Mitigating cascading and compounding hazards in the time of pandemic

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Key Messages

New Zealand is hopeful we are on a trajectory to eliminate COVID-19 and the government is turning to how to stimulate the country's economic recovery. This provides a window of opportunity to target economic stimulus funding in ways that achieve multiple benefits. We know:

- The economic and social impacts of the COVID-19 lockdown and its aftermath are going to be patchy across the country with certain parts/areas of its population being more affected.
- Climate-exacerbated flood hazard risk is still prevalent and there are areas in New Zealand at greater combined risk of potential flooding and pandemic-related social and economic pressures.
- Winter is approaching, with its higher rainfall and risk of flooding for many areas. Should pockets of COVID-19 infections remain after New Zealand emerges from its lockdown period, evacuation efforts for any flood areas could be further hampered by moving potentially COVID-19-infected people or those in isolation, thereby increasing the exposure for at-risk populations.

Identifying areas likely most affected by pandemic-induced social and economic impacts and facing flood hazards can be one way to improve flood resilience and boost the economy in at-risk areas. Using green infrastructure, as opposed to 'bricks and mortar' or grey infrastructure provides further benefits through improvements in water quality and biodiversity while still boosting employment in those areas.

The rapid spread of COVID-19 has created an unprecedented global health, social, and economic crisis. All over the world, governments are seeking to balance the immediate needs of responding to the pandemic with minimising economic damage central to long-term recovery. There is a danger, however, that in our haste to return to a new normal, we overlook the possibility of exacerbating existing risks and hazards.

Disasters can have significant economic consequences, some of which are likely to be magnified by the pandemic. Studies of previous disasters have already shown that the adverse effects fall disproportionately on vulnerable populations, including the poor, elderly, and indigenous and other ethnic groups. A recent news article notes that low income New Zealanders are both more likely to be exposed to the virus and also suffer from pre-existing health conditions, with implications for greater morbidity. Income security and forced unemployment are also a concern, as well as lockdown-induced isolation. Elderly or unhealthy populations can be more difficult to evacuate from disaster zones, and current quarantine and requirements for physical distancing are keeping people apart. Social and physical isolation, particularly among the elderly, poses health risks, including cognitive decline, depression, and heart disease.

Flooding is New Zealand's most frequent and costly natural hazard, and has the potential to magnify the economic, social, and health-related effects of the current pandemic. To help with recovery and enhance long-term community resilience, it is essential to identify those areas facing potential compounding and cascading risk.

KNOWN FLOOD VULNERABILITY

New Zealand is no stranger to flooding and flood risk, due to our mountainous terrain, high rainfall, and extensive coastline. Climate change is projected to significantly increase flood risk. Average annual precipitation across the country is between 600 and 1600mm, with 134mm being

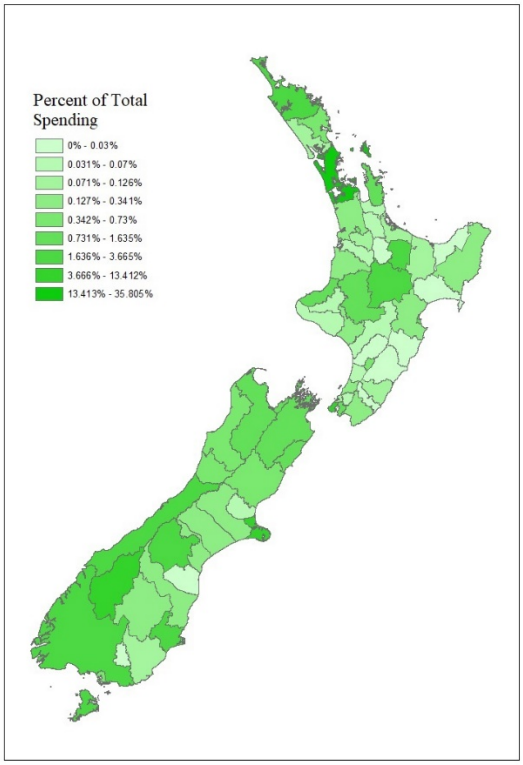
the highest recorded rainfall event in a 1-hour period in 2004.[i] The previous 1-hour highest rainfall event was in 109mm in 2001.[ii] Since 2014, there have been over $300 million in insurance claims from flooding.[iii] Although flood protection used to be managed by central government, responsibilities have been devolved to local and regional authorities' flood schemes, levees, and other measures. The result is a patchwork in the number and efficacy of flood schemes across New Zealand based on assessed risk and councils' financial resources to invest in protection.

