

Recovery and resilience of communities in flood risk zones in a Small Island Developing State: A case study from a suburban settlement of Port Louis, Mauritius

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Abstract

Small island developing states (SIDS) are characterised by their small size, remoteness and their dispersal in vulnerable regions globally. In Mauritius, rapid economic growth and expansion of suburban and coastal settlements in flood risk zones have exacerbated challenges from increased vulnerability of local communities to frequent flooding and inadequate resilience. While most studies are devoted to coastal flooding due to sea level rise, inland flooding aggravated by human settlements on exposed areas and by human-environment interaction is rarely considered. Generally, studies have focused on immediate flood impacts rather than on post-event recovery factors that reduce resilience and lead to the inability to recover through successive events. This includes living through onslaught of secondary hazards post-event. This study (2008-2014) focuses on the recovery and resilience of a flood-prone community living in a suburban area of Port-Louis, the capital of Mauritius.

A mixed method of quantitative and qualitative approaches was used to examine the recovery and resilience of the community at household level. Results from quantitative analysis showed significant associations at $p \leq 0.05$ between variables relating to recovery and those of income level, literacy level, and household size with children, and/or elderly persons. Qualitative results from focus group interviews indicated that social inequity and environmental injustice hindered recovery among low-income households. However, some resilience was present through community capital, with solidarity in times of adversity amongst some community sub-groups. Outcomes from a participatory exercise showed that experiential knowledge of how to cope with floods was crucial in resilience-building strategies of households and communities.

Keywords: SIDS; inland flooding; recovery; community resilience; environmental justice; experiential knowledge

1 Introduction

Small island developing states (SIDS) are characterised by their small size and their remoteness in tropical or subtropical locations that make them vulnerable to a wide range of natural hazards including floods, cyclones and other extreme events whose impacts are exacerbated by climate change and sea-level rise (Pelling and Uitto 2001; Méheux et al. 2007; IPCC 2014). While SIDS have certain characteristics in common, they are geographically, politically, socially and culturally diverse and differ in their levels of economic development.

Whereas sea-level rise is of particular concern to SIDS, IPCC projects that inland settlements and rural communities will also be adversely affected by the negative effects of climate change due to changing rain patterns and more intense storms (IPCC 2013). These issues are particularly significant in relation to overall development trends towards urbanisation as nearby rural villages are gradually drawn in to form large urban agglomerations within SIDS (UN-Habitat 2015). A report by CRED-EMDAT in 2015 recognised that of the 65 million inhabitants in SIDS, 38 million (59%) live in urban settlements that increase human vulnerability to natural disasters. The report also revealed that some 19% of all natural disasters in SIDS (1994 to 2013) occurred as a result of development trends and became worse as a result of climate change. Consequently, some sectors of communities have been found to be unable to cope and recover from successive flood events (Cannon et al. 2003; Cutter 2006; Pelling, 2007). Studies carried out in the Caribbean islands (Pelling and Uitto 2001; Linnekamp et al. 2011; Pelling and Uitto 2001; Ferdinand et al. 2012), and in Fiji (Mohanty 2006) have shown that underprivileged sectors of communities have limited capacity to cope with hazards or overcome vulnerability.

The vulnerabilities of SIDS to natural hazards have increased over the last two to three decades, whilst resilience building has not kept pace (Howort 2005; Tita 2014; UNEP 2014). This growing vulnerability results from increased exposure to hazards (IPCC 2014), in particular among more deprived groups. Increasingly, governments are being urged to address, with the help of civil society, the challenge of natural hazards impacting on human settlements through resilience building, a commitment reinforced by The Sendai Framework for Disaster Risk Reduction 2015–2030 (UN/ISDR 2015a). At the same time, they have to take into account the relationships between primary and secondary hazards during recovery

processes, and the vulnerability of citizens of lower socio-economic status living in hazard zones.

The research gap, in the context of SIDS, involves understanding issues of resilience through lack of recovery during successive flood events or through secondary hazards. In particular, over 75% of disasters in SIDS relate to torrential rain and flash floods (UN/ISDR 2015b). In Mauritius, these issues have not been researched despite disaster losses (1980-2014) amounting to over US\$420 million, with 51,951 people affected (CRED-EMDAT 2015). Research reported here aims to investigate the factors that determine the vulnerability and resilience building capability of households within a Mauritian community in the recovery phase of flood hazards caused by torrential rain, over the period 2008 to 2014. It then assesses the implications of the findings for policy and practice of hazard mitigation, reductions in vulnerability, building of resilience, with specific reference to the recovery phase, among deprived flood risk groups in Mauritius.

2 Background framing

2.1 Linking concepts of vulnerability, resilience, environmental justice (EJ) and lay knowledge to recovery and rehabilitation processes

Resilience and vulnerability represent two related yet different approaches to understanding the response of systems and actors to change; to shocks and surprises, as well as slow creeping changes. Their respective origins in ecological and social theories largely explain the continuing differences in approach to social-ecological dimensions of change. However, there are many areas of strong convergence (Miller et al. 2010). The concept of vulnerability has its roots in geography and natural hazard research, but the term is used in a variety of other research contexts (Füssel 2007) and in various disciplines. Consequently, there is no universally accepted definition of vulnerability (Adger 2006; Cutter 2006). The United Nations Office for Disaster Risk Reduction differentiates physical, social, economic and environmental vulnerability. It defines “social vulnerability” as:

‘the inability of people, organizations and societies to withstand adverse impacts to hazards due to characteristics inherent in social interactions, institutions and systems of cultural values. It is linked to the level of wellbeing of individuals, communities and society. It includes aspects related to levels of literacy and education, the existence of peace and security, access to basic

human rights, systems of good governance, social equity, positive traditional values, customs and ideological beliefs and overall collective organizational systems.'

Variables that impact on wider vulnerability therefore encompass the social, economic, cultural, political, environmental and geographical contexts in which people live (McEntire 2001; Pelling and Uitto 2001).

The concept of resilience has been extensively framed in various disciplines to denote ideas of resistance, transformation, coping, adaptation and recovery (Zhou 2010); hence it has gained multiple meanings (Manyena 2006; Rose 2007). Timmerman (1981, p21) was among the first to apply the concept to natural hazards, to express the idea of the ability of a system or a community to plan ahead to 'cope, accommodate, resist or adapt and recover' from a disaster impact (Matyas and Pelling 2014). Implicit in the above definitions are ideas of 'exposure to' and 'recovery from' hazards and the building of long-term resilience. Critical is differentiating the ability to "bounce back" to a previous state and to "bounce back better" through adaptation. More recently Manyena (2016) argued that adaptation is not synonymous with living with conditions previous to the occurrence of a disaster. Instead he suggested the need to transform by bringing in new ideas in areas of social and environmental justice, good governance and equitable allocation of resources to vulnerable groups. He visions transformation as the best option in building resilience. Matyas and Pelling (2014) have also elaborated transformation, as well as resistance and incremental adjustment, as expressions of resilience in policy for disaster risk management.

Over the years, the linkage between resilience and vulnerability has become a debatable theme because of the lack of proper theoretical or philosophical understanding. According to Buckle et al. (2001) and Akter and Mallick (2013), resilience is linked to vulnerability in multiple ways. Some authors define resilience as the opposite of vulnerability, meaning that a high level of vulnerability implied a low resilience and vice-versa (Timmerman 1981; Cannon 2008; Adger 2000; Shaw 2006). Others consider that resilience and vulnerability are linked (Gallopín 2006; Folke et al. 2006; Cutter et al. 2016) and overlap in complex ways (Kelman et al. 2016). As an example, a person may be vulnerable to flooding but still have resilience in terms of adequate personal skills to devise ways to cope and recover (Buckle et al. 2001).

Recognising these opposing or overlapping characteristics of vulnerability and resilience several studies (Manyena 2016; Kelman et al. 2016; Cutter et al. 2008; Matyas and Pelling 2014) consider these as two key concepts that are crucial in the prevention and mitigation of the impact of hazards on communities. Resilience assessment, like vulnerability, could be applied as an additional tool in the collection, analysis and interpretation of data when assessing community resilience (Ferdinand et al. 2012; Ainuddin and Routray 2012) in the recovery process (Manyena 2016). According to Matyas and Pelling (2014), adopting the concept of resilience-thinking in disaster risk management could eventually be used to reveal the root causes of vulnerability of communities exposed to hazards. Hence, most of the factors that determine the vulnerability of a community, namely social, economic, environmental and psychological factors could be similar to those determinants that also influence community resilience.

Another important concept that originates from studies of the relative vulnerability and exposure of communities to risk is 'environmental justice' (EJ) that recognises disproportionate exposure of certain community groups to environmental harms (Schlosberg 2007; Walker 2012). This issue was first highlighted in the case of communities that were exposed to pollution and toxicity problems in the US in the context of the politics of race and civil rights. But the application of EJ has now been extended to more and less developed countries for the purpose of addressing poverty, exclusion, marginalization of minority groups and social inequities that increase the susceptibility of a community to hazard impacts (Singh et al. 2014). Environmental injustice has been reported in hazard impacts within some More Economically Developed Countries (MEDCs). According to Houston (2013), social and environmental inequalities prevailed in the aftermath of Hurricane Katrina in New Orleans, resulting in complex differential impacts on lower income groups and on African American residents - for diverse systemic reasons (including racism, institutional failure and neglect by the authorities). In a rather different setting, Werritty et al. (2007), working in Scotland, evaluated the extent to which flooded households experienced participative justice from the perspectives of both environmental vulnerability and EJ. They found that low income households were disproportionately more vulnerable to flood risks, and were more susceptible to lasting impacts that could reduce post-disaster recovery (see also Rowntree Foundation's climate injustice/disadvantage work, 2014). In developing countries and SIDS, the impact of each new hazardous event can exacerbate existing vulnerability with the consequence that fragile sub-groups of communities have weakened capacity or resilience to

cope with hazards on their own (Cannon et al. 2003; Pelling 2007). This can lead to a decline in resilience, with reduced likelihood of any increase.

