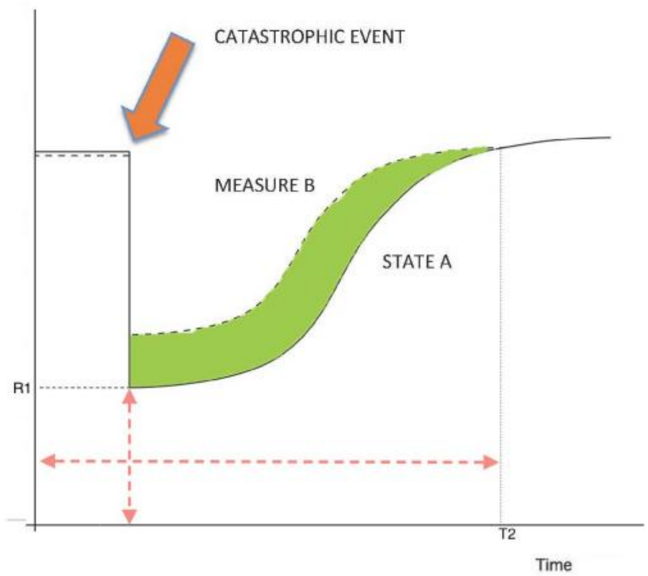

Figure 1. Recovery curves – area in green a measure of increased resilience

Community resilience is about communities using local resources and knowledge to help themselves during an emergency in a way that complements the local emergency services (UK Cabinet Office, 2013). Even in highly developed societies people hit by a disaster, in the first days have to fend for themselves. Neighbours rescue each other. At a societal level Keck and Sakdapolrak (2013) define social resilience as being comprised of three dimensions: 1. coping capacity – to cope with and overcome adversity; 2. adaptive capacity – the ability to learn from past experiences and adjust to future challenges; 3. transformative capacities – the ability to create institutions that foster individual welfare and sustainable societal robustness towards future crises.

Bruneau et al. (2003) define seismic resilience as the ability of a system to reduce the chances of a shock, to absorb such a shock if it occurs and to recover quickly after a shock. They argue that a resilient system is one that shows: reduced failure probabilities, reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences, and reduced time to recovery (restoration of a specific system or set of systems to their "normal" level of functional performance). This suggest that resilience might be quantified in terms of:

1. Probability of failure
2. Consequences of failure
3. Time to recovery

Resilience they suggest can also be conceptualised as comprising four distinct dimensions: technical, organizational, social and economic. This is important as it suggest that resilience needs to be viewed from different perspectives which leads to a focus on:

- Technical performance of physical systems,
- Organisational ability to cope, especially of lifeline critical facilities,
- Community and social and economic robustness, including self-help, or

- Decision support system of emergency management, relief agencies and local administration.

Bruneau et al (2003) argue that resilient systems have the following properties: robustness, redundancy, resourcefulness and rapidity. For the purpose of this paper, however, these four properties are considered distinct, interrelated, concepts and it is proposed that resilience be measured simply in terms of speed of recovery.

SATELLITE IMAGERY

Data from satellite imagery are reported for case studies in Thailand after the Indian Ocean tsunami of 2004 and in Pakistan after the Kashmir earthquake of 2005 (Brown et al., 2010). Cumulative normal distribution curves were fitted to data extracted from analysing satellite imagery. The curves show clear differences in the speed of recovery in the two countries in terms of the speed of physical reconstruction of buildings.

A Least Squares method was used to fit a variety of sigmoid functions to reconstruction curves assembled from data acquired at four locations that have recently experienced post-disaster recovery: Ban Nam Khem, Chi Chi, Muzaffarabad and Sri Lanka. The functions tested include the Cumulative Normal Distribution, the Logistic function and the Gompertz function. The technique is based on a method developed by Osamu Murao, who is based at the Graduate School of Systems and Information Engineering, University of Tsukuba (Murao et al., 2007).

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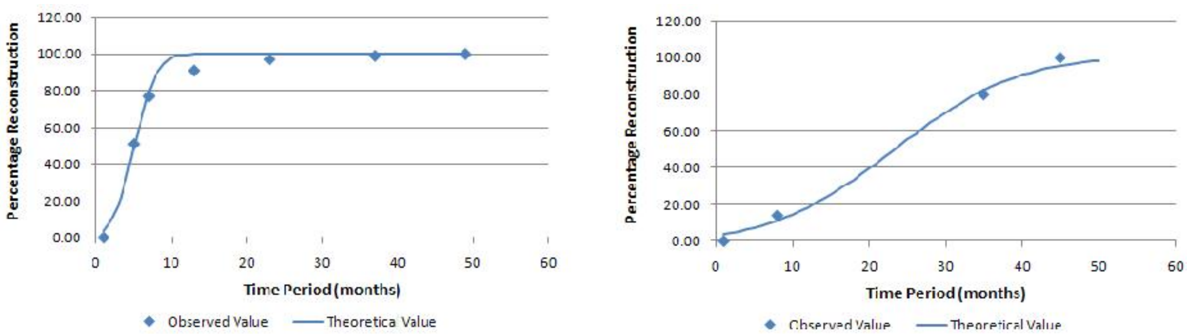
Cumulative Normal Distribution (CND): $R(t) = \Phi((t - \frac{\lambda}{\zeta})$



