Summary Report

Spatial Analysis and Mapping of Community Vulnerability to Natural Disasters in the Hunter, Central Coast and MidCoast regions.

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Prepared by

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For access to the associated Spatial Data Library and User Guide, contact the HJO Environment Division

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The views expressed herein do not necessarily reflect the views of the NSW Government.

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Executive Summary

This Summary Analysis Report (report) provides an overview of the process undertaken to develop a spatial data library for the purpose of identifying relative community vulnerability to natural hazards across the Central Coast, Cessnock, Dungog, Lake Macquarie, Maitland, Mid-Coast, Muswellbrook, Newcastle, Port Stephens, Singleton and Upper Hunter Local Government Areas (LGAs). The spatial data library facilitates the integrated collation and analysis of spatial information datasets (representing population, environmental and natural hazards) that are relevant to identifying the location and relative vulnerability of communities.

The report presents an overview of the outcomes of the analysis process that was undertaken, key findings of which are provided in Table 1 below. Key terms and definitions that underpin this analysis include:

Exposure	Refers to the inventory of elements (i.e. people and assets) in an area in which hazard events may occur. Exposure is a necessary, but not sufficient, determinant of risk. It is possible to be exposed but not vulnerable (for example by living in a floodplain but having sufficient means to modify building structure and behaviour to mitigate potential loss). However, to be vulnerable to an extreme event, it is necessary to also be exposed[1].
Vulnerability	A characteristic of human behaviour, social and physical environments, describing the broad measure to the susceptibility or propensity to suffer loss or damage.
Sensitivity	Identifies the physical predisposition of human beings, infrastructure, and environment to be affected by a dangerous phenomenon due their lack of resistance and/or predisposition to suffer harm. This may also be referred to as fragility.
Adaptive Capacity	The capacity to be flexible, both during and after a disaster as well as to change preparation and response behaviours to disasters in non-crisis periods.

Table 1 Key Findings

Hazard Analysis	Findings
Generic Sensitivity and Adaptive Capacity	The results of this analysis indicate that those communities and infrastructure '*most at risk*' are generally located within the coastal urbanised areas across the project area. This includes areas in the LGAs of Central Coast, Lake Macquarie, Newcastle, Port Stephens & Mid Coast. These areas didn't appear to be clustered (e.g. occurring across a group of adjacent statistical areas), often appearing as a localised occurrence within urban centres rather than a widespread (or regional) issue. Overall, risk was generally well distributed between the LGAs with no single LGA appearing significantly more at risk.
Bushfire	The results of the bushfire analysis indicate that, in general, those communities '*most at risk'* from bushfire are located rural areas. The distribution of higher relative risk in rural areas appears to be quite cohesive with only a few outliers breaking this pattern. Within urban areas

[1] Intergovernmental Panel on Climate Change Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation 2012 https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/determinants-of-risk-exposure-and-vulnerability/

Hazard Analysis	Findings
	this distribution is not as consistent, with a number of isolated clusters of '*elevated risk*' occurring in proximity to areas of lower risk. However, despite these differences it is clear that overall vulnerability to bushfire is highest in rural (bushland) areas. One interesting trend identified is that there is a consistent lower risk 'corridor' from Newcastle to Muswellbrook which reflects the lack of large bushland in this area.
Extreme Flooding	Communities '*most at risk'* from flooding were typically located in areas of low lying terrain, almost exclusively below 10m Australian Height Datum (AHD), with small Statistical Area 1 (SA1) footprints and in proximity to major waterways within the project area. The results show that higher density urban areas near large bodies of water (e.g. rivers, lakes, ocean) received the '*most at risk*' and '*elevated risk*' ratings. Areas located in and around the town centres of Muswellbrook, Singleton & Scone are at a higher elevation, but due to their proximity to the Hunter River and relatively small SA1 footprints, they result in a higher risk score.
Extreme Heat Events	Communities '*most at risk'* from extreme heat events were typically located in the more inland areas of low canopy presence. This trend is again noticeable through the higher risk 'corridor' from Newcastle to Muswellbrook, where there has been substantial development, which had areas categorised '*most at risk*' and '*elevated risk*'. The areas '*least at risk*' were areas of high canopy presence (less development), higher elevation or within coastal communities.
Combined Hazards (Bushfire, Extreme Flooding & Extreme Heat)	This combined risk profile illustrates the '*average risk*' scores recorded against each of the three hazards considered. The combined risk profile aligns well to the bushfire and heat profiles as each of these hazards shared similar results. The 'corridor' from Newcastle to Muswellbrook, along the Hunter River was identified with generally *'most at risk'* and *'elevated risk'.* This is due to the higher scores for flooding and extreme heat in this area from low canopy density and high population density. The areas located along the inland project boundary were also subject to *'most at risk'* due to higher scores for bushfire exposure and extreme heat. The remaining areas subject to *'elevated risk'* were generally well distributed across the project area. Areas identified as '*lesser risk*' were generally coastal and well distributed across the coastal LGAs and the areas identified as '*least at risk*' were the urban areas directly along the coast as these areas have low exposure to bushfire and extreme heat as well as have a higher level of adaptive capacity given investment in these more populated areas.

1.0 Introduction

1.1 Background

The substantial impacts of natural disasters on population health, public health systems and the capacity of emergency service providers are increasingly being confirmed through both direct experience and a growing body of research. Key factors determining the risk posed to communities by natural disasters include[1]:

- **Exposure** refers to the degree that people, their property and infrastructure are in places where they could be adversely affected by an extreme event. An example is where settlements have been placed on the floodplain of a river.
- **Vulnerability** refers to the susceptibility or propensity to suffer negative impacts from a natural disaster. For example, children and elderly people tend to be more vulnerable to extreme heat events. Overall vulnerability is influenced by s*ensitivity* and *adaptive capacity* and these terms are explained in more detail in Section 2.0.

A substantial body of research exists that consistently identifies the influence of climate extremes on the occurrence of climate induced natural disasters[2]. The severity of impacts associated with climate extremes depends strongly on the level of the exposure and vulnerability to these extremes. As a result, more vulnerable community groups (e.g. young, old, mobility challenges) are often disproportionately affected by events of this nature, due to a reduced capacity to prepare, respond and recover to their impacts both in the short term and in response to changes over time.

In recognising this, the Hunter Joint Organisation (HJO), in partnership with member Councils (Central Coast, Cessnock, Dungog, Lake Macquarie, Maitland, Mid-Coast, Muswellbrook, Newcastle, Port Stephens, Singleton and Upper Hunter), NSW Health and the Australian Red Cross, received funding through the Natural Disaster Auxiliary Grants Scheme (a joint initiative of the NSW and Commonwealth Governments) to implement the '*Natural Disaster Resilience Project – Building Community Preparedness*'. Consistent with national, state and regional priorities, this initiative aimed to identify and build the preparedness of communities considered most 'at risk' from climate induced natural disasters across the member Councils. In particular it sought to:

- Use existing spatial information and data to understand the interface between 'at risk' communities and natural hazard exposure;
- Understand the risk perceptions and preparedness of 'at risk' communities; and
- Increase the emphasis on heat wave planning within the region.

1.2 Project Outline & Objectives

One of the core components of the Natural Disaster Resilience Project has included development of a spatial data library to facilitate the integrated collation and analysis of spatial information datasets (representing population, environmental and natural hazards), to identify the location and relative vulnerability of communities most 'at risk' to natural disasters. This directly supports the ultimate objective of the project to identify and build the awareness and preparedness of 'at risk' communities to natural disasters. For the purposes of the project 'at risk' communities have been defined as:

1. Low income households (i.e. under or in proximity of the poverty line);

   Underneath $650 weekly total personal income.

[2] IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21.

2. Very young and elderly communities:
   - People < 5 years of age.
   - People > 65 years of age.
   - People > 75 years of age.
3. People with disabilities; and
4. Culturally and Linguistically Diverse (CALD) communities.

This report provides a summary of the findings that have been generated through development of the spatial data library and analysis of the data it contains. The project area includes the LGAs of Central Coast, Cessnock, Dungog, Lake Macquarie, Maitland, Mid-Coast, Muswellbrook, Newcastle, Port Stephens, Singleton and Upper Hunter Councils (Figure 1).

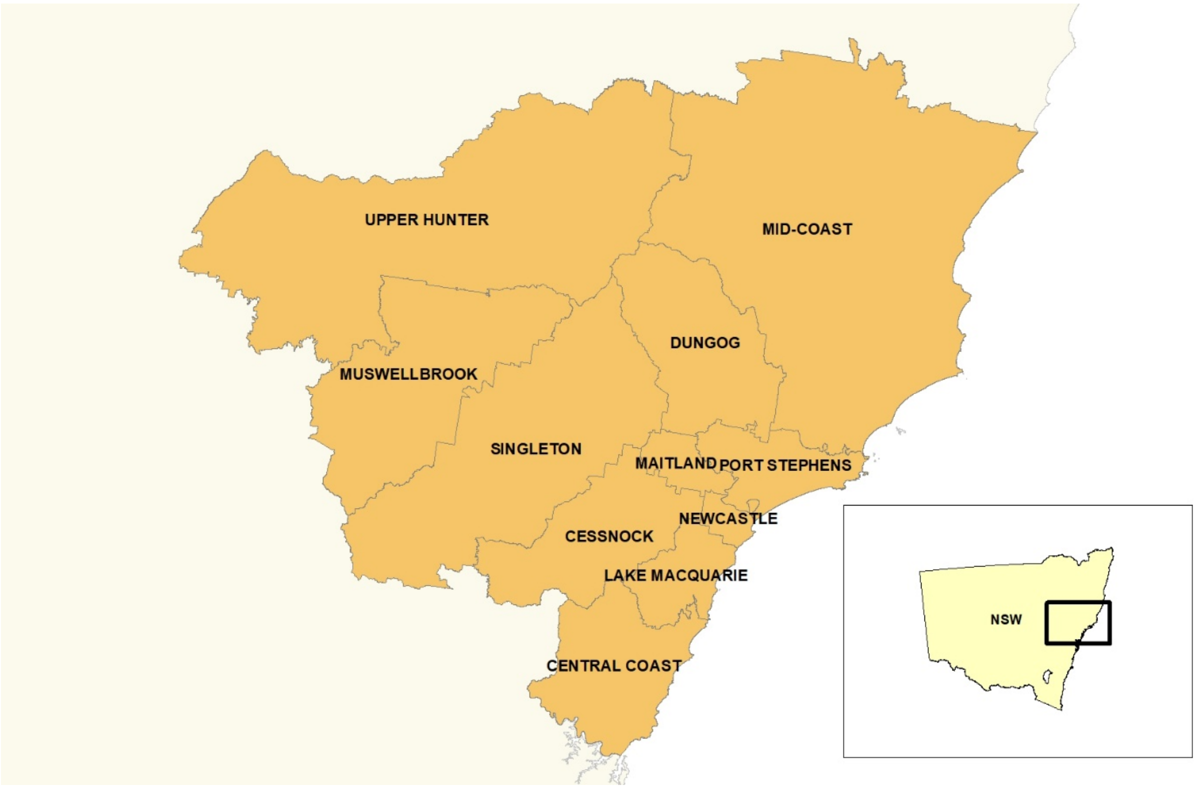

Figure 1 The Project Area

1.3 The Role of Spatial Data in Building Community Preparedness

Previous studies have identified the feasibility of integrating spatial information to identify the location and nature of communities most vulnerable to extreme climate events (AECOM, 2013)[3]. The Natural Disaster Resilience Project has progressed development and application of spatial analysis frameworks and mapping as a process (using a Geographic Information System) to identify and map those communities most vulnerable to natural hazards. Key objectives of this process included:

- Providing an analytical framework for identifying vulnerable communities '*most at risk*' from natural hazards;

[3] AECOM. (2013). Resilience to Natural Hazards in the Lower Hunter - Discussion Paper. Canberra, ACT 2600: AECOM Australia Pty Ltd.

- Assessing exposure of the project area to natural hazards (including bushfire, flooding, and extreme heat events);
- Assessing the relative risk that selected natural hazards pose to vulnerable communities; and
- Providing a tool to assist and better direct future efforts to build the preparedness of vulnerable communities.

The framework that has been developed provides a spatial representation of different socio-economic and biophysical factors which influence community vulnerability. The spatial analysis that has been completed utilised multiple criteria and characteristics including demographics, geographic and land surface characteristics, natural hazard mapping, land use mapping, housing data and statistics focused on medical care and dependency. Three hazards were considered for analysis across the project area.

These include:

- Bushfire;
- Extreme Flooding; and
- Extreme Heat Events.

It is noted that sea level rise was embedded into the flooding data sets provided by Central Coast, Lake Macquarie & Port Stephens councils; however, not provided for any of the remaining council areas.

This work represents an important first step in providing the theoretical and technical basis for more complex and comprehensive future analysis. A detailed User Guide has also been prepared separately which is designed to assist end users in understanding, applying and updating the spatial data library. It includes specific detail on the analysis methods that have been used, along with information on all spatial input data sets and complete metadata statements.

2.0 Key Project Concepts

In order to evaluate the relative risk natural hazards pose to vulnerable communities within the project area, some key terms have been used. These are identified in Table 2.

Table 2 Key Terminology and Definitions

Terminology	Definition
Exposure	Refers to the inventory of elements (i.e. people and assets) in an area in which hazard events may occur. Exposure is a necessary, but not sufficient, determinant of risk. It is possible to be exposed but not vulnerable (for example by living in a floodplain but having sufficient means to modify building structure and behaviour to mitigate potential loss). However, to be vulnerable to an extreme event, it is necessary to also be exposed[4].
Vulnerability	A combination of an asset's adaptive capacity, sensitivity and exposure to climate.
Sensitivity	Responsiveness of the asset to its physical location.
Adaptive Capacity	The capacity to be flexible, both during and after a disaster as well as to change preparation and response behaviours to disasters in non-crisis periods.

These terms define the different elements which contribute to the overall risk a given natural hazard may pose. Figure 2 identifies the relationship between each factor and demonstrates that vulnerability is a function of sensitivity and adaptive capacity.