2.2 *Disaster cycle and recovery*

In exploring vulnerability and resilience alongside issues of environmental justice, it is important to consider the four phases of disaster cycle, namely Mitigation, Preparedness, Response and Recovery (WMO 2006). In hazard studies, the recovery period following a disaster is defined as ‘the restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors’ (UN/ISDR 2009, p.23). Referring to the major disaster of the Indian Ocean tsunami of 2004, Shaw (2006) considered that recovery itself involves several activities at three different potentially overlapping phases: ‘*rescue*’ - during or immediately after a disaster, involving helping out or evacuating trapped victims; ‘*relief*’ - may last longer depending on severity of the impact on communities; and ‘*rehabilitation and reconstruction*’ - related to the community’s needs for increasing its capacity to face and develop greater resilience to future disasters. The recovery process, especially during the rehabilitation and reconstruction phase, offers an opportunity not only to improve livelihoods and build capacity but also to increase resilience.

If issues of vulnerability, marginalization, and environmental justice (EJ) are left unresolved during recovery, community resilience is reduced (McEntire 2001; Pelling and Uitto 2001). The Sendai Framework for Disaster Risk Reduction 2015-2030 encourages nations to involve communities in preparedness and recovery through Community-based Disaster Risk Management (UN/ISDR 2015a). This approach marks a shift from previous top-down approaches to risk reduction to more innovative ways of working where recovery is seen:

‘not simply as the replacement of what has been destroyed and rehabilitation of those affected’ but as ‘the coordinated process of supporting affected communities in the reconstruction of the built environment and the restoration of emotional, social, economic, built and natural environment wellbeing’ (Carey 2011, p.17).

Such change in attitude among different stakeholders should lead to reducing vulnerability, building more robust resilience, and ensuring a faster and fuller recovery.

2.3 *Framing lay knowledge and its importance in disaster risk management*

Lay knowledge is also described as “*common knowledge*”, “*local knowledge*” or “*common wisdom*”. Sometimes known as “*indigenous knowledge*” or “*traditional knowledge*”, inter-generational knowledge is acquired by local people and handed down from one generation to the next (Mavhura et al. 2013; McEwen et al. 2016). UNESCO (2016) places increased recognition of the value and importance of indigenous knowledge in climate change adaptation in small island communities. It has been found that local knowledge can play an important role and serve as “*tangible evidence*” (Scammell et al. 2009; McEwen and Jones 2012) in coping strategies and in building community resilience to floods as in Zimbabwe (Mavhura et al. 2013). While these types of knowledge result from the historical learning of communities when they interact with their local environment, “*experiential knowledge*”, as a type of local knowledge, specifically refers to things or events a person recalls from personal experience (Stokerson 2009). According to Spiekermann et al. (2015), such knowledge is relevant to specific circumstances where a person acts instinctively to what needs to be done in order to avoid a risk or to face a danger. Mercer et al. (2007) found that lay experiential knowledge was often excluded in decision-making processes, and proposed the need to integrate such knowledge with the expert knowledge of the development agencies of governments, which rely mostly on scientific or technical evidence in disaster risk management (Scammell et al. 2009; Gaillard and Mercer 2012). Similarly, Cottrell (2005) emphasized the importance of complementing experts’ knowledge with lay knowledge (Haughton et al. 2015) resulting in “*hybrid knowledge*”. As such, the role and capital of all stakeholders in the recovery process should be acknowledged and valued as a crucial element in community resilience building (Lopez-Marrero and Tschakert 2011).

Schelfaut et al. (2011) suggested that community participation in flood mitigation plays an important role in promoting resilience. A bottom-up approach takes into account the community’s perspective, its lay/experiential knowledge, and stakeholders’ views at all levels in building community resilience. However, this approach may present daunting challenges to some countries. For instance, bringing together all stakeholders in many developing countries and SIDS to form linkages and networks could be difficult to achieve. As an example, in the Maldives, a SIDS in the Indian Ocean, Pardasani (2006) noted that international agencies, and governments were not able to work together effectively with local NGOs and the affected communities in building community resilience during the reconstruction stage of the 2004 tsunami. The main barrier was lack of knowledge of

community needs, culture and psychological well-being in the reconstruction programme. This prompted the Government to set up National Disaster Management Centres as official permanent mechanisms where the concerted efforts of all stakeholders could be mobilised in support of the recovery programme.

3 Case-study

3.1 *The overall setting*

The Republic of Mauritius is situated between latitudes 19° 58.8' and 20° 31.7' South, and between longitudes 57° 18.0' and 57° 46.5' East, approximately 850 km East of Madagascar (Figure 1). The Republic includes the distant islands of Rodrigues, Agalega, St. Brandon, Tromelin and the Diego Garcia Archipelago.

[INSERT FIGURE 1]

The area of the main island of Mauritius (Figure 1) is approximately 1,865 km², out of a total land area of ca. 2,040 km² for the Republic. Mauritius was formed by volcanic activity ca. 12 million years ago and has a central plateau, bordered by three steeply-sloped mountain ranges and a narrow coastal plain except in the north. A number of rivers and rivulets flow swiftly down these slopes to the sea, and act as a natural drainage system during cyclonic and torrential rain. Therefore, prior to the wide-ranging infrastructure development in the 20th century, extensive flood conditions were not common for extended periods (Chacowry 2016).

Mauritius's population of 1,255,020 (2012) is culturally diverse, with Indian descendants (68%), African and Malagasy descendants (27%), Chinese descendants (3%), and European descendants (2%) (Foreign and Commonwealth Office 2009) exacerbating potential challenges in risk communication. Over the last few decades, pressures from increasing population, economic development and the exploitation of wetlands for building houses and other infrastructure have amplified flood conditions (Pellegrin 1999; Bhankaurally et al. 2010; Government of Mauritius 2011). Previously, flood conditions preceded or persisted after the passage of torrential rainfall associated with tropical cyclones. As such they frequently did not receive any separate attention, and hence records of individual flood events are sparse. Local inhabitants often recall the association between flooding and cyclones, dealing with these floods as a natural phenomenon, with flood water receding quickly along natural storm drains. However, two major surface flooding events in 2008 and 2013 (ISDR

2015b) resulted in unprecedented casualties (Khedo 2008; Ramessur 2013; L'Express 2013; Le Mauricien 2013) and increased adverse social, economic and environmental impacts in many localities. Continuous records of rainfall floods, as distinct physical events, are not readily available from official sources but were retrieved from newspaper reports from 2003 to 2011 (Chacowry 2016). The number of days when flood events were reported, defined as 'flood-days' over the period 2003 to 2011, was recorded (Figure 2). The year 2008 was considered exceptional with the highest number of 'flood-days' over that period in Mauritius (Chacowry 2016).

[INSERT FIGURE 2]

It is projected that the frequency of hazards such as floods will increase as a result of climate change (IPCC, 2013), and the island's population will be more at risk from hazards due to associated phenomena such as sea level rise, beach erosion and more intense cyclones. In Mauritius, much concern is given to coastal flooding due to sea level rise, but inland flooding exacerbated by human settlements on exposed areas and by human-environment interaction is rarely considered. Flood mitigation management policy has exclusively focused on the immediate impacts of flood events in the recovery phase until 'the situation is normalised' (NDRRMC 2015, p. 23) rather than addressing vulnerability of affected people in post-event recovery phase. These issues are explored in this case study, carried out from 2008 to 2014.

3.2 Cité La Cure - The case study

Cité La Cure (CLC) is a suburb of Port Louis, the capital of Mauritius. This particular area was selected for the case study on the basis of the local knowledge of one of the authors, an NGO worker, and in view of the geography and frequent flood conditions that prevail in that locality. CLC is situated in a valley, the *Vallée des Prêtres*, between Long Mountain Range and the Port Louis Mountain Range. Figures 3A and 3B provide maps of Cité La Cure which is drained by *Rivière Lataniers* and its tributaries that originate in the nearby mountains and flows about 2km to the sea. Owing to its topography, the region is characterised by two types of floods: (i) torrential rain and flash floods that cause the river and streams to overflow; and (ii) water accumulation in surrounding wetlands that have a low drainage capacity. In Figure 3B, flood zones are shaded in blue.

[INSERT FIGURE 3A and 3B]

Official documents on the development of CLC are limited. Most of the information was obtained from the narratives of the inhabitants. The area was once grassland with a few farms. The region underwent rapid development in the late 1960s and early 1970s to accommodate the growing population from other regions of Mauritius and the victims of the cyclones, who were mostly from the suburbs of Port Louis. During this period, the Government built relatively low-cost housing in the area to provide accommodation for the victims. Many lower middle income people settled in the area as the land was affordable. In the last decade, along with a number of poor Mauritian families some 200 families from Rodrigues (an outer island), motivated by job opportunities in Mauritius, have settled in very precarious conditions (UNDP 2013) in the flood prone area. Over the years, the authorities have come to tolerate the fact that squatters are settled in an illegal and inappropriate location, and now find it increasingly difficult to evict them or to provide the necessary amenities. In 2010, the population of CLC was estimated at 17 334 (Government of Mauritius 2011) but the exact number of people living in the flood zone is undocumented.