Ban Nam Khem, Thailand

Muzaffarabad, Pakistan

Figure 2. CND curve fitted to observed data using least squares method

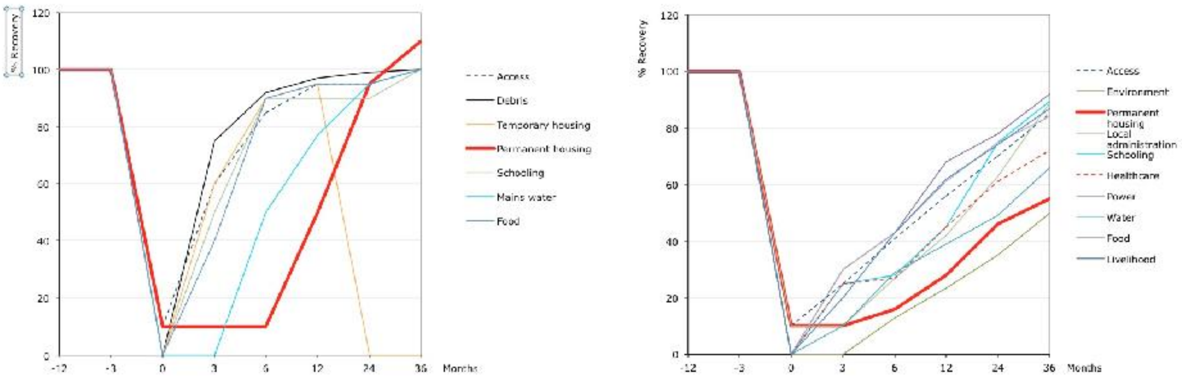
Figure 2 shows clearly that the speed recovery in two of the places studied – Ban Nam Khem, Thailand and Muzzafarabad, Pakistan. In terms of reconstruction of buildings recovery is quite different in Thailand and Pakistan. Reconstruction began very quickly and progressed rapidly in Ban Nam Khem and 90% of buildings had been replaced within 12 months and 100% within 2 years. In contrast, in Muzzafarabad reconstruction was much slower to start and only 20% of buildings had been replaced in 12 months and 50% in 2 years.

We saw this for ourselves when we visited both places. In Ban Nam Khem land had been compulsory purchased inland away from the coast and housing had been built by a variety of government and international agencies. In Pakistan ERRA, the earthquake authority established by the government after the earthquake, decreed that homes would be rebuilt by their owners and the government would provide guidance about earthquake resistant construction and give grants at different stages in the process. Although a good policy in terms of empowering local people and ensuring homes were rebuilt where and how people wanted, there were inherent problems with this system. The cost of building materials escalated two or three times and, in most cases, did not cover the cost of reconstruction. Many families were destitute, livelihoods were lost and families had to use the grants to buy food and clothes to survive. There was also a severe shortage of skilled labour, due both to casualties in the earthquake and the fact that many men with building skills are working in construction in the Gulf and sending essential remittance payments home to their families (Brown et al., 2010).

KEY INFORMANT INTERVIEWS

In Pakistan 50 households and 12 key informants in Muzaffarabad were interviewed by post-doctoral researchers from Peshawar University. In Thailand 50 households and 11 key informants were interviewed in Ban Nam Khem by researchers from Kasetsart University, Bangkok. They were asked to remember what percentage recovery had been achieved for various indicators at six monthly time intervals after the Kashmir earthquake in 2005.

As in the previous section, the curves shown in Figure 3 demonstrate clearly that recovery was much slower in Pakistan than in Thailand. What the graphs make clear is that it is not just physical reconstruction that was faster in Thailand, but all aspects of recovery, including: access, debris clearance and environmental recovery, schooling, healthcare, mains water and livelihoods. Focusing on housing, shown by the red line in both graphs, 100% of houses in Ban Nam Khem were replaced 2 years after the event. In contrast, only 50% of homes had been replaced in two years in Pakistan. These results closely mirror those from the satellite imagery analysis above.