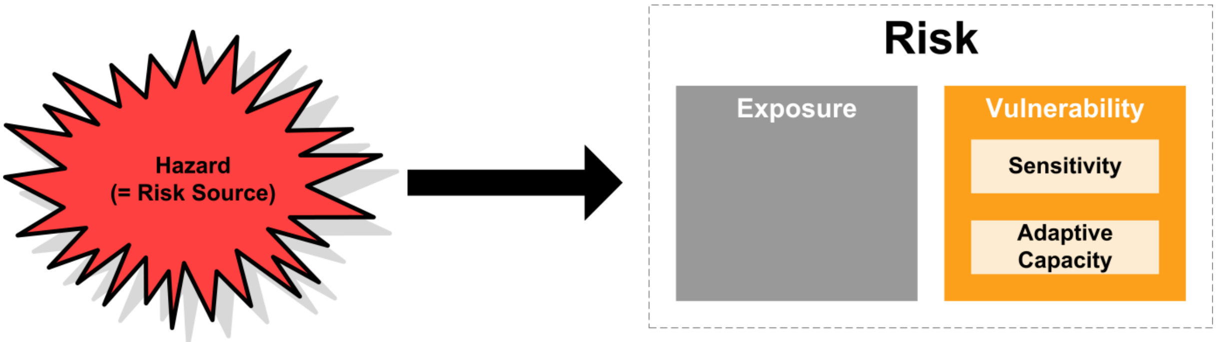

Figure 2 An Overview of the Different Components which affect Risk linked to Natural Hazards

This is further expanded in Figure 3 where it is shown that factors which influence sensitivity and/or adaptive capacity may be generic in nature or apply specifically to the natural hazard considered. For example, homes built according to old building codes may be specifically more *sensitive* to ember attack during a bushfire. However, communities with low mobility (e.g. low vehicle ownership) may exhibit reduced *adaptive capacity* to all natural hazards in a more generic way. This distinction enables generic risk factors to be considered with equal merit across all hazards.

[4] Intergovernmental Panel on Climate Change Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation 2012 https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/determinants-of-risk-exposure-and-vulnerability/

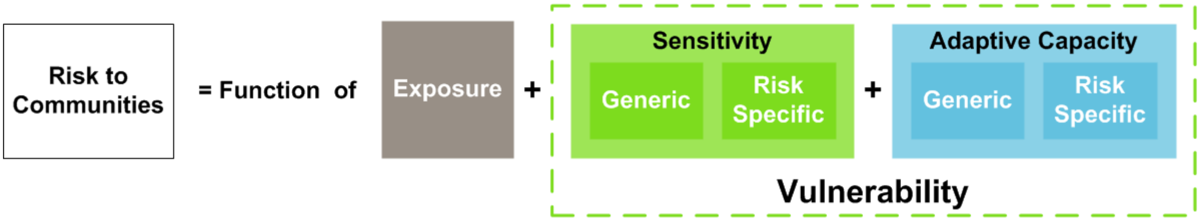

Figure 3 Simplified Equation used to represent the Key Risk Factors which influence Risk to Communities

By identifying each of the risk factors individually as shown in Figure 3 a weighting factor can be applied to those factors considered to be of greater significance. For example, it may be desirable that proximity to bushland (which influences the likelihood of *exposure*) plays a more important role in assessing risk from bushfire than the median household income (an example of *generic adaptive capacity*).

These key concepts form the foundation of all analysis work that has been completed under the project.

3.0 Spatial Analysis Method

The spatial analysis methodology involved collation and review of available data provided by project partners and other stakeholders, from which a spatial data library / database was constructed and populated with information to identify and assess the:

- Exposure of the project area to natural hazards (bushfire, flooding, and extreme heat);
- Location and distribution of communities most vulnerable or 'at risk'; and
- Relative risk each natural hazard posed to vulnerable communities.

During the initial data review process, datasets were linked to relevant hazard and risk factors (e.g. exposure, sensitivity or adaptive capacity) utilising the hierarchy identified in Figure 4.

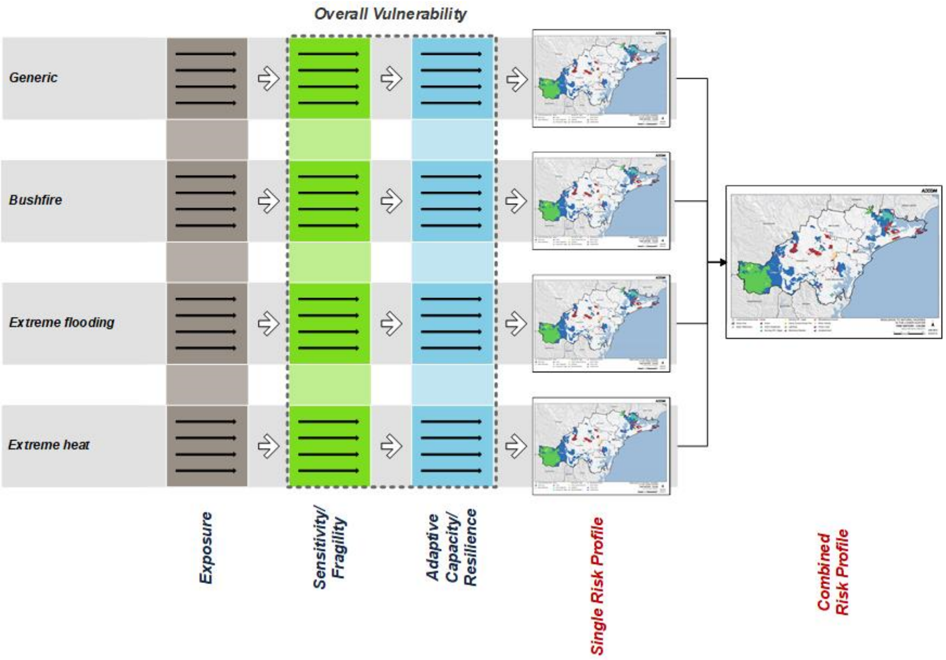

Figure 4 Approach Overview

This approach generated the following outputs:

- **Hazard Specific Risk Profiles** – A series of risk profiles considering each hazard individually; and
- **Combined Risk Profile** – A combined risk profile for the entire project area. This dataset provided a combined risk ranking based on the combined single hazard specific risk profiles prepared for the project area.

In respect to outputs it is important to note that extreme heat was excluded from any analysis other than generic community sensitivity and adaptive capacity. This reflects the absence of available information to accurately assess exposure for this hazard.

Scale of Outputs

All outputs are provided down to a Statistical Area 1 (SA1) scale. These are the smallest geographic regions in which the 2016 Census data is provided by the Australian Bureau of Statistics (ABS). On average SA1s have a population of around 400 people and most are designed to be within a population range of 200 - 800. SA1s are designed to have either a predominantly rural or predominantly urban character. Figure 5 illustrates the breakdown of the project area by SA1s.

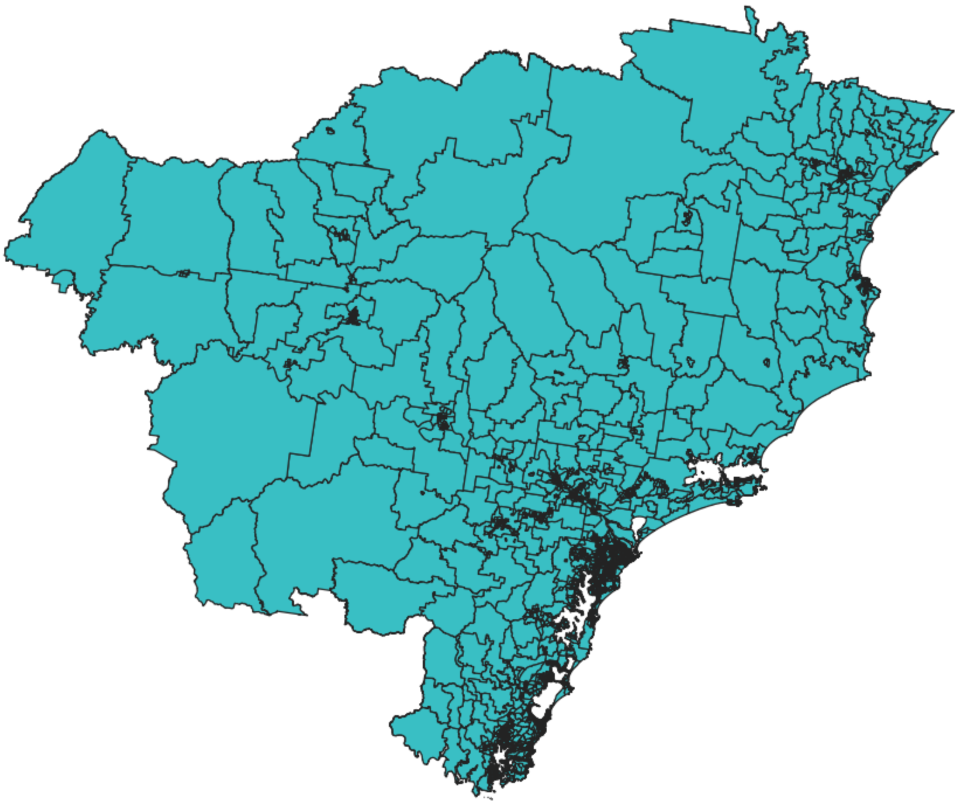

Figure 5 Overview of Level 1 Statistical Areas within the Project Area

Whilst analysis has been predominantly undertaken at the SA1 level, SA2s have also proven useful to aggregate data to a broader scale. On average SA2s have a population of around 10,000 people and most are designed to be within a population range of 3,000 to 25,000. SA2s provide for larger scale analysis than SA1s, providing a general-purpose medium-sized area built from an amalgamation of whole SA1s. Their aim is to represent a community that interacts together socially and economically. Analysing data at an SA2 level has been particularly useful in urban centres where greater variation within SA1s is recorded within relative close proximity. Therefore, aggregating data to the SA2 level has provided an overview of general trends in these locations.

Weighting Factors

Weighting factors have also been applied to the different risk elements used to construct the risk profiles. These were applied in accordance with the outcomes of a similar previous vulnerability analysis project conducted by AECOM & Hunter Joint Organisation (HCCREMS, 2014). Weightings factors were determined based on the representativeness of each element to the overall risk profile and the robustness and availability of data to characterise each element. The generic or hazard specific nature of each risk element was also considered.

An example of a risk specific element is the presence or absence of Neighbourhood Safer Places. These play a role in determining a community's adaptive capacity when responding to bushfire exposure but are unlikely to play a role in assessing a community's vulnerability to an extreme heat event. Conversely the distribution of low household incomes is an example of a generic risk element where a household's economic status is likely to influence their adaptive capacity to respond to many natural disasters in a similar way.

In the above example the relationship between risk specific hazards and overall vulnerability is relatively direct, clearly defined and deals with a short-term outcome (e.g. the availability of shelter during a bushfire). People who are able to seek shelter are expected to be less vulnerable to bushfire and provision of Neighbourhood Safer Places responds to this issue directly. However, whilst it is clear that people with higher incomes may have greater ability to rebound from any given natural disaster the effect is likely to be more long term, subject to the specific circumstances relevant to each natural hazard event.

Based on this premise generic risk factors, which often shared a less direct or measurable influence across all hazards, were given a reduced weighting. On the other hand, hazard specific elements which were seen to have a direct influence on the community's vulnerability to natural hazards were given a stronger weighting factor.

Elements representing exposure were given a higher weighting factor as there was adequate and generally robust data, specific to the hazards being investigated. As exposure is the driving factor behind all risk (there is no risk without exposure) it was important that it was adequately represented in the results. Sensitivity was broadly given a neutral weighting as these factors represented the direct impact of exposure and identifies those communities or services most affected in the relative short term. Factors influencing adaptive capacity tended to be indirect (e.g. social economic indicators) and relative to the resilience and recovery of a community during and following an exposure event rather than its immediate effects.

It is noted that whilst the final weightings were based on some preliminary analysis, all weightings were assigned on a qualitative basis, that is, no detailed statistical or probability-based analysis was employed to refine initial weightings. However, these weighting factors and subsequent analysis could be revised in the future as more comprehensive quantitative data sets become available. The final weightings adopted for the project are provided below:

Table 3 Final Risk Profile Weighting Factors

	Exposure	Risk Specific Sensitivity	Risk Specific Adaptive Capacity	Generic Sensitivity	Generic Adaptive Capacity
Weighting Factor	1.5	1.25	0.75	1	0.5

Once each statistical area had been scored using the risk profile weightings, to highlight differing trends, the distributions of scores were categorised using Natural Jenks on the Combined Risk Profile and applied manually to the remaining layers. Distributions were established separately for five separate classifications (see Table 4) and four separate classifications (see Table 5) to emphasise the extremes.

Table 4 Combined Risk Profile Ranking Distribution with 5 breaks using Natural Jenks

Risk Category	Risk Category	Percentile
1	Least at Risk	0-20%
2	Lesser Risk	20-40%
3	Average Risk	40-50%
4	Elevated Risk	50-70%
5	Most at Risk	70-100%

Table 5 Combined Risk Profile Ranking Distribution with 4 breaks using Natural Jenks

Risk Score	Risk Ranking	Percentile
1	Least at Risk	0-10%
2	Lesser Risk	10-50%
3	Elevated Risk	50-90%
4	Most at Risk	90-100%

When assessing the combined risk profile no bias was provided between any of the three hazards considered (i.e. bushfire, extreme flooding and extreme heat) as these were considered to share equal significance (see Table 6). Applying a different weighting between hazards for this purpose would have resulted in a bias towards a particular hazard. In future weightings may be adjusted based on relative confidence in results between hazard specific risk profiles. For example, where risks associated with a single hazard are better understood it may be desirable to increase the weighting to emphasise risks associated with that hazard in the results. Conversely if there is uncertainty in the results for a particular hazard (e.g. based on limited data inputs or a lack of research) a lower weighting would reduce the influence of risks associated with that hazard on the final results.

Table 6 Combined Risk Profile Weighting Factors

	Bushfire	Flooding	Extreme Heat	Generic
Weighting Factor	1	1	1	1

4.0 Summary of Results

The below summary provides an overview of the results obtained from the spatial analysis and includes:

- A broad analysis identifying the location of relatively more vulnerable communities and infrastructure within the project area;
- An analysis of community vulnerability for each of the three hazards considered; and
- A combined risk profile assessing community vulnerability to bushfire, flooding and heat.