Transcripts from local newspaper articles (2012 to 2017; Table 1) reveal that a sector of the community which occupies flood prone dwellings in CLC is still vulnerable and continues to live in poor conditions. This study therefore examines the vulnerability and resilience of this flood-prone community, and the factors that are crucial in its resilience-building strategies.

[INSERT TABLE 1]

4 Methodology

4.1 Research strategy

The research strategy adopted is a case study approach which according to Qi (2009) offers a powerful research tool, enabling the researcher to explore interrelated issues of complex social systems. A case study is well-suited to the collection of *in situ* data on demographic and socio-economic conditions, as well as on householders' perceptions of various issues related to the disaster cycle. The methods used to collect data in three inter-related stages - questionnaire survey, focus group interviews and participatory activity - and themes explored at each of three stages are outlined in Table 2.

[INSERT TABLE 2]

A quantitative approach was employed using the questionnaire survey to collect information about households and their perceptions of several aspects of their vulnerability and resilience in the recovery phase of flood hazards. This study covered households that are susceptible to flooding, as they live on 'marginal lands' on the slopes, on river banks, and on wetland areas. The researcher, who has local knowledge, carried out a 'door to door' survey with the help of a local community member who further facilitated contact with a number of households known to have experienced flooding in the past few years. Out of about 400 questionnaires distributed, 236 households responded and returned the completed questionnaires. The survey was implemented from August to September 2010. The data were analysed descriptively to obtain frequencies of responses. A statistical analysis using chi-square tests was performed (significance level $p < 0.05$) to identify possible relationships between characteristics of vulnerable household groups as independent variables and the parameters of vulnerability as dependent variables. The statistical analyses were used to gain insights into the factors and possible causes of vulnerability of different households, as a basis for determining their recovery and resilience building strategies.

The themes and patterns identified within the quantitative analysis were explored further and in depth using a focus group interviews and participatory activities among the affected members of the CLC community. Building on the trust established during the survey, it was possible to organise a focus group interviews in October 2010 with a group of seven householders who volunteered to express their views and experiences with flooding. Their views were digitally recorded in the local Creole language and later transcribed by the author into English. The participatory activity was conducted in December 2011, providing a further opportunity for in-depth discussions on all aspects of local flooding as a basis to gaining participants' views about possible solutions. Recruitment was by the 'snowballing' technique, whereby one known reliable person in a household contacted other households in the community. Some fifteen participants were selected thus to carry out participatory exercises. These included seven participants from the focus group, and eight other members from the community. Two sub-groups were formed and using diagrams they compiled their experience and issues, and on how best to address and solve the perceived flood-related problems that affect them. At the end, a general discussion session resulted in a consolidated list of findings.

5 Results

5.1 Questionnaire survey

Data were analysed for frequencies and also for statistical relationships with household characteristics (Table 3). Not all respondents answered every question; the number responding to a particular question is indicated in brackets after the percentage in the sections below. Figure 4 shows the distribution of family size while other main household characteristics are shown in Figures 5a-c. The other figures are discussed in sections dealing with vulnerability (Figure 5d) and with coping strategies for resilience building (Figure 5e-f).

[INSERT TABLE 3]

[INSERT FIGURE 4]

[INSERT FIGURE 5]

5.1.1 Household characteristics

Results of the questionnaire analysis (Figure 4) showed that the average number of members in each household was 5.5, with 72% (n=169) of households having more than the national average of four members. According to the 2006/2007 population survey by the Mauritius Central Statistics Office (Government of Mauritius 2009), households with more than four members are considered to be “*large households*”, which may generally consist of extended families with children and elderly persons.

The number of members in each age group (Figure 5a) shows that 34.5% of members were children below the age of 14 years while 8.0% were elderly persons above 60 years of age. A study on poverty in 2012 showed both groups are generally considered as vulnerable in Mauritius (Government of Mauritius 2011). Of those who replied to the survey, a large majority (61.7%) had at least primary education and some 40% had secondary education (Figure 5b). In responding about their occupation (Figure 5c), it is likely that many respondents were stating the occupation of their spouses while those who answered ‘none’ were likely to be unemployed, looking for work, or doing “petty jobs”. Based on the salary scale of the 2013 Government Pay Research Bureau (PRB), it could be considered that 146 (factory, artisans, housewife, and those with no occupation), representing about 60% of the households surveyed, were in the low-income category (Government of Mauritius 2013).

5.2 Vulnerability of households to flood hazards

The responses highlighted the extensive flood experience within the community. Some 70% (number of respondents $n=233$) of households agreed or strongly agreed that they had experienced more than one flood event every year (Table 3) during heavy rainy days. Statistical analysis using chi-square test ($p\text{-value}<0.005$) suggested that lower income households experienced floods more frequently than others, and had their houses inundated during each rainy season. The extent of tangible or material damage caused by the flood water varied from household to household. Over half of the respondents ($n=124$) indicated damage to their house structure (floorings, walls), and about 87% of the respondents ($n=110$) suffered damage to their personal belongings, as a consequence of flooding annually. Based on the chi-square analysis, households with elderly people claimed to have most of their personal belongings damaged or lost during the flood ($p\text{-value}=0.044$). About 75% ($n=232$) of the households agreed or strongly agreed that they were upset with the damage caused by the flooding since it took them time, effort, and resources to recover. Most likely the remaining 25% did not wish to express their feelings about the damage they sustained. Emotional impacts were reported from the disruption of families (about 35% of respondents $n=229$) with the exposure to recurrent floods. Mostly significant emotional impacts were amongst low income households ($p\text{-value}=0.003$).

The socio-economic situation of the affected population is shown in Figure 5d. Nearly 60% ($n=133$) of households owned land with houses on it, while 27% ($n=62$) of households lived on state lands in temporary houses which were constructed with corrugated iron sheets that were vulnerable to adverse weather conditions. There was a strong relationship between income group level and property ownership, as most lower income groups occupied Government property and lived in precarious housing conditions ($p\text{-value}=0.001$). Respondents reported a variety of environmental factors that influenced living conditions. The majority of the households agreed or strongly agreed that they were living in an unsafe environment and were at the risk of exposure to vector-borne diseases. It is noted that during the 2005/2006 rainy seasons, there was an outbreak of chikungunya, a disease caused by mosquitoes (Beesoon et al. 2008; Goorah et al. 2008). This explains the high level of responses from households who felt they were living in an unsafe condition. Of those who replied, households with a low level of literacy were more exposed to mosquitoes and

possibly other vector-borne diseases than were households with a high level of literacy (p-value=0.003). The results from the statistical analysis showed that households with children (p-value=0.023) lived in crowded conditions and were highly susceptible to catching diseases after each flood event (p-value=0.020). Almost 80% (n=233) of households agreed or strongly agreed that they were living among disrupted families after the flood. Statistical analysis showed that the lower income groups were particularly affected (p-value= 0.003). Some 44% (n=231) of responses indicated that there was a lack of support from local authorities to improve their quality of life after floods in particular within the lower income group (p-value=0.003). This evidence highlights the poor socio-economic and environmental conditions, which may account for the higher vulnerability of the low-income categories of households.

5.3 *Recovery and resilience building of households after flooding*

Some 46% (n=210) of the households perceived that that time and effort was required to get back to normal (Table 3). This issue was considered highly significant amongst lower income groups of households (p-value=0.001) who perceived that they were more likely to take longer time to get back to normal. However, a small proportion of the households of the lower income group (23.4%, n=111) never got back to normal, probably due to lack of resources or other reasons. The results also showed that households with elderly persons were more inclined than those without elderly persons to perceive that their houses did not get back to normal since the last flood event (p-value=0.047). Some 94.4% (n=102) of households reported that they lived in damp conditions after floods (Table 3). Statistical analysis showed that households with children were more affected by these damp conditions (p-value=0.038). Of the 86 households that responded, forty-nine agreed or strongly agreed that their living conditions remained unchanged while the rest perceived that their living conditions worsened after a flood. Those people who responded that their living conditions remained unchanged had already established coping capacities, such as raising their floors above water-level since last flood events so that they were not significantly affected. Households with low income perceived that the quality of life of their families had significantly deteriorated after a flood event (p value=0.038). Of the 113 responses, only 20% had agreed to be relocated elsewhere by the Government (Table 3). The relocation strategy was generally not favoured by flood victims. Resettlement often required them to face new

challenges including adaptations to a new environment such as being uprooted from their community, change of school for children and incurring extra expenses for travel to the workplace. This was particularly significant among households with elderly persons who were not willing to be relocated elsewhere (p-value=0.004).

Various coping strategies to resilience-building, learning from past floods were adopted by the respondents. Their range and relative importance are given from Figure 5e. As regards actions taken immediately ahead of a flood event, about 60% (n=142) responded that they made furrows to divert flood water from coming into their houses. Around 44% (n=103) placed flood guards at their doorsteps while some 24% (n=66) moved out to a safer place. However, a small proportion of households (8%, n=20) did not take any action but lived throughout until the flood receded. Informal interviews with several of the inhabitants revealed that those experiencing flooding quite frequently had become indifferent, as there was no change in their situation from one flood to the next. It is likely that they accept things as they are and some have adapted to living with floods. Longer-term adaptive measures taken by 165 households who responded to the survey were to raise the floors above previous flood water levels. During flood events, one way to increase resilience is to rely on someone or an entity to overcome any disaster (see Figure 5f). About 65% (n=155) of the householders who responded said that they relied on themselves and their families for protection against flooding. Less than 10% relied on neighbours or their own community for physical flood protection. In addition, 63% (n=97) of households relied on various external sources (charities, local authorities and the Government) for protection and support during flood events. About 80% (n=187) of responses indicated close collaboration among neighbours including in planning to mitigate flood impacts and the provision of moral support to each other. However, only 47% (n=112) were prepared to participate in cleaning debris, and 35% (n=18) were ready to collaborate with local authorities and NGOs in flood mitigation planning.

