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Community adaptation to cope with disaster related road structure failure

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Abstract

Natural hazards can cause a wide range of social and economic impacts both to the area directly affected by the hazards as well as to the broader community. Although community resilience is an important aspect that influences post-disaster response and recovery stages, it has not been explicitly studied by most scholars, and is rather taken to be embedded in the socio-economic landscape studied in the literature. Road structures such as bridges, culverts and flood-ways play a vital role in times of natural disasters as their functionality directly influences evacuation, rescue, recovery and reconstruction activities. In addition to the direct benefits derived from road structures, in the event of a disaster, they play a vital role in resilience by connecting individuals and communities. This paper identifies adaptation methods practiced by disaster affected communities targeted at increasing their accessibility and mobility, and analyses how such adaptation activities can minimise the negative effects brought on by the failure of road structures. The paper uses a recent case study from regional Queensland, Australia, to understand how adaptation options vary in rural areas and to explore possible methods to improve resilience of communities.

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1. Introduction

Disasters induced by natural hazards can cause a wide range of social and economic impacts both to the area directly hit by the disaster as well to the broader community. The level of impacts of a disaster can vary based on the type and frequency of the disaster [1, 2] as well as other social and economic factors [3, 4] prevalent in the area. Road structures such as bridges, culverts and flood-ways play a vital role at times of disasters as their functionality directly influences evacuation, rescue, recovery and reconstruction activities and affects the resilience of a community after a disaster event.

This paper combines literature on community adaptation practices with the literature on disaster related road structure failure in order to understand what adaptation methods can be used by disaster affected communities to increase their accessibility and mobility and to analyze how such community activities can minimize the negative effects brought on by the failure of road structures. The paper also provides an opportunity to compare the adaptation actions carried out in the case study area with those identified in previous studies in order to propose how such activities could be improved to reduce vulnerability of communities. The results are drawn from interviews conducted among residents in a regional area of Queensland, Australia after two flooding events that occurred within a span of 2 years.

Community adaptation and resilience are two very much connected terms and has been used in very different ways by scholars. While some scholars use the two terms interchangeably by identifying the adaptive capacities to be similar to the resilience resources of a society [5], others distinguish two separate facets of resilience as inherent resources and adaptive capabilities [6]. However both these two schools of thought rest on a common ground that identifies adaptation as a dynamic concept.

Hence we could define community adaptation for the purpose of this paper, as those actions taken by communities after a disaster event to reduce impacts and expedite the recovery process by utilizing community resources in innovative ways and can be graphically explained as in Fig 1 below. As community adaptation is fundamentally a dynamic concept, it cannot be studied in isolation but has to be viewed together with the social, economic and political systems in place as adaptation options will be inter-dependent with such factors.

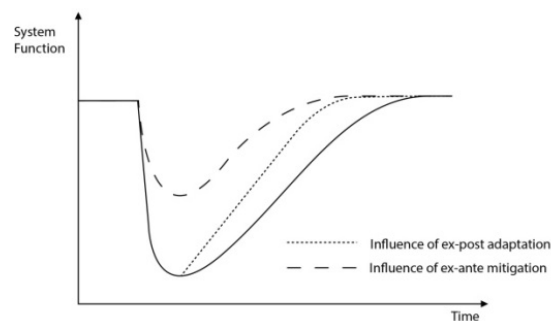


Fig 1. Effects of decision making on resilience (adapted from [7])

2. Literature review

A brief literature review was carried out as part of this research in order to analyze previous work carried out in the area of community adaptation and disaster related road structure failure. The review helped to identify different types of adaptation techniques and to comprehend how such adaptations reduce the vulnerability of communities.

The major direct tangible impacts of road structure failure are emergency clean up, restoration and repair of the damaged infrastructure. As most of these costs are typically borne by a local authority or a government institution,

distinguishing adaptation measures from the stipulated roles of such organizations can be very challenging. However there have been instances where restorations of roads were carried out by communities because government resources were channeled to more pressing issues and road reconstruction was not prioritized [8].

In contrast there is more research focusing on the indirect tangible impacts of road structure failure where the focus is on behavioral changes to reduce the impact of decreased accessibility due to the disaster. Commuters generally adapt to disruptions in transport infrastructure in varied methods and it has been found that changing route and changing schedule (departing early or departing late) are the most widely adopted travel adjustments while changing mode, choosing alternative destinations, car sharing and telecommuting are used less frequently [9-12].