4.1 Relative Community Vulnerability to Natural Hazards

A broad analysis which focused on identifying the location of relatively more vulnerable communities and infrastructure was undertaken. This considered generic sensitivity (e.g. age and health data) and adaptive capacity risk factors (e.g. income data), but not data related to actual hazard exposure (i.e. it assumed equal exposure to hazards across the entire project area). In effect, this analysis aimed to identify relative vulnerability based primarily on demographic data, existing land use and sensitive infrastructure. Further assumptions are detailed in the User Guide.

The results of this analysis indicate that those communities and infrastructure '*most at risk*' are generally located within the coastal urbanised areas across the project area (refer Figure 6 & Figure 7). This includes areas in the LGAs of Central Coast, Lake Macquarie, Newcastle, Port Stephens & Mid Coast. These areas didn't appear to be clustered (e.g. occurring across a group of adjacent statistical areas), often appearing as a localised occurrence within urban centres rather than a widespread (or regional) issue. Overall, risk was generally well distributed between the LGAs with no single LGA appearing significantly more at risk.

One notable point of risk is around the Williamtown area in the Newcastle/Port Stephens LGA as this value was heavily influenced from most of the area containing Newcastle airport & Williamtown RAAF base which hosts a large amount of critical infrastructure for the region thus increasing the risk of exposure.

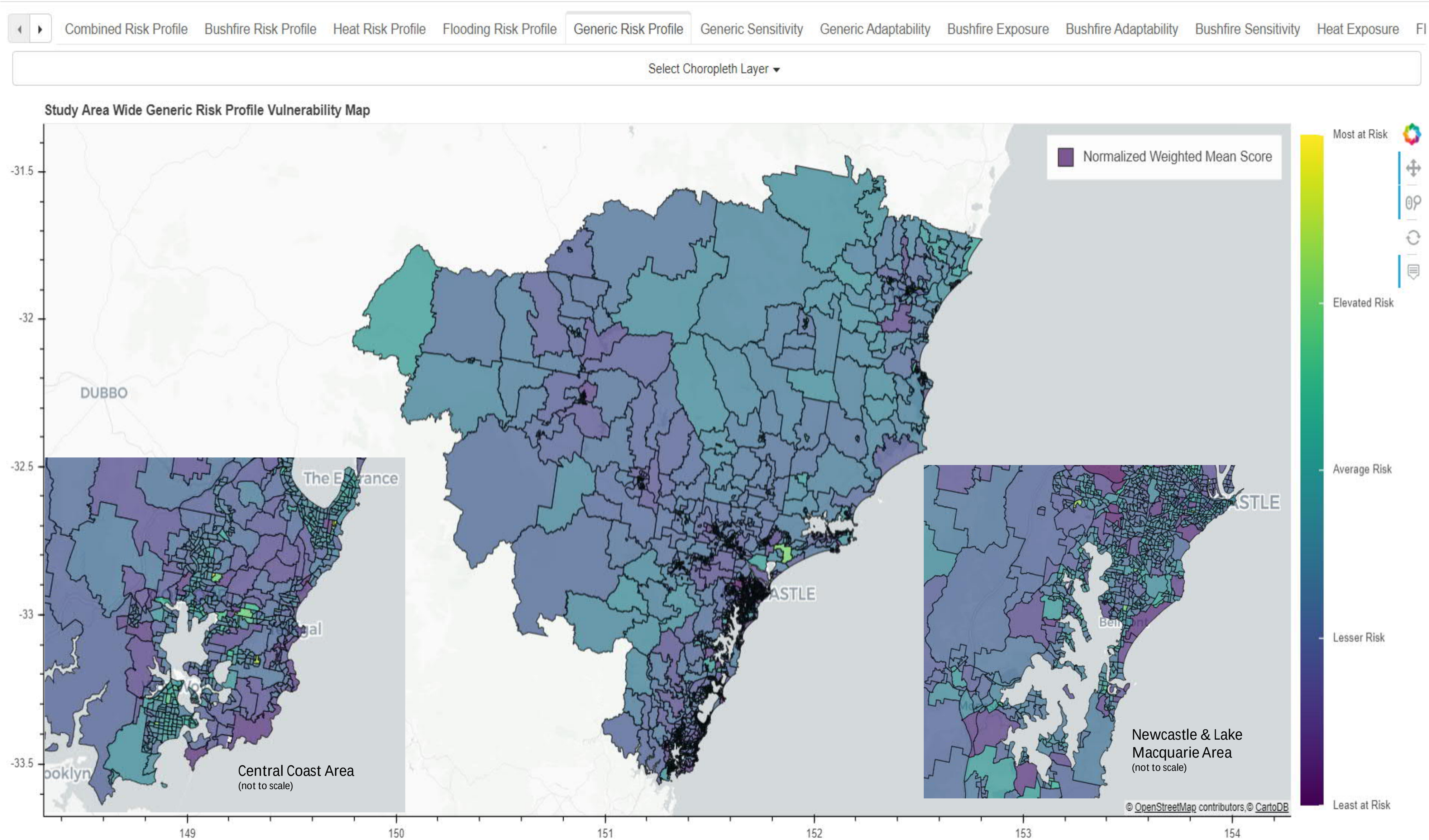

Figure 6 Relative Community Vulnerability – SA1 Level - Generic Risk Profile

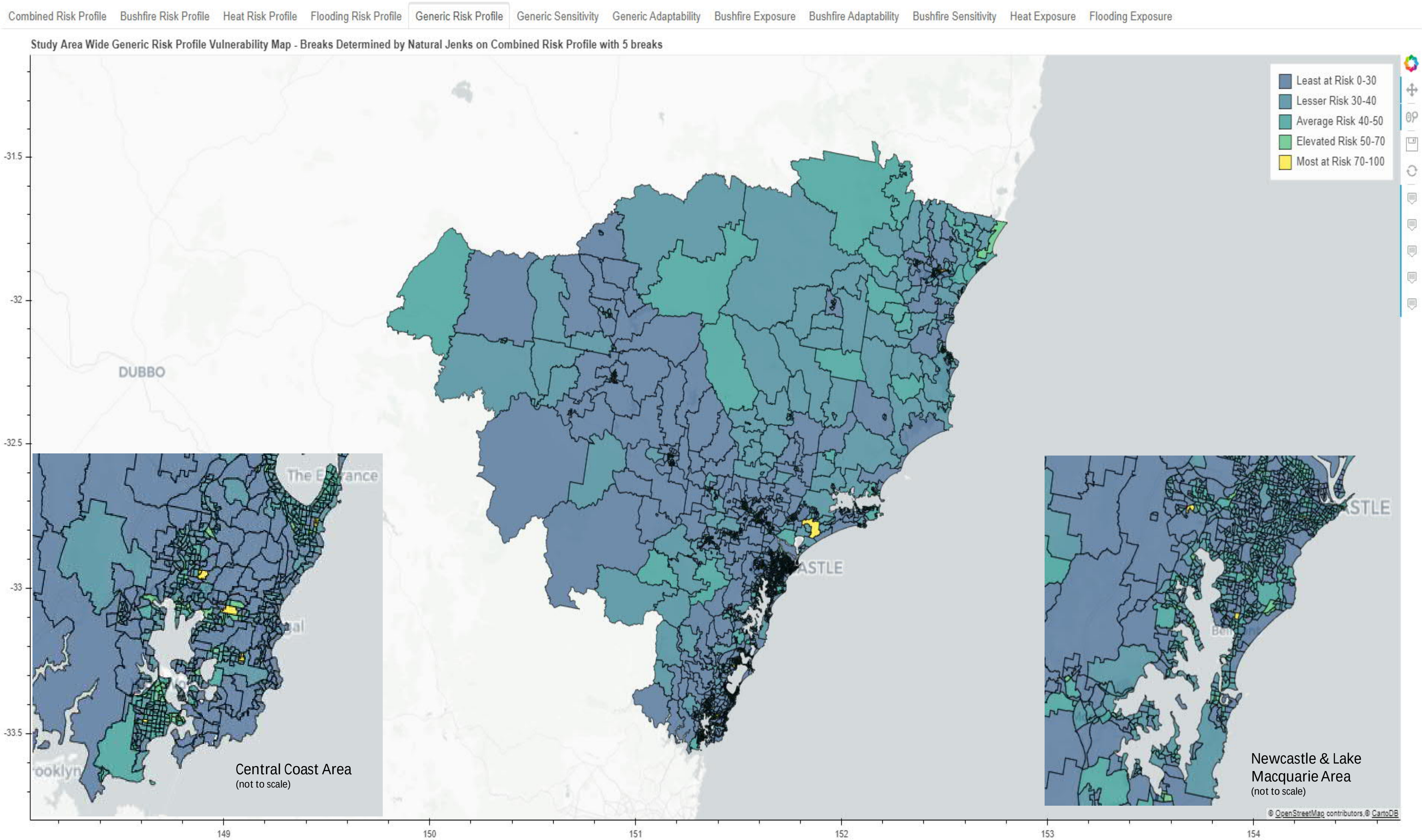

Figure 7 Relative Community Vulnerability – SA1 Level - Generic Risk Profile with 5 Breaks

Generic Sensitivity

When viewed in isolation the sensitivity profile indicates a strong trend towards high risk scores in urban areas whilst rural areas scored very low by comparison (see Figure 9 & Figure 10). Figure 8 provides an overview of the risk factors which contributed to the generic sensitivity scores. Typically, '*elevated risk*' scores in urban areas can be attributed to concentrations of young and elderly in urban centres. It is also noted that several generic sensitivity risk factors including higher population densities, industrial and commercial land use zones and higher infrastructure density are also synonymous with urban centres.

