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1 Floods

1.1 Hurricane Katrina in New Orleans, USA

In August 2005 hurricane Katrina killed between 1,300-1,500 people and forced 1.5 million to evacuate. Most damage in New Orleans was caused by flooding (Bostic and Molaison, 2008). The event was not just a natural disaster: it is also an example of a na-tech disaster in that the floods initiated accidents which resulted in the releases of hazardous materials. Flooding was caused by storm surges but, critically, it was also caused by failure of the technological solution for the protection of the city: these are the levee system which failed. Severe institutional shortcomings led to a failure to maintain the required technical standard of protection and contributed significantly to the disaster (Figure 1.1). In this case study the na-tech element of the disaster is exemplified by the largest chemical spillage to occur in the Katrina event which was the Murphy oil spill which affected the residential areas of Chalmette and Meraux, Louisiana.

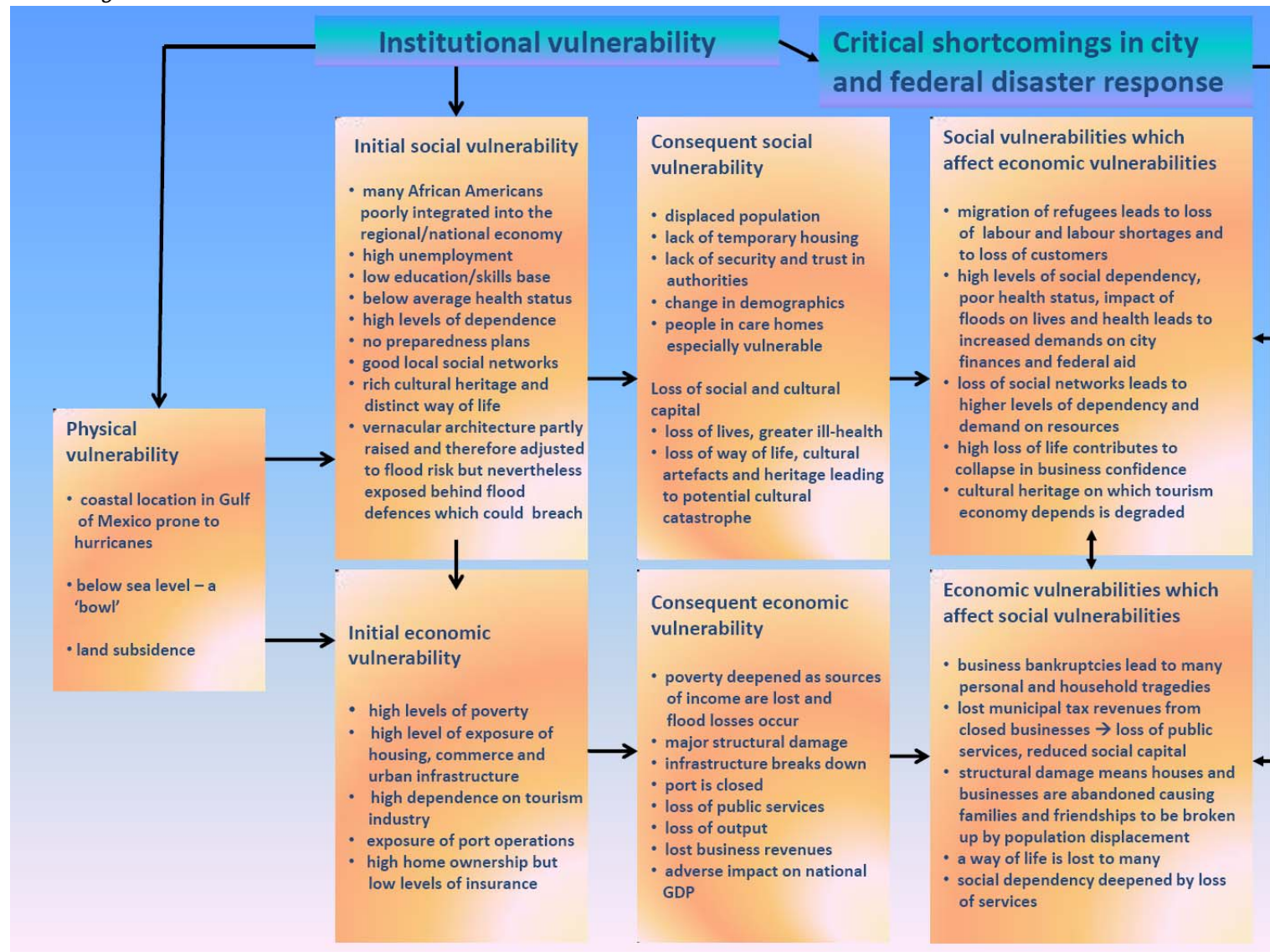


Figure 1.1: Relations between social vulnerability and economic vulnerability: New Orleans, a type of na-tech flood disaster

Physical vulnerability of New Orleans

New Orleans is located close to the coast in the hurricane belt of the Gulf of Mexico so that it is inherently vulnerable to hurricanes (Figure 1.2). The city is also below sea level and is gradually subsiding (Lee and Willardson, 2008), and is like a 'bowl' that can easily fill with water. Levees to protect the city began to be constructed in the late 1880s. In 2005 a massive storm surge overwhelmed the levees of the Mississippi River Gulf Outlet Channel and flooded parts of New Orleans. Flooding from Lake Pontchartrain (which covered 80% of the city) was caused by multiple, catastrophic levee failures along the city's canal system causing many deaths. Flood depths reached up to 6m and floods lasted for up to 43 days. Controversially it is alleged that a controlled levee breach may have saved the financial centre, leading to flooding of poorer districts (Cordasco *et al.*, 2007). Over 200,000 structures were damaged (Bostic and Molaison, 2008). Losses were estimated as \$150 to \$200 billion (i.e. 220-294 Euros) (Kunreuther and Michel-Kerjan, 2008).

St Bernard Parish, in which Murphy Oil Corporation's oil refinery is located, was flooded to a maximum depth of 4.3m when the storm surge from Hurricane Katrina caused the Mississippi River Gulf Outlet levee to fail. The oil refinery, as well as a neighbouring one, is located in the 100 year floodplain. An oil storage tank was dislodged releasing over 1 million gallons of mixed crude oil impacting 1,700 homes in Chalmette and Meraux. The specific impacts of this chemical spillage on residents in terms of their vulnerabilities are discussed in a separate section, below.

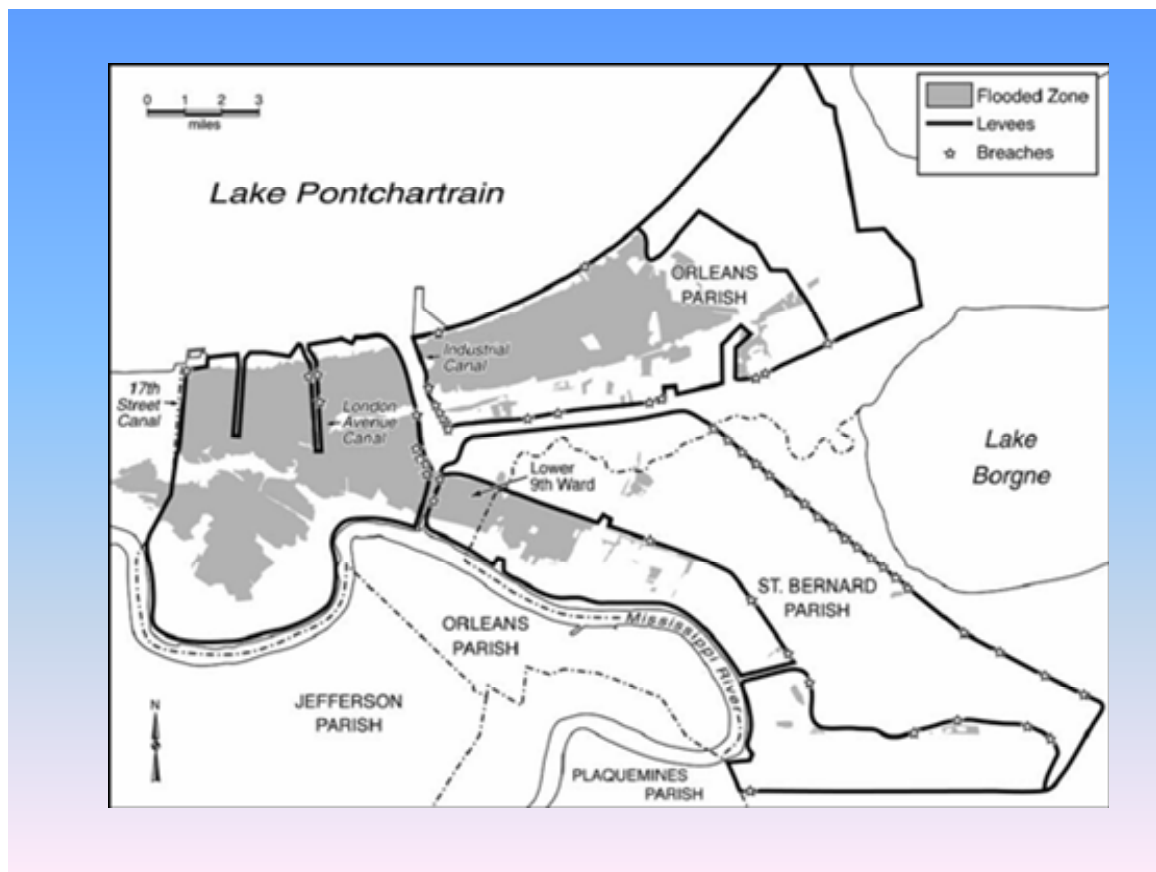


Figure 1.2: Map of flooded areas in New Orleans. Source: Colten, 2006

Institutional vulnerability and failure leading to technical failure

New Orleans' levees and floodwalls protecting New Orleans in 2005 were designed to a 1:100 year standard and to withstand a category 3 hurricane. There were, however, indications that the actual protection standards were lower, and in 2005 the levees failed to withhold Katrina, initially a category 4 hurricane downgraded to category 3 on landfall. Flood protection improvements had been implemented slowly and with many funding delays (Southwell and von Winterfeld, 2008); maintenance standards were flawed; and many levees became structurally deficient. Scientists predicted the devastation that a hurricane like Katrina would produce, but none were in positions of power (Clarke, 2008). Human actions contributed significantly to the disaster. Katrina was also an institutional disaster and is an example of institutional vulnerability (see Appendix): the government and private enterprise system failed. Clarke (2008, 88) explains that New Orleans "was left to drown" because of bureaucratic bungling; jurisdictional uncertainty; the belief that it couldn't be prevented; and that it was in someone's interest. Organizational and institutional problems also afflicted response and recovery efforts (Southwell and von Winterfeld, 2008; Clay, 2008). The nation's preparedness for large-scale disasters was also seriously flawed. Despite record levels of federal aid, the emergency response capacity was seriously lacking (Figure 1.1).

Initial social and economic vulnerability

Hurricane Katrina struck a city characterized by large pockets of social vulnerability (Figure 1.1). The central city has a large, poorly educated, lowly-skilled African American population with below average health indicators, above average levels of dependency (e.g. 27% of people were under 18 years of age), often living in low quality houses. Human capital limitations were therefore widespread and contributed to the potential for loss. The city is famous for its cultural diversity, song and dance and for a care-free, easy-going life-style which is associated with some well-developed social networks and social support systems. However, many African Americans are disadvantaged and are poorly integrated into the commercial mainstream of the United States. Many work in the low-skilled, local tourist economy. About one fifth of respondents interviewed in one post-event study had done nothing to prepare for Katrina and a much greater proportion had no disaster plan in place (Hauser *et al.*, 2008). In terms of economic vulnerability, the port and its economy and the oil and gas industry were particularly vulnerable, accounting for very large economic losses. Parts of the city contained very high levels of poverty setting up economic vulnerability. Severe poverty had already increased by 20% between 2000 and 2004. The Ninth Ward, particularly the Lower Ninth, was hard hit. More than a third of residents (37%) in the Upper Ninth Ward were living below the poverty line as were 34% in the Lower Ninth (Census 2000 cf Green *et al.*, 2007, 314). In the Lower Ninth nearly 14% were unemployed. However, 59% owned their own homes, many of which had been passed down through generations. This increased vulnerability as without a mortgage there was no requirement to have flood insurance.

Consequent social vulnerability and its effects on economic vulnerability

Figure 1.1 shows how Katrina deepened initial social vulnerability (i.e. see consequent social vulnerability) and how, in turn, this impacted economic vulnerability. Although it is difficult to

identify and trace, the high loss of life, stress, anxiety and ill-health that Katrina caused must have had a major impact upon human and social capital: ruining lives, devastating families and social relationships and networks, and impacting adversely on the most vulnerable such as those in care. Population displacement has had similar effects, reflected in the lasting impact of Katrina on demographic composition. New Orleans Parish had a population of 458,393 before Katrina (Bostic and Molaison, 2008). One year after the floods the white population was two-thirds of its former size while the black population was down by nearly three-quarters (Logan, 2008). In total, 49% of the pre-Katrina population had returned a year after the storm, with the white proportion of the New Orleans metropolitan area increasing from 59% to 73%. This indicates that white, affluent residents are disproportionately returning to the city (Green *et al.*, 2007: 322). The majority of the City's population is still living elsewhere, of these the largest share is outside the state, and black residents (especially poor blacks) are disproportionately found at the greatest distances from their former homes. Some neighbourhoods have been left to die along with their social capital (Green *et al.*, 2007). Most public housing complexes were sealed with metal bars to prevent tenants returning (Logan, 2008). The heavy damage in the Lower Ninth Ward meant that 59% of housing lots in one survey showed no visible signs of recovery one year after the floods while others were in various stages of recovery. Residents were strongly committed to rebuilding their neighbourhoods. But compared with other heavily damaged neighbourhoods in the Parish, the recovery of the Lower Ninth Ward has lagged.

Much of the social capital of New Orleans is associated with its culture which exists in people and their artefacts (and how people relate to these artefacts), and both are now substantially 'gone' from New Orleans (Clarke, 2008). Examples include the range of ethnic, racial and religious groups that used to live there. It was in the minds of the people and their relationships that used to be present that the history and culture of the city lived. Cultural heritage is important in fostering a quality of life with value and pride in all civilizations (Fallahi, 2007). Along with historic patrimony, cultural heritage can be particularly vulnerable to flood hazard. After Hurricane Katrina the World Monuments Fund added the Gulf Coast and New Orleans to the World Monuments Watch list of 100 Most Endangered Sites for their distinctive cultural heritage. Katrina may have been the greatest cultural catastrophe America has ever experienced. Moreover, destruction of physical identity also deprives locations which attract a large number of tourists that are a tool for economic recovery (WMF, 2005).

The financially deprived were disproportionately affected by Katrina, and they are also the most vulnerable to the health and social effects of environmental problems and stressors. Many survivors have experienced significant physical and mental health impacts (e.g. see Rath *et al.*, 2007). Those with existing chronic conditions such as asthma saw this worsen and others missed hospital visits and ran out of medications. Those with chronic conditions were more likely to exhibit significant psychological consequences of the hurricane, such as overall sadness, withdrawal and behavioural changes. Poorly organised and managed evacuation of those without transportation added to the distress to those who are flooded (Nossiter and Schwartz, 2008). One study following Hurricane Katrina measured social capital in terms of social interactions before and after the Hurricane to identify predictors of

health outcomes; findings support the evidence that social capital in positive forms can result in positive health outcomes (Beaudoin, 2007). Depression was more common among those with low levels of pre and post hurricane positive social interactions but high levels of negative social interactions (e.g. experience of violence and negative interactions).