While there is research to show that a change in commuter behavior due to a disruption in infrastructure can have a lasting impact on the way people travel [13], others have found that such changes don't have long term effects and travel behavior reverts back to pre-disaster patterns after the rebuilding of infrastructure [14].

MacMahon, Smith [15] studying the food shortages in the Rockhampton, Queensland, found that food retailers adopted different adaptation options in the wake of the 2010/11 floods based on the complexities of their supply chains. Large retailers adapted to the floods by changing routes and modes of transport, sourced from new suppliers and relaxed quality standards, while smaller community based retailers were found to have adapted by acting as distribution hubs, donating food and connecting with local communities to deliver food to inaccessible areas. However there is disagreement among scholars as to the resilience of these supply chains, where some argue that shorter supply chains are more resilient due to the ease of adaptation to external shocks [16, 17], while a different school of thought is that shorter supply chains do not have capacity to scale up in times of a disaster [18].

The ability of employees to commute to work can hinder business operations prompting employers to take various options to reduce the disruption to business. Some such examples are where employers set up temporary vanpools, subsidized hotel expenses to enable their employees to remain in the vicinity rather than drive through inundated areas [13] and a shopping bus service operated by a local super market to provide access to people who had lost their vehicles due to the tsunami [8].

Cottrell [19] found that isolated communities in Northern Queensland are prepared for floods by ensuring that they have adequate provisions, back-up power, medical supplies and organizing a place to stay for their children in case of being isolated. Taking such precautionary actions could reduce the reliance of communities on road networks during and after the disaster and thereby minimize the negative impacts caused by road structure failure.

It is evident from the analysis of literature that the majority of research on community adaptation in a natural disaster context tends to have a very broad sociological focus and tries to assess how adaptation practices differ in varied communities and disaster scenarios. The research that does look at transport related adaptation tends to focus on the transport related impacts due to infrastructure failure rather than on how such adaptation practices could reduce the negative impacts of infrastructure failure.

Thus it can be seen that there is a lack of research connecting community adaptation and road failure in order to analyze how such adaptation practices can reduce impacts of road structure failure. This paper is an initial study that looks to fill this gap by analyzing adaptation options used in regional Queensland following a flooding event.

3. Data and methodology

The data for this research was obtained by community engagement work carried out in the Lockyer Valley region to examine community resilience to repeated flooding events and the resulting research report published by the Bushfire and Natural Hazards CRC [20]. The research was conducted in an area coming under the purview of the

Lockyer Valley Regional Council (LVRC), which had been affected by flooding in 2010/11 and 2013 providing a good opportunity to understand how adaptation varied from one flood to the other.

Information was obtained through 23 semi-structured interviews, of which the majority was face to face interviews, while a few telephone interviews needed to be conducted as the final day's interviews were interrupted by an impending cyclone. The majority of the interviews were with local families who had been living in the area for some time, while additional interviews were carried out with families that had settled after the 2011 floods and some others who work in the area. The interviews were conducted along three major roads, which had a total of 58 flood-ways and 20 culverts along them. The roads are either dead-ends or lead into the remote National Park, exacerbating the seriousness of flooding and road disruption to the communities.

This paper uses a qualitative approach in analyzing the data, which gives the opportunity to explore the many complex and dynamic adaptation practices carried out, while also providing an opportunity to identify areas where further quantification would be worthwhile.

4. Results

Based on interviews that were conducted, various community adaptation actions taken to reduce the impact of road failure were identified. These adaptation actions are categorized into four different sections, which help to assess how such actions would have reduced the vulnerability of the communities.

4.1. Restoration of road structures

The restoration of road networks was seen to take a very long time, especially after the 2013 floods, and this had a significant impact on the accessibility of the communities. The reason for such delays could be due to the fact that the floods impacted large areas of Queensland, forcing government agencies to concentrate on the rebuilding of more populated and economically significant areas.

As there are many farm lands around the Lockyer Valley region, individuals who own heavy farm machinery used such equipment to help clear roads and clear river crossings of debris to make the roads more accessible. Such measures made accessibility after the floods faster, in contrast to waiting for government authorities to clear the roads. Interestingly similar community adaptation methods were not identified in the literature, and this may have been due to the fact that, most studies focused on urban areas, where individuals may not have access to such equipment.

4.2. Travel time

A number of adaptation options to reduce travel time in the post-disaster period were identified through the interviews. The most common adaptation option was the use of alternative routes, either by using more accessible public roads or travelling through private lands. In one instance the residents had used a temporary road made by the electricity company workers to restore power to the area.