The respondents cited varying reasons for the increase in flood events in their region (Figure 5g), including primarily due to blocked waterways and the lack of sufficient drainage (95%, n=226), and due to excessive building and infrastructure development. Climate change and deforestation were considered less important. These reasons reflected their awareness and local experiential observational knowledge of issues impacting on their community living in the flood risk zone. Almost all the respondents (98%, n=232) surveyed agreed or strongly

agreed that the Government should improve emergency services and structural measures in flood protection and should undertake other measures besides flood warning. The survey showed that a high proportion of respondents (n=218, 92%) had received flood warnings which were delivered through the media. Statistical analysis showed that flood warning was less understood by households of lower income groups (p-value=0.001). However, those who received flood warnings agreed or strongly agreed that warnings were delivered in time for them to act. They still felt that the warning system had to be flood-specific. The system was based on cyclone warning which may be issued days in advance while flood conditions can prevail over a very short time period.

5.4 Results from focus group interviews and participatory exercise

Building on the evidence from the questionnaire survey, the focus group results provided further insights about households' experiences of flooding, on coping strategies, recovery, assistance from authorities and relocation. The participatory activity with the affected households complemented some findings from the focus group interviews with an emphasis on resilience building as seen by the householders themselves.

Some of their comments reflect the frustration of the flood victims and a sense of injustice:

'We have lived on Crown (State) marginal lands for the last 10 years - we do not have a land contract - and we know that we have no right to build a house on land that does not belong to us. We still wait, while others have got the authorisation to build; they can build, have electricity and water supply. Some occupy higher ground, the water goes around them; those staying on the lower ground are more affected'. (Focus group participant)

This quote reflects the situation of many of the houses in CLC that had been constructed haphazardly on State or Crown lands by squatters without any authorisation or land use planning. Those households in CLC within the focus group stated that they were exposed to river overflow that brings in mud, sewage, and other pollutants that often contribute to health problems.

The participatory activity revealed that the participants were aware of their civic duty regarding the safeguarding of their environment and in helping to reduce the flood risk. These included suitably disposing of garbage and keeping the area and the drains clean. They also

felt that they should develop good neighbourliness and reinforce community ties, which were seen as important elements in vulnerability reduction and resilience building.

The most common coping strategies deployed before and during flood events were moving their belongings and foodstuffs to higher ground, moving to neighbours' houses or sometimes taking shelter in Government refugee centres. Helping out neighbours in difficulty was an accepted practice in close-knit communities, as was stated by one participant as neighbours help out in life-threatening conditions:

'A mother had gone out to work; her children were at home, and the neighbour had to break in to pull out the children to safety'. (Focus group participant)

Participants indicated that often the communities had little or no time to take precautions when torrential rain suddenly triggered flash floods. By the time they were aware that a flood warning had been issued, water had already rushed into their homes. The communities often experienced flooding even with slight rain as the water table in the wetland areas and the densely occupied lands was just below the surface. Flood water remains stagnant over a period of several days and poses serious impediments to accessibility and threats to health.

Most of the focus group participants were from low-income backgrounds and had limited resources. Their houses were not in a suitable condition to withstand severe weather conditions. They complained about lack of apparent concern by the authorities:

'The lack of timely intervention in times of greatest need and the apparent attitude of indifference shown by the authorities at CLC have shaped negative attitudes of 'being left aside'. (Focus group participant)

'The authorities concerned do not turn up. Visits come well after a disaster, but no action is taken to improve our conditions'. (Focus group participant)

In CLC, there appeared to be a high degree of community cohesion. This was noticed during the focus group interviews when the participants talked more in terms of 'we and us' and showed sympathy to their neighbours in difficult situations. The community solidarity was more prevalent when the community had to take their case to the authorities. Otherwise, they claimed that they had learnt to take care of themselves.

Some of the community members expressed a sense of helplessness regarding their living conditions immediately after a flood event:

'The tin roof and the flooring have not been fixed. We wash our dishes outside, our clothes outside. All the tasks are performed outside the house. We have no electricity. Once in a while, we get some assistance in terms of money for repairs from the Government but it is not enough to buy the materials'. (Focus group participant)

Several of the participants acknowledged receiving short-term assistance in the form of household items, foodstuffs, school materials, and limited cash to meet their immediate needs:

'We receive help mostly from charity organisations and also from the local authorities.' (Focus group participant)

The lack of timely intervention in times of greatest need and the apparent attitude of indifference shown by the authorities have shaped negative attitudes of 'being left aside'. Such perceptions often gave rise to self-reliance as evidenced during the participatory activity when the participants expressed that they should rely more on themselves in overcoming the problems caused by flood events.

Members of the community often join together to contact non-official sources such the media to air their grievances and call for urgent help to meet specific needs for shelter and improve the living conditions of those in dire distress, particularly families with children. This form of solidarity is often present in small communities in times of adversity; an indication of having the skills to undertake self-help projects such as the one initiated by a local radio station:

'Maison Petit Bonheur' (House of Good Fortune) to accommodate one family was built from public donations through an appeal by a local radio station. We do not know what will happen next; we will know only when the rains come. The house is beautiful and located on higher ground. The primary aim was to move the family with children away from areas that are usually inundated'. (Focus group participant)

However, relocation is favoured by only a few households from CLC. In general, households preferred receiving assistance to rebuild their house rather than being moved elsewhere. The reasons for the choice was due to the fact that relocation often brought some uncertainties and also had an adverse effect on displaced families by increasing the risk and vulnerability:

'My neighbour has stayed here for 12 years on Crown land. The land gets heavily inundated. The Government has moved the family to a new place, but the new location is hit worse than the original place. My neighbour has obtained title deeds, but we have not yet received any. How is that possible?'

(Focus group participant)

The above statement also suggests that there is an element of social inequity in the allocation of land permits among the vulnerable households. The results obtained from the participatory activity further reinforced these views. Instead of being relocated elsewhere, participants would like to receive some help from the authorities, such as a better drainage system and assistance in the construction of flood-resistant houses with raised floors and good sanitation facilities. To improve their social conditions, the participants mentioned that the authorities, should address the concerns of the community while giving priority attention to the most needy. Furthermore, they wished to be visited by the authorities more systematically and ensure that the authorities' concern does not wane immediately after each flood event.

6 Discussion

6.1 Differential vulnerability and ability to recover

This research found that sectors of the community in CLC have differentiated vulnerability according to their age group, educational level, socio-economic status and other external factors that determine their ability to recover from one flood event to the next. The survey results showed that the low-income groups within the community were more likely to be exposed to frequent flooding as they occupied hazardous wetland areas and poorly drained marginal lands along river banks which were liable to flooding. The compelling reasons for occupying the flood-prone area seemed to be job availability, low-cost housing, stable schooling, community belonging and proximity to numerous facilities and amenities in suburban CLC.

The extent of impacts from a flood event was felt differently by groups of people with varying levels of preparedness, resilience, and capacity to recover. Even within the same locality, vulnerability varied from one socio-economic group to another. Thus, there was evidence to suggest that some people with progressively lower capacities to anticipate, cope with, resist, and recover from disaster had progressively higher vulnerabilities (Schroeder and

Yocum 2006) although the relationship was not straightforward. Some households took a long time to recover if at all; in particular, households with lower socio-economic backgrounds did not recover by the time the next flood event occurred, thus further entrenching their vulnerability. Results showed that some low-income families remained in damp conditions for many days and suffered social disruption and economic stress, as they were constantly concerned about not having enough resources to improve their housing. Additional information from the focus group interviews further reinforced that households with poor socio-economic conditions lived in fragile houses built on state lands. These participants were reluctant to build strong houses and invest in flood proofing, as their households occupied state lands without any authorisation. Over the years, the residents continued to live with anxiety and the possibility of being evicted from the land at any time. These groups took an inordinately longer time to recover from flood impacts.

Psychological impact of flooding was mostly associated with households with large families, and with those with children. Concern about diseases and chronic stress has been found elsewhere to be a factor that has led to reduced resilience (Pelling 2003; Wisner et al. 2006; Linnekamp et al. 2011), and hence impeding recovery. According to Whittle et al. (2012), psychological anxiety could result from the disempowerment of communities, who were then unable to make themselves more resilient. The greater awareness of health issues among households with higher levels of literacy can be explained by their generally better living conditions and greater access to information (Government of Mauritius 2011). Level of education was an important factor that contributed to the understanding of environmental issues, including exposure to health risks, as was found by Tobin (1999) in the case of South Florida. Also households with low levels of literacy were not able to understand information given by the Government on health risks and health protection, as similarly found in Vietnam by Few and Pham Gia Tran (2010). Greater awareness and education on health issues on the risk of catching flood borne diseases could be enforced in the agenda of community health programmes.

6.2 *Coping strategies and resilience*

Key factors in coping were physical measures undertaken, and the extent of local experiential knowledge and community solidarity. In terms of enhancing environmental resilience and of reducing their exposure to associated risks, the majority of households took pre-emptive

measures before floods, making furrows to divert water during and after a flood hazard. Infrastructural measures, involving building higher floors and constructing walls around the property, were used as longer-term adaptive strategies, but these could be afforded only by households that were economically better-off. One drawback of building protective structures against floods was that it could divert the flood water into the neighbouring areas, and thus cause more harm to others and increase the overall vulnerability of the community. As a last resort, household groups with limited means simply had to endure flood conditions thus perpetuating their vulnerability from one flood disaster to the next. The enforcement of existing laws and greater civic responsibility among residents were considered by respondents in the participatory exercise as essential elements of resilience-building.