Green *et al.* (2007) suggest that pre-existing social and economic marginalisation, limited resources, the widespread assumptions of non-viability and the slow pace of infrastructure recovery in certain neighbourhoods played a significant part in retarding repair and re-occupancy (e.g. the majority of lifeline service companies were out of operation). These conclusions were substantiated by Masozera *et al.* (2007). Pre-existing socio-economic conditions were not predictors of flood damage but played an important role in recovery and response. Access to properties has been refused in some areas due to significant levee failures there. In some areas residents had to wait three months before they were allowed to 'look and leave' their properties.

Social vulnerability has impacted on economic vulnerability in a variety of ways (Figure 1.1). Population displacement and migration (temporary and permanent) robbed New Orleans businesses (both flooded and attempting recovery, and non-flooded) of a workforce and generated a labour shortage. At the same time, loss of population meant loss of customers for local businesses. In consequence, many businesses failed to recover and bankruptcies became common leading to a further round of social vulnerability impacts. Here we see social vulnerability impacting economic vulnerability which, in turn, further impacts social vulnerability as these relations, and feedbacks, play out over time. As businesses and infrastructure companies went out of business and properties were destroyed, municipal tax revenues plummeted leading to cut-backs in public services just as they were needed. Loss of social networks and support groups meant that dependency levels rose placing an increased burden on the resources of city and state services. Many neighbourhoods lacked economic vitality prior to Katrina, with some having unemployment rates 5 or 6 times the national average. Many of these were neighbourhoods that saw the most extensive damage. The prospects for improved economic performance in these areas are worse than before the storm (Bostic and Molaison, 2008: 268). Not surprisingly, the disaster caused a collapse in business confidence which has been slow to return (Deloughery, 2008). However, tourist numbers have been steadily increasing since 2006 and by the summer of 2007 the airport was functioning at 72% of its pre-Katrina activity and is still experiencing growth every month.

Consequent economic vulnerability and its effects on social vulnerability

Figure 1.1 also shows how Katrina deepened initial economic vulnerability (i.e. see consequent economic vulnerability) and how, in turn, this impacted social vulnerability. As the New Orleans economy staggered after the impact of Katrina, many local businesses went into bankruptcy causing a trail of personal and household/family tragedies and dislocations. Formerly successful local traders found themselves in financial deprivation. The collapse in municipal revenues led to financial tightening and to a loss of public services which are part of the social capital of the city and its communities. Social dependency was deepened by these harsh economic and financial realities. Again, here we observe one type of

vulnerability affecting another in various cycles of effect. There is considerable uncertainty regarding the level of housing investment warranted given the city's economic realities. Supply shortages for housing have driven up purchase and rental prices since Katrina, which disadvantages those on low incomes from returning. In future whites are more likely to be home owners and to have more resources to reinvest in their homes. The city will be much smaller and have a smaller footprint than in the past. It will also have a smaller share of black residents, tenants and poor and working-class families. As the city's labour force continues to require a certain share of persons with low skills and low wages, which is typical of a service tourist economy, this means that these workers will mostly live elsewhere (Logan, 2008). One issue is the extent to which economic activity can adequately support housing demand at prevailing market prices.

Vulnerability of residents to the oil spillage

The oil spillage was the worst residential crude oil spill in America. The properties were already heavily damaged by flooding, but 114 residences suffered heavy oil contamination, 286 medium contamination and the remainder light contamination. The spillages caused considerable added anxiety and uncertainty amongst residents about the potential immediate and long term additional health effects and additional effects on property values, as well as subsequently sparking off continuing anxieties about the risks associated with the continuation and expansion of oil refinery and storage operations at this site. Most of the home sites were cleaned by Murphy and placed back into residential use. However, properties in four roads were given an option to participate in a Murphy property buyout program. Although Murphy had stated in the Federal court that the property would be used for a green zone buffer, the refinery plans to expand into this established residential area, starting with a petrochemical testing laboratory. The combined flood and chemical spillage disaster caused enormous disruption to lives, work and social networks in the aftermath. To the considerable despair and stress associated with the flood and oil damage, the residents have had the added stress of enduring conflicting advice, a major court action and prolonged environmental monitoring. All of this is likely to have adverse health impacts. Although a clean-up operation has taken place, dangerous residues may have seeped into the soil. It is not known what short term financial deprivation was suffered by the residents, although at least some were not insured for their losses ([www.corpwatch.org.artcile.php?id=13016](http://www.corpwatch.org/artcile.php?id=13016)). How economic and social vulnerability interacted is not known in any detail. Some residents have decided not to return to the neighbourhood and, with visibly abandoned homes, some feel that the neighbourhood has been lost as a community and that their roots have gone (www.truthout.org/article/3330-million-settlement-deal-katrina-oil-spill). Following the court action against Murphy, the plaintiff residents were awarded 330 million (US\$) (i.e. 486 million Euros) financial compensation for negligence.

Systemic vulnerabilities and scalar linkages

The impacts of Hurricane Katrina on New Orleans in 2005 are also a powerful illustration of the systemic vulnerabilities and scalar (i.e. spatial) linkages, propagated by physical and economic vulnerabilities and the differential fragilities of businesses. The economic impacts in New Orleans reduced annual national economic growth by up to 1%, and seriously

affected the global insurance/re-insurance industry. Against this, construction materials markets and businesses saw gains in reconstruction. Some companies and public agencies with business continuity plans in place fared much better than those who did not, but generally SMEs may often be particularly susceptible to loss and bankruptcy (Birch and Wachter, 2006; www.brookings.edu/reports/2007/08neworleansindex.aspx).

1.2 The summer 2007 floods in Hull, England

A flood disaster in the city of Kingston upon Hull (called Hull hereafter), England (Figure 1.3) also illuminates linkages between economic and social vulnerability. Hull is located on the Humber estuary which flows into the North Sea. The city, which has a population of c.250,000, was flooded in June 2007. Hull has some comparative economic disadvantages and is one of several cities in the Yorkshire and Humberside region where deprivation is concentrated. The loss of manufacturing jobs and the growth of a service-based economy has produced disparate and polarized socio-economic conditions in the region. The city's economy has struggled to keep up with many other UK cities, and Hull has been at the wrong end of unbalanced growth in Yorkshire (Government Office for Yorkshire and Humberside, 2008).

In the context of the entrepreneurial market economy which characterised the UK between the late 1980s and 2007, Hull developed a negative image which hindered progress. Hull was a city at the wrong end of the rail lines; for some an undesirable place to live where population and the economy has been declining and where there are poor employment and income prospects; high unemployment insecurity; high crime; high fuel poverty; and a dependency culture characterised by high levels of council housing and social welfare payments – these are all elements of this image which helped to marginalise Hull. An Independent Review Body examined flood causes and flood prevention opportunities in Hull: their reports (Coulthard *et al.*, 2007a, 2007b) are drawn upon here. Summer 2007 saw the worst floods since 1947 in England. They affected hundreds of thousands of people. The Government's Pitt Review, which is also drawn upon here, examined the lessons to be learned from all 2007 floods (Pitt Review, 2008).

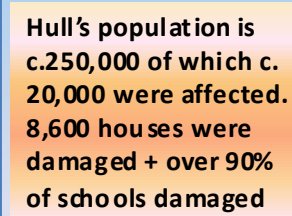


Figure 1.3: Kingston upon Hull showing the roads and properties affected by floods in June 2007 (from Coulthard et al., 2007b).

Physical vulnerability and root causes

The city is inherently physically vulnerable to flooding as 90 per cent of it lies below high tide level. The drainage system is entirely pumped. Reliance on pumps increases the city's vulnerability to flooding. In 2007, Hull experienced severe surface water flooding largely owing to the urban drainage system being overwhelmed by rainfall rather than the pumps malfunctioning.

The root causes are complex (Figure 1.4). The city grew as a port and was prosperous in the 19th century, but was located on low-lying land, presumably because of the flood risk was largely unrecognized. From the 1920s onwards the city witnessed industrial decline exacerbated by the collapse of the fishing industry in the 1970s. However, a large part of Hull's vulnerability to flooding is explained by (a) the physical characteristics of its location, and (b) social/financial deprivation. The city is the 9th most deprived area in England and the most deprived area in its region.

Economic vulnerability

The economic vulnerability of Hull to flooding is related to the widespread nature of flood exposure and its potential for flood damage (Figure 1.3). Over 8,600 houses were damaged, as well as schools and businesses. Over 20,000 people were affected. Hull City Council is a major owner of rented housing: 1,986 council houses (7% of the stock) were flood damaged. Hull's economic vulnerability is caused by physical flooding susceptibility; the indirect effects of flooding; and the economic/financial weaknesses of households and businesses (Figure 1.4). Economic vulnerability is selective or differential leading to winners and losers. The largest losers are those whose houses suffered the most damage (i.e. those whose houses are at the lowest altitude); the uninsured; those for whom insurance payments are delayed; those with large debt payments to make relative to their income; and those who had to lose work and wages owing to the need to look after children whose schools were badly damaged. The largest gainers include companies with repair and rehabilitation skills and capabilities, and those who supply them.

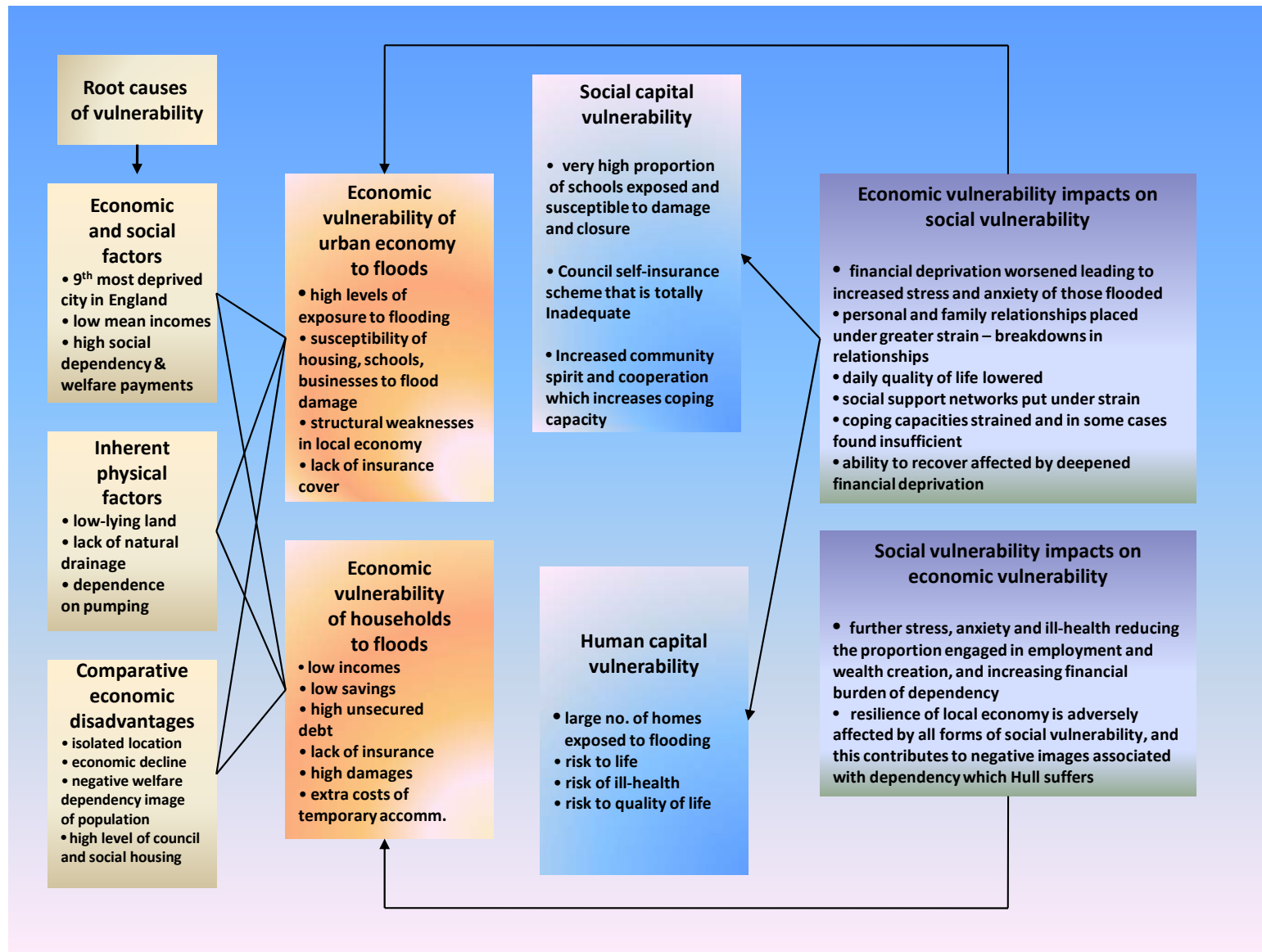


Figure 1.4: Linkages between economic and social vulnerability exemplified by the serious flooding in Hull, England in June 2007

Hull is the ninth most disadvantaged of the 354 English local authorities. More than 50% of its population live in wards which are among the 20% most deprived in the country. Approximately 100,000 persons (40% of the city's population) receive means-tested welfare benefits. The physical damage to homes exposed people's financial vulnerability: the damaging effects of flooding were magnified by existing financial deprivation. Many households affected had lower gross incomes, fewer savings, larger debts, and less access to further credit than the average English household. Typically, they also faced significantly increased costs. One quarter of households were without flood insurance. Many were council house tenants whose insurance did not cover their contents losses. Insurance companies were slow in making essential payments. Families are still struggling with increased debt problems, such as keeping up mortgage payments. Of the 8,600 households affected by the flooding, 6,300 were forced to find alternative accommodation, and over 1,400 of these moved into caravans. The house repair work has progressed slowly. Not only did private homeowners have to keep up their mortgage payments, but they also had to pay the rent on their temporary accommodation. Incredibly, only 8 out of 99 schools in Hull were unaffected by flooding. Over 114,000 pupil days were lost. Assuming that one adult cannot be at work for every 2 children off school, and a conservative minimum wage rate is used (£42.80 (i.e. 38.73 Euros) per day), this equates to £2.4 million (i.e. 2.17 million Euros) on lost (Coulthard *et al.*, 2007b). Hull City Council's 28,500 council houses, schools and other buildings were uninsured. The Council considered that the excess of £250,000 (i.e. 226,244 Euros) required to take out the insurance was too high. Instead, the Council opted for a self-insurance scheme in which £9 million (i.e. 8.1 Million Euros) was set aside to cover damage and repairs. However, in total the Council faces a £200 million (i.e. 181 million Euros) bill following the floods.

The economic vulnerability of businesses to disruption in Hull is comparatively high, given that the local economy suffers significant structural weaknesses owing to the mixed fortunes of its industrial base. Many large businesses experienced direct flood losses of over £25,000 (i.e. 226,244 Euros); the comparative figure for small businesses was £5,000 (i.e. 4,525 Euros). Of those small businesses which experienced lost sales, approximately 40% incurred an indirect cost of over £10,000 (i.e. 9,050 Euros) and a further 25 per cent judged this to be over £25,000 (i.e. 22,624 Euros). Many large businesses experienced indirect losses of over £100,000 (i.e. 90,498 Euros) (Pitt Review, 2008, 387).

In the June 2007 floods economic vulnerability was to a small extent reduced by two Government flood compensation schemes, and by funds from public flood relief schemes and donations from the Red Cross, which are examples of nurtured economic resilience. This led to payments to individual households in Hull, including to those who were uninsured. The net effect on vulnerability of individual household flood compensation payments is difficult to determine. On the one hand, the immediate and short term effect of such payments is to alleviate economic hardship and personal anxiety and suffering, which should have had the effect of reducing economic and social vulnerability. However, providing compensation for those who occupy flood risk areas simply encourages them to remain in these areas in the future, prolonging their physical, economic and ultimately their social vulnerability (because it removes any incentive to move).