Ban Nam Khem, Thailand Muzaffarabad, Pakistan

Figure 3. Recovery profiles for Ban Nam Khem, Thailand after Indian Ocean tsunami 2004 and Muzaffarabad Pakistan after Kashmir earthquake 2005

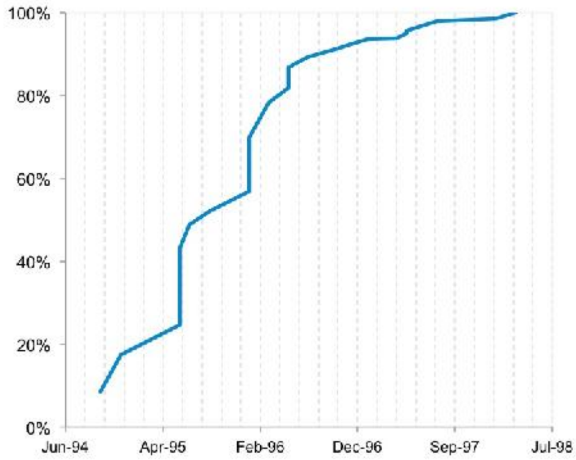
Successful recovery is not just about speed but also relates to quality. Quality is notoriously difficult to measure since it is subjective and dependent on individual appreciation. In Thailand, the household survey asked residents about their level of satisfaction with the new housing. 58% of the interviewed families felt their current housing was worse than before the tsunami and most were unhappy with the size of their new homes, being significantly smaller than their previous accommodation. In contrast, 50% of residents in Ban Nam Khem thought access was better than before. Similarly in Muzzafarabad 58% of residents felt their current housing was worse than before the Kashmir event. Most of these respondents were still living in temporary shelter. 70% also thought access was worse than before.

BUILDING CONTROL AND INSURANCE DATA

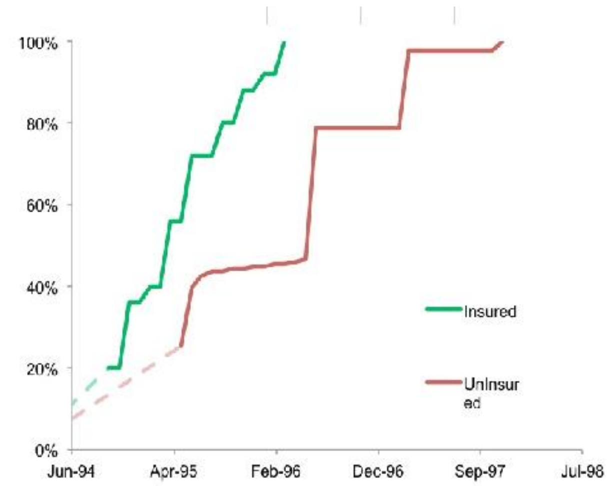
The authors conducted a scoping study for the Lighthill Risk network, a consortium of insurance brokers, to see if it was possible to define simple meaningful metrics that reflect the impact of insurance on the socio-economic and physical environment recovery. Specifically our aim is to consider separately the extent and time taken to recovery for insured and uninsured properties

One of the main findings was that it proved surprisingly difficult to find data to support the study. Three events were considered: Northridge, California 1994, Maule, Chile 2010 and Christchurch, New Zealand, 2011. It was thought that the recent timing of the Chile and New Zealand events and the extensive coverage they received would allow us to find relevant data. This was not the case. There was however, information about the Northridge event two decades ago. We also explored data from various sectors – housing, commerce, industry and infrastructure but the most practical approach was to plot data for the repair of all 'properties' without differentiating between types of use.

A recovery profile was drawn using building permission data from Olshanky et al. (2006). Nearly 95% of all permits were issued within three years of the event. Several papers then provide useful loss data for the Northridge even and help differentiate between insured and uninsured property. Petak and Elahi (2000) state that 67% of all estimated direct losses were uninsured, although 16% were covered by federal and state financial aid. This data aligns well with Siembieda, Johnson and Franco (2012) who quote a figure of 35% insured, meaning that 65% was uninsured. Eguchi (1998) provides a plot of the cumulative loss with respect to time after the event, covering multiple categories and totalled over all losses. The total loss (approximately $21Bn) aligns well with the 50% reimbursed figure quoted in Petak and Elahi (2000). Furthermore the breakdown of the losses that were reimbursed – 33% insured and 16% financial aid – is in reasonable alignment with the total insured ($12-13Bn) versus all other losses ($8-9Bn) (Eguchi, 1998).