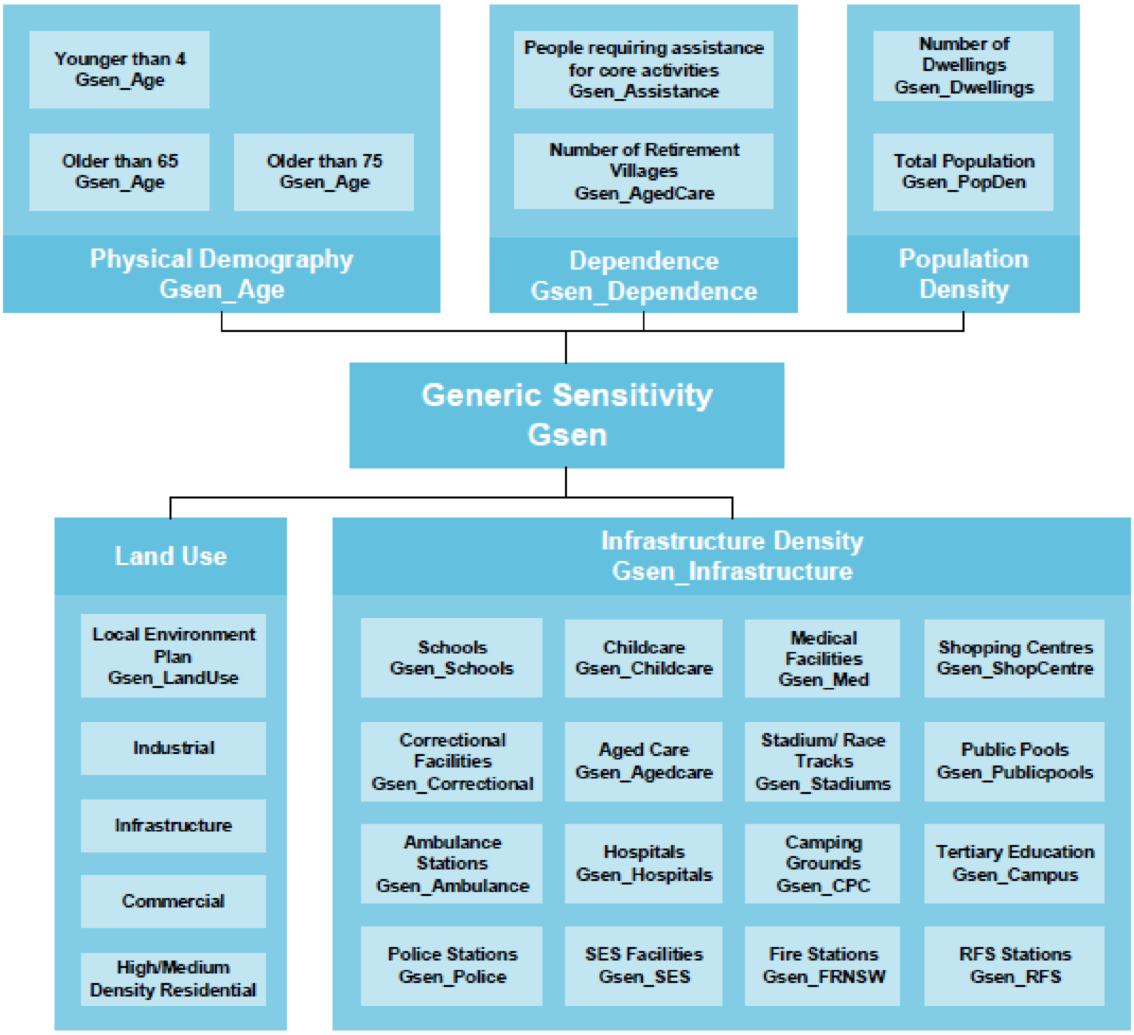

Figure 8 Vulnerability Relationship Diagram - Generic Sensitivity Factors

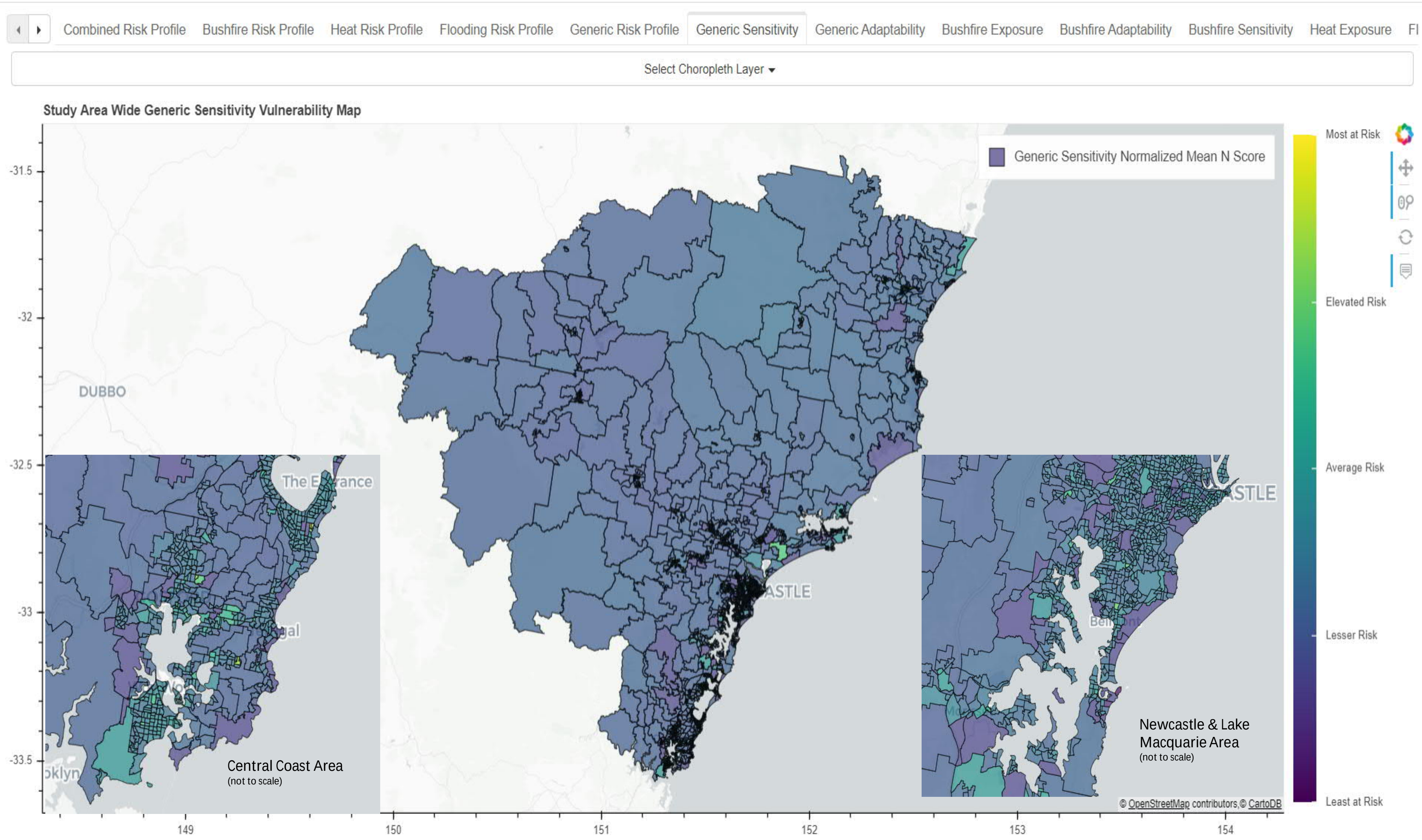

Figure 9 Relative Community Vulnerability – SA1 Level - Generic Sensitivity

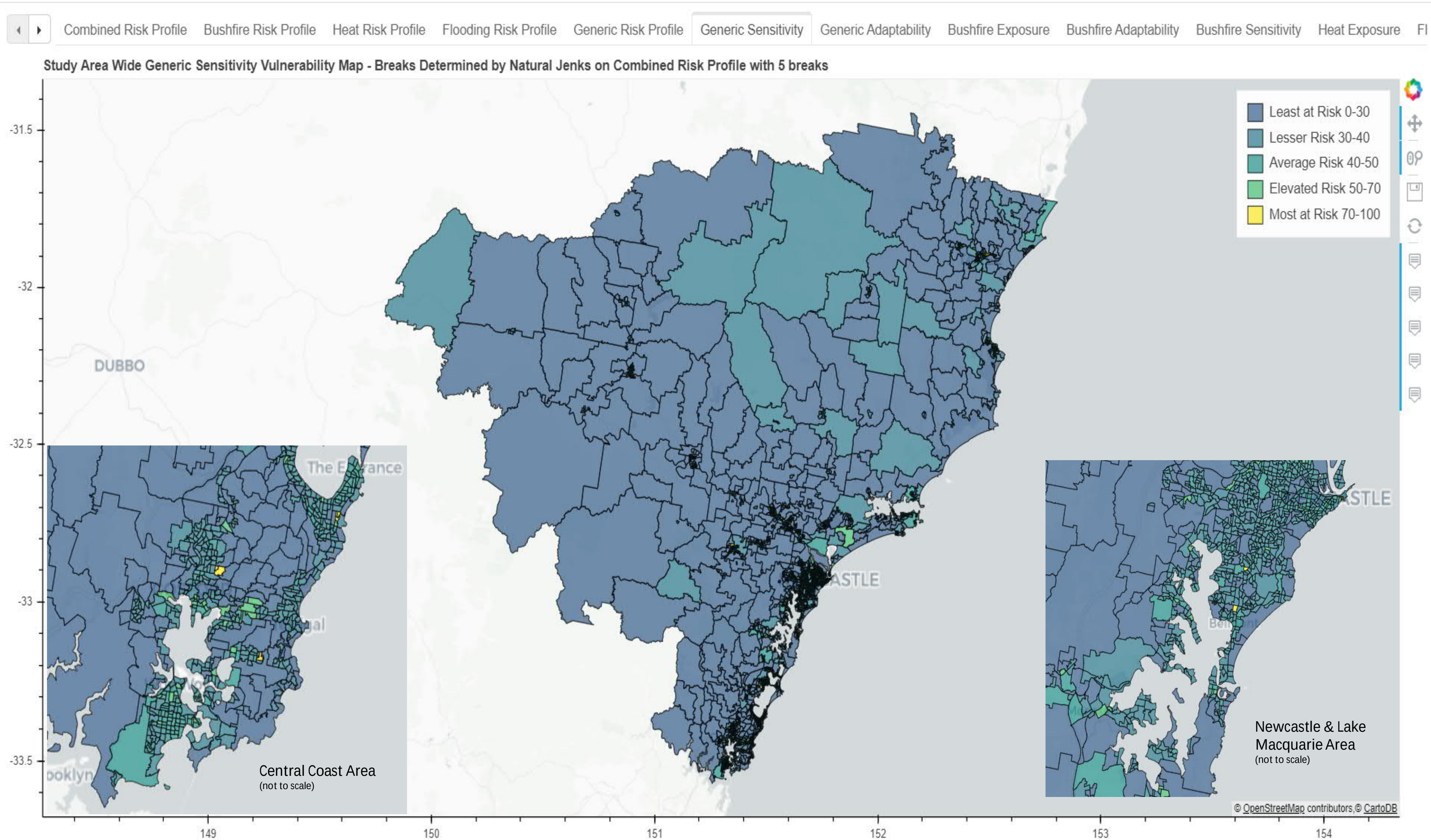

Figure 10 Relative Community Vulnerability – SA1 Level - Generic Sensitivity with 5 Breaks

Generic Adaptive Capacity

Whilst the generic adaptive capacity profile at times coincides with relatively higher sensitivity risk scores in urban centres, a clear trend towards '*elevated risk*' in rural areas is also apparent (see Figure 12 & Figure 13). Figure 11 provides an overview of the risk factors which contributed to the generic adaptive capacity scores. Based on these input datasets, '*elevated risk*' in rural areas may be associated with reduced access to emergency services (based on general proximity) and somewhat reduced economic access (e.g. many households with low income).

Indicators for financial resources, information and awareness in urban areas generally reflect the inverse of the findings associated with generic sensitivity in these locations. For example, the results confirm variability between economically disadvantaged neighbourhoods with lower levels of education when compared to immediately adjacent wealthier suburbs. In comparison to the generic sensitivity findings, generic adaptability expressed more higher risk locations in rural areas and generally distributed evenly across the LGAs.