Social vulnerability

Social indices suggest that the city's population is socially vulnerable from sudden and unforeseen events such as these floods. Hull has more people with a long-term limiting illness, a larger number of working age population with a disability and a greater prevalence of mental illness than the national average. The birth rate is also appreciably higher and teenage conception is over 60% more frequent than elsewhere in the country. A post-flood survey of 250 residents by the National Flood Forum showed that 48% had sought medical help in the past six months, and 44% attributed this to flooding. The stress that flooding caused led to various stress disorders and difficulties with family and working relationships. In a post-flood survey undertaken for The Pitt Review following the summer 2007 floods across the country (i.e. not just Hull), of the 647 respondents 71% reported that their physical or mental health or both had been affected by the floods, and these effects were also reported in children by many of these who had children.

However, as Coulthard *et al.* (2007b) observe, the people of Hull are not only vulnerable in different ways and for a variety of reasons, but they are also resilient. People exhibited an amazing capacity to cope with and recover from the floods. This resilience takes many forms, including the degree of neighbourliness exhibited, and the number and strength of informal and formal networks devoted to mutual assistance and community welfare. Coulthard *et al.* (2007b) draw attention to the vibrancy of Hull's social capital, the goodwill of people, how neighbours offered each other assistance and comfort, the general pro-active approach toward problem-solving and how the flood fostered a community spirit. This resilience reflects an underlying strength of communities and the social cohesion within neighbourhoods in the city. The capacity of a community to help itself or its resilience is an important part of its social capital, and the physical and economic impacts of the floods appear to have strengthened this social capital thereby reducing social vulnerability. Whether the counter-balancing effect of the strengthening of social capital compensates for the deepening of social vulnerability which the floods also appear to have caused, is difficult to estimate, but it appears unlikely.

How economic vulnerability and social vulnerability are inter-related

The economic vulnerability Hull's households and businesses to flooding is intimately related to their social vulnerability, so that sometimes the two types of vulnerability are difficult to clearly separate. The inter-relationship is symbiotic. Economic vulnerability can impact adversely upon social vulnerability (Figure 4.4). For example, the financial deprivation which people face in Hull was deepened by the flood, and this affected people's stress and anxiety levels and their health. Worsening financial deprivation, difficulties in keeping up with mortgage payments and so on, place household relationships under greater strain, and is linked to ill-health as well as to breakdowns in relationships. People's daily quality of life is eroded. The stress and disruption which a family experiences when it witnesses its possessions damaged and lost in a flood is bad enough, but when families are forced to move out of their homes into temporary accommodation for months at a time because of these economic impacts, this stress and disruption is magnified, as is the adverse impact on quality of life. Disruption of this nature also puts social support networks under greater strain

and may erode the effectiveness of social capital, although this may be countered by opposite tendencies (see above). Businesses which suffer financial losses because of flooding are a further dimension of the way in which social vulnerability is deepened. Those owning and managing flood-affected businesses come under greater strain, and when a firm's financial position worsens this leads to concerns about people losing their jobs. People's discretionary spending power will have declined as a result of the flooding and the higher fixed costs which they will have borne, and through multiplier effects this usually has a detrimental effect within the local economy and its ability to recover from a damaging flood event. There is, however, usually a counter-balancing effect of increased spending on repairs which acts to boost local economies.

Although some of these impacts are difficult to measure, probably to a lesser extent social vulnerability plays a part in deepening the economic vulnerability of Hull's people and economy to floods. The floods superimposed a further level of stress and ill-health upon the existing high levels of illness found in Hull, thereby further degrading the ability of the city's population to participate in employment and wealth creation. This has the effect of further weakening economic resilience and also increasing levels of financial dependence. Here again we observe a temporal cycle of vulnerability in which economic vulnerability adversely affects social vulnerability which in turn further affects economic vulnerability in a downward direction.

2 Drought

2.1 The case of the Northern Negev, Israel

The Negev region is located in the southern half of Israel while the northern Negev includes all areas extending between the 100 to 400 mm isohyets. Due to its geographical, climatic and socio-demographic characteristics, this area is vulnerable to droughts. According to the climatic and weather data, droughts intensified from 1995 onwards. Only a few of the last 15 years can be classified as years that have average or higher than average amount of rains.

This case study examines the relationships between social vulnerability and economic vulnerability in the context of on-going drought. While the urban population is affected in minor ways, two population groups, characterized by different social and economic levels, are highly affected: the nomadic Bedouin (tent settlements) and the Jewish agricultural settlements. These groups have different social and economic vulnerability. Both groups exploit the land, whether directly by cultivation or grazing or indirectly by feeding sheep or goats on hay and grains produced in the fields. While the Jewish sector cultivates the land in a very systematic, well organized and sophisticated manner, the Bedouins, cultivate their land in a more traditional manner, although they use machinery. While cattle and sheep are raised in enclosures in the Jewish sector, the traditional method of open land grazing of sheep and goats is common in the Bedouin sector.

These differences may largely stem from fundamentally different cultural, social and economic characteristics. Both populations differ markedly in their social structure. Whereas most of the Jewish farmers reside in Kibbutzim (a closed community advocating equality and the sharing of the community resources in a more or less equal manner) or Moshavim (a slightly more open community where only some of the revenue resources are shared), the Bedouin are either scattered (tent dwellers) or residing in towns. Most of the scattered part of the community reside either on disputed land (claimed by the Bedouins) or illegally on state-owned open spaces, and in small towns some of which evolved spontaneously with no legal foundations and therefore with no infrastructure. Others however reside in pre-planned towns where the infrastructure and the municipal facilities are provided by the government.

Conceptualization of the Northern Negev vulnerability

The term physical vulnerability relates here to the economic sector (e.g. agricultural crops) which could be influenced by droughts directly. Accordingly, systemic vulnerability includes the relevant factors and components that determine the level of the northern Negev's physical vulnerability regarding functioning of infrastructure and services within and out of the region. Consequent economic vulnerability refers to the level of the economic dependency of population on the economic sector that can be influenced directly by drought, while initial economic vulnerability refers to the economic ability to cope with long periods of droughts. Consequent social vulnerability means here the potential effect of drought on the social and human capital while initial social vulnerability refers to the relevant social and human capital to cope with long periods of droughts. The relationship between these forms of vulnerability is presented in Figure 2.1.

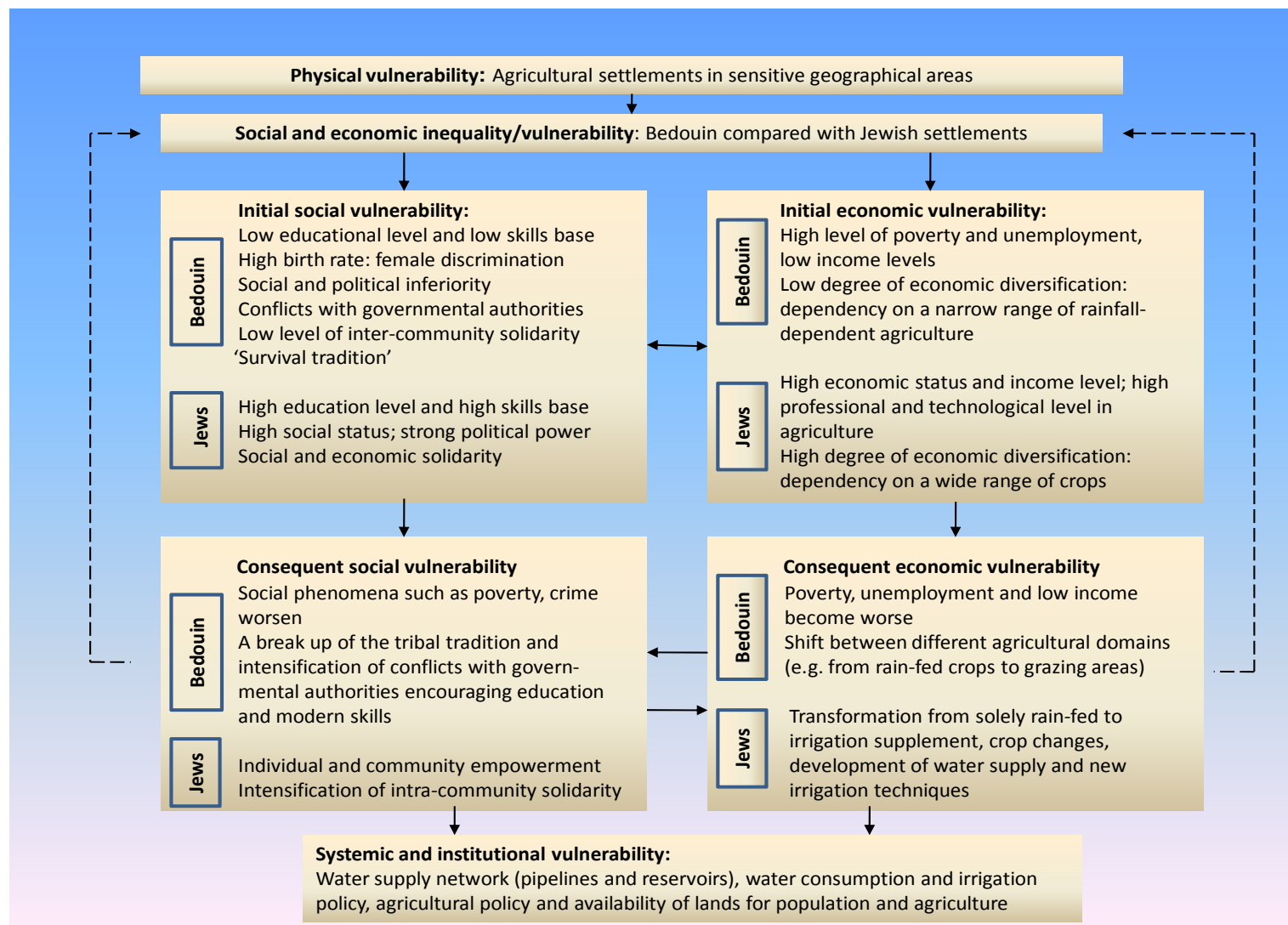


Figure 2.1: Relations between social and economic vulnerability in the northern Negev, Israel, between the Bedouin and Jewish agricultural settlements

The nomadic Bedouin population: social and economic vulnerability

Several factors contribute to the social vulnerability of the Bedouin population in periods of droughts. First, the Bedouin have a low level of human capital - education, knowledge and professional skills on the one hand, and a high birth rate on the other (here the high birth rate places a strain on household finances). Second, the interaction with the outer and more modern society leads to a significant decay in the intra- community social solidarity within and between the Bedouin tribes. Third, is the low level of solidarity between the Bedouin community and the state of Israel. Fourth, as a cultural-ethnic-national minority, the Bedouin community is in sharp conflict with the Jewish majority and the state of Israel as a political entity. These four conflicts are bounded with the feeling of social and political discrimination among the Bedouin and their distrust of government authorities. In contrast, the Bedouins' "survival tradition" – the collective experience of coping with drought disasters – may make them less vulnerable in periods of economic shortage and poverty.

The inherent economic vulnerability of the Bedouin stems mainly from the dependency on a narrow range of rainfall-dependent agricultural crops, which are particularly vulnerable to the droughts and their consequences. In addition, the Bedouin population is characterised by a low income and a low degree of economic diversification.

How social vulnerability of the Bedouin influences their economic vulnerability

Low skill base and education level (i.e. elements of human capital) are the main factors that determine economic vulnerability of the Bedouin population. These disadvantages further limit the Bedouins' ability to transfer employment from agriculture to other economic sectors during continuous periods of drought. The high birth rate of the Bedouin, all of whom rely on only one salary, essentially limits their economic development and further contributes to extreme economic vulnerability. Furthermore, due to traditional Muslim tradition, women are not encouraged and in many cases are not permitted to work and thus to contribute to the family income, and the husband remains the only wage earner.

Traditionally, the Bedouin population is characterised by relatively high intra-community social solidarity among tribes and extended families ("Hamulot"); this contributed formerly to the group's social capital and further to their economic resilience. To some extent this social solidarity remains but is reducing. Living in the proximity of a modern society leads to the gradual break-up of the tribal tradition, with the shift in leadership from the elders to the rich or successful individuals (Knesset, 2007). The institutionalized social inferiority of the Bedouin has significant impact on economic vulnerability that results from policy: lack of access to economic resources as regards employment (e.g. employment in governmental institutions), and infrastructure (water supply network) interacts with limited availability of agriculture lands. Yet, one may argue that the low level of education of the Bedouin population limits their capabilities to join the "sophisticated" governmental job market. All the above factors contribute to increasing economic vulnerability as a consequence of droughts.

In contrast to the situation of the Bedouin, the Jewish agriculture settlements, Kibbutzim and Moshavim, are characterized by high levels of social and human capital and vast political

power within Israeli society. In addition, due to high professional and technological levels and advanced infrastructure – the water supply network and comprehensive system of irrigation - these settlements can better cope with drought. The Negev Jewish population demonstrate how social capital positively affects the ability to use institutional assistance in coping with drought. Many national and local projects aimed at alleviating the hazardous effect of drought on agriculture settlements were initiated in the Negev. For example, the highly purified sewage water of the Tel Aviv metropolitan area was transferred to the Negev, providing irrigation for more than 80% of the agricultural settlements. Reservoirs for the collection and purification of the sewage water were established in the majority of the Negev agriculture settlements. Public institutional involvement is high and acts to mitigate the drought effect by implementing new techniques such as no-tillage cultivation, machinery that increases surface storage, new irrigation techniques that save water such as drip irrigation and new seed varieties. This development is possible due to the high skill base and education level of the Jewish farmers. Social solidarity among the Jewish population in the Negev mitigates the impact of droughts and provides additional economic advantages. For example, heavy machinery is jointly bought by several Kibbutzim and one kibbutz member is in charge of field production. These Kibbutzim invested in building large reservoirs to mutually utilize the sewage water from a major Bedouin town, Rahat. Similarly, all 34 Moshavim in the Negev combine some of their fields to cultivate wheat, potatoes, carrots and sunflower, all of which are cheaper and easier to grow in large plots.

The strong economic base and social solidarity enable pre-adaptation to the threat of drought. The investment in greenhouse construction is a good example. While investing in a greenhouse may be costly and risky for the individual (the farmer must show a steady income in order to receive a loan), the financial obligations and risks essentially decrease when several Moshavim apply for the financial support to establish common greenhouses; in addition better loan conditions can be obtained. The solidarity between Kibbutzim and Moshavim mitigates risk when new technologies are implemented.

How economic vulnerability affects social vulnerability

The consequent economic vulnerability to drought has implications for social vulnerability, as decreasing income from agriculture can cause unemployment. In the case of Bedouin families, children may leave the education system, entering the low-skill labour market – further increasing Bedouin social inferiority. Social stress, especially in periods of economic shortage, creates conflicts inside Bedouin society. The lack of pasture lands increases tensions within the extended families ("Hamulot"), the tribes and within the families and tribes, decreasing social solidarity. In addition, the conflict between the Bedouin community and the state of Israel is intensified due to the reduction in grazing land.

In the Jewish agriculture settlements the situation is totally different. Due to a high level of human and social capital, this population generates many initiatives and actions that aim at coping with drought e.g. new irrigation techniques and seed varieties. Social solidarity and economic collaboration between the Negev settlements become stronger as droughts intensify. That is, the need to cope with drought strengthens social interaction and activates systemic mechanisms to face the implications of drought.

To summarize, the northern Negev demonstrates how the relationship between social vulnerability and economic vulnerability affects the capacity of the population to cope with drought. In turn, this relationship is affected by the drought. The differential impact of drought on Bedouin and Jewish populations with their different social and economic vulnerability is clear: while drought reinforces poverty, crime and unemployment in the Bedouin population that is characterized by low human and social capital, the Jewish population with high human and social capital has the ability to cope with this continuous hazard by activating different forms of social and economic empowerment and intensifying existing social networks and solidarity. As a result, the economic gap between Bedouin and Jewish populations grows larger and the vulnerability of the weaker Bedouin population increases. All this leads us to the conclusion that droughts strengthen the social and economic inequality in the affected region. While worsening the Bedouin's situation, it may reinforce the adaptation of new techniques that will improve production. In this regard it is worth mentioning that crop production per unit of water used increased over three fold in the Jewish sector between 1950 and 2000 (Nativ, 2004), increasing the resilience of the Jewish sector to droughts. Thus, along with the drawbacks, new opportunities emerge with droughts. It enforces the adaptation of new technologies that increase crop production subsequently decreasing vulnerability to droughts.