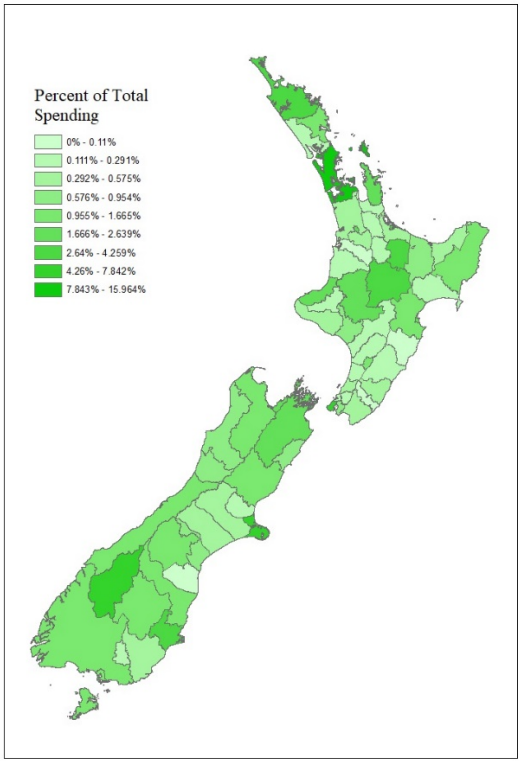
THE PATCHINESS OF PANDEMIC-INDUCED ECONOMIC VULNERABILITY

The current national 'lock-down' to halt the spread of COVID-19 has the potential to entrench existing social and economic vulnerability across New Zealand. Vulnerability here is used to refer to the potential for loss or harm when exposed to stress or hazard. For instance, adverse impacts are more likely to affect places with high un- or under-employment and poor/no internet connection or those with few or no qualifications. For this demographic, job losses are likely to be high or they will be unable to find work during New Zealand's lock-down period (from 26 March, 2020) or in the post-pandemic recession. We acknowledge that some people with no qualifications could also be in essential employment like supermarkets and transport; however, this group may also be exposed to greater risk of infection.

Tourism is our biggest export industry (in terms of foreign exchange earnings) and directly employs one in eight New Zealanders.[iv] The tourism industry, arguably, will be hardest hit during the lock-down and the anticipated 12–18 months of restricted travel as the world races to find a vaccine and other ways to reduce the spread of the virus and future re-infections. Figure 1 uses StatsNZ data to show differences between international and domestic spending on accommodation, at the territorial authority (TA) level. The figure shows TAs that are likely facing economic impacts from travel bans. The picture also shows a few areas that receive more domestic than international travel, such as the central North Island. These areas may perform better after the lockdown has been lifted, but while international travel is still limited. In the South Island, the local economies of Queenstown, Wanaka, and Central Lakes, however, are significantly exposed to the downturn in international travel, with a large proportion of their economies focused on international tourism. It is likely, however, there will be some substitution effects where New Zealand domestic tourism increases with the restricted opportunities for New Zealanders to travel abroad.

Figure 1: Mean spending on accommodation ($ million NZ), international (top) vs. domestic (bottom)





ACCELERATING POST-PANDEMIC ECONOMIC RECOVERY

On 1 April 2020, the New Zealand government called for 'shovel-ready' infrastructure projects from the public and private sector to accelerate construction-related spend.[v] Government stimulatory packages of this sort are expected to fast-track economic recovery.

Flood protection infrastructure should fall into the "three waters" category of projects (drinking water, wastewater, and stormwater) that have received substantial government attention, and could yield national and regional benefits. While it appears government is currently prioritising built infrastructure in its thinking, this could be broadened to include green infrastructure as well. In areas impacted by localized flooding, green infrastructure practices can prevent water from overwhelming pipe networks and pooling in streets or basements, and can reduce the volume of stormwater that flows into streams and rivers, thus protecting the natural function of floodplains, and reducing the damage to infrastructure and property. Green infrastructure, in the context of flood schemes, is likely more enduring, less costly in the long run and provides far greater social and environmental benefits (fostering biodiversity, amenity values and well-being) than 'bricks and mortar' or grey infrastructure. Green infrastructure can provide some labour-intensive jobs for unskilled labour, which is likely a characteristic of areas at higher risk of pandemic-induced economic impacts.

TARGET ECONOMY-BOOSTING PANDEMIC RECOVERY IN AREAS OF GREATER VULNERABILITY

Economic stimulus packages of the nature being discussed by governments should be considering areas of greatest COVID-19-induced economic vulnerability alongside other known disaster risks. This would be an effective way to leverage investments to mitigate the effects of the pandemic with future flood risk, one we know will increase with climate change.

To illustrate potential areas of need, we compare known flood hazard regions with indicators of at-risk populations, based on modified indices of Social Vulnerability.[vi] There are several ways to represent economic and social risk, with several common census variables regularly deployed. However, although individual census variables can capture different aspects of vulnerability, poverty, or resilience, it is difficult to portray a more holistic picture. For instance, there may be areas of high median household income that have other notable vulnerabilities, such as a lack of local job diversity. In areas that are highly dependent on dairy farming, international price fluctuations can cause rapid changes in fortunes. Large proportions of elderly residents can be difficult to evacuate and hence be more vulnerable to flooding risks. Social vulnerability has been described as the product of both social and location-based inequalities.[vii] Both of those factors influence a community's ability to respond to environmental stressors and hazards.

The Economic and Social Vulnerability Index (ESVI) presented here incorporates a range of important Census variables and can be estimated at either the national or regional council level. The ESVI is further differentiated from other similar indices by including Census variables that represent important interactions with environmental variables, such as heat source (gas, bottled gas, coal, wood, electric, solar). If air quality policy is under consideration, it would be important to account for both areas of high air pollution and areas where coal and wood are the predominant heat sources, as local populations may be more sensitive to air quality. The heat source could also suggest areas of potentially greater risk of respiratory conditions, a factor that increases the severity of COVID-19 infections. The ESVI is comparable to other NZ-based indicators, such as the New Zealand Deprivation Index,[viii] and a more in-depth analysis could compare across multiple indices from national and international literatures.