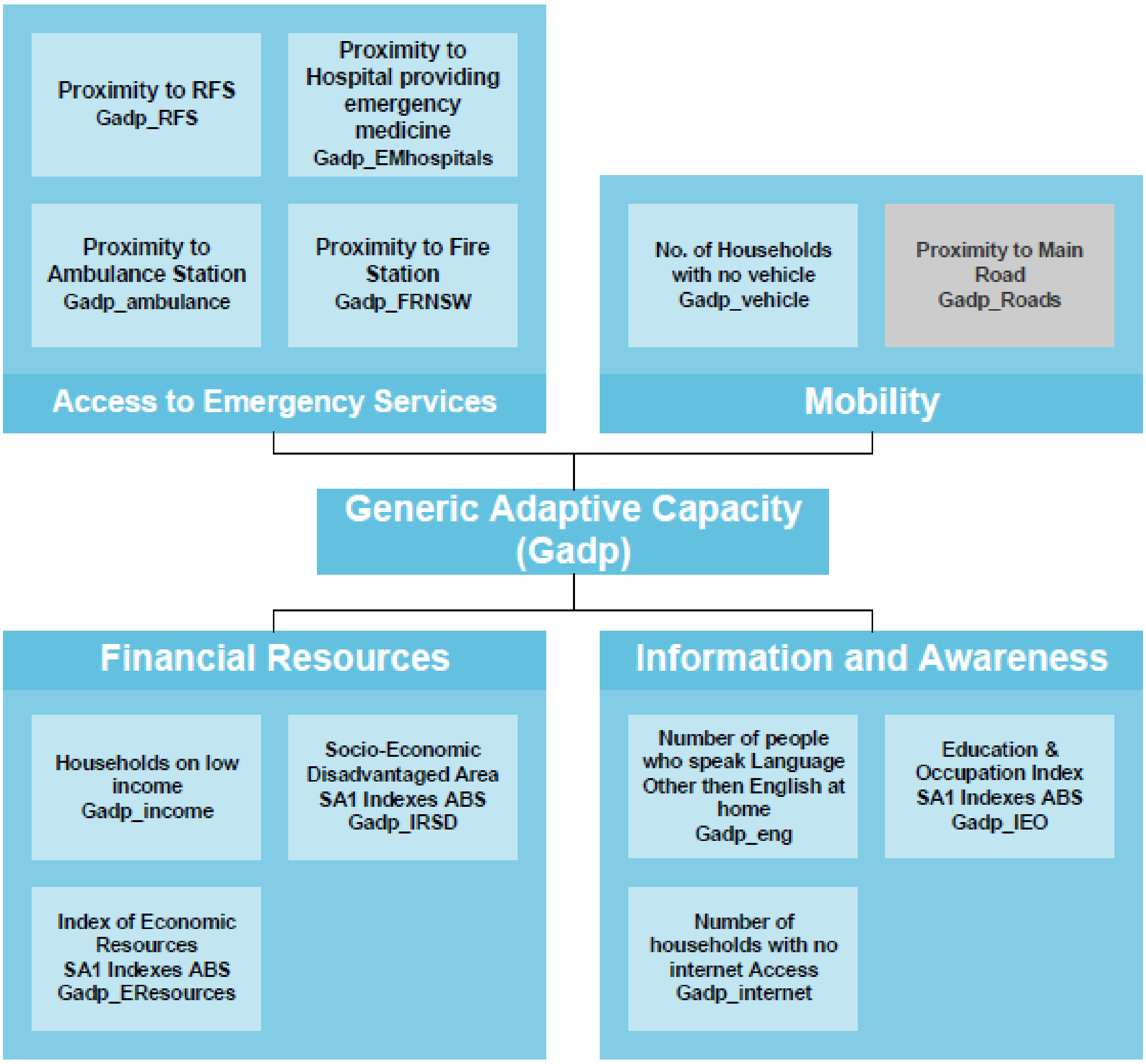

Figure 11 Vulnerability Relationship Diagram - Generic Adaptive Capacity Factors

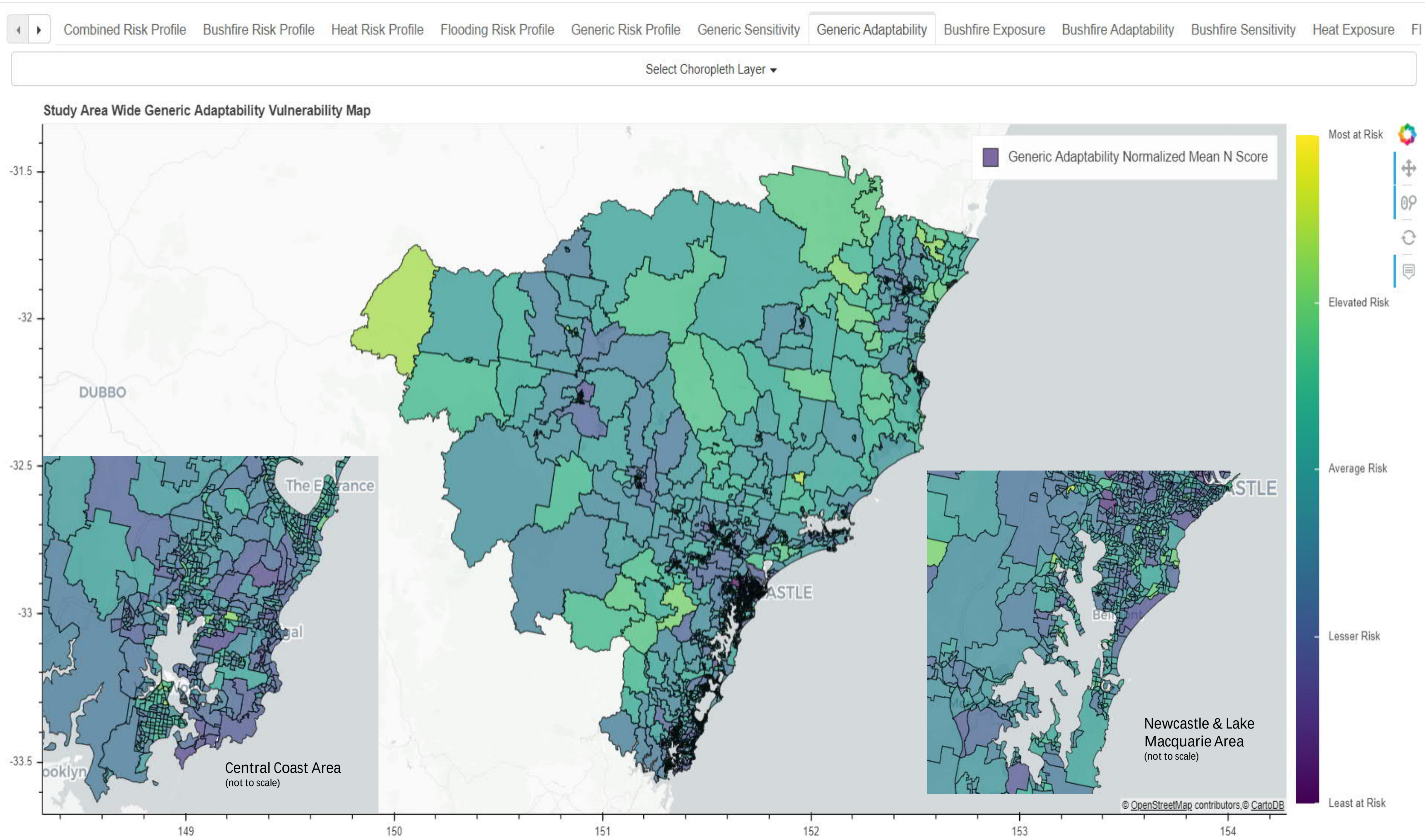

Figure 12 Relative Community Vulnerability – SA1 Level - Generic Adaptability

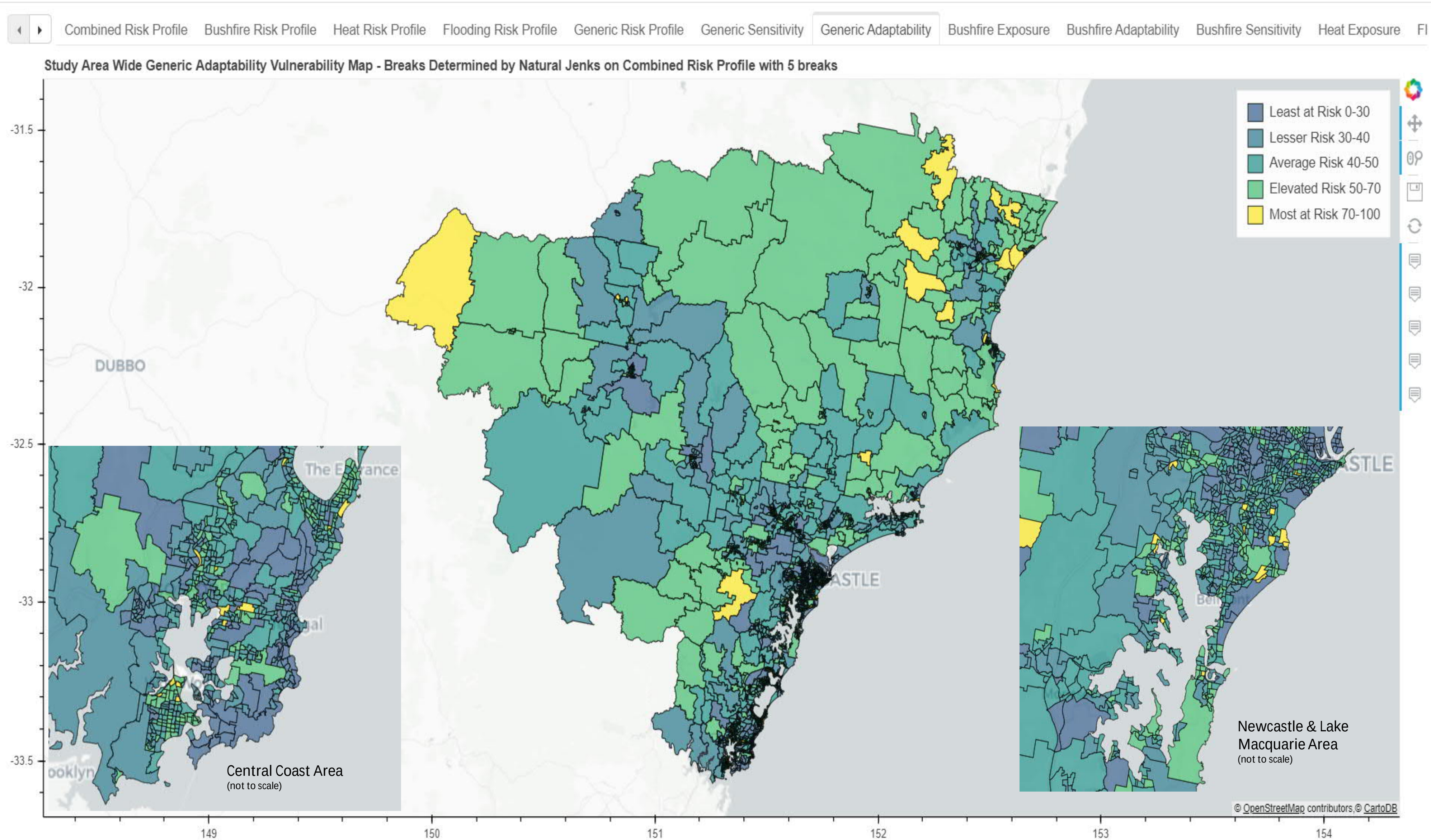

Figure 13 Relative Community Vulnerability – SA1 Level - Generic Adaptability with 5 Breaks

Summary of Results

Typically, the generic risk factors provide a good representation of variability between neighbourhoods within urban areas whilst also identifying some broader trends between rural and urban regions within the project area. Proximity to emergency services played a clear role in determining adaptive capacity scores and this contributed to the final '*elevated risk*' scores within rural areas. These areas may otherwise have been attributed a lower final risk score. It is noted that the relationship between proximity to emergency services and actual quality of service (and consequential risk) was not considered within the context of this project. Therefore, substituting proximity with an alternative indicator could yield different results within rural areas.

Finally, urban areas are likely to receive higher risk scores when using the adopted framework due to the tendency for higher population densities, dwellings and concentrations of infrastructure found within urban areas and this trend was well represented in the results. Overall the results of the generic risk profile provide a robust basis on which to assess generic influences against various hazards within the project area.

4.2 Relative Community Vulnerability to Bushfire

The results of the bushfire analysis indicate that, in general, those communities '*most at risk*' from bushfire are located in the more rural areas. The distribution of higher relative risk in rural areas appears to be quite cohesive with only a few outliers breaking this pattern (see Figure 14 & Figure 15). Within urban areas this distribution is not as consistent with a number of isolated clusters of '*elevated risk*' occurring in proximity to areas of generally lower risk. However, despite these differences it is clear that overall bushfire vulnerability appears to be highest in rural (bushland) areas. One interesting trend identified is that there is a consistent lower risk 'corridor' from Newcastle to Muswellbrook which reflects the lack of bushland in this area.

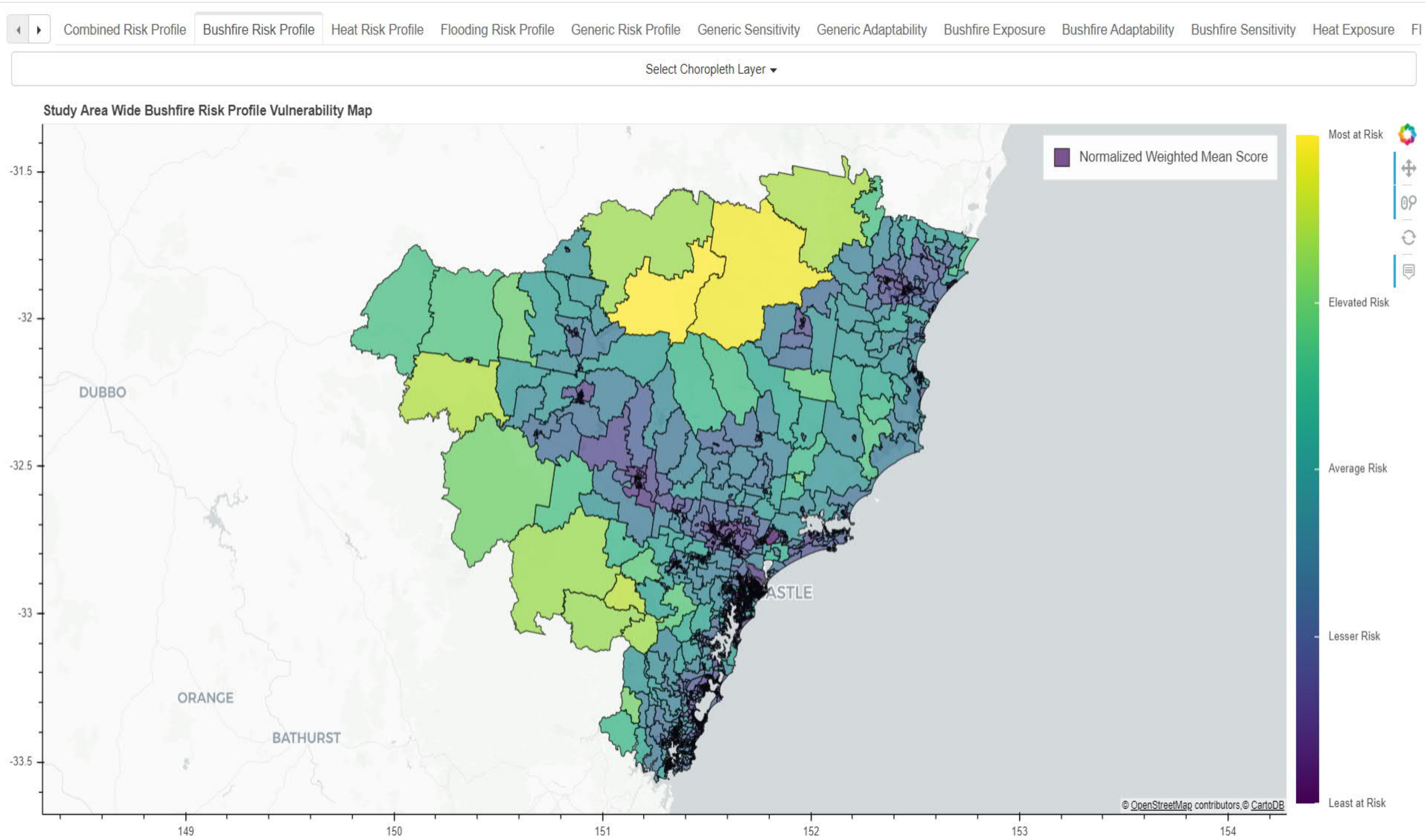

Figure 14 Relative Community Vulnerability – SA1 Level - Bushfire Risk Profile

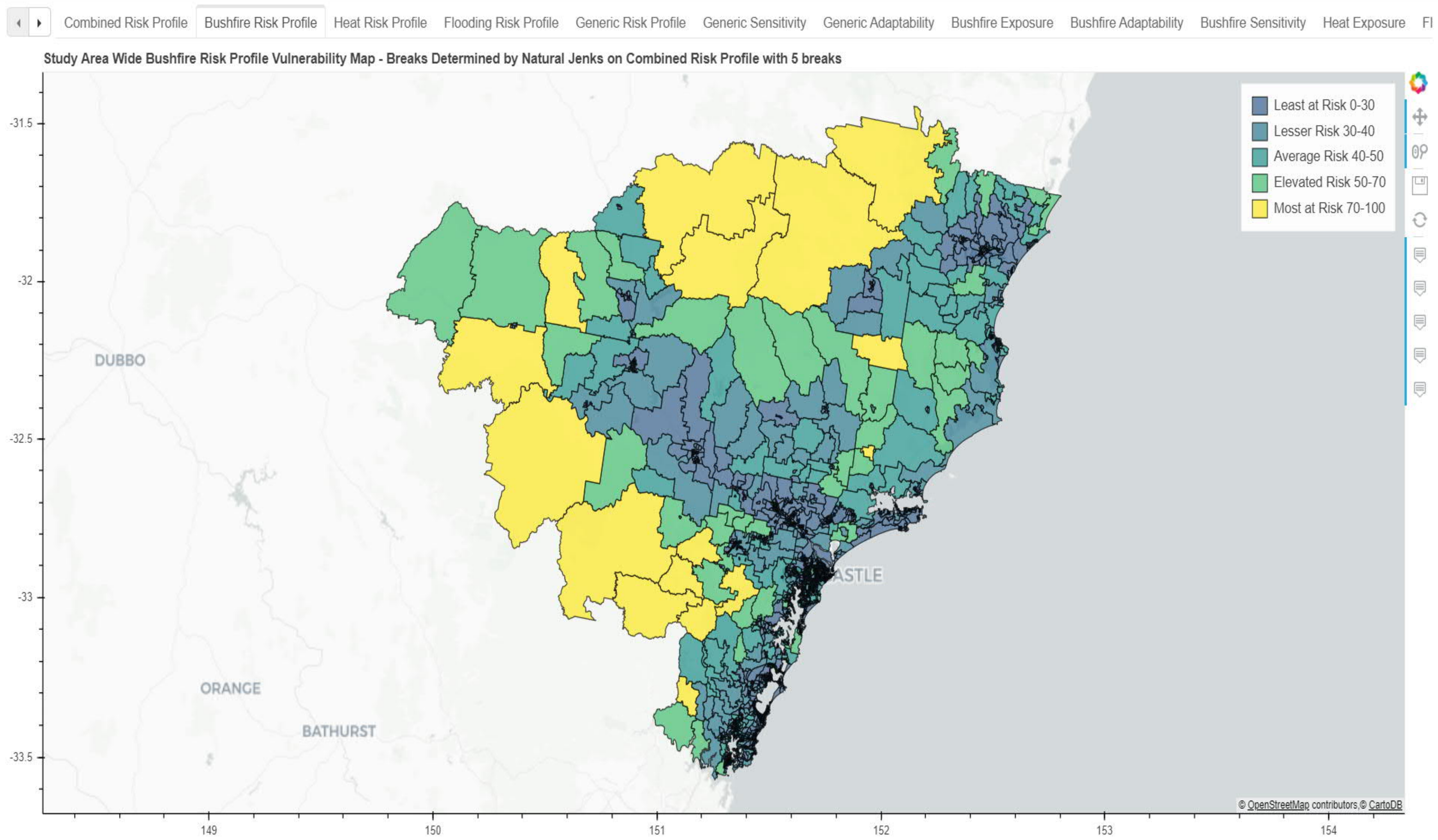

Figure 15 Relative Community Vulnerability – SA1 Level - Bushfire Risk Profile with 5 Breaks

Exposure

Exposure and adaptive capacity contributed significantly to this trend both as a result of the weightings applied but also due to a tendency for better correlation within the raw input data (refer Figure 16. For example, when considering overall bushfire exposure, areas with relatively high tree canopy presence were also likely to be mapped as bushfire prone land or have a history of bushfire activity (see Figure 17 & Figure 18). As a result, existing land use played a significant factor in determining exposure, with urbanised areas recording significantly lower levels of bushfire exposure. This was confirmed when directly comparing bushfire vulnerability risk rankings to population density which identified a clear correlation between lower population densities and relatively higher risks of bushfire exposure.