Differential socio-economic vulnerability of the population in northern Negev makes this region a good example for the assessment of potential implications of drought on geographical regions that include populations with different social and economic vulnerability. In this regard, the similarities between Israel and Morocco are striking. Yet, whereas the population is divided economically according to ethnicity in Israel, it is divided by social status (rich farm owners that use heavy machinery versus poor and small farmers that use traditional cultivation methods) in Morocco. As in Israel, the vulnerability of the small farmers to droughts is much higher (Swearingen, 1992).

3 Fire hazards

3.1 A case study of social and economic vulnerability relations in Portugal

Fire is a complex phenomenon influenced by multiple factors that evolve over different spatial and temporal scales. The factors contributing to the occurrence and spread of forest fires can be grouped into three (Figure 3.1). In the Mediterranean basin, and specifically in Portugal, the lack of economic development in some areas has generated migration to the large, coastal urban centres (Alexandrian *et al.*, 1999). The consequent abandonment of agriculture has increased fuel loads and thereby increased the fire risk. Despite the influence of climatic factors, and the inflammability of plant and tree species, forest fires are heavily influenced by population behaviour. In Portugal the majority of forest fires are intentional acts or negligence (DGRF, 2007).

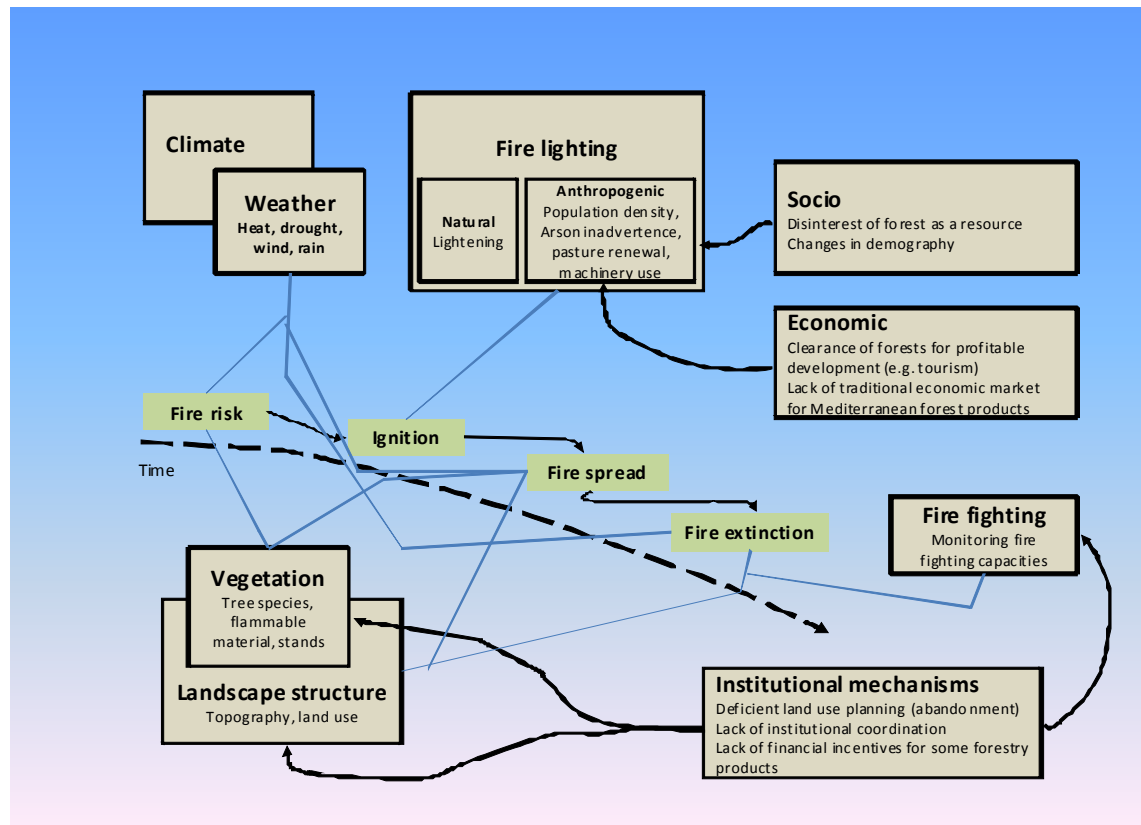


Figure 3.1: Chain sequence of a forest fire hazard exploring the key social, economic and institutional factors influencing vulnerability

Economic vulnerability influences upon social factors and vulnerability in Portugal

Economic vulnerability is partly demonstrated by susceptibility to economic loss, particularly the susceptibility to fire damage and also the need to take costly preventative measures to reduce loss potential. It is also demonstrated by the costs of restoration and recovery. In 2002-2006 in Portugal, the average losses because of forest fires are estimated to be more than 300 million Euros per year (DGRF, 2007). This includes the value of timber and non-timber products lost, of damage to recreational activities and carbon sinks, and to the protection of agricultural soils and aquifers and biodiversity protection. As Figure 3.2 demonstrates, the worst annual losses occurred in 2003 and 2005 - about 600 million and 500 million Euros respectively. At about 1 billion Euros, European Commission estimates for 2003 were even higher. More than 2,000 buildings were affected (EC, 2005). More than 2,000 km of electrical cables were destroyed, leaving half a million people without electricity. Telephone networks were also destroyed in some areas, leaving more than 10,000 homes without communication. Estimates by the Portuguese Catholic University (Mendes, 2004) provide a gross figure for the overall externality cost of forest fires. The estimates include forest fire prevention costs (including more than 3 million Euros covered by pulp and paper companies, 11 million Euros by the Portuguese government and 3 million Euros by EU funding), fire-fighting costs (about 36 million Euros - including government expenses, pulp and paper company investments and the opportunity costs of the time spent by volunteer

fighters), losses in timber products (about 38 million Euros) and the cost of restoring burnt forest (45 million Euros).

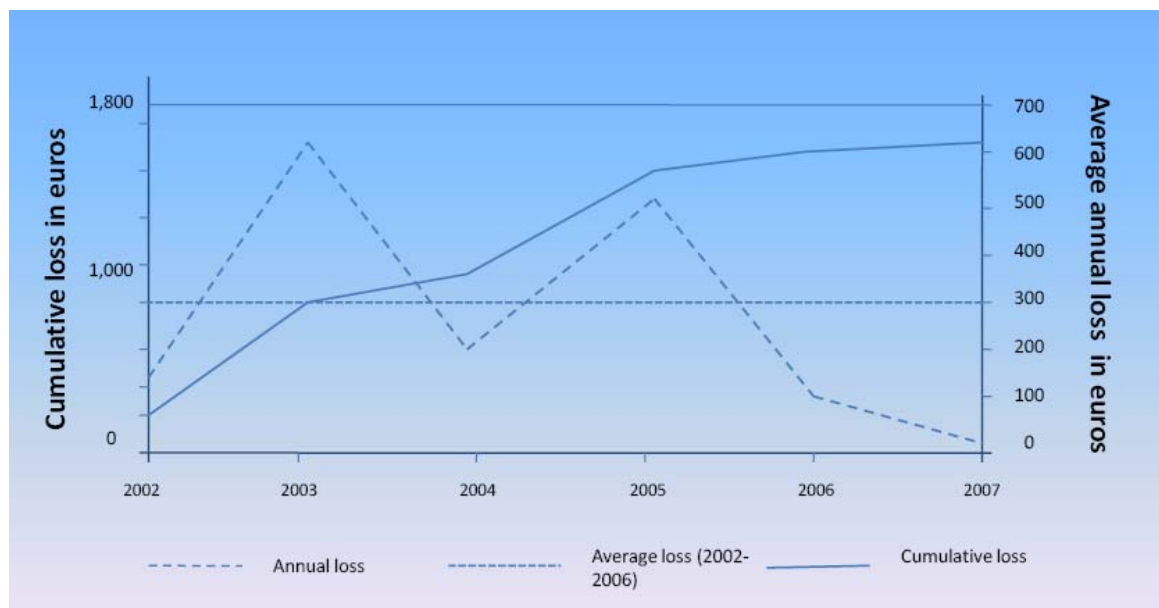


Figure 3.2: Cumulative and average economic loss caused by forest fires in Portugal (2002-2007) DGRF (2007)

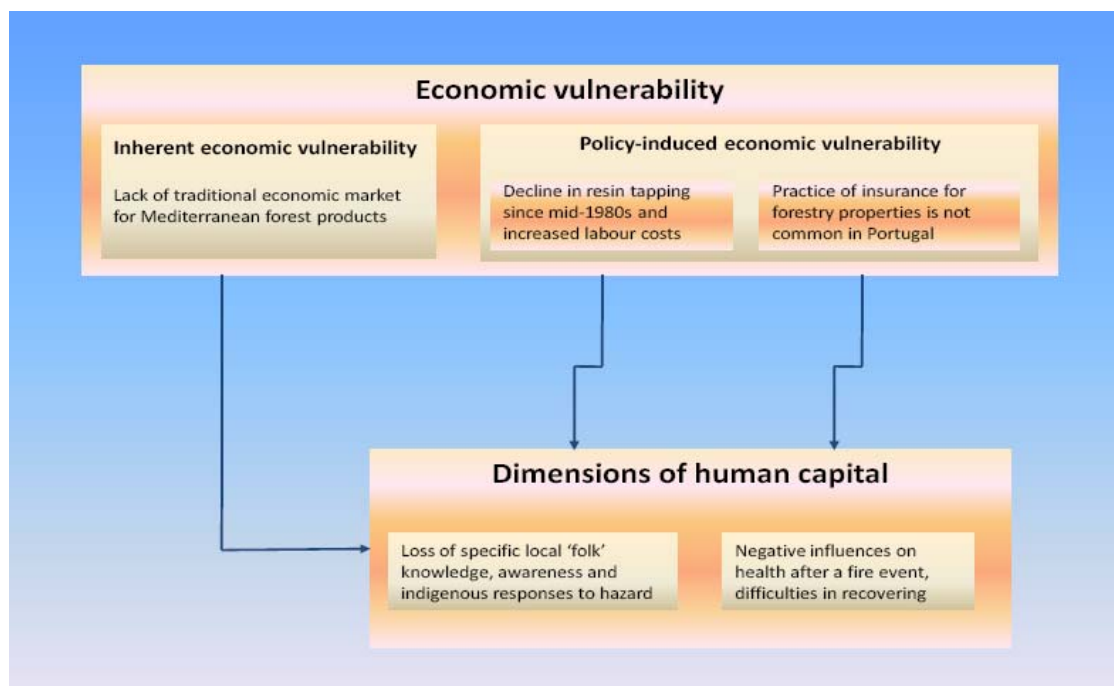


Figure 3.3: Influences of economic vulnerability on dimensions of human capital in relation to fire hazards

Figure 3.3 illustrates the influence of economic vulnerability on social vulnerability focusing upon human capital dimensions of social vulnerability. There is an inherent economic vulnerability in the decline in traditional markets for forest products, and this discourages investment in forest management. In this case, 'policy-induced' economic vulnerability is of

a negative kind (whereas it is often a positive factor). The decline in resin tapping has deprived the forests most vulnerable to forest fires (Maritime Pine forests) of the regular presence of tappers who played an important role in alerting about the risks of forest fire. The tappers worked to reduce the quantity of inflammable material in forests (Bassi, 2008). This also occurred in Greece where the resin subsidy was removed in the 1980s causing a decline in the resin industry. These changes increased the social vulnerability of specialized workers as their skills were too narrowly based or over-specialised. Other factors have also had their negative influence. In Portugal, fire-prone shrub land was historically controlled in part by using the shrubs for animal bedding, but today this is not economically viable due to increased labour costs (Pereira *et al.*, 2004). Insurance for forestry properties is not a common practice in Portugal because of a lack of knowledge and awareness amongst forest owners and the fact that the recurrence time of a forest fire in Portugal is rather short. The high probability of forest fires makes insurance companies resistant to provide insurance. This exacerbates economic vulnerability and negatively severely affects ability to recover. However, the EU solidarity fund was activated by Portugal and Greece after the extreme forest fires of 2003/2005 and 2007. This helped to reduce economic vulnerability in Portugal, but the process of fund evaluation and distribution caused delay which impacted negatively. Owing to the selective nature of economic vulnerability, the most affected individuals were small individual owners of forest stands. Large company owned plantations were also affected but they had been able to invest in fire prevention and management to limit their losses.

Social vulnerability and social factor influences upon economic vulnerability in Portugal

In the case of forest fire in Portugal, social vulnerability influences economic vulnerability mainly via physical vulnerability which functions as a mediator or intermediary (Figure 3.4). Forest fires in Portugal cause loss of human lives, both among firemen and civilians. 21 people died in the 2003 fires and over 1,000 required medical assistance due to smoke intoxication, burns, wounds and other injuries. The damage caused almost 200 homeless (EC, 2004). In 2005, 18 deaths were registered and over 1,000 were injured (EC, 2004). However, it is various dimensions of human capital, such as tradition, a lack of knowledge about alternative markets, and inefficiencies in the norms for land use planning, that have lead to a lack of forest management and a maintenance of pine and eucalyptus stands that has led to greater physical vulnerability (Figure 3.5). In turn this heightened physical vulnerability has produced economic losses which are a symptom both of vegetation inflammability and the high susceptibility of the forest and related assets to economic damage. The dependence on a narrow range of forest products and incomes from them also contributes to economic vulnerability.