Building repair permits 1994-98 (Olshansky et al, 2006)



Cumulative recovery profiles for insured and uninsured properties (Platt et al, 2014)

Figure 4. Building recovery post Northridge earthquake, California 1994

ETHNOGRAPHIC APPROACH

Platt has visited ten countries that have suffered major earthquakes, including Pakistan, Thailand, China, New Zealand and Iran. (See Table 1) It should be noted that the speed of recovery varies considerably from country to country, for example from less than 2 years for most people to be re-housed in Turkey after the Van earthquake 2011 to Iran, where most homes are still unfinished over 10 years after the Bam earthquake in 2003. Similarly the economy in the Van region is booming thanks to government investment in reconstruction and new infrastructure and 'traditional border trade' with Iran. In contrast, the agricultural economy of the Bam region based on date production was severely damaged by the earthquake and may not recover fully. Similarly the Arg of Bam was destroyed which has affected the tourist trade.

Table 1. Data from 10 major earthquakes (Platt, 2015)

Country	Name	Year	Date	Size	Displaced	Deaths	Deaths % of Displaced	Loss US$ bn
USA	Northridge	1994	Jan-17	6.7	125,000	61	0	44
Iran	Bam	2003	Dec-26	6.6	75,000	26,271	35.0%	1.5
Thailand	Indian Ocean	2004	Dec-26	9.2	1,690,000	276,025	16.3%	14
Pakistan	Kashmir	2005	Oct-08	7.6	3,500,000	100,000	2.9%	2.3
China	Wenchuan	2008	May-12	8.0	1,940,000	90,000	4.6%	75
Italy	L'Aquila	2009	Apr-06	5.8	67,000	309	0.5%	16
Chile	Maule	2010	Feb-27	8.8	800,000	550	0.1%	30
Japan	Tohoku	2011	Mar-11	9.0	130,927	18,499	14.1%	235
New Zealand	Christchurch	2011	Feb-22	6.3	25,000	185	0.7%	16
Turkey	Van	2011	Oct-23	7.1	50,000	604	1.2%	1

It is instructive to compare the speed of recovery in three of them – Tohoku Japan and Van Turkey in 2011 and Chile 2010.

In Turkey, TOKI, the government housing agency, built 15,000 new apartments within a year of the disaster. By the time of my second visit to Van 18 months after the earthquake nearly everyone had been moved out of the temporary camps. This speed is unprecedented. But there was no urban planning of the new settlements and no public consultation.

In Japan recovery along the Rias coast was stalled by discussions about the size of the new embankments and about relocating people to higher ground and amalgamating villages. Tohoku was a much larger event than either of the other two and the cost of recovery is about 25% of annual GDP. But, in part the delay is because there is an obligation to consult local residents, and Japan isn’t very good at participatory decision-making.

In Chile, architects seconded to the regional government for eighteen months were responsible for master planning. Not only did they consult residents and keep them informed of progress, they also succeeded in ‘building back better’. Tsunami resistant housing is being built where people want it, essential services are being relocated to safer sites and sensible coastal protection measures are being installed that do not ruin the environment or separate fishermen and tourists from the sea.

DISCUSSION

People live and decide to return to live in hazardous places because it is economically advantageous to them. The trick is that decisions integrate resilience into wider questions of economic and social futures. Resilience is therefore a trade-off between risk and economic prosperity. The best way to achieve this trade-off is to balance bottom up involvement of the people affected with top down government led policy making. Japan is trying to do this, by incorporating community values with scientific led decisions about increasing resilience. Studies of post disaster recovery in a wide range of countries suggest that in general the poorest sections of society are the most vulnerable and suffer the highest casualties and relative economic loss. Although developed countries suffer the highest absolute economic loss, the poorest countries and the poorest neighbourhoods suffer the highest casualties and biggest relative losses. They also have the greatest difficulty in organising recovery and take the longest time to recover. A combination of factors are involved – poor people are on the worst sites in terms of soil condition and landslide hazard and have poor building construction in terms of structural integrity, quality of materials, engineering and build quality; they may lack the information and resources necessary to take precautions and to recover quickly and their livelihoods are often precarious and may have been destroyed by the disaster and they are likely to have difficulty re-engaging with the regional economy.

CONCLUSION

‘Building back better’ involves increasing robustness and reducing risk. But people also value quality of life – the quality of new housing, of livelihoods and the environment and they seem prepared to live with risk. Should we keep a measure of resilience simple and limit it to speed of recovery or should it involve measuring other aspects of resilience as suggested by Chang et al. (2004).

Greater resilience and greater robustness are not necessarily better. Too speedy a recovery may change the nature of the socio-economic system in ways that people don’t want. For example, their new homes may be more robust but they may be in the wrong place and of the wrong size and form for the way people want to live. So should be abandon measures of resilience or should we accept that these measures have to be balanced against other criteria – economic utility and social well-being etc.

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