Helping neighbours and liaising with local authorities to clean up soon after flood hazards was a common sign of solidarity. This action bears similarity to sectors of a community in the Windward Islands in the Caribbean who through collaboration among themselves built resilience (Ferdinand et al. 2012). However, the authors noted that resilience building required broader multi-stakeholder partnerships, and that working in isolation could further exacerbate vulnerability. In this respect, the integration of other stakeholders (NGOs, Government) in vulnerability and resilience management is essential.

Experiential and local knowledge were important capital for households. The results showed that a large majority of households that had experienced flood hazards during rainy days were the low-income groups within the community. The experiential knowledge was a valuable asset for adopting suitable coping strategies. In several cases, their previous experience of floods had reinforced some households' approach, and had no other option left but to 'live with flooding'. Elderly persons who had occupied the land area for a long time had gathered memories of their coping strategies against flooding, such as raising their floorings above flood level. Evidence from informal interviews indicated that households with disabled or elderly persons were unwilling to leave their homes or relocate elsewhere because they retained a strong attachment to property and place.

Results from the questionnaire survey showed that the respondents evoked varying reasons for the increase in flood in their region in the past years. The responses reflect understanding of the community's local knowledge of such issues, having lived through several events in the flood risk zone. For families with elderly persons, the flood experience may extend over a couple of generations. Hence, integrating experiential knowledge of past flood memories

from the community with that of ‘expert knowledge’ from agencies and authorities could help to better understand the problem and needs of local inhabitants, and at the same time enforce community resilience (Mercer et al., 2009; McEwen and Jones 2012).

Community solidarity was more prevalent when the community representatives or local activists had to take their case to the authorities. Otherwise, they claimed, that they had learnt to take care of themselves. Many of the areas had been occupied principally over the last generation, and over the relatively short period, people with diverse backgrounds, cultures, and religions had moved into a relatively small flood-risk neighbourhood. It took a long time to build trust with new neighbours. The results from participatory activities showed that residents were conscious of their responsibility in “care of place”, as well as their ethical values in keeping their environment clean and reducing the risk of flooding and vulnerability. Developing civic action and awareness among the participants of not throwing garbage on the road and of keeping the area and the drains clean were seen to reinforce community ties. These were seen as important elements in the case study for long-term vulnerability reduction and building resilience to flood disasters.

This case study has provided evidence to suggest that there is capacity amongst the community to respond to The Sendai Framework for Disaster Risk Reduction 2015–2030 (UN/ISDR 2015a) imperative of moving to a community-based assessment of disaster risk, as well as community-based responses in the response and recovery phases. This community-based response may be better placed to enable the most vulnerable communities to close the gap in resilience and recovery between the communities that are most vulnerable and those that are more resilient. This is something that has become increasingly important in a SIDS like Mauritius where, as the population grows it densifies, and a growing proportion of the most vulnerable find themselves inhabiting places that are more exposed to flood risks. This situation is particularly relevant where poverty and repeated flood events can result in a reduction of resilience in some communities.

6.3 Environmental justice for more deprived groups?

Findings from the questionnaire survey showed that there was a feeling of ‘being left out’ and abandonment among some sectors of the community, in particular among the low income groups. Both small and large households with children perceived a lack of support from the

authorities to assist them in the recovery phase of flood hazards. Marginalised and underprivileged groups, mainly households with children and elderly persons within the communities, who were differentially exposed to flood risk, were threatened by higher levels of health hazards. Consequently, these groups were found to be the most vulnerable and the least able to recover with increased vulnerability to successive hazards (Cannon et al. 2003). As noted by Wisner et al. (2006) and Cutter (2006) vulnerability is driven by poverty among groups of people who live in precarious conditions, thus raising issues of environmental justice. This sentiment was strongly echoed by the participants in the focus group in CLC. The perception of marginalisation was profound among the low-income groups, who perceived that there were strong disparities in the way they were treated with regard to land allocation and the construction of flood-proof housing during recovery and rehabilitation phases. Any complaint about environmental problems and poor living conditions during flooding were considered as disregarded by the authorities. The feeling of environmental injustice seemed to grow with time, leading the underprivileged group to adopt a fatalist attitude of acceptance of impacts, while its vulnerability increased from one flood to the next ratcheting down its resilience.

Reduction of poverty, inequality and exclusion strategies were recognised as challenges that institutions and aid agencies face (UNDP 2013). The evidence in this paper underscores the importance of these strategies to reducing vulnerability and improving resilience amongst communities like CLC. The Government of Mauritius announced in February 2015, a Marshall Plan to combat poverty and social exclusion (UNDP 2017). The recent publication of The National Disaster Risk Reduction and Management Act (Government of Mauritius 2016) has called for the setting up of a local committee whose function will be to work in close collaboration with local communities for any '*disaster risk reduction and management activity*' (p19). This also means that NGOs' involvement with vulnerable community groups should extend well beyond just providing short-term assistance to flood victims in small community groups during flood hazards. They should 'bridge the gap' by liaising between marginalised communities and Government authorities. Furthermore, they should be represented in the National Disaster Scheme Programme and be able to point out policy recommendations on risk reduction and on enhancing resilience in the most marginalised communities.

7 Conclusions

This research has highlighted the importance of understanding how the recovery and rehabilitation phase within the disaster cycle plays out locally in unravelling factors affecting community resilience in an exposed, flood prone, suburban area of Port-Louis, the capital of Mauritius. Significant evidence existed of reduced resilience and inability of some households to recover through either successive events, or of living through the onslaught of secondary, post-event health hazards.

Households' vulnerability is a mix of location in relation to environmental (both natural and built) risk combined with internal and external social, economic and demographic factors. These factors are all dynamic. The evidence from this research demonstrates that differences in the level of vulnerability between households arose from their relative (in)ability to recover after a flood event due to precarious socio-economic, environmental, and other external linkages with political networks. Factors that increased vulnerability included numbers of children and older people in extended households. Systemic issues leading to inequalities included literacy levels - affecting ability of groups to engage with Government health guidance, while actions to mitigate were impacted by limited resources – a problem compounded where lower income groups lived without land rights. Factors that increased ability to cope and adapt in the resilience-building strategies of households and communities included experiential and intergenerational flood memories and lay knowledge of how to live with floods. Extremely marginalised groups showed some degree of solidarity amongst themselves in times of adversity; relocation to safer places was perceived to disrupt their livelihoods and especially their community ties. Key is to empower them so they can express their needs; however, if their voices are unheard then they will still ultimately be trapped in a vicious cycle of vulnerability and decline of resilience to flood disasters.

Many of the challenges faced by affected community groups in reducing their vulnerability and in building resilience in the recovery phase in this suburban area remain. The findings suggest that issues of social inequity and environmental injustice hindered recovery among low-income households. However, the Anti-Poverty Marshall Plan to combat poverty and The National Disaster Risk Reduction Management Act (2016), with two administrative frameworks for Mauritius, if suitably implemented, could build resilience against flooding through multi-sector involvement including NGOs and communities themselves. Here, a

prerequisite is to recognise and take into account the needs of the vulnerable and the experiential flood knowledge and ensure their involvement in the implementation of resilience building strategies.

Further research needs to focus first on ways of co-working with all sectors of communities to plan strategies and implement strategies for resilience-building that place emphasis on participation and developing and sharing community-based knowledge. Second, it is now important to appraise whether the learnings gained here might have wider applicability in other settings within SIDS where there has been rapid expansion of lower income groups into exposed risk zones, and where there are also histories of strong top-down approaches to hazard management. This could inform a community-based framework for mitigation of hazards, including floods, within SIDS.

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References

- Adger WN (2000). Social and ecological resilience: are they related? *Progress in Human Geography* 24(3): 347–364.
- Adger WN (2006) Vulnerability. *Global Environmental Change* 16:268–281.
- Ainuddin S, Routray JK (2012). Community resilience framework for an earthquake prone area in Baluchistan. *International Journal of Disaster Risk Reduction* 2:25-36.
- Akter S, Mallick B (2013) The poverty–vulnerability–resilience nexus: Evidence from Bangladesh. *Ecological Economics* 96:114-124.
<http://dx.doi.org/10.1016/j.ecolecon.2013.10.008>. Accessed 12 Nov 2016
- Beesoon, S, Funkhouser E, Koteea N, Speilman A and Robich R M (2008) Chikungunya fever, MBeessauritius, 2006. *Emerging Infection Disease* 14(2): 337-338.
- Bhankaurally D, Nowbuth B, Umrikar (2010) Flood Hazard Mapping by Integrated GIS Model *International Journal of Geomatics and Geoscience* 1(3):489–498.
- Buckle P, Marsh G, Smale S (2001) *Assessing Resilience & Vulnerability: Principles, Strategies & Actions. Guidelines*. Canberra: Emergency Management Australia
- Cannon T (2008) *Reducing People's Vulnerability to Natural Hazards: Communities and Resilience*. Research Paper 2008/034. Helsinki: Univeted Nations University World Institute for Development Economics Research (UNU-WIDER).
- Cannon T, Twigg J, Rowell J (2003) *Social Vulnerability, Sustainable Livelihoods and Disasters*. Report to Department for International Development (DFID) Conflict and Humanitarian Department (CHAD) and the Sustainable Livelihood Support Office, UK. 63pp

Carey R (2011) *Australian Emergency Management Handbook Series. Community Recovery. Handbook 2*. Canberra: Attorney-General's Department.