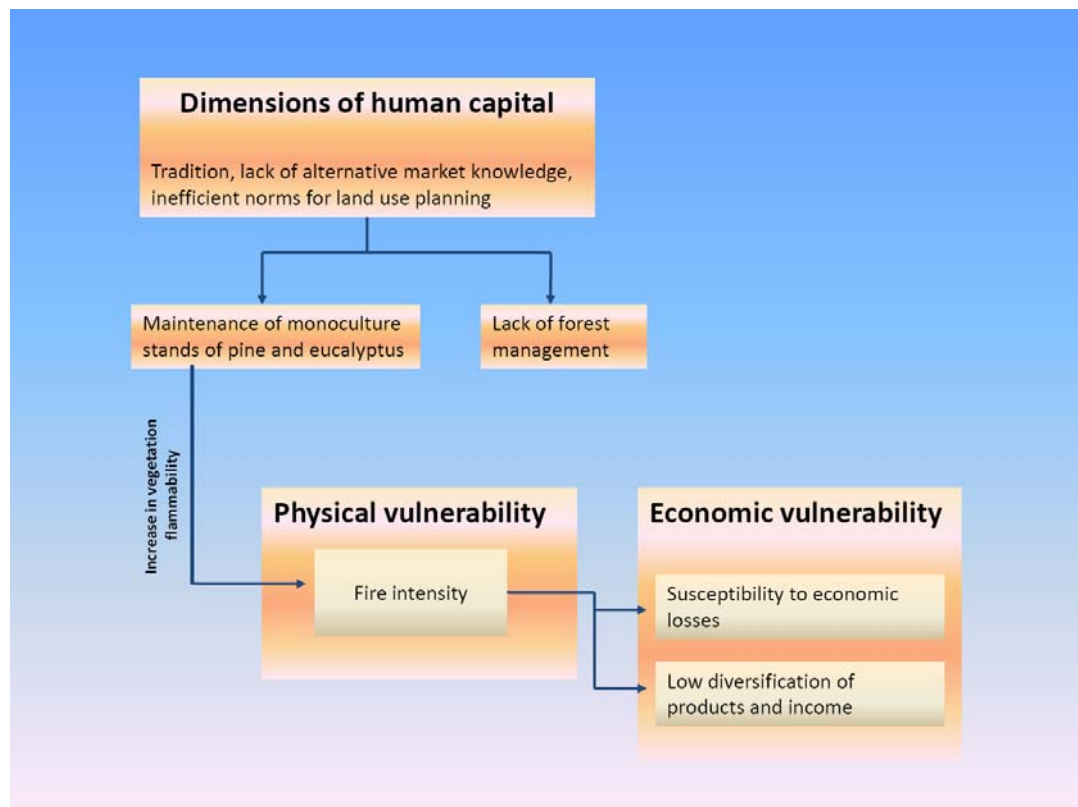


Figure 3.4: Influences of human capital dimensions on economic vulnerability in relation to fire hazards

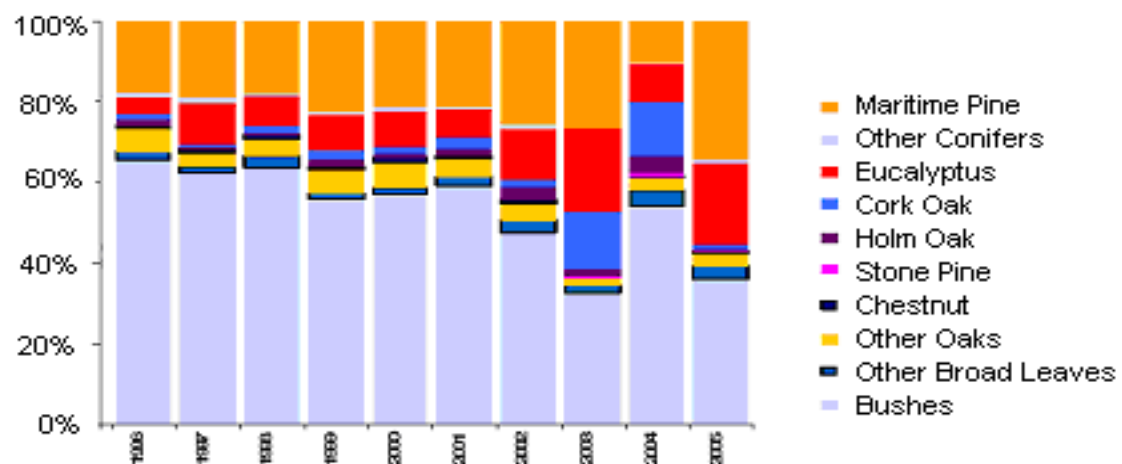


Figure 3.5: Type of forest burnt in Portugal (1996 -2006)

Social vulnerability is deepened by lack of education and training, and lack of investment in social capital through education and training leads to greater economic vulnerability. In many areas of Portugal, seasonal prescribed burning is undertaken by shepherds to maintain the ecosystem in the early succession stage of grassland, and this is an important factor increasing fire ignitions (Pereira, 2004). When they plan to burn the shepherds should communicate their intentions to the forest and agriculture authorities, but lack of

appreciation of the consequences of their burning activities and lack of training means that in Portugal this procedure is not often followed. Also as the rural population's age composition becomes older, the number of experienced shepherds who had the skills and knowledge to properly perform prescribed burning are decreasing. This lack of expertise (i.e. human capital) leads to the existence of less, but more careless, prescribed burning enhancing the risk of economic losses from forest fires.

In Portugal a set of persistent social factors combine to increase economic vulnerability to forest fires. There is a consistently high prevalence of Pine and Eucalyptus forests burned each year (Figure 3.5). Opting for pure 'monoculture', stands of Pine and Eucalyptus, instead of for mixed stands, makes plantation owners more susceptible, and therefore more vulnerable, to large economic losses (Figure 3.5). Producers choose pine and eucalyptus pure stands because pine and eucalyptus have fast growing characteristics and also because of inertia. There is a long tradition of Maritime Pine stands management. This is linked to a lack of knowledge about other potential forestry markets, with deficient land use planning that does not promote forest species diversity, and with a prevalence of small, privately owned forests. Each of these factors increases flammability of the vegetation and increase fire intensity and severity. By diversifying stand types producers could access a wider range of markets (e.g. furniture, cork industry, resin, pellets etc.) enabling them to cope better with fire losses.

The influence of norms and social networks embedded in social capital are visible in the structure of forest ownership, especially in the north and centre of Portugal. Most forests (about 93.4% according to Mendes, 2004) are privately owned and managed, making standardized and effective prevention planning against wildfires difficult. The average size of private forests is between 2–30 ha in the north and centre, and up to 100 ha in the south (Costa, 2007). Forest owners often have little incentive to invest in a resource that is at high risk due to fire and yields little return given the small scale of their activities (Pereira *et al.*, 2004). However, recently Forestry Producers Associations (Associações de Produtores Florestais) have emerged in several regions of Portugal. These associations gather small producers' forests together to manage them more effectively, to diversify products (reducing economic vulnerability), and to improve fire protection.

Conclusions

The interactions and feedbacks between social factors, social vulnerability and economic vulnerability are shown in Figure 3.6. In Portugal, social and economic factors and vulnerabilities interact with and influence physical vulnerability, but even so influences of social vulnerability upon economic vulnerability and vice-versa can also be clearly traced. The impact of economic vulnerability on social vulnerability appears to be direct and strong, whereas the influence of social vulnerability upon economic vulnerability appears to be more indirect and possibly less powerful. Social vulnerability leads to an increase in physical vulnerability which has a subsequent impact upon economic vulnerability. There is also feedback in the relations between economic, physical and social vulnerability. The increase in economic vulnerability due to low diversification of income translates into impacts on dimensions of human capital such as health. The lack of insurance causes difficulties in

recovering after a forest fire. These human capital impacts further translate into the promotion of unmanaged land and lack of market opportunities influencing fire intensity leading once again to economic vulnerability. Once again, we can observe the cycle of impacts of economic vulnerability on social vulnerability which in turn affects economic vulnerability in a downward direction.

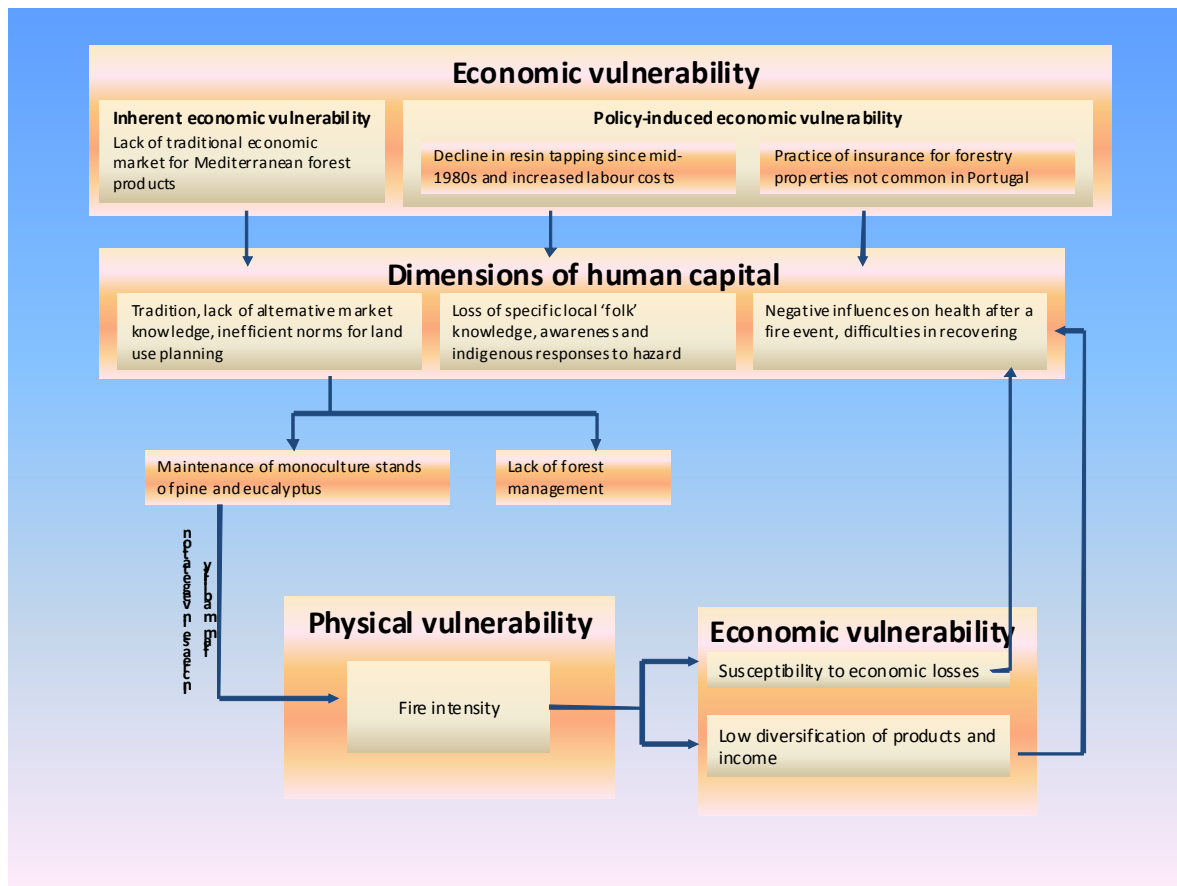


Figure 3.1: Interactions and feedbacks between social and economic factors and vulnerability in relation to fire hazards

3.2 Fire case study from Australia

This case study examines the relationships between social and economic vulnerability in the context of two wildfire emergencies in south-eastern Australia during 2003. The first fire affected the Australian Capital Territory and city of Canberra, as well as adjacent areas of New South Wales. The second fire affected parts of the state of Victoria in the Australian alpine region, and so it is known in Australia as the 'Alpine fire'. The Canberra fire struck an urban community at its interface with the surrounding rural area. In contrast the Alpine fire struck a predominantly rural community with small towns. The two areas in which the fires occurred are used to illuminate the vulnerabilities and their inter-relationships, but they are

also used to demonstrate how wildfires can produce starkly different levels of vulnerability in one area compared to another, depending upon the particular local economic and social circumstances and factors at work. This emphasises a key point about vulnerability made in 3.1 above, that vulnerability is likely to be significantly affected and explained by location-specific variables.

The Canberra fire

Canberra has a well documented history of major fires occurring in 1920, 1926, 1938/39, 1952, 1982/83. On the 8th January 2003 lightning started a number of fires in rugged inaccessible country to the west of Canberra – a city of some 300,000 people surrounded by the state of New South Wales. These fires burnt for about eight days in moderate fire weather conditions - helped along by the low moisture content of fuel, as a result of the long drought, and easterly winds - defying ground and aerial fire-fighting efforts. After a change in the weather pattern on the 17th January the fires started burning eastwards towards Canberra. The weather conditions shifted to strong northwesterly winds with hot dry conditions. These conditions need to be seen in the context of the drought which, based on rainfall deficits, was the third worst recorded during the 20th century. The drought was accompanied by unusually high temperatures even when the long term warming trend is taken into account (Karoly *et al.*, 2003). This combination of drought and heat resulted in forest fuel being exceptionally dry and flammable. The fire reached Canberra on the 18th January. 474 houses were destroyed with many others severely damaged. Four lives were lost, the Mt Stromlo observatory (an astronomical and astrophysical research facility of the Australian National University) was destroyed, much infrastructure was damaged, and the Tidbinbilla nature reserve and endangered species breeding area was destroyed leading to a major loss of animals. Many people reported that water pressure failure made fire fighting difficult. When the fire reached the suburbs it lost momentum and its massive smoke column collapsed on the city turning day into night. The insured losses amount to 350 million Australian \$ (i.e. 592 million Euros) (direct losses only) but most utilities are self-insured, and do not take out insurance cover. Virtually all households had insurance for their homes, although most were seriously underinsured. At least two thirds of households were underinsured for the dwelling structure. The average underinsurance was 30% but was up to 50%. Many people carried no contents insurance and many others were massively underinsured.

The Alpine fire (in particular Wulgulmerang)

On 7 January 2003, a day of Total Fire Ban in the state of Victoria, a weather system brought many thunderstorms across eastern Victoria. Lightning started over 80 fires located across a broad area of National Park and State forest, often in rugged, forested terrain with limited access. These fires were to lead to Victoria's largest bushfire since the devastating fires of 1939. In the 59 days that followed the lightning the fires burnt over one million hectares, or almost 5% of Victoria and 15% of the State's total area of public land. Forty one houses and 213 other structures were lost, but about 1,000 houses were saved. There were very significant forest losses, about 9,000 head of stock were lost, some water

catchments were affected, and the areas lost much tourist revenue. This is all in addition to the very substantial loss of ecosystem services, issues of the value of carbon, and injuries to people.

Vulnerability differences

Marked differences in economic and social vulnerability are illustrated by these two wildfires (Figures 3.7 and 3.8). Canberra is the national capital. It is a wealthy city with a strong employment base and a highly educated population who are generally well connected through personal and professional networks with people elsewhere in Australia. Important dimensions of human and social capital are therefore very well developed. It is a steadily expanding city. In contrast much of the rural Alpine area affected by fire is dependent on seasonal economic activities and farming which has become increasingly marginal over the last few decades. The population on the land is small, elderly and declining with shrinking services, all reducing local capacity for emergency management. The rural area is generally off the political and media map and receives limited attention.

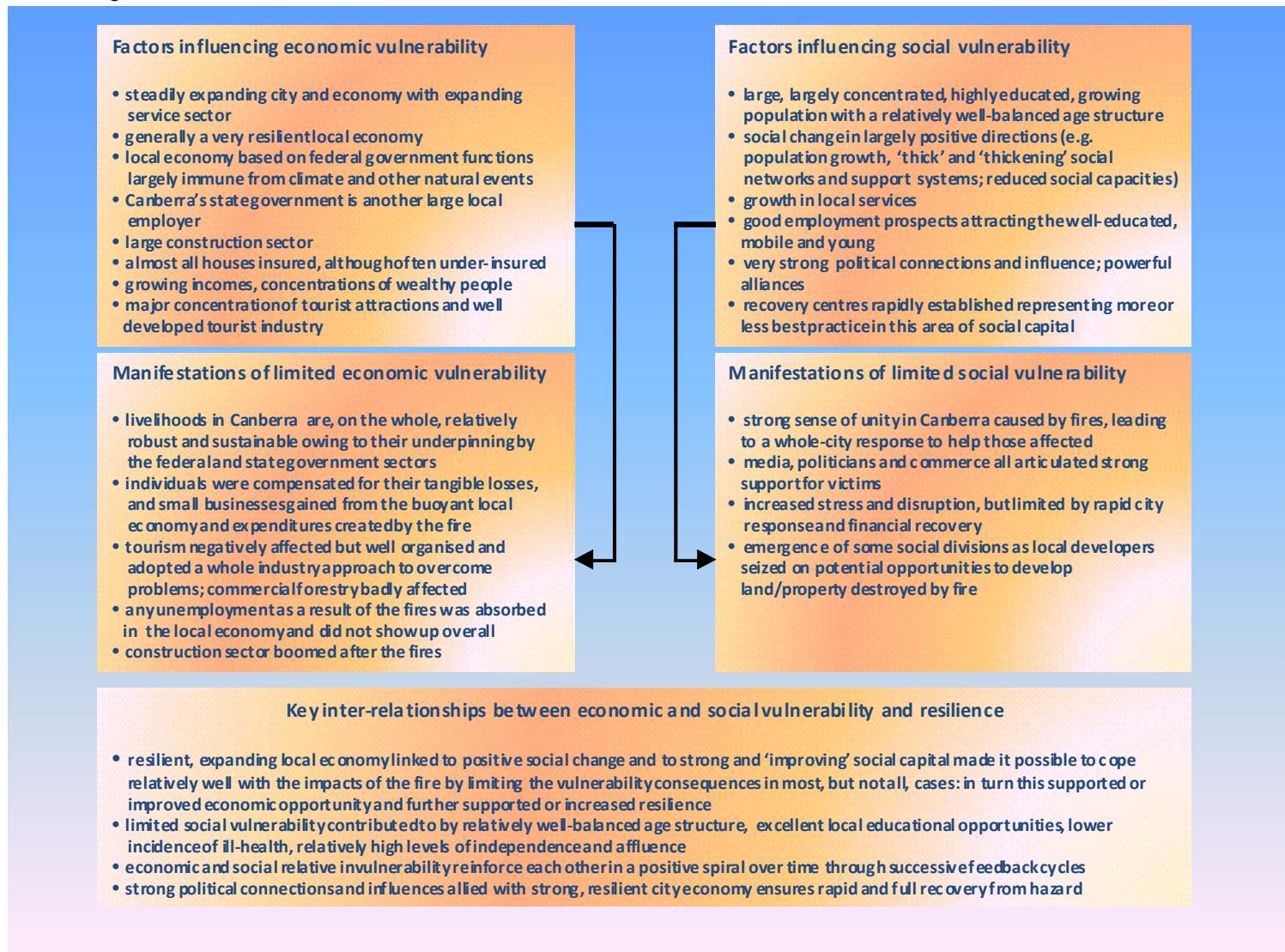


Figure 3.2: The characteristics and manifestations of economic and social vulnerability, and the relationships between them, revealed by the 2003 Canberra wildfire

