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## Resilience Assessment: Recovery of Brisbane Neighbourhoods after 2011 Flood

Leila Irajifar, PhD candidate, Urban Research Programme, Griffith University

Email: [Leila.irajifar@griffithuni.edu.au](mailto:Leila.irajifar@griffithuni.edu.au)

Tooran Alizadeh, Lecturer, Urban Research Programme, Griffith University

Email: [t.alizadeh@griffith.edu.au](mailto:t.alizadeh@griffith.edu.au)

Neil Sipe, Program director, Planning and Environmental Management, University of Queensland

Email: [n.sipe@uq.edu.au](mailto:n.sipe@uq.edu.au)

### Abstract

The purpose of this study is to evaluate the link between resilience attributes and conditions of each neighbourhood on recovery of 26 neighbourhoods of Brisbane after the 2011 flood. A systematic review of literature on urban disaster resilience and recovery was conducted to extract the indicators used to measure and monitor recovery. The required data were obtained through governmental and private sector sources including Queensland Reconstruction Authority, Australian Census, Australian Community Capacity Survey (Wave four) and previously studies in the Brisbane area. A cross-case comparative analysis was performed using fs/QCA software to assess the necessity and sufficiency of pre-disaster and post disaster conditions and also to evaluate the combination of these conditions that led to recovery.

The results show that there were several pathways combining pre-disaster situation and post disaster conditions which led to recovery in Brisbane neighbourhoods, as measured by the housing reconstruction after the flood. For instance, post-disaster financial assistance played a critical role in recovery of neighbourhoods like Riverview and Graceville; on the other hand, a combination of low Social Vulnerability (SoVI) and high economic stability also led to successful housing recovery. This study showed which pre-disaster and post-disaster causal and mediating factors were associated with housing recovery in Brisbane neighbourhoods after the 2011 flood. These results could be used in the development of resilient community recovery guidelines.

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### Introduction

Disaster recovery is one of the least understood aspects of disaster management phases (Chang & Shinozuka, 2004; Smith & Wenger, 2007). Considering its dynamic and complicated nature, monitoring and evaluating recovery progress is considered as a multidimensional concept which has been approached as a social, economic, design, management, finance or planning problem. Previous studies on disaster recovery mostly used qualitative and subjective information, obtained

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by social-audit techniques and participatory methods (e.g. focus group meetings, household surveys and key informant interviews). However, recently a series of quantitative, systemic and objective recovery studies are conducted using direct observation and non-participatory methods (e.g. remote sensing, repeat photography and advanced field survey techniques) that allow detailed geocoded observations. These tools each have their own strengths and weaknesses and have been used in previous recovery studies to collect different forms of data (subjective/objective, quantitative/qualitative, cross-sectional/longitudinal, primary/secondary etc.). Urban disaster recovery is mostly assessed by using recovery indicators. For example, Brown et al. (2010) in the Recovery Project conducted by the Centre for Risk in Built Environment at Cambridge University identified 24 recovery indicators in Six major categories of Vulnerability, Livelihoods, Housing (including drinking water access), Services, Environment (including vegetation and removal of floodwater sand and debris) and Infrastructures (including road access and reconstruction). However, the most frequently used recovery indicators are reconstruction of houses, critical facilities and lifelines, noncritical facilities and lifelines, transportation systems, number of building permits and population return. The focus of this research is on housing recovery at neighbourhood level.

The number of individual post-disaster recovery case studies has increased in recent years which advance understanding of the complexities, politics and processes of urban disaster recovery. But there have been very limited comparative studies in disaster recovery assessment. The Brisbane flood in 2011 and its subsequent recovery, provides a useful case study for a comparative recovery study. Different aspects of 2011 Brisbane flood has been investigated from community capacity assessment; buildings damage assessments, critical infrastructures and participatory social aspects of recovery. But there have not been a broad comparative study of Brisbane neighbourhoods' recovery after the flood. Hence, in this research we analysed the combinations of resilience attributes and conditions before and after the disaster to examine the causes of different recovery rates in neighbourhoods.

### **Research Method**

As we desire to comparatively analyse recovery in Brisbane neighbourhoods affected in the 2011 flood, a cross-case qualitative comparative analysis (QCA) seemed appropriate for this purpose. The first step in QCA involves identifying a particular outcome of interest, besides the conditions that are theorized to have an impact on outcome. Then it will analyse all the possible complex combination of conditions that could result in targeted outcome.