<http://www.em.gov.au/Documents/AEMHS+2+Community+Recovery.doc> Accessed 20 Oct 2016

Chacowry A (2016) Public perceptions of living with flood risk from media coverage in the small island developing state of Mauritius. *Journal of Disaster Risk Reduction* 19:303–310.

Cottrell A (2005) Sometimes it's a big ask, but sometimes it's a big outcome: community participation in flood mitigation. *The Australian Journal of Emergency Management*. 20(3): 27-32.

Centre for Research on the Epidemiology of Disasters Emergency Events Database (CRED-EMDAT; 2015) *The human cost of natural disasters. A global perspective Brussels*. 58 p.

http://cred.be/sites/default/files/The_Human_Cost_of_Natural_Disasters_CRED.pdf.

Accessed 20 Oct 2016

Cutter SL (2006) *Hazards, Vulnerability and Environmental Justice*. Earthscan, London.

Cutter SL (2016) Resilience to what? Resilience for whom? *The Geographical Journal* 182(2):110–113. doi: 10.1111/geoj.12174

Cutter SL, Barnes L, Berry M, Burton C, Evans E, Tate E, Webb J (2008) A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*. 18(4):598-606. doi:10.1016/j.gloenvcha.2008.07.013

Ferdinand I, O'Brien G, O'Keefe P, Jayawickrama J (2012) The double bind of poverty and community disaster risk reduction: A case study from the Caribbean. *International Journal of Disaster Risk Reduction*. 2:84–94. <http://dx.doi.org/10.1016/j.ijdr.2012.09.003>. Accessed 26 Oct 2016

Few R, Pham Gia Tran (2010) *Climatic hazards, health and poverty: exploring the connections in Vietnam*. DEV Working Paper, School of International Development, University of East Anglia, Norwich, UK ISSN 1756-7904

Folke C (2006) Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*. 16:253–267.

Füssel HM (2007) Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*. 17:155–167.

Gaillard J, Mercer J (2012) From knowledge to action: Bridging gaps in disaster risk reduction. *Progress in Human Geography*. 37(1):93–114. doi: 10.1177/0309132512446717

Gallopín GC (2006) Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16: 293–303.

Goorah, S., Ghamy, A. B., Caussy, B.S., Cheeneebash, J. and Ramchurn, S.K. (2009). Clinical complications of Chikungunya fever in Mauritius. *Internet Journal of Medical Update* 4(2): 3-8.

Government of Mauritius (2009) *Poverty Analysis*, 45pp
[http://statsmauritius.govmu.org/English/StatsbySubj/Documents/Poverty/Poverty Analysis](http://statsmauritius.govmu.org/English/StatsbySubj/Documents/Poverty/Poverty%20Analysis.pdf). Accessed 24 Oct 2016

Government of Mauritius (2011) *Statistics Mauritius*.
<http://statsmauritius.gov.mu/English/Pages/2011-Housing-and-Populations-.aspx>. Accessed 12 Oct 2016

Government of Mauritius (2013) *Pay Research Bureau Report*
<http://prb.pmo.govmu.org/English/PRB%20Reports/Pages/PRB-Report-2013.aspx>. Accessed 24 Oct 2016

Government of Mauritius (2016) *The National Disaster Risk Reduction and Management Act (2016)* mauritiusassembly.govmu.org/English/bills/Documents/intro/2016/bill0216.pdf. Accessed 11 Nov 2016

Haughton G, Bankoff G, Coulthard T J (2015) In search of ‘lost’ knowledge and outsourced expertise in flood risk management. *Transactions of Institute of British Geographers*. 40: 375-386.

Houston D (2013) Crisis is where we live: environmental justice for the anthropocene, *Globalizations*. 10(3):439-450. doi: 10.1080/14747731.2013.787771

Howorth, R. (2005) ‘Islands, Isolation and Vulnerability’. In: International Strategy for Disaster Reduction (ed.). *Know Risk*. Geneva: Tudor Rose Publications. Pp. 224-227.

IPCC (2013) *Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis*. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. <http://www.ipcc.ch/report/ar5/wg1/>. Accessed 10 Sep 2016.

IPCC (2014) *The Fifth IPCC's Fifth Assessment Report: What's in it for Small Island Developing States?* London: Climate & Development Knowledge Network http://cdkn.org/wp-content/uploads/2014/08/CDKN_IPCC_What's_in_it_for_SIDS.pdf Accessed 24 Oct 2016

Kelman I, Gaillard JC, Lewis J, Mercer J (2016) Learning from the history of disaster vulnerability and resilience research and practice for climate change. *Natural Hazards* 82:129–143. doi10.1007/s11069-016-2294-0

Khedo KK (2008) Real-Time Flood Monitoring using wireless Sensor Networks. *The Journal of the Institution of Engineers Mauritius* 1:59-69 pp. [http://www.iemauritius.com/upload/files/flood_monitoring_wireless_\(khedo\).pdf](http://www.iemauritius.com/upload/files/flood_monitoring_wireless_(khedo).pdf). Accessed.20 Nov 2016

L'Express (2013). Inondations: 3 nouveaux morts à Port-Louis. *L'Express*. 31 March 2013. Port Louis: L'Express. <http://www.lexpress.mu/article/inondations-3-nouveaux-morts-%C3%A0-port-louis>. Accessed 3 Sep 2017

L'Express (2017) *L'Express* on line archive <https://www.lexpress.mu/search/site/inondations%20Cite%20La%20Cure> Accessed 15 Aug 2017

Le Mauricien. (2013). Inondations meurtrières du 30 mars. *Le Mauricien*. 23 April 2013. Port Louis: At: <http://www.lemauricien.com> Le Mauricien. (2013). Accessed 3 Sep 2017

Le Mauricien (2017) *Le Mauricien* on-line archive http://www.lemauricien.com/search/apachesolr_search/inondations%20Cite%20La%20Cure Accessed 15 Aug 2017

Linnekamp F, Koedam A, Baud I (2011) Household vulnerability to climate change: Examining perceptions of households of flood risks in Georgetown and Paramaribo. *Habitat International*. 35(3): 447-456. doi:10.1016/j.habitatint.2010.12.003

- Lopez-Marrero T, Tschakert P (2011) From Theory to Practice: Building more resilient communities in flood-prone areas. *Environment and Urbanisation*. 23(1):229-249. doi: 10.1177/0956247810396055
- Manyena SB (2006) The concept of resilience revisited. *Disasters*. 30(4):433-450
- Manyena B (2016) After Sendai: Is Africa Bouncing Back or Bouncing Forward from Disasters? *Int J Disaster Risk Sci.* (2016) 7:41–53. doi 10.1007/s13753-016-0084-7
- Matyas D, Pelling M. (2014) Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters*. 39(S1): S1–S18. doi:10.1111/disa.12107
- Mavhura E, Manyena SB, Collins AE, Manatsa D (2013) Indigeneous knowledge, coping strategies and resilience to floods in Muzarabani, Zimbabwe. *International Journal of Disaster Reduction*. 5: 38-48. <http://dx.doi.org/10.1016/j.ijdr.2013.07.001>. Accessed.20 Nov 2016
- McEntire DA (2001) Triggering agents, vulnerabilities and disaster reduction: towards a holistic paradigm. *Disaster Prevention and Management*. 10(3):189-196.
- McEwen L, Jones O (2012) Building local/lay flood knowledges into community flood resilience planning after the July 2007 floods, Gloucestershire, UK. *Hydrology Research*. 45(5): 675-688. doi: 10.2166/nh.2012.022
- McEwen, LJ, Garde-Hansen, J, Holmes A, Jones O, Krause F (2016) Sustainable Flood Memories, Lay knowledges and the Development of Community Resilience to Future Flood Risk. *Transactions of the Institute of British Geographers*. 42(1): 4-28.
- Méheux K, Dominey-Howes D, Lloyd K (2007) Natural hazard impacts in small island developing states: A review of current knowledge and future research needs. *Natural Hazards*. 40:429-446. doi 10.1007/S1109-9001-5
- Mercer J, Kelman I, Taranis L and Suchet-Pearson S (2009) Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters*. 34 (1): 214–239. doi:10.1111/j.03613666.2009.01126.x

Miller FH, Osbahr E, Boyd F, Thomalla S, Bharwani G, Ziervogel B, Walker J, Birkmann S, Van der Leeuw J, Rockström J, Hinkel T, Downing C, Folke, Nelson D (2010). Resilience and vulnerability: complementary or conflicting concepts? *Ecology and Society*. 15(3):11. <http://www.ecologyandsociety.org/vol15/iss3/art11/> Accessed: 24 Nov 2016

Mohanty, M. (2006). Urban Squatters , the informal Sector and Livelihood Strategies of the Poor in Fiji Islands. *Development Bulletin*. 70:65-80.

NDRRMC (2015) *National Disasters Scheme*. Port Louis, Mauritius: National Disaster Risk Reduction and Management Centre, Ministry of Environment, Sustainable Development, and Disaster and Beach Management.

Pardasani M (2006) Tsunami reconstruction and redevelopment in the Maldives. A Case study of community participation and social action. *Disaster Prevention and Management*. 15(1):79-91. doi: 10.1108/09653560610654257

Pellegrin A (1999) Reinsurance cover against natural catastrophe risks in a small island developing state - the case of Mauritius. The Insurance Industry in Mauritius. PROSI Magazine, May 1999, No 364.

Pelling M, Uitto JI (2001) Small island developing states: natural disaster vulnerability and global change. *Environmental Hazards*. 3:49-62.