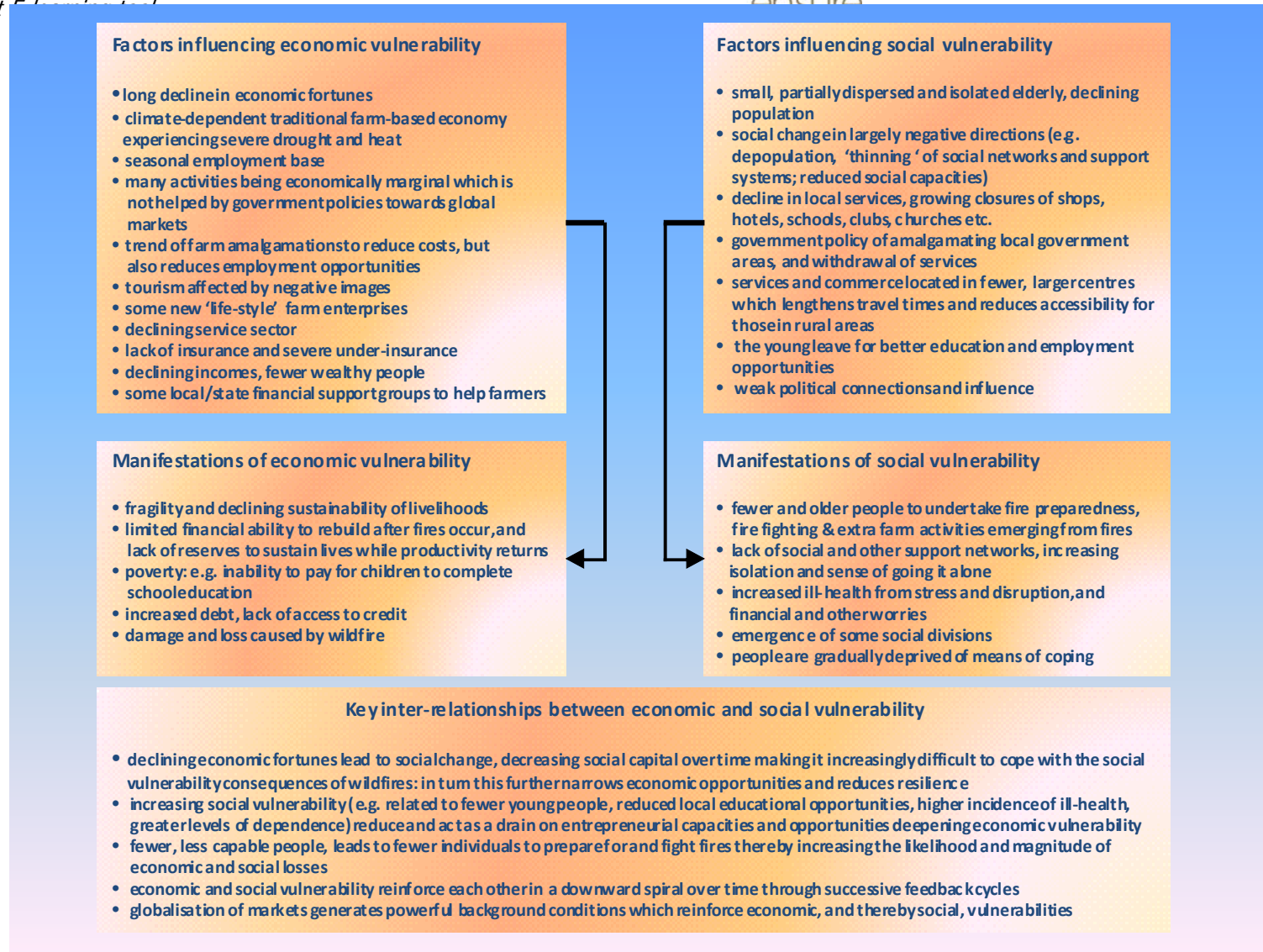


Figure 3.8: The characteristics and manifestations of economic and social vulnerability, and the relationships between them, revealed by the 2003 'Alpine' wildfire

Canberra was almost totally unprepared both physically and psychologically for the fire, while the Alpine areas were aware of the risk and the people were prepared, but many factors acted to reduce the effectiveness of this preparation. In Canberra there was widespread shock, while as the Alpine fire burnt across the state for weeks those in its path had time both to prepare and to worry. In both cases fire services were active and attempted to control the fires but were unsuccessful. In the extreme fire weather conditions experienced fires did not appear to be controllable in any fuel types.

Economic vulnerability in the two case examples is a study in contrasts – see Figures 3.9 and 3.10. Here the economic impacts are examined at the local and household level, rather than regional and national levels. In Canberra, the substantial economic losses were mostly well compensated and short lived – and critically the fire affected only part of the city. The Canberra economy is very resilient (Figure 3.9). The total destruction of the regions commercial forest plantations was a major loss. Although the loss of the Mt Stromlo Observatory was a shock for the global scientific community, the employment impact was modest. Generally, losses were made up through insurance, aid, or through government financial measures. Almost all houses were insured albeit generally underinsured, but insurers agreed to absorb much of the gap left by underinsurance. Major assets such as Canberra Forests and the Mt Stromlo Observatory carried limited insurance but received government support. However, many small home-based businesses suffered extensive losses of tools and records. For many of these recovery was not so straightforward in the absence of large well resourced associations, especially for those without insurance. Nevertheless, the fire's main direct impact was on housing, and large scale enterprises which could look after their employees. The housing market was tight before the fire. With the surge in demand for rebuilding there was significant local price inflation in the construction sector which boomed.

In the Alpine areas of Victoria, in particular Wulgulmerang, the losses generally impacted directly on people's livelihoods rather than their homes. These impacts came after many years – in some cases decades – of economic decline (Figure 4.13). Here, human and social capital is not so well developed and is declining. A key, possibly the key factor, was the lack of insurance or severe underinsurance. This was itself largely a function of declining rural incomes as a result of the drought. Importantly, much of the area's economy is based on farming, much of which is intimately tied to climate and weather events. Forestry which is a very important part of the Alpine economy is less affected by day to day weather, but is very vulnerable to bushfires – and losses were very large in this sector as in Canberra

In Canberra, the social impact of the disaster was likely greatly reduced by the fact that all those who lost houses were compensated rapidly, and that while many livelihoods were affected for most this was limited in duration. Ability to recover was generally very high. There was considerable support for those directly affected but some divisions arose. The fires had scarcely gone out before some politicians started blaming fuel accumulation, national parks and those with environmental and aesthetic concerns – who were allegedly responsible for trees around parts of the city - for the fires. Although in many respects the Canberra fire united the city, the coronial enquiry into the fires was divisive. The Territory government also moved quickly to establish a recovery committee to guide recovery

decision-making. This committee had community, recovery and development representatives among others. In stark contrast to much of the Alpine area of Victoria, government services in Canberra are generally relatively well funded and easily accessed. Fire victims had a high media profile and some powerful allies including a famous and very popular and articulate marathon runner. Social capital was strong.

For the Alpine area, the severe disruption of livelihoods and also people's health and social activities were the major impacts, in addition to stock losses. Existing social disadvantage was increased for many farming families. The long decline in economic fortunes of traditional farming activities in the Alpine area is closely connected to social change so that when a major disaster or shock occurs, groups affected in this way will have limited ability to respond both in terms of cash for rebuilding and living while productivity returns, and in terms of social networks for support, labour and expertise both during the fire and post-fire recovery (Whittaker, 2008a). In this context the local 'bush nurse', who has a roving health brief for the more isolated communities and people, was seen as a very important part of local social capital. The long drought – now with scientific assessment it is said to be more of a climate shift than a drought - has resulted in further economic strain resulting in among other things widespread lack of or under insurance and even fewer people living and working in the area with less disposable income, in turn leading to further decline in services and commercial activity (Whittaker, 2008b). The overall result is, at least in the more rural areas, less individual and community social capital.

Relationships between economic and social vulnerability

The key inter-relationships between economic and social vulnerability are shown in Figures 3.9 and 3.10. Although the circumstances of Canberra and the Alpine region affected by the wildfires led to stark contrasts in the factors influencing each type of vulnerability, and to the manifestations of these vulnerability types, the key inter-relationships are very similar, albeit with contrasting vulnerability, either exacerbating or containing vulnerability and its consequences and effects. The inter-relationships demonstrate on the one hand the importance of prosperity and economic buoyancy in effecting social capital maintenance and accumulation, and on the other the sapping effect of low incomes and declining economies upon social capital. As rural economies and communities 'hollow out' over time (i.e. as their strength and integrity declines), their capacity to support fire fighting and recovery from fires reduces causing greater economic and social vulnerability. In both fire disasters there are examples of vulnerability being selective in nature, with the poorer, geographically isolated, uninsured farmers or rural dwellers with limited support networks tending to be the most vulnerable in Alpine Victoria, and the uninsured, home-based businesses unsupported by well-resourced business associations coming off worst in Canberra. In these cases, the twin economic and social conditions of the adverse consequences of (a) taking economic or financial risks by being uninsured, and (b) not having strong support networks, appear to combine to produce the greatest vulnerability.

4 Earthquakes

4.1 The case of the Friuli earthquakes of 1976

On 6 May 1976 an earthquake of magnitude 6.4 on the Richter scale struck central Friuli, a region located in the hilly north-eastern part of Italy. On September 11, the earth shook again: two more shocks occurred which were followed by one of 6.1 magnitude four days later. The area directly affected covered some 4800 km², with a population of about 0.5 millions. The consequences were devastating: about 950 people died and more than 2,500 were severely injured. Over one hundred villages were almost completely destroyed. However, damages were different in various places mainly because of different features and physical vulnerabilities of affected communities (Geipel *et al.*, 1990, Cattarinussi, 2009).

Initial social and economic vulnerability

The Friulian case displays many of the types of economic vulnerability shown in Figures 3.3 and 3.5. Prior to the 1960s, Friuli's economy was principally agricultural with small and nearly self-sufficient farms. The market structure was poorly developed: most farmers sold their products directly to neighbouring regions. In such a context of limited non-agricultural job opportunities and restricted market facilities, the population growth in the 1960s-70s was affected by emigration and a consequent decline of agriculture in the region (Barbina, 1979). At the same time, some medium-sized cities, well located with respect to the industrial areas of both north of Italy and central Europe, expanded their economies (Geipel *et al.*, 1990)

At the time of the earthquakes, Friuli was characterized by two different socio-economic contexts. On one hand, there were many small rural villages in economic decline. In fact, because of emigration, most of those engaged in agriculture were elderly people who were no longer very productive (Barbina, 1979). On the other hand, there were a few medium-sized cities where the secondary and the tertiary sectors were expanding. These represented attraction poles for both young people and economic investments (Figure 4.1).

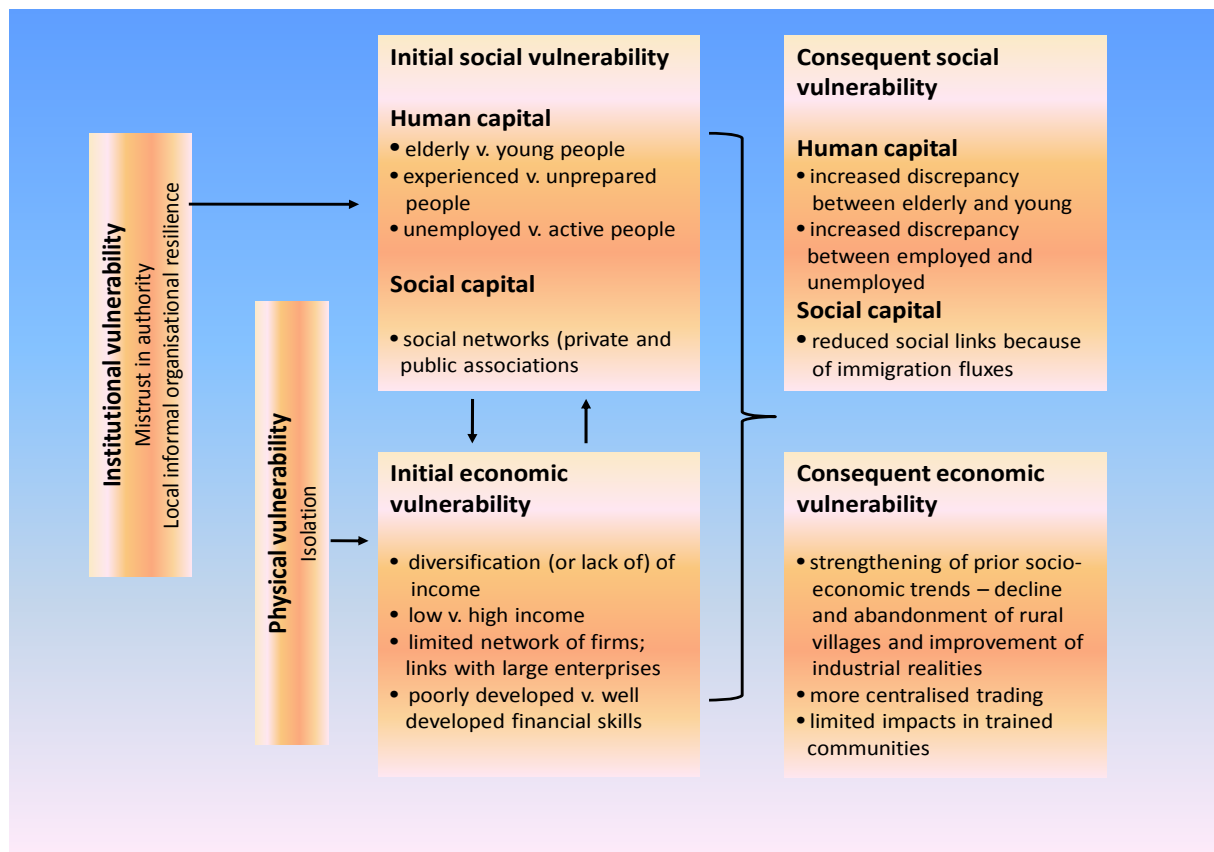


Figure 4.1: Social and economic vulnerability relationships revealed by the Friulian earthquakes

The socio-economic characteristics of earthquake-stricken communities and the socio-cultural features of the population became more relevant over the long term, above all, during the reconstruction after the events. The earthquakes simply encouraged and accelerated previous socio-economic trends (Cattarinussi, 2009). However, social vulnerability played a crucial role also in the aftermath of the disaster. This is also the case of some villages in Yugoslavia, affected by the earthquake of May 1976, where damages were less and community response was superior because of a major risk awareness by lay people (Cattarinussi, 2009).