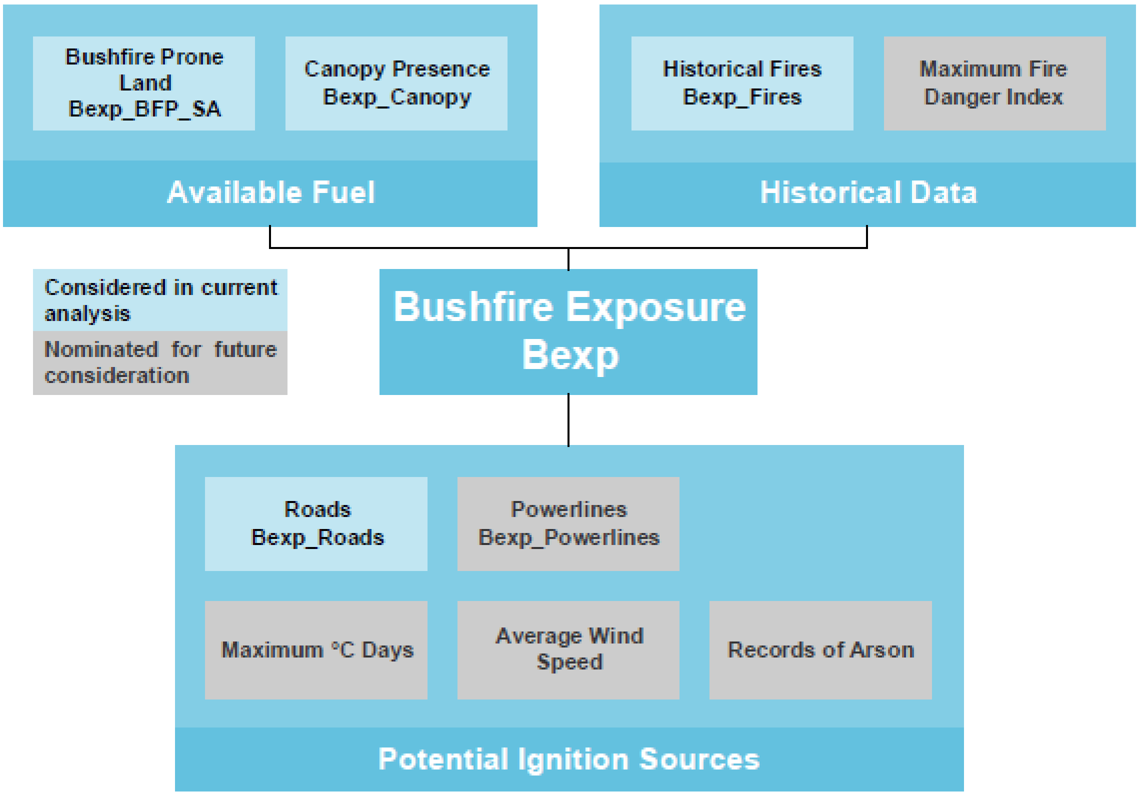

Figure 16 Bushfire Exposure – Vulnerability Relationship Diagram

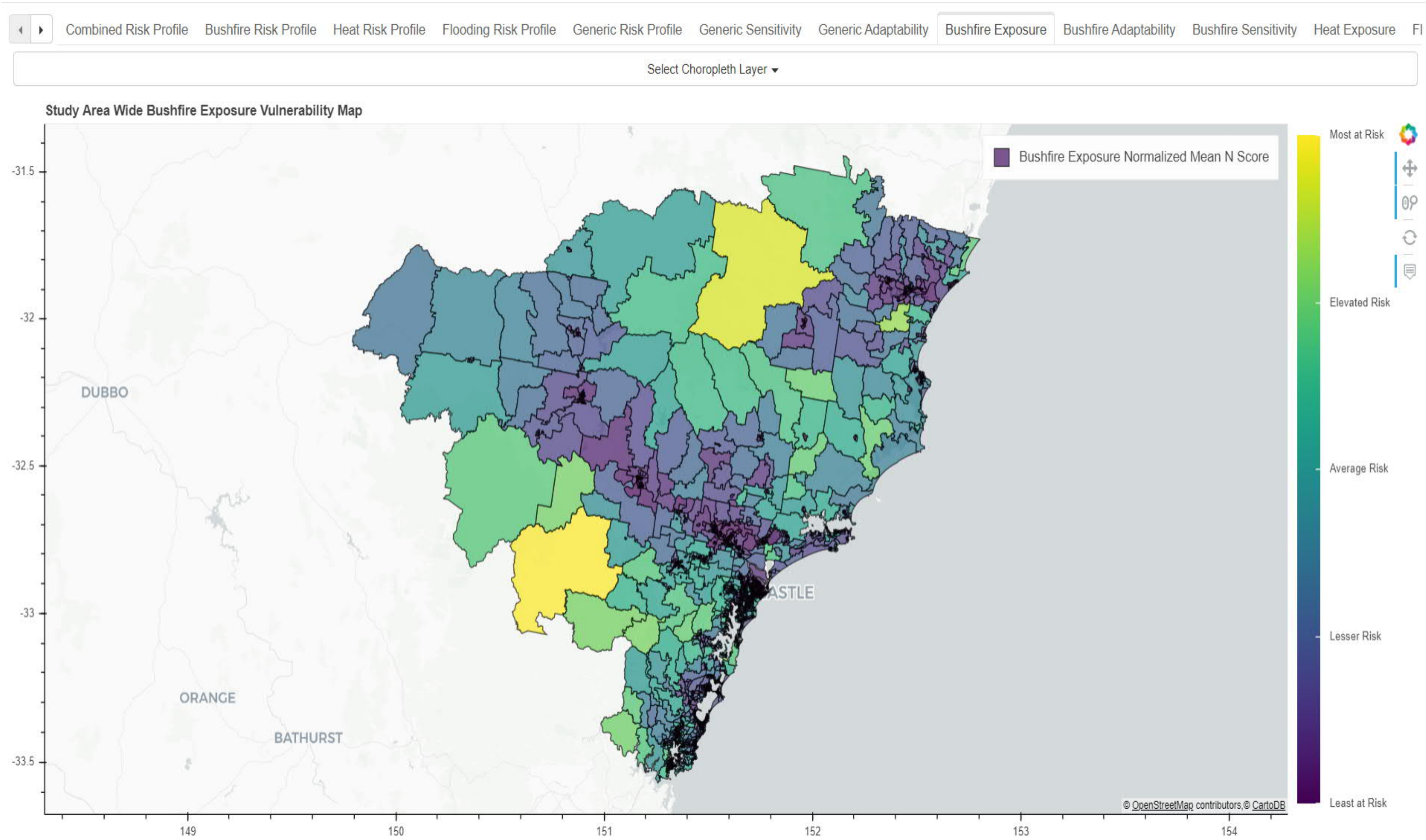

Figure 17 Relative Community Vulnerability – SA1 Level - Bushfire Exposure

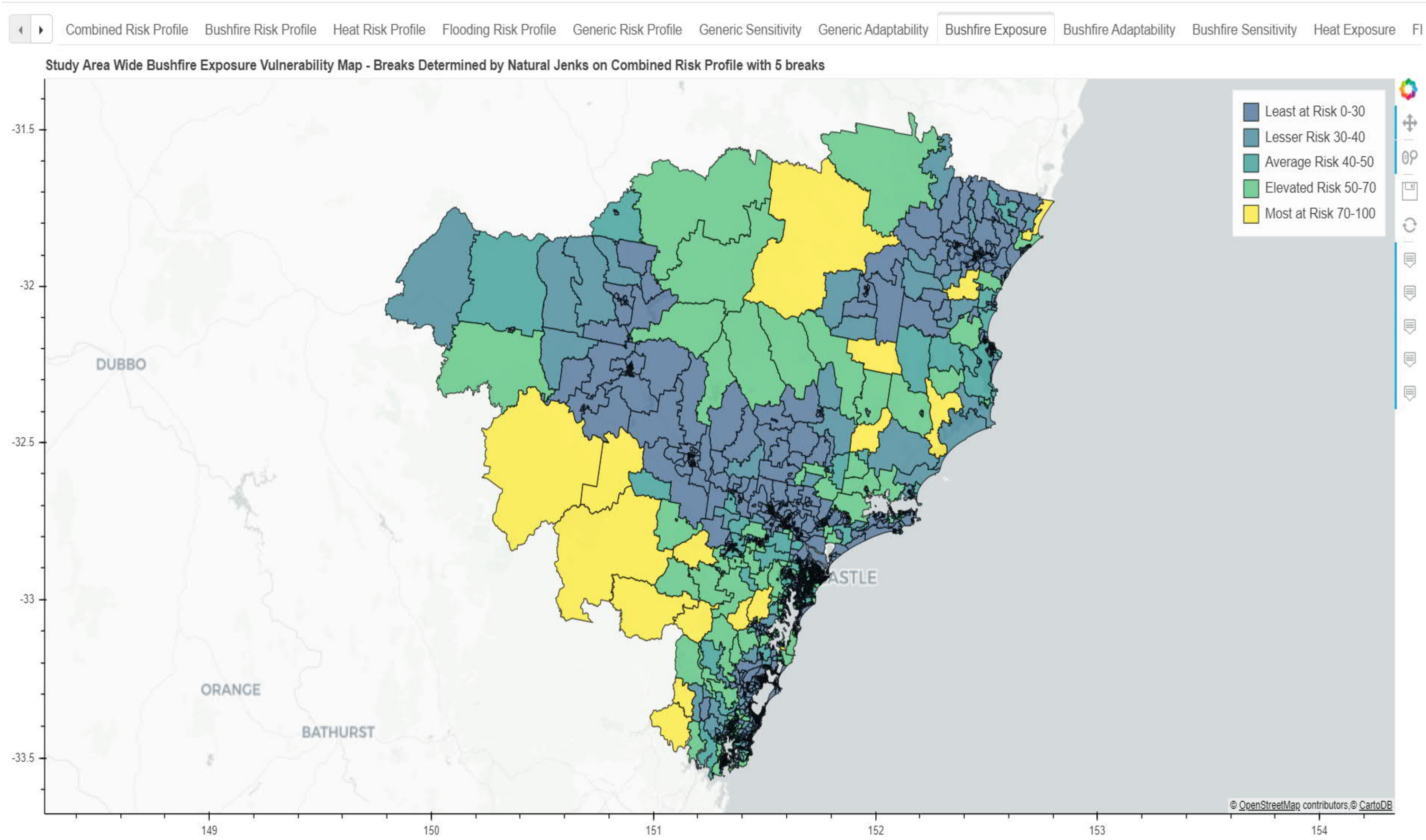

Figure 18 Relative Community Vulnerability – SA1 Level - Bushfire Exposure with 5 Breaks

Adaptive Capacity

In terms of adaptive capacity, the correlation was spatial (i.e. location based) with urban areas typically better serviced both in terms of emergency response (e.g. fire stations, hydrants) and preventative planning efforts (e.g. Neighbourhood Safer Places, community fire units) (refer Figure 19). Therefore, while there was no direct relationship (or overlap) between any given factors, once combined, the results contributed to the separation between rural and urban areas (see Figure 20 & Figure 21).