Here, we illustrate how the ESVI can be used alongside flood hazard zones and existing flood protection infrastructure to identify the most at-risk areas in New Zealand where flood risk and potential pandemic-induced economic and social impacts converge. Areas in Southland, West Coast, Waikato and Bay of Plenty are used to illustrate some of the at-risk areas around New Zealand.

Figure 2 shows several figures that use Invercargill-area meshblocks. Panel A is coloured based on the ESVI where the redder an area, the more at risk it is. Panel 2B includes flood hazards in the area (portrayed with diagonal blue lines). That panel shows that there are several meshblocks in the area facing flood risks, illustrating the magnitude of the problem locally. On the other hand, Panel 2C shows where flood protection schemes (portrayed with black cross-hatching) have been implemented. Comparing Figure 2B and Figure 2C, there are some notable areas that are not covered by flood schemes (although there could be other flood protection funded from general council rates).

To better identify larger areas with economic and social risk, we examine clustering of high ESVI scores. Geospatial tools allow the identification of statistically significant clustering of high or low values. These can be combined with flood hazard maps and flood scheme maps to detect areas that might face **both** significant economic and social impacts from COVID-19 **and** potential damage from flooding. Figure 2D shows hot and cold spots of ESVI scores in the Invercargill area, overlaid with the flood hazard and flood schemes

Figure 2A: Invercargill area (Southland) meshblocks and ESVI

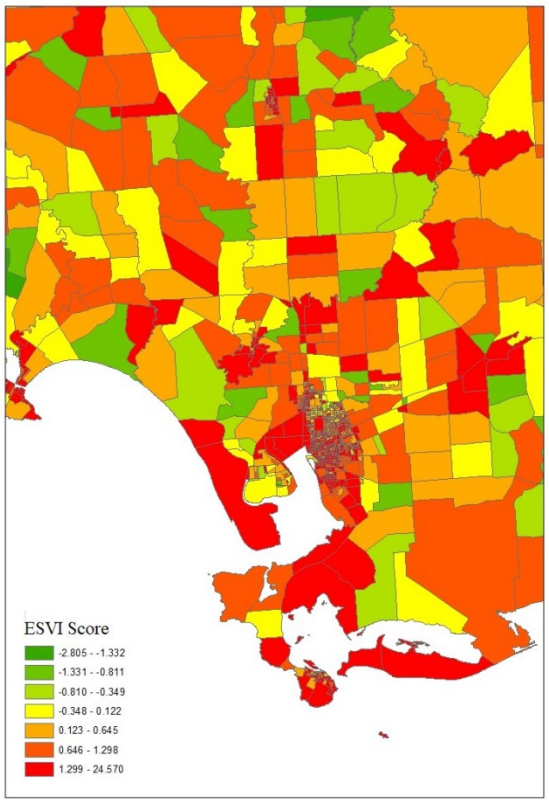


Figure 2B: Invercargill area (Southland) meshblocks, ESVI and flood hazards (blue diagonal lines)

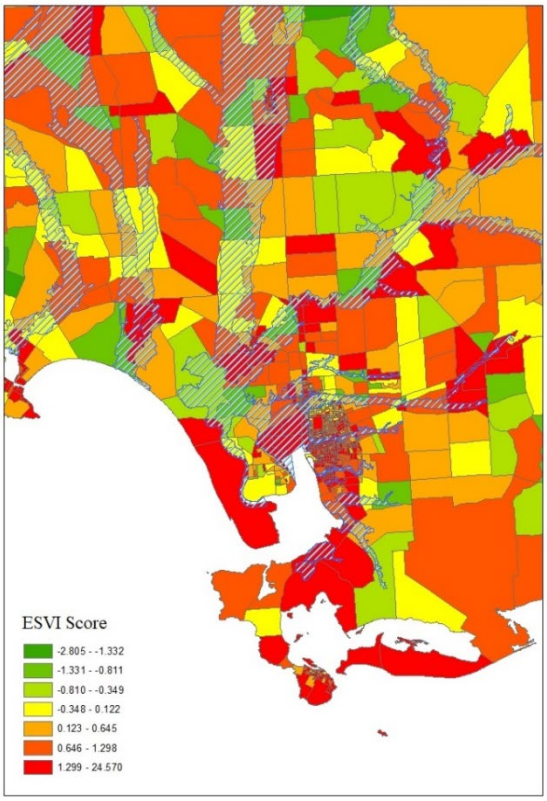


Figure 2C: Invercargill area (Southland) meshblocks, ESVI, and flood schemes (black cross-hatch)