A series of resilience indicators that are theorized to affect community recovery was extracted by reviewing the resilience assessment literature. However, considering the unit of analysis, disaster type and data availability in this case study, we used a subset of these identified indicators which includes: Social vulnerability (calculated based on Cutter et al's SoVI (2003)), Economic stability (Income level, employment, female employment), Socio-Economic status of the area (SEIFA as calculated by Australian bureau of meteorology), urban form (%not single family detached houses,

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dwelling density), Recovery funds (Federal/ State/ Local government financial assistance) and damage loss.

The data used for this analysis were obtained from a different range of sources. The data related to calculating the SoVI, SEIFA and economic stability and urban form were obtained from publicly available data sources including Australian Census and Queensland Government online database and NEXIS (National Exposure Information System). The recovery fund data were obtained from Australian community capacity survey (ACCS), a longitudinal survey that its fourth wave was conducted just before and after the 2011 Brisbane flood in 148 suburbs across the great Brisbane area. DARMsys data (Damage Assessment and Reconstruction Monitoring system) were used for calculation of the recovery outcomes. This dataset was obtained from the Reconstruction Authority of Queensland that monitored damage and reconstruction status by travelling street by street and auditing all the affected properties in the study area.

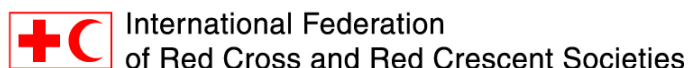
As mentioned in the introduction section, the recovery can be measured by a variety of indicators. However, here we use housing reconstruction in 10, 13 and 17 months after the flood as recovery outcomes. Housing reconstruction is calculated based on the longitudinal field survey damage data provided by the Reconstruction Authority of Queensland. The percentage of housing stock reconstructed in each time point for each neighbourhood was calculated and then directly calibrated using minimum-maximum scaling method. Four neighbourhoods (Paddington, Greenslopes, Kholo and Sinnamon Park) were fully recovered within 10 months after the flood and they were rated as 1 in the fuzzy set. While less than 50% of the affected properties in two neighbourhoods (Goodna and Yeerongpilly) were reconstructed over 10 months and were rated as 0. The same methods were used for calibration of housing recovery in 13 and 17 months after the flood. As there was a wide range of data values for conditions and outcomes, we used fuzzy set QCA in which each of the conditions and outcomes are assigned a value from 0 (completely out of the set) to 1 (completely in the set). Therefore we aggregated the indicators of each condition and used a minimum-maximum scaling method to directly calibrate the data to a fuzzy- set score.

These calibrated data were imported and analysed in fs/QCA software. The truth table was built within the software which summarizes the configurations of neighbourhoods' conditions. To generate an intermediate solution, some assumptions was made about the presence or absence of the condition based on authors knowledge. Moreover, two important factors were considered in pathways analysis: Consistency (which shows the extent to which the neighbourhoods represented by a particular configuration have the same recovery outcome), Coverage (which shows how many of the neighbourhoods are explained by a particular configuration).

### Research Results

The analysis of truth table resulted in three main pathways that are sufficient for successful housing recovery after the flood. Table1.1 shows these pathways and also indicates the specific neighbourhoods related to each of these pathways. The consistency cut-off, used for this analysis

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is 0.85 as there was a break in the consistency scores at this point. The overall combined consistency score of these solution is 0.88 and the overall coverage score is 0.68.

SEIFA seems to be an important factor in housing recovery as two of the three pathways has this condition in common. In addition to SEIFA, successfully recovered neighbourhoods have either low social vulnerability or low level of damages in more compact neighbourhoods. The third pathway to recovery in Brisbane neighbourhoods was through federal/local government financial assistance and insurance like what happened in Riverview and Graceville.

It should be noted that the coverage score of 0.69 shows that there are some neighbourhoods which are not represented by these three pathways. For instance, Gales and Redbank despite their high social vulnerability and low SEIFA level are in the set of successful recovery. Both neighbourhoods received high amounts of recovery funds, which are hypothesized to lead to successful recovery. It is also possible that recovery of the neighbourhoods which do not appear in the pathways in table 1.1 could be explained by other variables, which were not a part of this analysis.