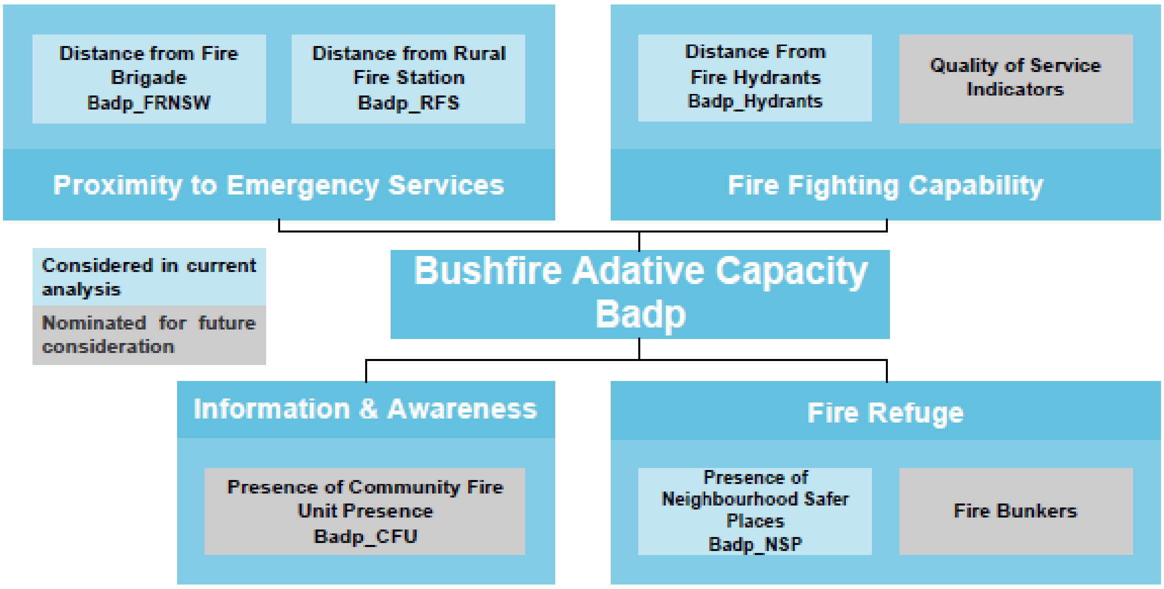

Figure 19 Bushfire Adaptive Capacity – Vulnerability Relationship Diagram

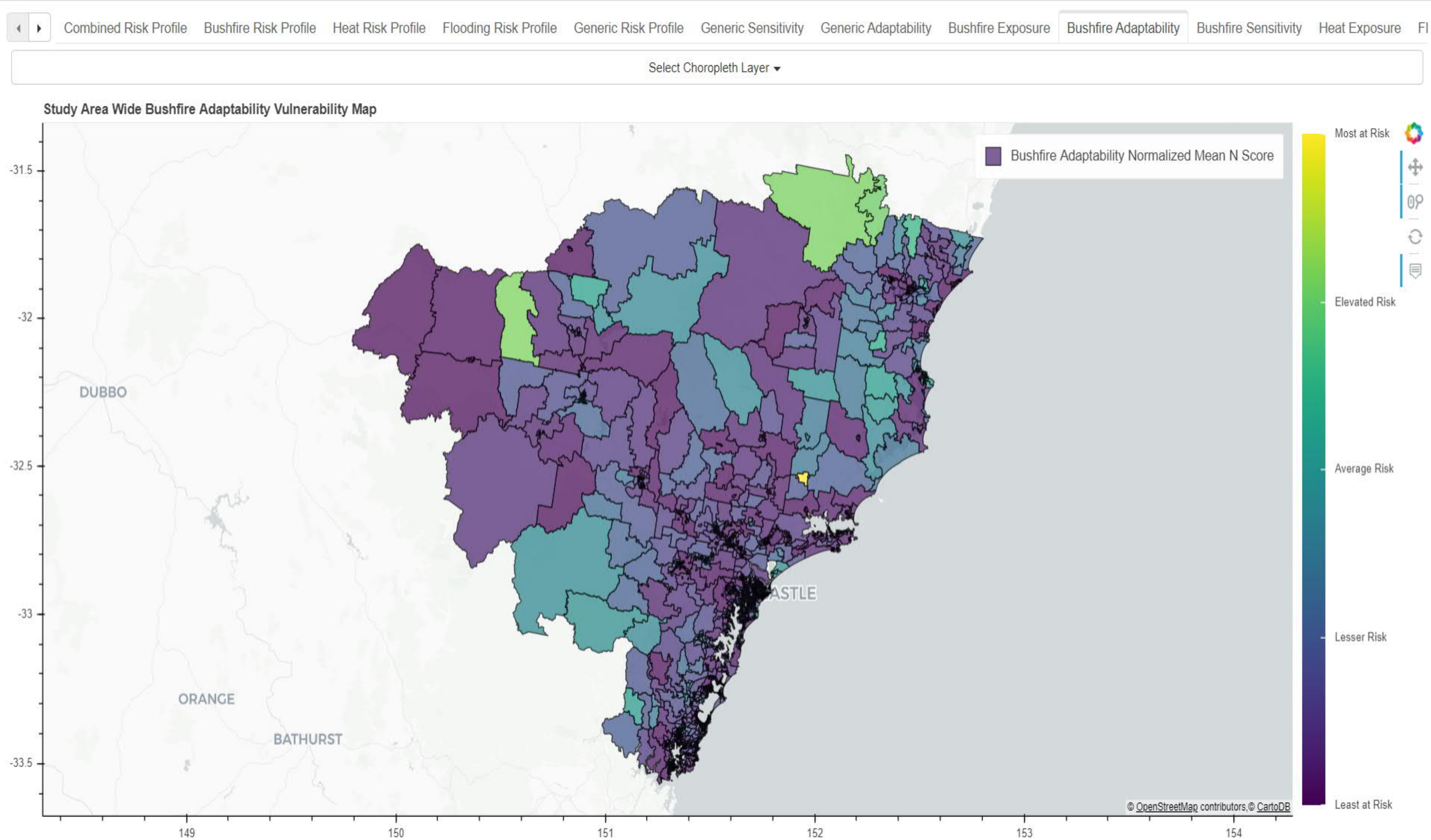

Figure 20 Relative Community Vulnerability – SA1 Level - Bushfire Adaptability

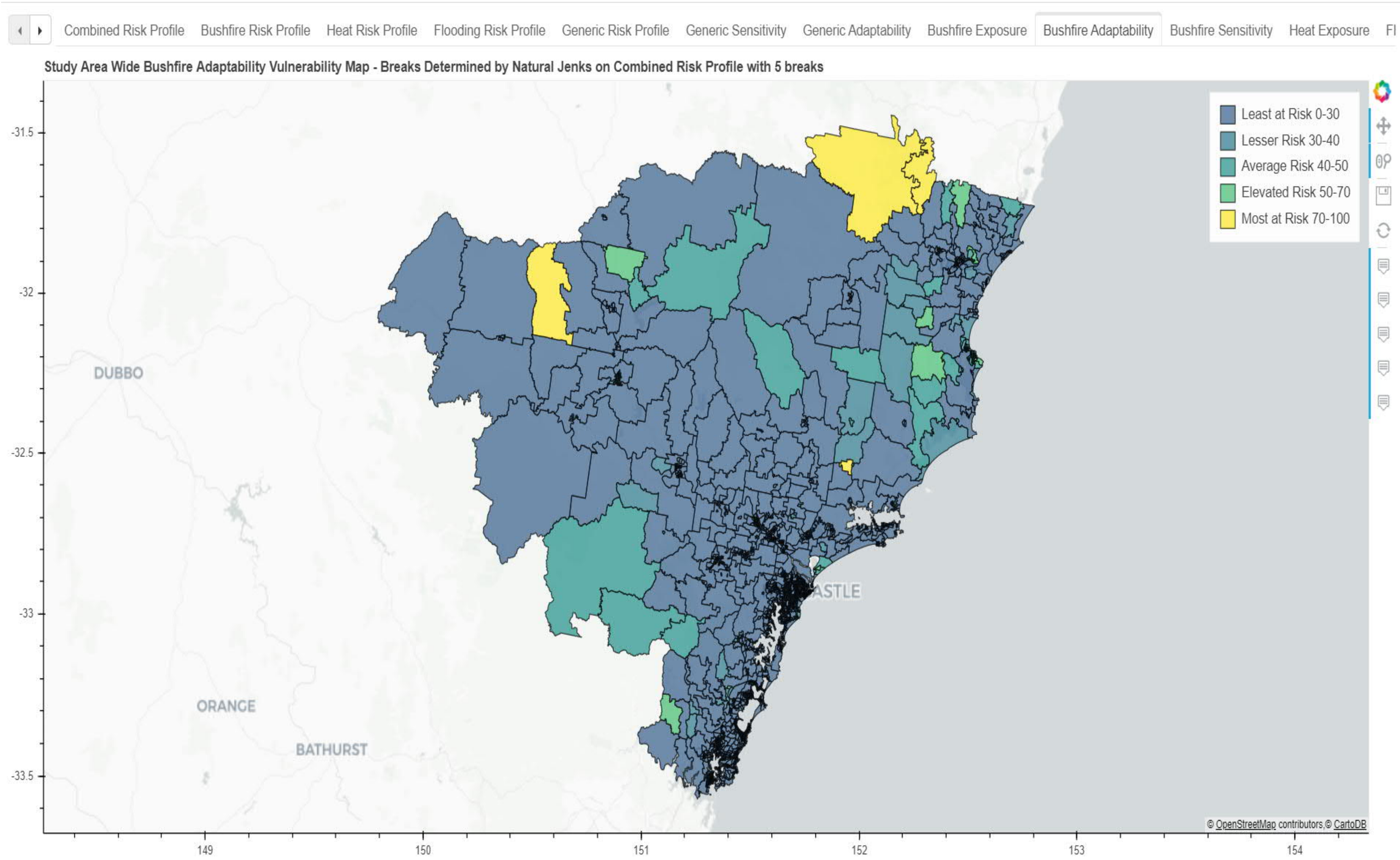

Figure 21 Relative Community Vulnerability – SA1 Level - Bushfire Adaptability with 5 Breaks

Sensitivity

The effects of bushfire sensitivity were localised due to the limited set of input data (essentially limited to critical infrastructure) (refer Figure 22). Whilst the influence of bushfire sensitivity data was generally limited to rural areas hence the '*most at risk*' & '*elevated risk*' occurring in these areas (see Figure 23 & Figure 24). This general trend being the larger footprint SA1 areas in the project area receiving a higher score as typically this category 1 infrastructure is more likely to be where less people are living (hence the larger SA1 areas).