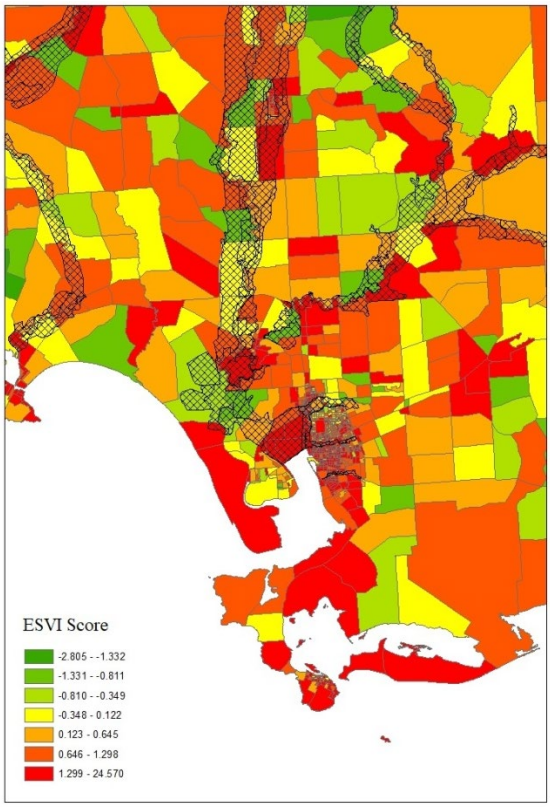
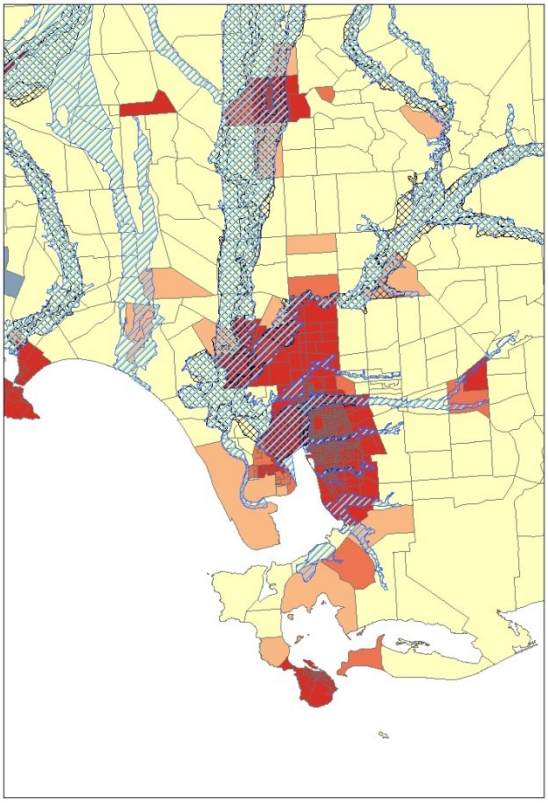
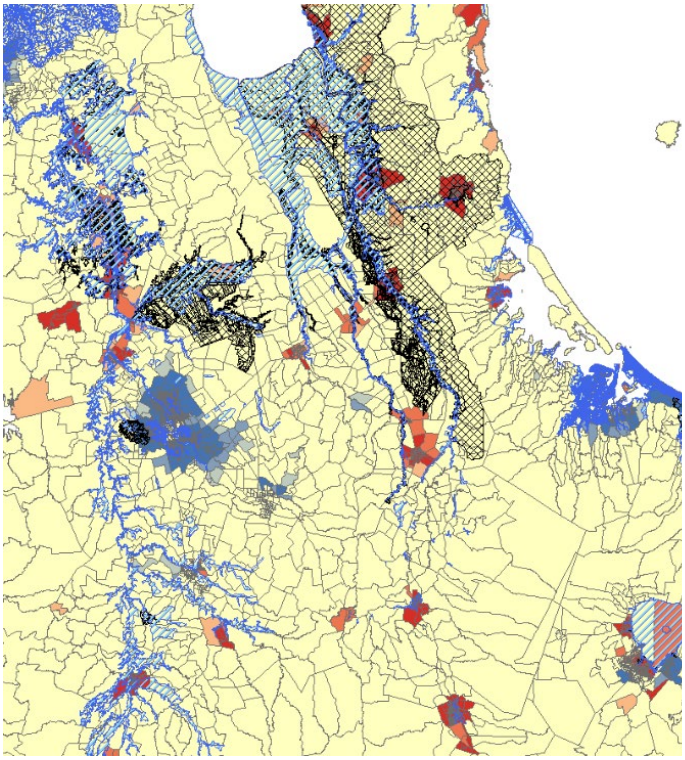


Figure 2D: Invercargill area (Southland) meshblocks and ESVI-based hot spots (red) and cold spots (blue)



In the following maps, we present some of the main intersections of flood risk and clustering of high ESVI scores. For example, Figure 3 shows the central North Island, where the hot spots (red), cold spots (blue), flood hazards (blue diagonal lines), and flood schemes (black cross-hatch) are depicted. The presence of compounding or overlapping flood risk and social and economic vulnerability can be readily identified.