It was identified that people opened up internal farm gates and allowed people to drive through private pathways or to drive around the edges of their fields. Such actions can be understood to be very specific to the Lockyer Valley case given the rural setting of the area.

In contrast to findings in previous research, changing the mode of transport and car sharing seem to be more prominent than changing schedule in the area investigated. The change in mode in the Lockyer Valley case was the use of farm vehicles and 4WD vehicles to travel on damaged roads and is very different to those adaptation practices identified in urban areas. The car sharing scheme too, was similar in nature as the community set up a 4WD pool for

children to attend school. The State Government had provided two 4WD vehicles for this purpose highlighting the importance of the adaptability of political institutions in the times of a disaster.

It was also reported that there was more congestion on the roads than usual because of the heavy vehicles used by contractors for the reconstruction of road structures. This resulted in temporary traffic lights being used and changes in the normal traffic patterns, with the school bus being given priority right of way with the intervention of the Council.

4.3. Business disruption

The impacts felt by businesses in the Lockyer Valley region due to inaccessibility of roads, are quite different to those identified in previous studies, as the case study area is a more farming based community.

The major business disruption due to road failure was identified as the loss to farmers due to the inability to sell produce as a result of loss of access to markets. Although no adaptation methods were identified to deal with the loss of sales, farmers adapted to the loss of access to public roads by driving around the farm and using alternative informal road networks. However this had the impact of increasing fuel and maintenance costs of the vehicles and thus dampening profits further.

The local quarry was seen to have used a few adaptation practices during the floods, by providing transport to employees who could not get to work due to inundation of the roads. The quarry also applied for an extension of its license to excavate bluestone, needed for the road repairs, which resulted in the increase in output and profitability of the quarry business. Local businesses in the area were found to have supported the delivery of food supplies, similar to the findings in other areas of Queensland during these times [15].

It is evident from the interviews that adaptation practices of businesses would not lead to a reduction in vulnerability but can go even further and lead to positive incremental impacts on profits. However, experiencing such positive impacts will depend not only on the level of adaptive capacities but also on the type of business being analyzed.

4.4. Preparedness

A well prepared community could result in the minimization of impacts due to road failure and as one interviewee noted, the floods could be a good time to spend time with family if one is well prepared. Similar to the findings of Cottrell [19], all those interviewed mentioned that they stored enough food and fuel to last a couple of weeks in case of a flood thus minimizing the reliance on the road network to purchase food, in the event of road failure due to a flood. Many of the interviewees also mentioned that they were going to stock up on perishables early as there was a cyclone warning at the time the interviews were being conducted.

In addition to the stocking up of food and other supplies, an inundated road could mean that people, who had travelled away from home, may not be in a position to return. Many stated how they prepare to stay away from home in the case of a flood and how the local school had asked parents to nominate a family their children could stay with in case of a flood. Another practice adopted was to park cars on a higher ground so that people could access the valley by car, if people can reach the parked car either on foot or by using farm vehicles to cross damaged roads after the water subsided.

As identified by Papangelis, Velaga [21], an individual's socio-economic level, social networks and availability of information will influence the level of preparedness of individuals living in a rural community. The ability to store enough food depends on the availability of funds for a household and different income levels would result in

varied levels of stocking of food and essential supplies. This is exemplified by the fact that some households had food stocks enough to last six weeks and some even stocked water.

Social networks, in the form of extended family and friends, play a role in the ability of a person to stay away from home without incurring any additional expense. In an instance where such social networks are not available people may have to incur costs as they may need to stay in commercial accommodation.

The availability of weather information is also crucial in order for individuals to plan and prepare, with people relying on the internet, radio and phone calls from neighbors to alert them on whether they should try to return home or not. It was noted that some individuals acted as information nodes and relayed weather information to other community members and to the council. Local leaders and the Council had organized CB radios to be distributed, and an initiative of the telecommunication company to hand out satellite phones were seen to have helped the information flow in 2013, in contrast to 2011. The most vulnerable were considered to be the sick and elderly, whose mobility can be restricted and may need to evacuate for their safety. This is exacerbated by the fact that it is difficult to store enough medicine required for a long period as pharmacies may not supply enough quantities to last the duration.

4.5. Communication

Although communication is typically not an impact identified with road network failure, the Lockyer Valley case highlighted how the lack of accessibility within an area relying on postal services as opposed to electronic communication (e-mail) can have drastic consequences. It was noted that bills were not received to be paid on time and that mail was lost within this time frame. The mail had been held at the local disaster management hall but was seen to be inadequate.