Pelling, M (2003) *The vulnerability of cities: Natural disasters and social resilience*. Earthscan, London: ISBN: 1-853838292 (212pp)

Pelling M. (2007) Learning from others: the scope and challenges for participatory disaster risk assessment. *Disasters* 31(4):373-385

Qi S (2009) Case Study in Contemporary Educational Research: Conceptualization and Critique. *Cross-cultural Communication*. 5(4):21-31.

Ramessur RT (2013) A Review of Coastal Zone Management Facing Climate Change and Natural Disasters in Mauritius. *Journal of Geography and Natural Disasters* S1: 003 doi: 10.4172/2167-0587.S1-003

Rose A (2007) Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions. *Environmental Hazards*. 7:383–398

Roundtree Foundation (2014) *Achieving climate justice: the agenda for action*.

<https://www.jrf.org.uk/report/achieving-climate-justice-agenda-action> Accessed 26 Aug 2017

Scammell MK, Senier L, Darrah-Okike J, Brown P, Santos S (2009) Tangible evidence, trust and power: Public perceptions of community environmental health studies. *Social Science & Medicine*. 68: 143–153. doi: 10.1016/j.socscimed.2008.10.002

Schelfaut KB, Pannemans B, van der Craats I, Krywkow J, Mysiak J, Cools J (2011) Bringing flood resilience into practice: the FREEMAN project. *Environmental Science and Policy*. 14:825–83. doi:10.1016/j.envsci.2011.02.009

Schlosberg D (2007) *Defining environmental justice: theories, movements and nature*. Oxford: Oxford University Press.

Shaw R (2006) Indian Ocean tsunami and aftermath: Need for environment-disaster synergy in the reconstruction process. *Disaster Prevention and Management*. 15(1):5-20. doi: 10.1108/09653560610654202

Singh SR, Moha Eghdami MR, Singh S (2014) The Concept of Social Vulnerability: A Review from Disasters Perspectives. *International Journal of Interdisciplinary and Multidisciplinary Studies*. (IJIMS) 1(6) 71-82.

Spiekermann R, Kienberger S, Norton J, Briones F, Weichselgartner J (2015) The Disaster-Knowledge Matrix – Reframing and evaluating the knowledge challenges in disaster risk reduction. *International Journal of Disaster Risk Reduction*. 13:96–108.
<http://dx.doi.org/10.1016/j.ijdrr.2015.05.002>. Accessed 26 Oct 2016

Stokerson P (2009) Experiential Knowledge, Knowing and Thinking. Experiential Knowledge Special Interest Group (EKSIG) Conference 2009 on Experiential knowledge, method and methodology. 19 June London Metropolitan University, London.
http://experientialknowledge.org.uk/proceedings_speakers_files/Storkerson.pdf. Accessed 18 Nov 2016

Timmerman P (1981) *Vulnerability, Resilience and the Collapse of Society. A Review of Models and Possible Climatic Applications*. Environmental Monograph No. 1. Institute for Environmental Studies, University of Toronto, Toronto.

Tita G. (2014). *Coping with inherent vulnerabilities and building resilience in small islands : Socioeconomic and governance perspectives*. Centre de recherche sur les milieux insulaires et maritimes (CERMIM), affiliated with Université du Québec à Rimouski (UQAR), Îles-de-la-Madeleine QC (Canada), iii + 18 pages. (www.uqar.ca/cermim/publications-scientifiques)

Tobin GA (1999) Sustainability and community resilience: The holy grail of hazards planning? *Environmental Hazards*. 1: 13-25.

UN/ISDR (2009) *UNISDR Terminology on Disaster Risk Reduction*, Geneva: UN International Strategy for Disaster Risk Reduction.
http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf. Accessed 12 Oct 2016

UN/ISDR (2015 a) *The Sendai Framework for Disaster Risk Reduction 2015–2030*. http://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf, 2015. Accessed 24 Feb 2016

UN/ISDR (2015b) *Working Papers on Public Investment Planning and Financing Strategy for Disaster Risk Reduction: Review of Mauritius*. 2015, Geneva.
<http://www.wcdrr.org/wcdrr> Accessed 12 Oct 2016

UNDP (2013) *Republic of Mauritius, Millennium Development Goals. Status Report 2013*. New York: United Nations Development Programme and Government of Mauritius.
<http://www.undp.org/content/dam/undp/.../MDG/.../MDG%20Country%20Reports/.../2013>
Accessed 12 Oct 2016

UNDP (2017) Mauritius Marshall Plan aims to eradicate poverty and exclusion
<http://www.un.org/africarenewal/news/mauritius-marshall-plan-aims-eradicate-poverty-and-exclusion> Accessed March 2017

UNESCO (2016) *Local and indigenous knowledge systems*. Paris: United Nations Educational, Scientific and Cultural Organization. <http://www.unesco.org/new/en/natural->

sciences/priority-areas/links/ Local and indigenous knowledge systems Accessed 14 Dec 2016

UN-Habitat (2015) *Urbanization and Climate Change in Small Island Developing States*. Nairobi: United Nations Human Settlements Programme. <http://unhabitat.org/cities-and-climate-change-initiative/> Accessed 24 Nov 2016

Walker G (2012) *Environmental justice: concepts, policy and evidence*. Abington: Routledge.

Werritty A, Houston D, Ball T, Tavendale A, Black A (2007) *Exploring the Social Impacts of Flood Risk and Flooding in Scotland*. Edinburgh: Scottish Executive.
<http://www.scotland.gov.uk/resource/doc/174676/0048938.pdf> Accessed .26 Nov 2016

Whittle R, Walker M, Medd W, Mort M (2012) Flood of emotions: emotional work and long-term disaster recovery. *Emotion, Space and Society*. 5:60-69.
doi:10.1016/j.emospa.2011.08.002

Wisner B, Blaikie P, Cannon T, Davis I (2006) *At Risk:Natural Hazards, People's Vulnerability and Disasters*. New York: Routledge, 2nd ed. 464 pp

Zhou H,Wang J, Wan J, Jia H (2010) Resilience to natural hazards: a geographical perspective. *Natural hazards*. 53:21-41.

World Meteorological Organization (WMO) (2006). *Preventing and Mitigating natural disasters- working together for a safer world-WMO No. 993*, Geneva: World Meteorological Organization.

Table 1 Examples of flood events at CLC as published by the media

Date /year	Article	Transcript from article (translated from French)
31.03.2012	<u>PLUIES DILUVIENNES: Les sapeurs pompiers à l'épreuve cette semaine</u> (<i>Le Mauricien</i>)	"About 16 families in Cité La Cure are desperate; their belongings have been swept away by flood. They are extremely poor and live in houses that are flooded during each rainy season. Every time they need the help of fire fighters to rescue them."
22.03.2014	<u>GROSSES AVERSES : Les squatters de Cité-La-Cure laissés à eux-mêmes</u> (<i>Le Mauricien</i>)	"The squatters have their houses flooded. The roofs are leaking, the drainage system is blocked, they have limited or no access to commodities and services and the children are unable to go to school."
19.03.2015	<u>SQUATTERS DE CITÉ LA CURE : Un an plus tard, la difficile survie</u> (<i>Le Mauricien</i>)	"Most of the belongings of the squatters are washed away. The inhabitants are frustrated as no action is taken over the last year by the authorities to relieve the situation. Even when their houses are flooded, the authorities refuse to open the shelter for the victims."
10.02.2016	<u>INONDATIONS À CITÉ BRIQUETTERIE, STE-CROIX ET LA CURE: Manif de colère ce matin devant le poste de police d'Abercrombie</u> (<i>Le Mauricien</i>)	"Many families whose houses have been flooded express anger and exasperation to authorities."
08.02.2017	Cite la Cure 'A chaque fois qu'il pleut, c'est la même chose' (<i>L'Express. mu</i>)	"Dozens of households are flooded with every heavy rainfall. The drains become blocked and muddy water spills over into the houses. They live with risk of threat to their lives and health."

(Source: Online Archive of Le Mauricien (2017) and Online Archive of L'Express (2017))

Table 2 Themes explored at each methodological stage

Methods used to collect data	Themes explored
Questionnaire Survey (n=236)	<p>(i) Household characteristics</p> <ul style="list-style-type: none"> • <i>Size of households (≤ 4 members in a household and ≥ 5 in a household)</i> • <i>Age groups of household members</i> • <i>Literacy level of households</i> • <i>Occupation/income level of households</i> <p>(ii) Vulnerability of household to flood</p> <ul style="list-style-type: none"> • <i>Type and frequency of flood experienced</i> • <i>Tangible and intangible impact</i> • <i>Socio-economic situation of households</i> • <i>Environmental factors of households</i> <p>(iii) Recovery from flood hazards</p> <ul style="list-style-type: none"> • <i>Getting back to 'normal' after the flood</i> • <i>Relocation after the flood(s)</i> <p>(iv) Resilience to flood hazards</p> <ul style="list-style-type: none"> • <i>Precautions taken by households before a flood</i> • <i>Adaptation measures taken by households</i> • <i>Collaborating with the community</i> • <i>Reliance for building resilience flood protection</i> • <i>Households knowledge on flood increase</i> • <i>Respondents' opinion on measures on enhancing resilience</i>
Focus Group (n=7)	<p>(i) Perception about living conditions</p> <p>(ii) Coping strategies during floods</p> <p>(iii) Recovery from floods</p> <p>(iv) Resilience building</p> <p>(v) Assistance from local Government</p>
Participatory Exercise (n=15)	<p>(i) Identification of the flood problem</p> <p>(ii) Discussion on addressing the flood problem</p> <p>(iii) Proposal of solutions to reducing the vulnerability and resilience building of the community to flood problem</p>