Figure 3: ESVI hot spots and flood hazard in the Central North Island (Waikato and Bay of Plenty)



For instance, in Figure 4, hotspots and flooding in the Tauranga coastal area are presented. There is a peninsula highlighted in red at the centre of the map (which was difficult to see in Figure 3 due to the flood hazards) with significant clustering of high scores and flood risk. Examining the determinants of the scoring, Census data for this area show a high proportion of elderly residents (Age: > 64 yrs). In the event of a flood, they may be immunocompromised, making them more susceptible to infection, and thus needing to maintain some degree of physical distancing; they may also, however, be less mobile in the event of an emergency requiring evacuation, putting them (and emergency service personnel) at greater risk during a flood event.

Figure 4: ESVI hot and cold spots and flood hazard in Tauranga (Bay of Plenty)

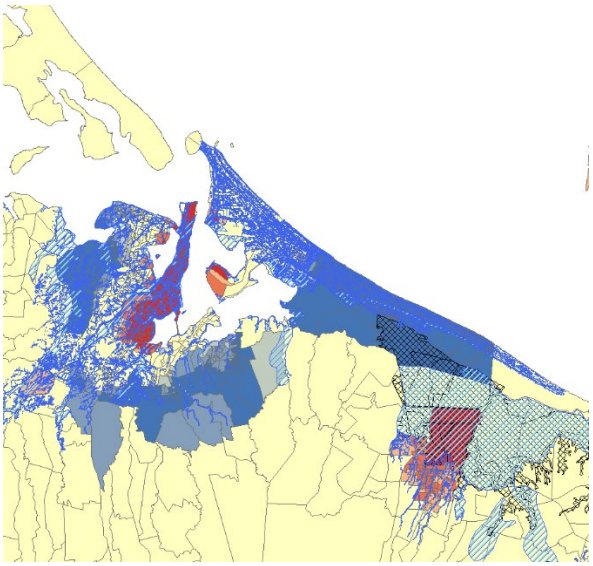
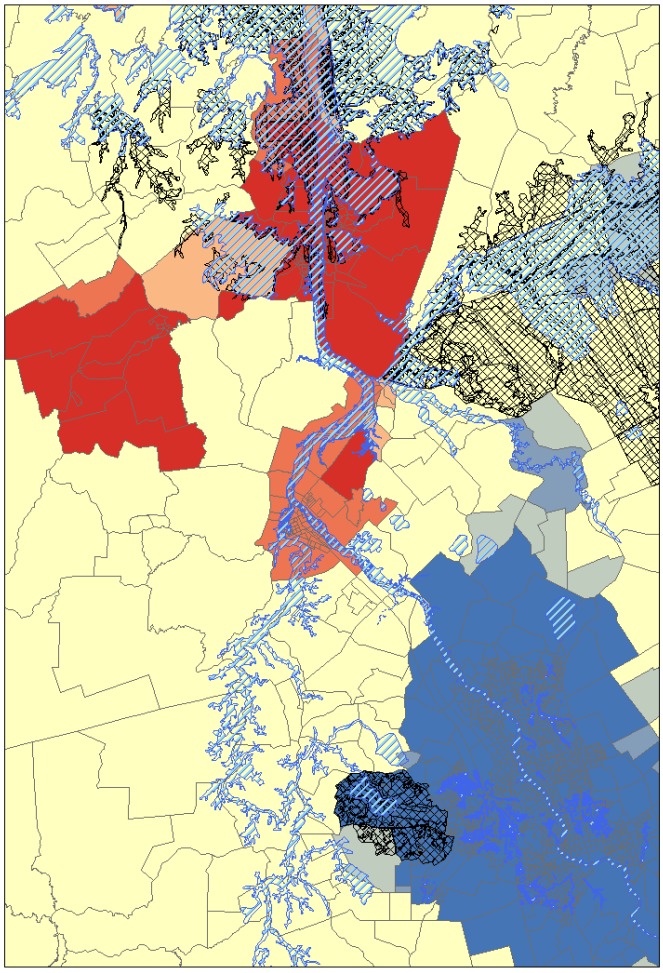


Figure 5: ESVI hot spots and flood hazard in Ngaruawahia (Waikato)

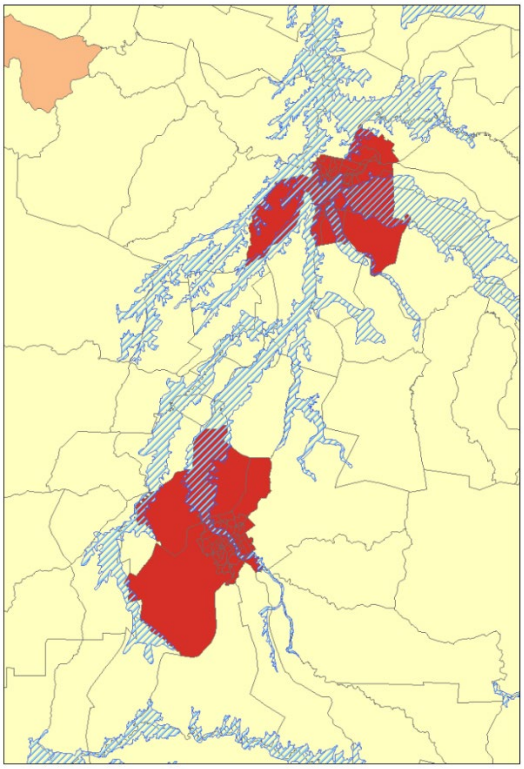


In Figure 5, we zoom into another notable area of the Waikato. In the centre of the figure, Ngaruawahia is a

vulnerability hot spot for flood risk. The drivers of the ESVI are higher than average levels of smoking and a high proportion of residents without qualifications. Economic outcomes for Māori in New Zealand are already typically lower than for Pākehā populations, and this too is likely to be exacerbated by the consequences of the COVID-19 pandemic.