Table1.1. Housing recovery pathways resulted from qualitative comparative analysis of Brisbane neighbourhoods conditions

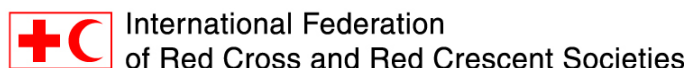
Pathways	Coverage	Consistency	Cases
SEIFA*~SoVI	0.54	0.90	Tennyson, Mount Ommaney, Anstead, Chelmer, Kholo, Sinnamon Park, Barellan, Karalee, Jindalee
SEIFA*~Damage*Urban Form	0.47	0.92	Paddington, Yeronga, Woolloongabba, Moorooka, Sherwood, Yeerongpilly, Fairfield, Greenslopes
Federal Assistance*Local Assistance*Insurance	0.28	0.93	Riverview, Graceville

Solution Coverage: 0.69

Solution Consistency: 0.88

The necessity and sufficiency of each condition was assessed directly using the fs/QCA software to further understand the recovery pathways. According to previous studies, the cut-off score for necessity and sufficiency is considered as 0.80 and 0.85 respectively. Necessity analysis (Table 1.2) showed high income level was not necessary for recovery in Brisbane neighbourhoods, yet it was nearly sufficient. In other words, not all of the successfully recovered neighbourhoods necessarily had high levels of economic stability but if they had high economic stability, in most cases (coverage=0.78) they recovered successfully. This sounds reasonable as people with financial resources can survive without jobs and rebuild without waiting for recovery funds. Nonetheless,

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the pathways show that even a low-income, socially vulnerable neighbourhood such as Riverview and Redbank recovered when other conditions like recovery funds and insurance were present.

Table1.2. Necessity and sufficiency of conditions for each recovery outcome

Condition	Recovery after 10 month		Recovery after 13 month		Recovery after 17 month	
	Necessity	Sufficiency	Necessity	Sufficiency	Necessity	Sufficiency
SEIFA	0.82	0.73	0.79	0.82	0.79	0.81
SoVI	0.69	0.81	0.65	0.78	0.63	0.82
Damage Loss	0.33	0.75	0.33	0.76	0.31	0.80
Federal Assist	0.54	0.80	0.55	0.83	0.50	0.84
Local Assist	0.37	0.88	0.37	0.91	0.36	0.98
Insurance	0.51	0.84	0.52	0.86	0.47	0.88
Urban Form	0.53	0.86	0.48	0.81	0.49	0.93
Income	0.70	0.82	0.69	0.81	0.66	0.86

### Conclusion

This research examined the link between resilience attributes of 26 flood affected neighborhoods in Brisbane and their housing recovery level over time. Fuzzy set qualitative comparative analysis was utilized to analyze the conditions and recovery outcomes in each neighborhood. The resilience and recovery assessment methods were reviewed to find the suitable indicators of recovery outcome and conditions. The recovery outcome was calculated using time series damage and reconstructions status data collected by Reconstruction Authority of Queensland during 17 months after the flood. The pre-disaster attributes used in this model was economic stability, urban form, SoVI (Social Vulnerability Index), SEIFA (Socio-Economic Index for Areas), and flood exposure. On the other hand, post disaster conditions considered in the model were damage loss, recovery funds available (Federal/State/Local government financial assistance) and Insurance. The necessity and sufficiency of each condition for housing recovery were evaluated and three different pathways for housing recovery were identified.

The combination of conditions identified in the analysis revealed that there are different areas that communities can invest on to build a more resilient neighborhood that successfully recovers from future floods. Different communities could have different pathways of recovery. For instance, community resilience can be improved by planning for social vulnerability reduction and increasing the economic stability. Strengthening social capital and networks in communities with high levels

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of social vulnerability can contribute to the resilience of the neighborhood. When these conditions are not available, resilience could be improved through interventions in issues such as access to resources, land use management and etc. The results also showed the importance of urban form in this context. Neighborhoods with a more compact design and less single family detached houses were recovered more quickly. Although it may create a density conundrum between high exposure and capability to recover quickly, but it emphasizes the fact that in cities like Brisbane that has been built on a floodplain and flood cannot be completely avoided, attention to the building types and development patterns could improve the resiliency.

Although SEIFA and lack of social vulnerability appeared in two pathways in table 1.1, none of them are entirely necessary across all neighbourhoods which could be promising where community resilience needs to be improved through different pathways. While social vulnerability and economic capacity are difficult to modify, resilience planners can get prepared to provide additional support to areas of concentrated social vulnerability during housing recovery.

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### Author's Biography

Leila Irajifar

Leila Irajifar is a PhD candidate at Urban Research Programme at Griffith University, Brisbane, Australia. She has a B.A. in Architecture and M.Sc. in Post disaster reconstruction from Shahid Beheshti University, Tehran, Iran. Her research interests include urban disaster resiliency, urban modelling and systems theory.