Table 1 summarizes the community adaptation practices adopted in the Lockyer Valley region based on the interviews conducted.

Table 1: Community adaptation practices in Lockyer Valley area

Type of impact	Adaptation actions carried out
Restoration of road structures	Using personal farm equipment to clear crossings and roads
Travel time	Opening internal farm gates and allowing people to drive around the edges of their fields Temporary road made by the electricity company School bus given right of way, as there was congestion, 4WD pool set up
Business disruption	Providing transport to employees Expanding mining operations to include material needed for road reconstruction
Preparedness	Storing food, fuel and water to last a couple of weeks in case of flood Buying perishable food items early if there is a threat of flood Preparing to stay away from home Parents to nominate a family their children could stay if roads are not accessible Parking on higher private grounds
Communication	Holding mail at the community hall

5. Discussion and analysis

The analysis of the community adaptation options practiced by the Lockyer Valley community in the wake of the 2010/11 and 2013 floods can be said to be somewhat different to those identified by scholars in previous studies. The differences between the Lockyer Valley case and other literature can be recognized to be due to the difference in the geographical and socio-economic dynamics of the area, as most previous studies on adaptation options dealing with road disruptions, have been carried out in more urban settings. This highlights the fact that adaptation options could vary depending on the type of community affected, influencing resilience in a very distinct manner.

The Lockyer Valley case provided the opportunity to understand the importance of previous experience of flooding events, and that there is a learning curve for those experiencing repeated flood events, thus changing adaptation methods practiced by such individuals. It was stated that some new comers to the area left after the floods as they did not know how to cope with floods. Such long term, drastic impacts may have been avoided, if there was a mechanism for those with experience of flooding events to pass on their knowledge to new settlers in the region, helping them to adapt better.

The case study also highlighted the importance and the inter-relationships between economic resilience, political systems in place, social dynamics and the type of adaptation methods practiced by a community. It can be seen that that adaptation actions taken with the involvement of individuals, businesses and government authorities acting together have more impact. Hence resilience of communities could be improved by all stakeholders acting collaboratively and through open discussions between parties.

Thus it is evident that the effectiveness of community adaptation will depend on various factors within a society. The two most important factors identified though this research is personal experience of individuals of similar situations and collaborative working practices of different elements of the community. Some recommendations for improving these factors in order to reduce the vulnerability of communities are listed below. The need for such action is accentuated for an area like Lockyer Valley, where the threat of flooding is high.

Table 2: Improvement options

Factors influencing effective adaptation	Improvement options
Prior experience of similar events	Disseminating information to new comers to the area Providing disaster preparedness information Using community groups for cross learning Understanding community practices in other similar areas Mapping out alternative route options based on previous events
Collaboration between individuals and government institutions	Improving communication between parties Appointing community representatives to ease communication Engaging community leaders to understand needs of the community
Effective use of community resources	Building a data base of individuals owning useful equipment (farm machinery for clearing debris, 4WD etc.) Utilising information nodes within the community to improve the dissemination of weather information Transitioning from the reliance of postal services to electronic systems

As identified earlier in this paper the resilience of the community will depend on its resources and capabilities; where resources are constant, while capabilities are seen to be a more dynamic factor, which can vary depending on the community. Hence the improvement options proposed above looks to convert effective adaptive capabilities to more tangible community resources that can be utilized within a community. Such changes will improve community resilience over time, without a community having to rely on the capabilities of experienced community members, who may or may not be living in that area when a future event occurs. Improving community resources can be said to be a more effective and long-term method to increasing resilience of a community, rather than relying on ad-hoc adaptation actions by community members.

A good example of this is how the LVRC have distributed a booklet to the community on disaster preparedness and mitigation, through the Lockyer Valley Local Disaster Management Plan. Such actions bring together the valuable experience and capabilities of individuals in a community and local authorities, converting them into a community resource that can be utilized in the future.

6. Conclusion and future research direction

This research provided an opportunity to understand community led adaptation practices in the event of disaster induced road structure failure and to propose how such practices could be optimized in order to minimize negative impacts on rural communities. It was also identified that the resilience of a community could be increased by transforming adaptive capabilities into effective community resources. Since this research used a sociological perspective at community adaptation much of the data obtained was qualitative in nature. However future research in this area could try to obtain quantitative data, in order to quantify the impacts of community adaptation practices and also analyze the effect such practices can have on reducing economic impacts of road structure failure. Further research also needs to be carried out to ascertain the effectiveness of converting experience and adaptive capabilities into more tangible resources are in increasing the resilience of rural communities.

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