Otorohanga and Te Kuiti, Figure 6, are other at-risk hotspots in the Waikato region. Both areas have a high proportion of the population with no internet access, high level of smoking, and/or no qualifications. Therefore, the community is likely more susceptible to lockdown and post-pandemic economic consequences, as well as to greater risk of complications from COVID-19 infection.

Figure 6: ESVI hot spots and flood hazard in Otorohanga and Te Kuiti (Waikato)



Raphaphe**,** Figure 7, shows a West Coast at-risk example. This area is characterised by a population with few post-secondary school qualifications, limited racial diversity, coal heating, and 3-family households. The West Coast has a lot of international tourism (Figure 1) so job losses and/or employment opportunities may be affected by any restriction on international visitors.

Figure 7: ESVI hot spots and flood hazard in Rapahoe (West Coast)

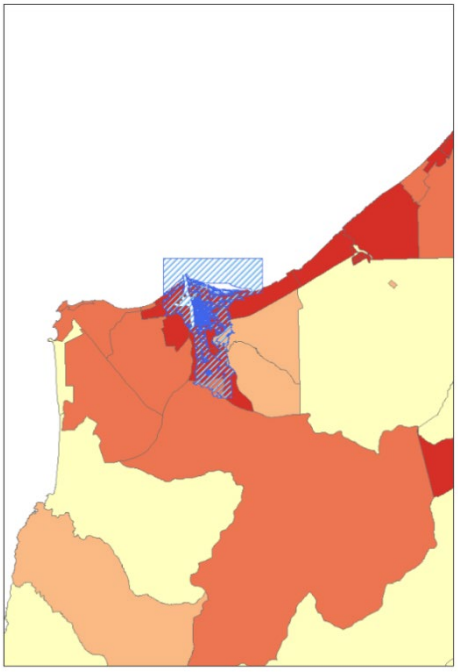
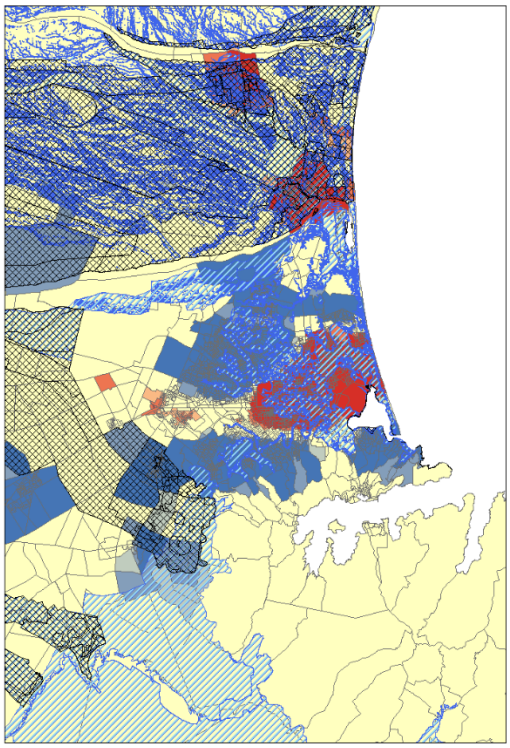
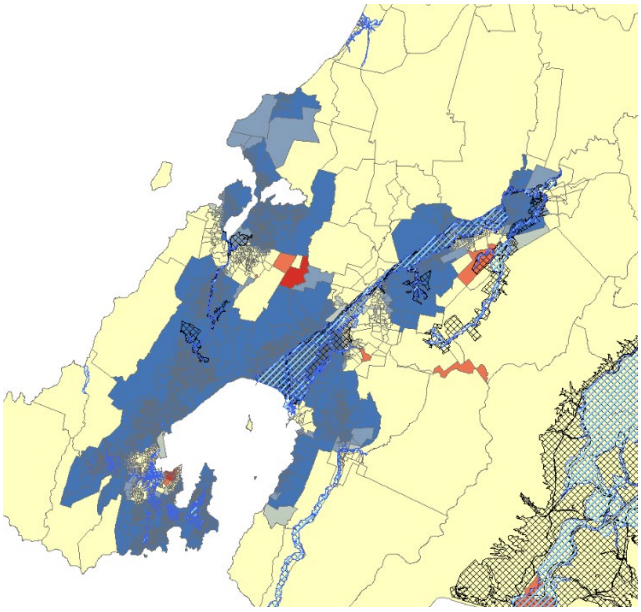


Figure 8: Christchurch ESVI hot and cold spots and flood hazard (Canterbury)



There are also at-risk areas near Christchurch (Figure 8). These are low income areas with larger portions of the population have no qualifications, poor internet access and a high proportion of smokers.