Table 3 Results of descriptive analysis of questionnaire survey (note changes in number of responses by question)

Perceptions of households	Response variables	Number of responses (n) from a total of 236 households	Frequency of responses in percentage (%)	
			Strongly agree/agree	Disagree/strongly disagree
Flood experience	Experience of flood)	233	70.9	6.5
	Flood originates in heavy rain	236	96.2	0
Tangible flood impact	House inundated	136	89.7	2.9
	Impact on house structure	124	89.9	2.9
	Damage to personal belongings	110	87.3	5.4
Intangible flood impact	Upset about damage	232	75.4	6.5
	Worry about family disrupted	228	35.1	46.1
	Suffer from recurrent floods	210	30.5	54.8
Living condition of households after a flood	Living in crowded conditions	219	32.4	40.7
	Large number of unemployment	229	60.7	17.9
	Living in unsafe environment	233	91.0	1.3
	Disrupted family structures	233	80.1	1.3
	Exposure to vector-borne diseases	234	50.9	27.3
	Living in damp conditions after a flood	102	94.4	3.4
Factors affecting recovery after a flood	Time and effort to come back to normal	210	45.7	50.4
	Lack of community cohesion	232	36.2	50.0
	Lack of support from local authorities	231	43.7	33.8
	Living conditions remained unchanged	108	84.0	0.8
	Living conditions deteriorated	37	80.0	5
Relocation after the flood	Relocation to a Government centre	104	2.9	97.1
	Relocation to relatives' place	105	1.0	99.0
	Relocation to other sites	113	18.6	80.6
Adaptation to flood	Raise floor above water mark	165	90	0
	Live through the event	21	100	0
Flood mitigation measures	Emergency services must be improved	232	89.2	0.9
	Other measures should be taken besides flood warning	232	88.8	1.3
	Structural measures in flood prevention should be improved	232	89.2	1.3

Figure 1 Map of the Republic of Mauritius (Source: <http://www.ezilon.com/maps/africa/mauritius-physical-maps.html>)



Figure 2 Number of days per year with flood events (2003-2011) as reported in the media
(Source: Author based on data obtained from the daily L'Express; Chacowry 2016)

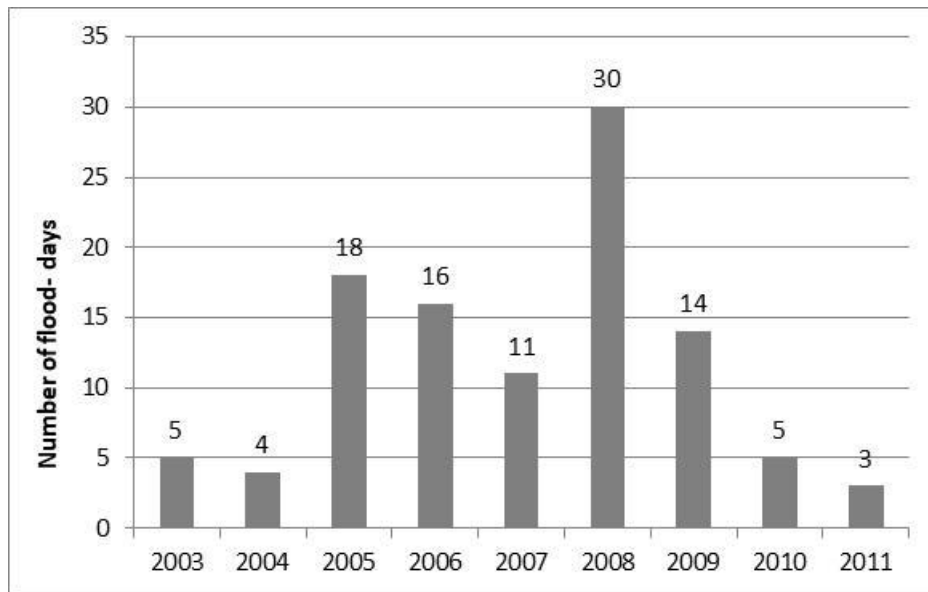


Figure 3 A. Map of Cité La Cure delineating study area in red line; B. Map of Cité La Cure with study area delineated in red line and flood zones in shades of blue from dark blue to light blue with return periods of 25, 50, 100 and 500 years respectively (Source: Ministry of Environment, Sustainable Development and Disaster and Beach Management, 2016)

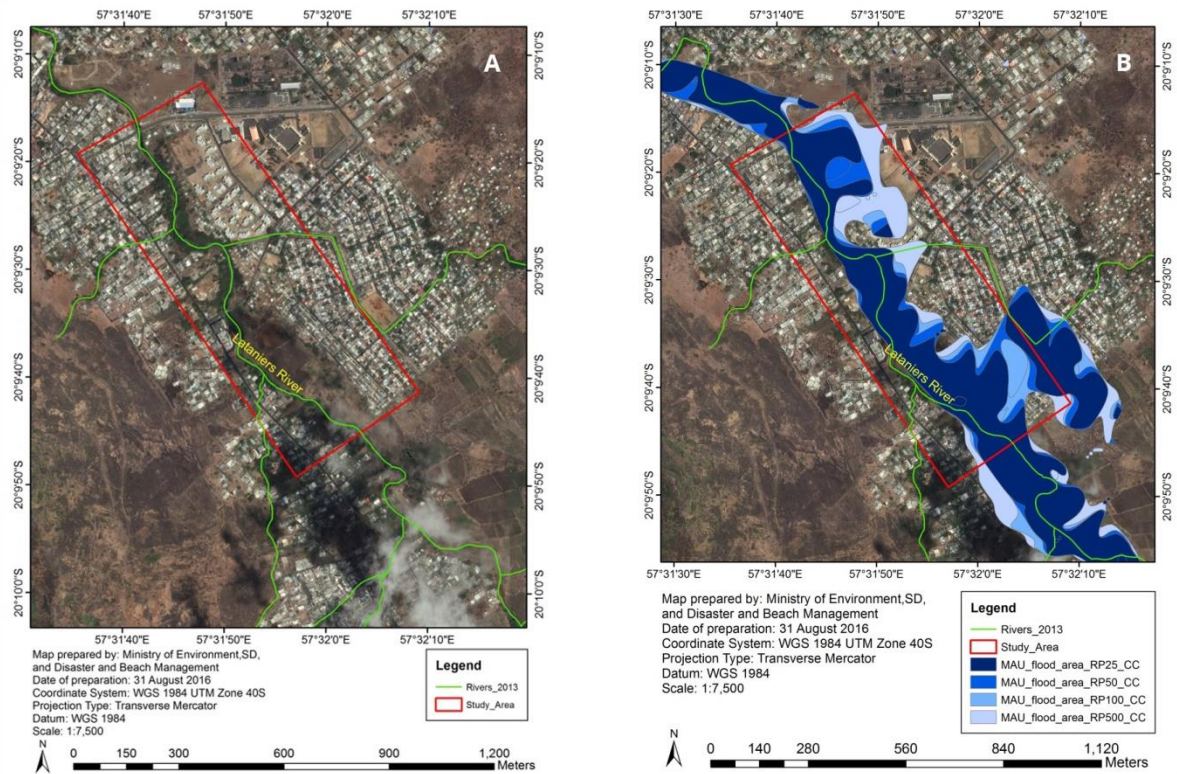


Figure 4 Distribution of the number of members in each family

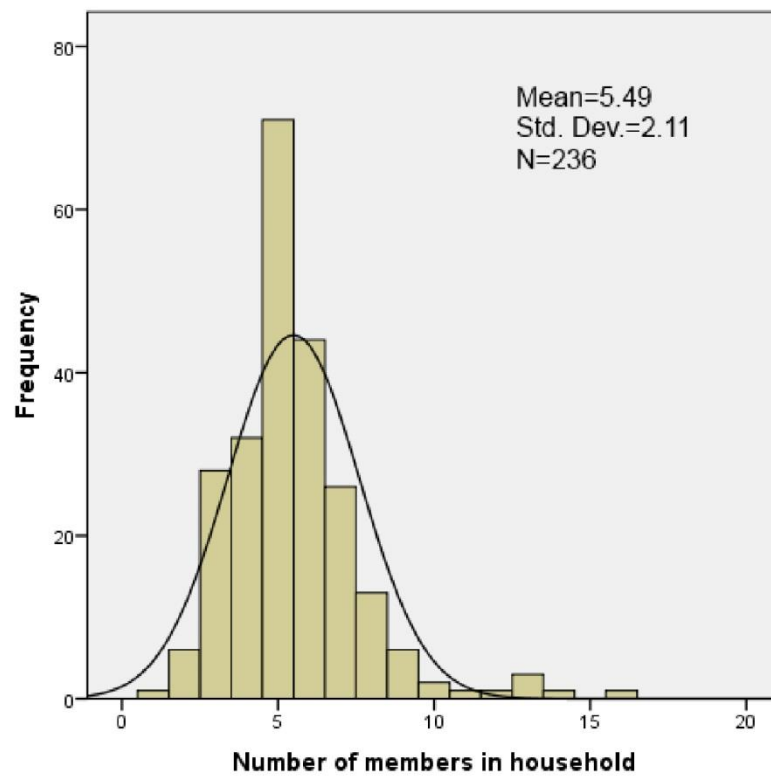


Figure 5 Charts of percentage responses by households in relation to: (a) Age group of household members (b) Level of education; (c) Occupation as indication of income level; (d) Land occupation and property ownership; (e) Types of precaution taken ahead of each flood event; (f) Type of support to build resilience; (g) Perceived reasons for increase in flood; (h) Social networking for flood mitigation.