Social vulnerability

The Friuli earthquakes demonstrate well how human and social capital shape social vulnerability (see Figure 4.1). Individuals in the more isolated, under-developed rural 'marginal' areas may be characterized as under-developed human capital: generally their level of educational attainment and their transferable skills are low. They are likely to have had a higher level of social vulnerability compared to those living in less marginal areas in the rest of the region. The presence of many elderly people with limited physical capabilities was also principal factor that influenced the level of human capital development. In contrast, the younger age profile of the urban areas appears to have reduced their social vulnerability.

However, Friulians were also characterized by a high level of a particular type of social capital which cushioned or lessened their social vulnerability, making the process of reconstruction easier. In fact because people lived in a border area, dominated by various powers in the past, this appears to have encouraged a sort of solidarity and cohesiveness among people (Geipel, 1979). This feature implies the existence of strong social networks in the form of public and private associations which had a leading role in seeking action during the reconstruction (Cattarinussi and Tellia, 1978). The situation in the Yugoslavian villages demonstrated the crucial role of training in reducing social vulnerability by increasing human capital. Here, the existence of a community that was properly trained to deal with emergencies was the main social factor that limited the impact of the event, thanks to the effective preventative measures being taken and emergency responses being made.

Economic vulnerability

The economically marginal areas were typified by economic factors which increased their economic vulnerability. These factors were a dependency on income from only one sector (agriculture), high unemployment and low incomes, a limited network of firms and leadership by elderly people with limited resources in finance and innovation. In contrast, urban areas were characterized by economic factors which created a sort of economic resilience. These factors were diversity of income sources from various secondary and tertiary activities, employment of many young people with high skills in investment and innovation, higher incomes and, finally, strong networks and linkages among firms.

Social and economic vulnerability influences

Various linkages can be identified between social and economic vulnerability (Figure 4.14). First, social vulnerability clearly affected economic vulnerability in the case of Friuli. Comparison between the impacts of the earthquake in Friuli, Italy and in Yugoslavia highlights how well-developed human capital - in this case represented by people's earthquake risk awareness - influences the level of economic vulnerability and consequent economic loss. Overall, losses were less in Yugoslavia compared with Friuli, partly because of contrasting human awareness and disaster preparedness. Institutional vulnerability in the form of mistrust in authority was a key influence on initial social vulnerability (Figure 4.14). Both the isolation of rural villages, and the fact that Friuli is a border area with a history of separate development and political domination from the region and state, led to a pre-earthquake situation in which people distrusted authorities (Geipel, 1979). Instead, they created a social cohesiveness in which local informal systems of government, represented by economic, civic and professional organisations, developed at the expense of local, regional and central government authorities. This is a partially counter-balancing institutional resilience. Being cognisant of this situation, the central government authorities elected to undertake the post-disaster reconstruction at the local level by leaving the responsibility to municipal government. But in practice, the local informal organisations led the reconstruction process rather than the local government. This led to patchy reconstruction activity which is where institutional vulnerability consequences are evident. Where local organisations were strong in the larger settlements, national financial assistance was well utilised, but in rural

villages the opposite was the case so that divergence in economic fortunes took place as a result of these social and institutional processes.

Urban-industrial areas were characterised by comparative economic resilience (i.e. lower levels of economic vulnerability than in the rural, agricultural areas). In the urban-industrial areas, national funding and large private investments (mainly by trade unions) were made in reconstruction in local economies which were already comparatively economically resilient. The similarity with the position of post-2003 wildfire Canberra, discussed above, is apparent. The result was rapid reconstruction and rapid growth of employment, which in turn limited the dangers of out-migration. This acted as an attraction for both migrants from Friuli and for further investments (Cattarinussi, 2009). Economic resilience cushioned the impact of losses. It also encouraged a vigorous process of reconstruction which in turn increased social and economic resilience. In contrast, in those municipalities with a lower level of economic resilience (i.e. higher economic vulnerability), the economic and social situation worsened. Here, the elderly composition of the population, the shortage of entrepreneurial and financial skills, slowed rather than prevented the reconstruction. The disaster accelerated the emigration process that was already under way. The loss of job and house, and the death of relatives, acted as a motivating force to migrate away from Friuli (Geipel, 1979). To summarise this is an example of how economic vulnerability causes consequent social and economic vulnerability.

Finally, the nature of reconstruction transformed the hierarchical structure of regional trade centres. Because of the earthquakes, in some middle-sized cities commercial activities were severely adversely affected and came to a standstill. In turn, this forced smaller centres to bypass trading with these middle-sized cities and to establish new trading dependencies with the large urban areas. This economic behaviour caused the decline of commerce in the middle-sized cities (Barbina, 1979).

5 Volcanic hazards

5.1 A case study of economic and social vulnerability in and following the volcanic emergency in Montserrat, 1995-1998

The small Caribbean colonial island of Montserrat is a self-governing UK Overseas Territory (Figure 5.1). From 1995 onwards its population experienced a protracted volcanic emergency. Prior to this, apart from periods of low level activity, the volcano had been dormant since the last eruption in the 17th century and the main response was to ignore it. The volcano is now classified as being 'persistently active'. Pre-eruptive activity began in 1989. Subsequently a largely unanticipated eruption of the Soufriere Hills volcano began in July 1995 and lasted until November 1998. The July 1995 eruption led to evacuation of the island's administration and population from the capital, Plymouth (Figure 5.1).

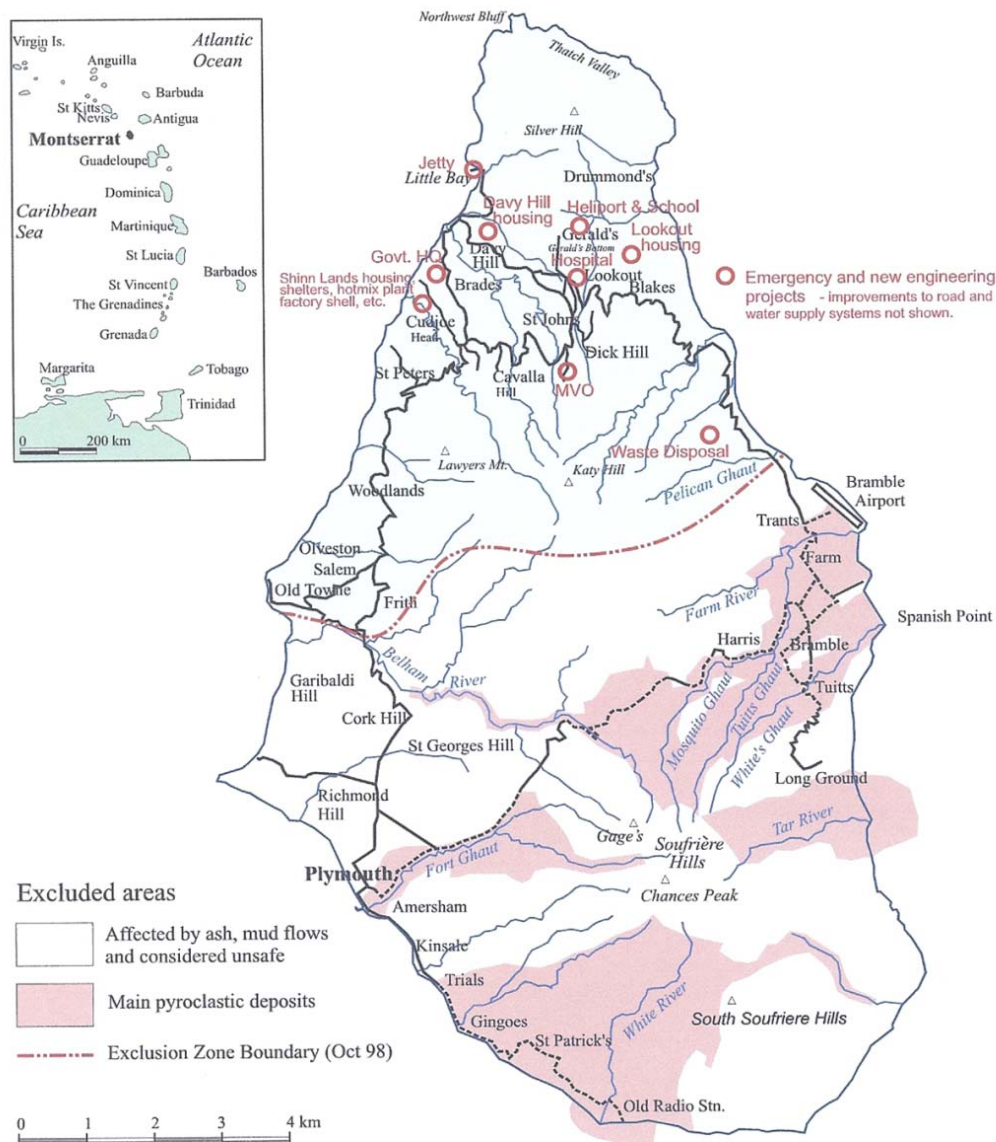


Figure 5.1: Location of Montserrat in the Caribbean and its Soufriere Hills volcano in the south of the island. Also shown are the main pyroclastic flows in the 1995-1998 emergency (from Clay *et al.*, 1999).

They returned after September 1995, but in 1997 violent, destructive events resulted in a second major crisis of evacuation. This time the main pyroclastic flow buried much of Plymouth with 19 confirmed deaths. Volcanic activity diminished in 1998 when the rehabilitation and reconstruction process commenced. However, subsequently new magma ascended and a new lava dome appeared. At the end of 2006, further pyroclastic flows caused people living in the lower Belham valley (Figure 5.1) to be evacuated, and in July 2008 a further major eruption generated pyroclastic flows which again reached Plymouth. This case study focuses mainly upon the 1995-1998 period which coincides with the emergency response period (Clay *et al.*, 1999) (Figure 5.2). The UK Department for

International Development commissioned a critical evaluation of Her Majesty's Government's (HMG) (i.e. the British government) response to the crisis and this is acknowledged as our prime source (Clay *et al.*, 1999).

Inherent physical vulnerability and the physical impacts of the volcanic activity

Being in a geologically unstable area, Montserrat is inherently physically vulnerable to volcanic activity. This vulnerability is magnified by the island being so small (63.7 sq.kms) and comparatively isolated from the UK (Figure 5.2). The size of the island severely constrains response options (Figure 5.3). In 1989, Hurricane Hugo vividly demonstrated the island's physical vulnerability, and severely damaged 90% of the island's buildings. Following the volcanic events, over 60% of the island is now an Exclusion Zone (Figure 5.2) and is unsafe for human habitation or activity. More than 15 per cent of the island has been affected by pyroclastic flows and lahars. Massive ash and rock fall deposits cover most of the southern and western side of the island south of the Belham River. Over 70% of the island's buildings were lost, including much of Plymouth. Most of the most productive agricultural land has been lost or made inaccessible. Human settlement is now spread in a ribbon development around the north of the island, considered to be relatively safe, whereas it used to be mainly in the south. The island's engineering capacity was insufficient to construct barriers to the movement of volcanic material, as happens in some other volcanic crises (see Gregg *et al.*, 2008). These structures require complex engineering and were judged to be impracticable (Montserrat Volcano Observatory *et al.*, 1998). Instead, evacuation to the higher north of the island provided safety.

Major volcanic events/threats	Impacts	Responses designed to reduce social and economic vulnerability	Timeline
First volcanic activity		British military team formulates evacuation plan	July 1995
First eruption		5000 evacuated from Plymouth which is reoccupied 3 weeks later	August 1995
First pyroclastic flow		6000 from Plymouth re-evacuated to the north, re-occupied 4 weeks later.	December 1995
First magmatic Explosion	Houses destroyed	Plymouth—re-evacuated for 3 rd and final time – 7000 people – to north of island	April 1996
Main period of pyroclastic flows, explosions and ash falls	19 killed, airport closed	Revised risk map creates large Exclusion Zone in south	August 1996
Largest explosive event	Much of Plymouth destroyed	Exclusion zone extended	September 1996
Volcanic activity reduces significantly	2/3 rd of pre-eruption population have left the island	Hospital upgrading project	May – July 1997
Resumption of volcanic activity	Govt. poverty survey shows vulnerability has increased	Project to develop education, training, health and community services	August 1997
Danger throughout of a cataclysmic event which would also threaten neighbouring Guadeloupe	Population decline of 42% since 1991 revealed	Project to provide sheltered accommodation for particularly vulnerable groups e.g. mentally ill	September 1997
Pyroclastic flows	Lower Belham valley evacuated	Tourism development project	December 1997
Major eruption	Effects reach Plymouth again	Little Bay (new capital) and port development project	March 1998
		Revised risk assessment	May 1999
		Crisis programme to support occupation of north of island: immediate housing	November 1999
		UK spend is now £58m on emergency aid	2000
		Assisted Passage Scheme commences	2001 Census
		Water storage and distribution project	Post 2001
		Private sector development project	December 2006
			July 2008

Figure 5.2 Major events and impacts, and responses designed to reduce social and economic vulnerability following the volcanic crisis on Montserrat

The contribution made by institutional vulnerability

Montserrat's strategy for dealing with its vulnerability to a volcanic crisis was entirely reactive: i.e. reacting to changing levels of risk as they were identified. Such a strategy places enormous importance on scientific monitoring and risk assessment. However, in hindsight, the procedures were found to be completely inadequate to ensure that any increasing volcanic risk would be sufficiently well anticipated and then effectively monitored. In consequence, the crisis was largely unexpected and unplanned for by the government and public (Figure 5.3). Monitoring was inadequate, surprisingly little was learned from the hurricane disaster which preceded the volcanic crisis and revealed vulnerabilities, and scientific input to policy was lacking. Seismic monitoring and volcanic preparedness were accorded a low priority. These institutional shortcomings were effectively transferred to the population and economy of the island when the volcanic activity occurred and served to deepen social and economic vulnerability. Other institutional vulnerabilities emerged during the crisis, including that deeply rooted racial and political relationships complicated response (Haynes *et al.*, 1998). Also the UK government had no contingency plans for a disaster of this nature which contributed on occasions to uncoordinated and slow responses. In addition, in hindsight, slowness of some aspects of the emergency response transferred institutional vulnerabilities to the most socially and economically vulnerable inhabitants.

Social characteristics, social vulnerability and social impacts

Montserrat was first settled in 1632 from Saint Kitts, and the earliest colonists were English and Irish (Messenger, 1975; Fitzgerald and Fergus, 1997). The island became a haven for Irish Catholics escaping religious persecution. They came as indentured servants and slaves as a plantation economy and culture was established. Eventually black African slaves outnumbered the Irish. The pattern of social stratification that emerged after slavery ended remained relatively unaltered up to 1995. Lower socio-economic groups predominated: blacks with poor skills and a precarious relationship with permanent employment. Many relied upon subsistence farming. Prior to 1995, the middle and upper socio-economic groups were primarily salaried employees or civil servants, with at least one domestic servant per household. The highest socio-economic groups were white or light-skinned and the owners and managers of large estates, expatriate colonial officials, large merchants etc. There were no poor whites. Gender roles were rigid in the lower socio-economic groups (Irish, 1991). Educational services were, however, relatively well developed prior to 1995: most children attending primary and secondary education, and the University of West Indies had established a higher education presence on the island. Medical services were also relatively well developed.