Figure 9: ESVI hot and cold spots and flood hazard in Wellington (Greater Wellington)



Last, we provide an example in the Wellington area of ESVI cold spots (lowest likelihood of social and economic vulnerability) where there is good flood protection infrastructure in the flood-hazard zones.

ENHANCING RESILIENCE NOW AND FOR THE FUTURE

The concept of resilience has been extensively studied and applied in diverse disciplines, from ecology to psychology. While there are a number of interpretations of resilience, they share common features, including the capability and capacity to withstand and recover quickly and effectively from shocks and stressors, by minimising losses in lives, livelihoods, and health and in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries.

In studies of disasters, there has been growing emphasis on the social dimensions of resilience as a result of the large number of major disaster events across the world and a recognition that disasters have a significant social dimension due to their increasingly devastating impacts on local communities. Rapid urbanization and poor development planning, for example, have increased the global exposure of communities to disasters, generating new risks or exacerbating existing risks, all of which have led to a sharp increase in disaster-related losses.

Communities need proactively and consistently to prepare for and mitigate risks to build resilience to the severity of disaster impacts and to recover more rapidly from disaster losses. However, the speed and extent of recovery from disasters often differ significantly across communities, depending on a range of complex factors such as their socio-economic status, the extent of their external support and aid provision, their past experience of disasters, and the nature and severity of the disaster.

Many of the communities in New Zealand most affected by the current pandemic are also vulnerable to climate change and associated water-related hazards. Not only are they physically at risk – due to their location and proximity to rivers, coastal margins, and floodplains – but their vulnerability is related to social and economic factors such as:

- demographic change within communities, including new migrants with limited experience of extreme events or elderly residents who may be less physically mobile
- low income, high unemployment and under-employment, boom-bust cycles and related issues of housing access and affordability
- strained emergency response systems, particularly outside major urban areas, including infrastructure (roads, hospitals and shelters) vulnerable to major events
- specific vulnerabilities of core economic industries (e.g. tourism and agriculture), and
- a high proportion of significant physical and mental health impacts compounded by well-defined health, justice, and social disparities, which are particularly relevant for Māori.

For policy makers and practitioners, resilience is increasingly used to guide efforts on reducing risk and vulnerability from natural hazards. In late 2019, government released the National Disaster Resilience Strategy, outlining the vision and long-term goals for civil defence emergency management, and the objectives to be pursued to meet those goals. Critical to realising the vision of the strategy is understanding the underlying social resilient characteristics/capabilities of communities so as to help them better prepare for and recover from disasters, and enhancing the ability of social entities and social mechanisms to anticipate, mitigate, and cope effectively with disasters and implement recovery activities that minimize social disruptions and reduce the impact of future disasters.

In 1984, the political scientist John Kingdon introduced the concept of window of opportunity or 'policy window' to describe how problems get included in the political agenda through three streams of policy change.[ix] This is no easy task. There are several interacting forces behind the 'opening of a window of opportunity' and its possible exploitation. There is significant complexity when it comes to actors, driving forces, economic forces, what opened the window, why, and when was it closed. Often, what is needed is a focus event, sudden, visible and dramatic. A focus event, suggested Kingdon, makes problems obvious, creating a window for intervention.

There is an urgent need not to let the current crisis go to waste. Undoubtedly, the global outbreak of COVID-19 will have significant social, cultural and economic impacts for New Zealand. While the full extent of the effects are impossible to predict with any certainty, it is clear that recovery will be a long-term effort, contingent in part on how effectively other countries are able to contain the virus, exit lock-down, and reawaken economies. It can, however, also be an opportunity for targeting investment where it is needed most. It can be a window of opportunity to address long-standing needs, to enhance not only the green infrastructure/engineering needed to reduce losses from flood events, but also to invest in building community capability and capacity for preparing for and recovering from future climate change. Focusing on vulnerable communities can pay social and economic dividends for resilience now, and in the future.

IN CONCLUSION

New Zealand is hopeful we are on a trajectory to eliminate COVID-19. However, as we move to boost the economy post-pandemic key points to keep in mind include:

- The economic and social impacts of the COVID-19 lockdown and its aftermath are going to be patchy across the country with certain parts/areas of its population being more impacted. The ESVI can help identify where those patches are likely to be.
- Climate-exacerbated flood hazard risk is still prevalent and there are areas throughout New Zealand that are at greater risk of the effects of potential flooding and pandemic-related social and economic pressures. The intersection of the ESVI hotspots, flood hazard zones, and flood protection infrastructure illustrate the areas of greatest dual risk.
- Winter is approaching, with its higher rainfall and risk of flooding for many areas. Should pockets of COVID-19 infections remain after New Zealand emerges from its lockdown period, evacuation efforts for any flood areas could be further hampered by moving potentially COVID-19-infected people or those in isolation, thereby increasing the exposure for at-risk populations.
- There is a window of opportunity to target economic stimulus spending in areas that provide multiple benefits – stimulating the economy in at-risk areas for pandemic-induced social and economic impacts and improving flood resilience. Using green infrastructure to improve flood resilience provides further benefits through improvements in water quality and biodiversity while still boosting employment.
- Longer term recovery investment can use similar approaches to maximise the wider benefits of any government (and aligned private) expenditures.

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ABOUT THE DATA:

We assess the compounding risk of flood events with the on-going and potential future COVID19 health and economic impacts. We use an economic and social vulnerability index, the ESVI, constructed using 2013 census information (Table 1) at the meshblock level (contiguous geographic units for statistical reporting in New Zealand). The ESVI incorporates aspects from both the New Zealand Deprivation Index[viii] and the Social Vulnerability Index.[vi]

From the ESVI we can identify those at risk from the impacts of COVID-19 including:

- those economically impacted due to unemployed or part-time work status or with no qualifications or internet connection. People with no qualifications are more likely to have jobs that may have been lost during New Zealand's 4-week lockdown period. We do acknowledge that while some people with no qualifications could also be in essential employment like supermarkets and transport, they may also be exposed to greater risk of infection. Unemployed or part-time workers are also likely to experience greater job losses and have greater difficulty finding a job. Lack of internet connection also means reduced ability to maintain employment during lock-down or periods of restricted movement.
- populations at greater risk of complications due to COVID-19 infections. This includes people aged over 65 and under 4 years of age, which are the age groups that seem to be at highest risk of mortality with COVID-19. Populations at risk of respiratory conditions can also be identified based on the people who are smokers or in households with wood or coal-based heating.

Table 1: Census variables (2013) included in the Economic and Social Vulnerability Index (ESVI)

No vehicle	*Couples with no children*	*Managers*
Income 20,000 or less	*Ethnicity: European*	*Technical trade work*
Dwelling owned	*Ethnicity: Maori*	*Clerical admin work*
Internet access	*Ethnicity: Pacific*	*Labourers*
Smokers	*Ethnicity: Asian*	*Heat: Electric*
Married	*Bachelor's degree*	*Heat: Gas*
3-Family households	*No qualification*	*Heat: Bottled Gas*
Male	*Full-time work*	*Heat: Wood*
Age group: under 4	*Part-time work*	*Heat: Coal*
Age group: 5–9 yr olds	*Unemployed*	*Heat: Solar*
Age group: 65 plus	*Not In labour force*	

From the flood hazard zones and flood scheme locations, we can identify those areas that are at greatest risk of flooding but have no protection currently in place.

From the StatsNZ data on international and domestic tourism (by territorial authority) we can identify those areas most impacted by the rapid downturn in the tourism industry.

Table 2 provides an overview of the ESVI intersection with flood-hazard zones and flood schemes. In most cases, comparing the areas without flood risk with unprotected flood hazard areas (comparing the first and third columns) suggests that those in unprotected flood hazard areas are more vulnerable. This is indicated by a higher ESVI value in the third column for most regions. However, there are no clear trends across regions between the second and third columns. In some areas, unprotected areas are more vulnerable, in some the ESVI scores are quite similar, and in others the ESVI score is higher in the protected areas. We can, however, identify those areas potentially at risk of pandemic-related economic and social impacts and future flood risk.

Table 2: Mean meshblock ESVI by regional, with and without flood hazard and flood scheme

	No Flood Hazard, No Flood Scheme mean(ESVI)	Flood Hazard, Protected (scheme) mean(ESVI)	Flood Hazard, Unprotected mean(ESVI)
Auckland Region	-0.531		-0.076
Bay of Plenty Region	0.128	0.324	0.497
Canterbury Region	0.104	0.237	0.234
Gisborne Region	0.421	-0.056	0.242
Hawke's Bay Region	0.336	0.150	0.871
Manawatu-Wanganui Region	0.087	0.385	0.367
Marlborough Region	0.463		0.178
Nelson Region	0.072	0.391	
Northland Region	0.294	0.989	0.665
Otago Region	0.324	1.024	0.885
Southland Region	0.775	1.174	0.641
Taranaki Region	-0.038	1.042	0.887
Tasman Region	0.248	0.346	0.203
Waikato Region	0.073	0.497	0.492
Wellington Region	-0.440	-0.347	0.421
West Coast Region	1.256		1.802

[i] NIWA. 2016. Climate extremes. https://niwa.co.nz/education-and-training/schools/resources/climate/extreme (accessed 6 April 2020).

[ii] Brenstrum E. 2006. 'Weather - Lows – depressions', Te Ara - the Encyclopaedia of New Zealand, http://www.TeAra.govt.nz/en/diagram/7771/record-rainfall (accessed 6 April 2020).

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[iv] Tourism New Zealand. 2020. About the tourism industry. https://www.tourismnewzealand.com/about/about-the-tourism-industry/ (accessed 7 April 2020).

[v] New Zealand government. 2020. Government seeks infrastructure projects. https://www.beehive.govt.nz/release/government-seeks-infrastructure-projects. (accessed 7 April 2020).

[vi] Cutter SL, Boruff BJ, Shirley WL 2003. Social vulnerability to environmental hazards. Social Science Quarterly 84(2): 242–261

[vii] *Ibid.*

[viii] Salmond C, King P, Crampton P, Waldegrave C 2005. A New Zealand index of socioeconomic deprivation for individuals. Wellington: U. o. O. Department of Public Health.

[ix] Kingdon JW. 1984. Agendas, Alternatives and Public Policies. Boston: Little, Brown.