The reliance of the poor on subsistence farming, their undeveloped skills and the social and economic inequalities which existed prior to the volcanic activity which began in 1995, meant that a predominantly black, lower class which made up 90 per cent of the island's population, was particularly vulnerable to the impacts of the volcanic activity. They were severely affected by loss of settlements and their homes, fertile farmland, subsistence farming livelihoods and to the major family and social disruption and trauma which ensued. In addition to the deaths of 19 people, the social fabric of the island was torn apart by a

substantial population exodus. Family and neighbour relationships, and social networks, were shattered with untold consequences. The population fell from 11,500 to 3,000 and has since stabilized at around 4,500, but many of those remaining have had to move to the north of the island. 90% of Montserratians were forced to relocate or emigrate. 35 per cent migrated to the UK and 25% to other Caribbean locations (Figure 4.17). Although there have been some returnees, some aided by a government return air fare scheme, many are not minded to return to Montserrat. Much of the public infrastructure and physical manifestations of social capital were destroyed, and with this public services on which the most socially vulnerable relied were suspended for lengthy periods before they could be restored (Clay *et al.*, 1999).

The most obvious social need has been for accommodation and social assistance for those who had lost their homes, livelihoods and savings and who were struggling to survive and to sustain a community and a way of life. Many people had to endure living in crowded public shelters for long periods with no private facilities: this had a detrimental effect on social well-being. Although the distress and loss of general well-being caused by the disaster has had severe adverse health effects, medical evidence indicates that the prevalence of respiratory symptoms, which might be expected from the high concentrations of volcanic ash, are so far relatively low (Cowie *et al.*, 2002). The degree of personal physical vulnerability experienced by islanders was enormous and is illustrated by the interview with Phiona Langevine available at <http://www.spacecentre.co.uk/e-mission/montserrat/interview.aspx> who eventually emigrated to the UK. Her interview identifies the high and escalating level of fear of death which afflicted islanders for many months during which numerous warnings were sounded, leading many of them to become mentally ill and socially vulnerable. Lack of trust in governmental authorities and the world media was also a significant cause of distress, and many were also distressed by conflicting information about which areas were safe and which were dangerous (Haynes *et al.*, (1998). Psycho-social impacts included sense of loss of physical landmarks, such as well-known beaches or vistas, loss of positive feelings (happiness, joy, peace), loss of togetherness and belonging, loss of lifestyle, loss of control, loss of connection to history and the past, and loss of connection to one's dreams of the future (Ring, 2002).

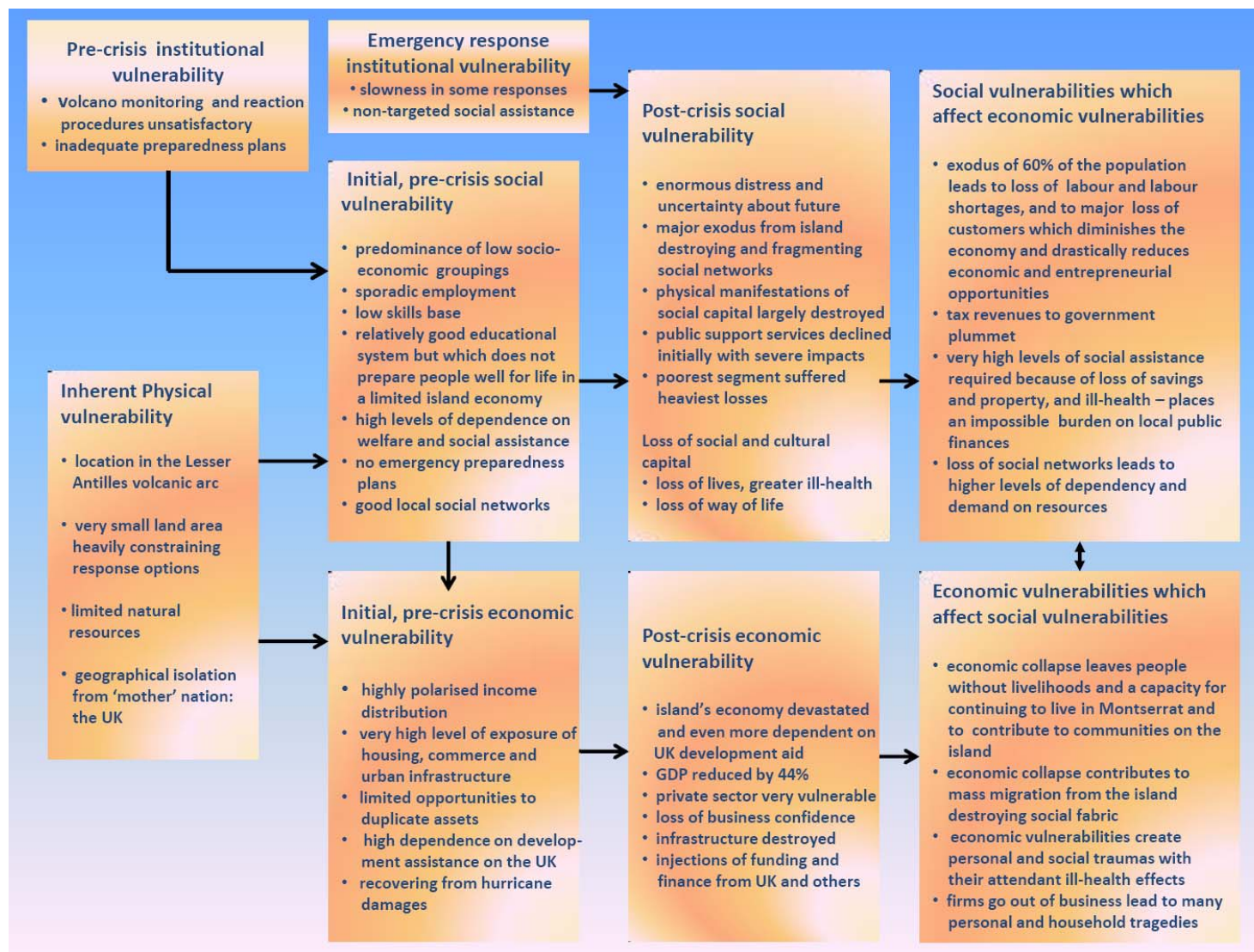


Figure 5.3: Relationships between different forms of vulnerability in the volcanic crisis on Montserrat

Economic vulnerability and impacts

Figures 3.3 and 3.5 suggest examining economic vulnerability from both national and individual viewpoints. Although it has important modernizing constitutional ties to the UK, Montserrat is similar to a very small nation state. During the 1970s and 1980s Montserrat's economy expanded steadily, including through experiments in high-end residential tourism. Prior to 1989, GDP per capita was modest (US\$4,000 or 5,887 Euros). Although by Caribbean regional standards, standards of health, housing and education were relatively high, the least well-off and elderly were among the most financially and socially vulnerable.

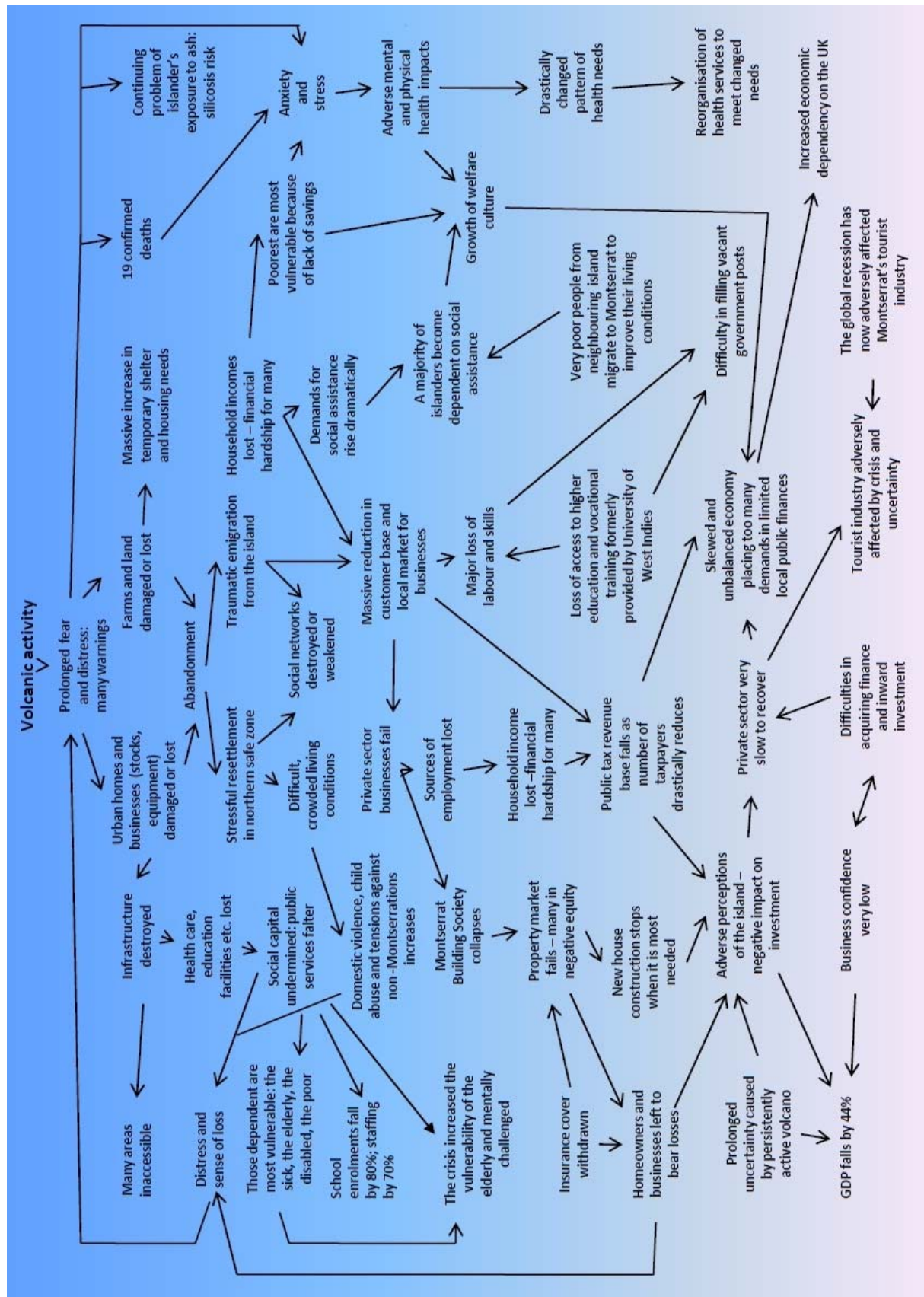
The volcanic crisis has had a devastating impact on Montserrat's economy. There was a 44% decline in GDP by the end of 1997. Most of the types of inherent and non-inherent economic vulnerabilities applied at the national/regional economies scale in Figure 3.5, are exemplified in the case of Montserrat. The island's physical assets and infrastructure proved to be particularly susceptible to the barrage of ash, mudflows, pyroclastic flows and lateral blasts that the volcano produced. The capital city became submerged in volcanic material including ash and has been abandoned. Damage to buildings alone was estimated to be £40m (i.e. 44m Euros) in 1999. The island's production facilities, most notably many of its farms, have been lost along with their fertile farmland – a key element of the island's meagre natural resource endowment. Transportation facilities were destroyed and many areas made largely inaccessible. Overall, the total capital loss is estimated at about £1bn (i.e. 1.1bn Euros). The island and its economy are far too small to withstand the effects of the volcanic activity (Figure 5.3). Many firms were forced to close and the real estate market collapsed. The Montserrat Building Society, which provided 90% cent of the island's mortgages, collapsed. Most of the insurance industry withdrew cover at the height of the crisis leaving homeowners and businesses to bear the considerable losses. All of this affected people's ability to cope and to recover without public support, and this has had a negative multiplier effect through the whole economy. There is a pervasive problem of negative equity, and quite apart from the stress and anxiety engendered by the volcanic eruptions and the threats surrounding them, people's financial losses have caused considerable psychological distress and related health problems. The distribution of financial impacts has been very uneven with the poorer segments of society faring particularly badly (Clay *et al.*, 1999) (Figure 5.3).

Historically, the island's economy has been heavily dependent upon UK budgetary and development aid and many of the jobs outside of agriculture have been largely dependent upon finance from the UK. The level and distribution of wealth on the island enhanced economic vulnerability: with average incomes being low and income polarisation being marked. The majority black population suffered various degrees of economic marginalisation mediated by provision of public services and welfare, although some of this has been poorly targeted. Montserrat's economic dependence on the UK has also been a source of resilience in the face of economic disaster, because the UK has provided over £200m (i.e. 221m Euros) of development assistance since 1995 (Clay *et al.*, 1999; DID, 2005). Other assistance has come from the EU and from Caribbean economic alliances.

How economic and social vulnerability affected each other

Figure 5.4 shows how, in general, social and economic vulnerability was fully revealed and deepened by the volcanic crisis which commenced in 1995. Figure 5.4 shows in some detail the very complex interactions between social and economic impacts and consequences which lead to, and also reflect, vulnerability. These interactions appear to be particularly entwined. Pre-crisis social and economic vulnerabilities were present and were contributed heavily to by inherent physical vulnerability. The crisis is on-going (Figure 5.3) but in Figure 5.4 post-crisis social and economic vulnerability refers to the period after the initial eruptions up to 1997. The emerging social vulnerabilities, such as the traumatic breaking up of social networks caused by a) the mass exodus from the island and b) the evacuation from the south to the north, had severe consequences for people and also the economy of the island, including the loss of more than half of the local consumer market and much of its labour force, from which the economy has not recovered. The loss of social capital, both in its physical and social forms, has had a negative impact upon the economy which has been devastated, and in turn this makes it difficult to restore the social capital which has been shrinking. The plight of those remaining increased levels of financial dependence which, without incoming emergency aid from the UK (the underlying guarantor) and others (which has included provision of food vouchers and cash payments), would have placed a further intolerable burden on an economy seeking to recover from the disaster.

The private sector collapsed causing enormous distress. The economic impacts were felt more by those in the private sector than those in the public sector, and the private sector has been slowest to recover. The abandonment of the capital, Plymouth, meant total loss of trading and trading facilities there. Employment opportunities in commerce and industry were also lost across the island as a negative multiplier affected the economy, producing a further round of reduced or lost employment and income earning opportunities affecting people's ability to recover, and affecting stress and health levels amongst the population.



Figures 4.17 and 4.18 do not show the policy-induced, institutional vulnerabilities and resiliences which developed in the post-crisis period as the emergency response and post-disaster reconstruction, largely funded by the UK, without which Montserrat could barely have survived if at all. Figure 4.16 shows the main responses which were overwhelmingly positive in terms of reducing physical, social and economic vulnerability, but which also – paradoxically – introduced a number of policy-induced, institutional, vulnerabilities which sharply and adversely affected particular groups at certain times. The Emergency Investment Programme announced in August 1996 (Figure 4.16) was too slowly implemented so that the housing crisis was not effectively addressed and the emergency jetty was not completed as quickly as it should have been. This forced some people to live longer in public shelters deepening their social vulnerability, and left emergency evacuation arrangements in a perilous position. Social assistance was untargeted so that it may well have not reached the most needy, again deepening their social and economic vulnerability (Clay *et al.*, 1999).

Conclusions about social and economic vulnerability at ‘national’ and community levels

This case study reveals that social and economic vulnerability are caused by physical and institutional vulnerability, and also by the historical, cultural legacy of colonialism and inequality. Paradoxically, the colonial legacy also provided a very effective, vulnerability-reducing, emergency funding and technical assistance guarantor when the crisis arose. Even so these same emergency institutional arrangements contributed to deepening social and economic vulnerability for particular groups at certain times while alleviating vulnerabilities for other groups and at other times. Once again we can observe that vulnerability can be, and often is, highly selective. Social and economic vulnerability is a function of the complex interactions modelled in Figure 5.4 which also reveals systemic vulnerabilities within a territorial vulnerability context. They are also a function of the responses shown in Figure 5.2: they are almost what remain when the effects of responses in Figure 5.2 are ‘deducted’ from the impacts and consequences in Figure 5.4. Social and economic vulnerability clearly influence each other with feedback cycles as shown in Figure 5.3. The Montserrat case also demonstrates types of ‘national’ economic vulnerability, albeit in a tiny national context, as well as community, group and personal level vulnerabilities.