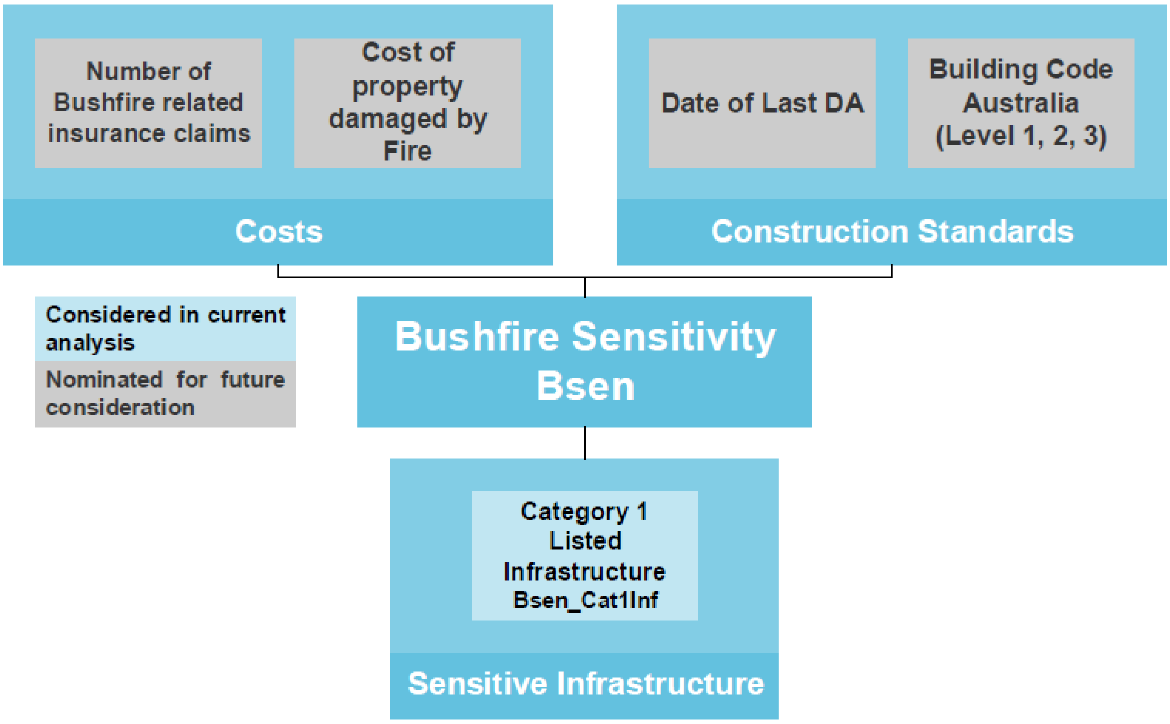

Figure 22 Bushfire Sensitivity – Vulnerability Relationship Diagram

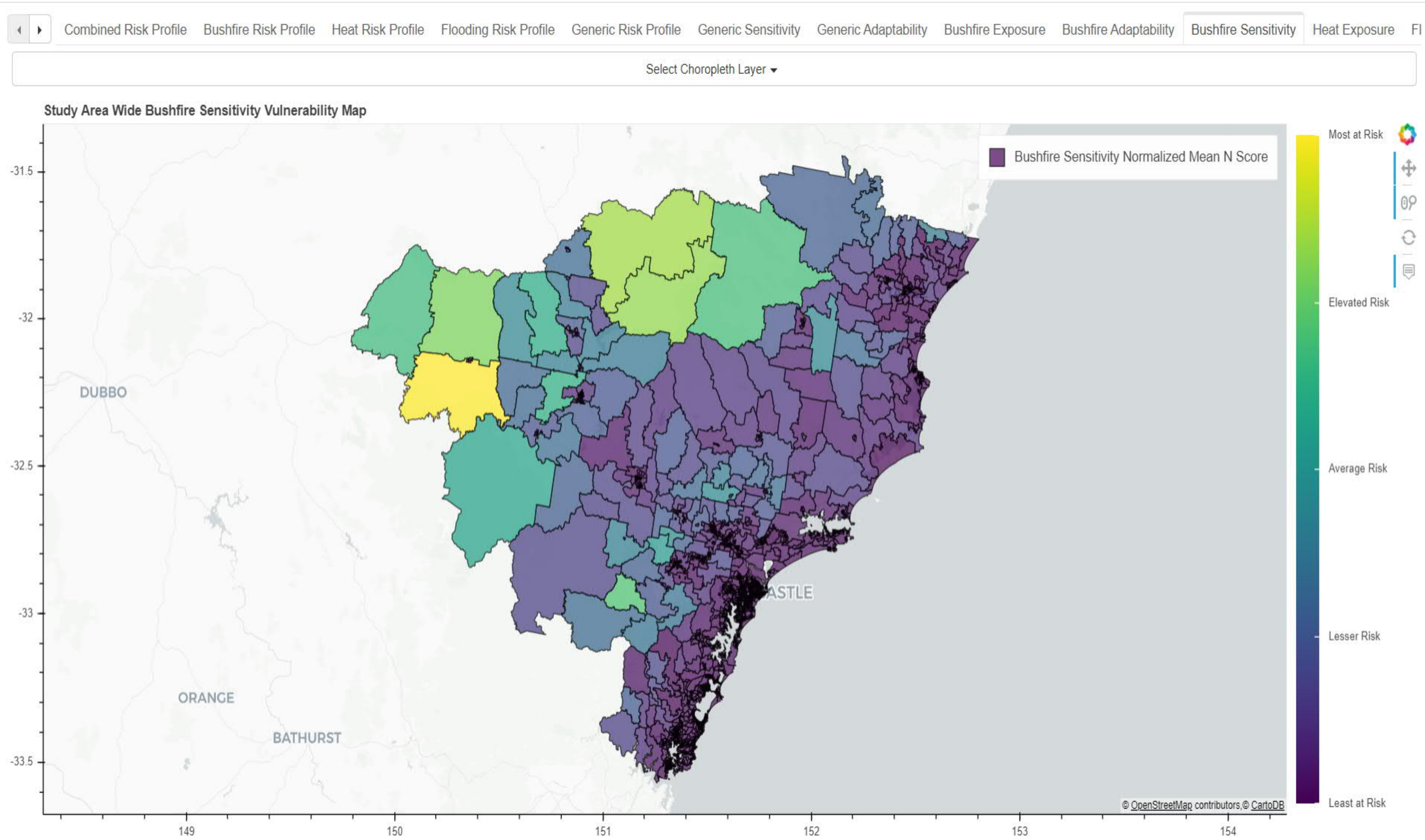

Figure 23 Relative Community Vulnerability – SA1 Level - Bushfire Sensitivity

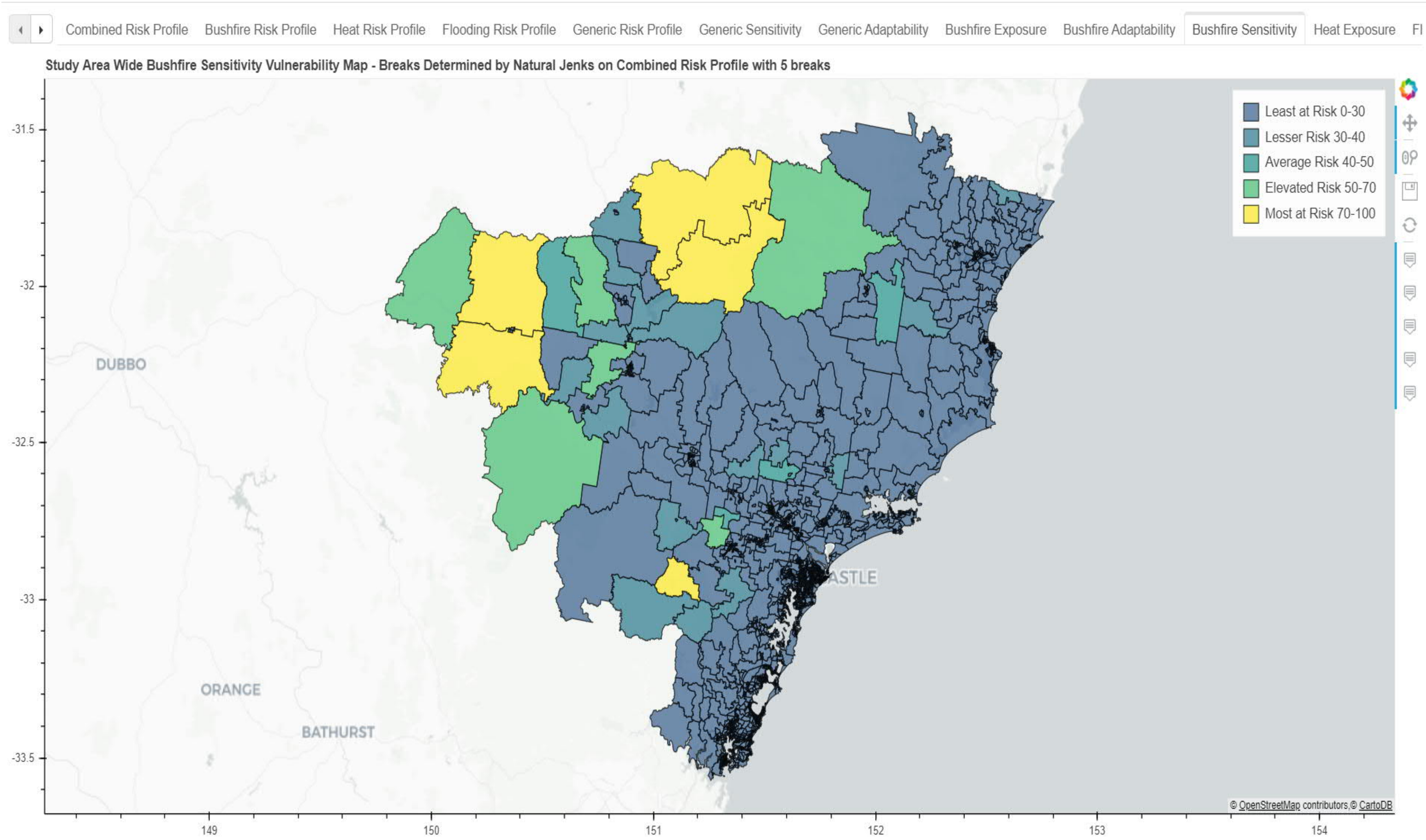

Figure 24 Relative Community Vulnerability – SA1 Level - Bushfire Sensitivity with 5 Breaks

Summary of Results

Overall bushfire vulnerability appears to be influenced heavily by the amount of canopy coverage, roads nearby to canopy (ignition source) & proximity to emergency services. A notable trend was made through the 'corridor' between Newcastle & Muswellbrook LGAs where there are more urbanised areas, and a comparatively lower level of bushland. Typically, the presence of community planning schemes such as Neighbourhood Safer Places or community fire units are more common in urban areas than rural ones, thereby influencing higher levels of adaptive capacity.

Ultimately it is clear that existing land uses play a major factor in determining the degree and spatial extent of relative bushfire exposure across the study area. As would largely be expected, areas dedicated to urban development typically have less bushland than their rural counterparts and so there is a strong correlation between the final vulnerability rankings (as shown in Figure 14, Figure 15, Figure 17 & Figure 18).

Therefore, the tendency for higher risk rankings to prevail in rural areas is of note and arises in part due to comparatively lower levels of adaptive capacity. An investigation into adaptive capacity (in respect to bushfire) in isolation identifies that urban areas are typically situated in closer proximity to emergency resources and are supported by better infrastructure. Perhaps most notably, these areas exhibit closer proximity to Neighbourhood Safer Places and community fire units and are potentially better equipped to respond to bushfire. Therefore, as well as receiving comparatively lower exposure scores, adaptive capacity scores were also typically far lower (e.g. 'better') in urban centres.

4.3 Relative Community Vulnerability to Extreme Flooding

Exposure

Communities '*most at risk*' from flooding were typically located in areas of low-lying terrain, almost exclusively below 10m Australian Height Datum (AHD), with small SA1 footprints and in proximity to major waterways within the project area. The results (see Figure 26, Figure 27, Figure 28 & Figure 29) show that higher density urban areas near large bodies of water (e.g. rivers, lakes, ocean) received the '*most at risk*' and '*elevated risk*' rating. Areas located in and around the centres of Maitland, Raymond Terrace & Singleton are comprised of relatively small SA1 footprints (higher density of populations) and due to their proximity to the Hunter River, they result in a higher risk score. Gloucester and Bulahdelah are also two notable areas of relatively small SA1 footprints which are located near waterbodies (Gloucester River and Myall River, respectively) and received a higher risk score. It is to be noted that sea level rise projections were embedded into the flooding data sets provided by Central Coast, Lake Macquarie & Port Stephens councils.

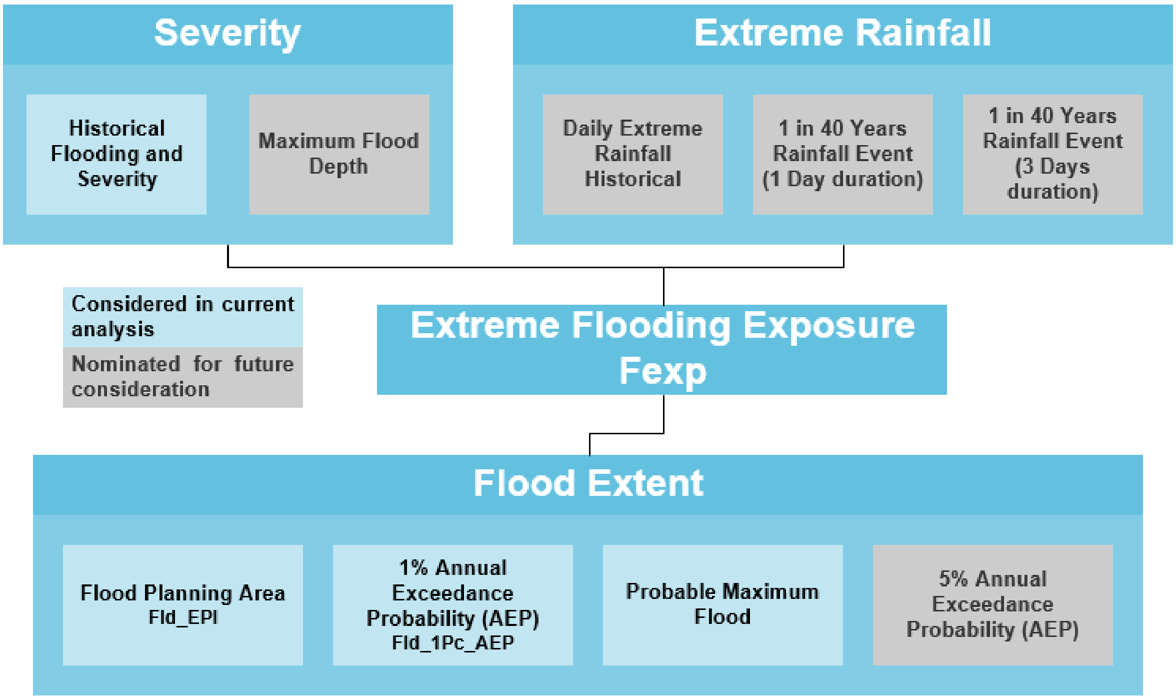

Figure 25 Extreme Flooding Exposure – Vulnerability Relationship Diagram

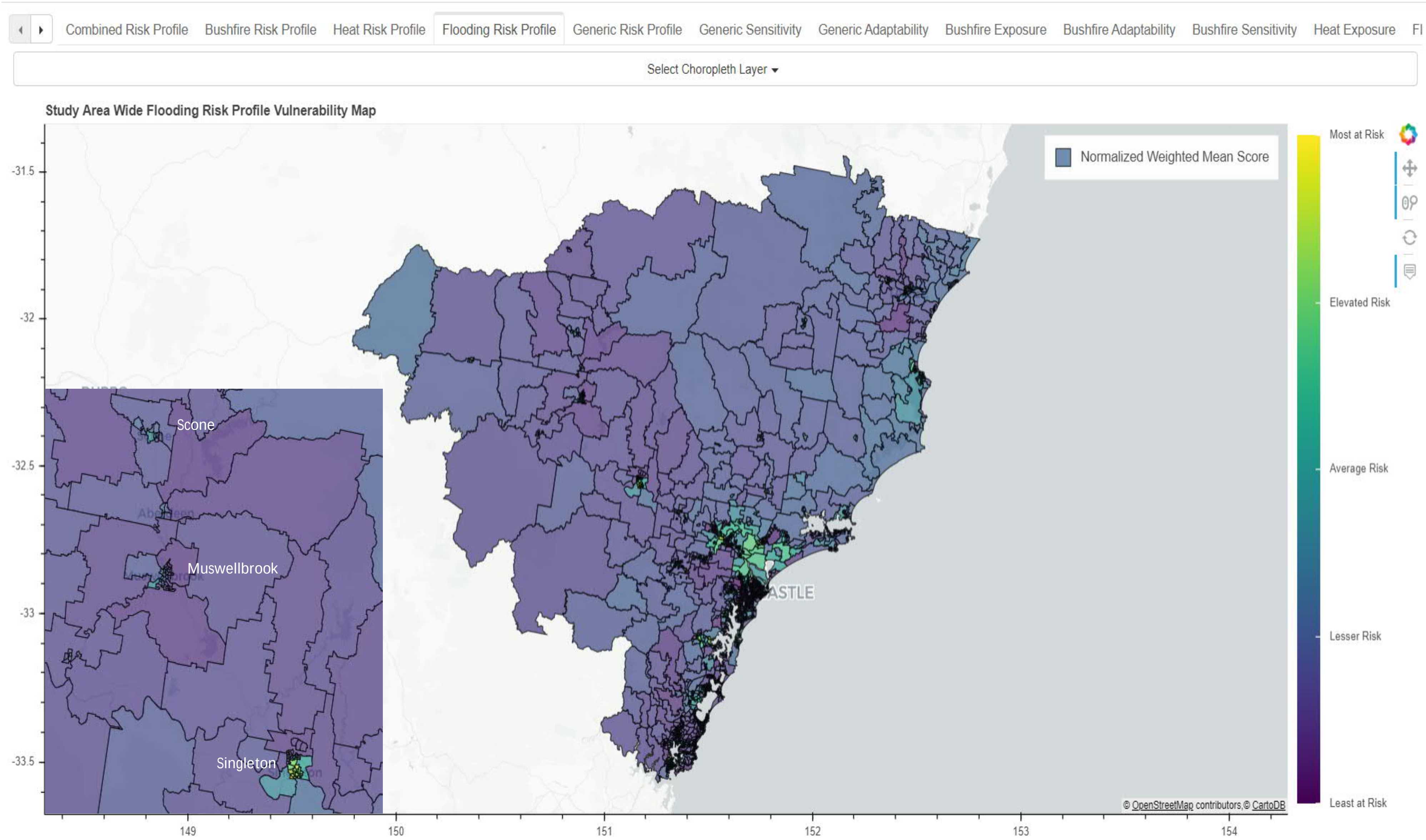

Figure 26   Relative Community Vulnerability – SA1 Level - Flooding Risk Profile

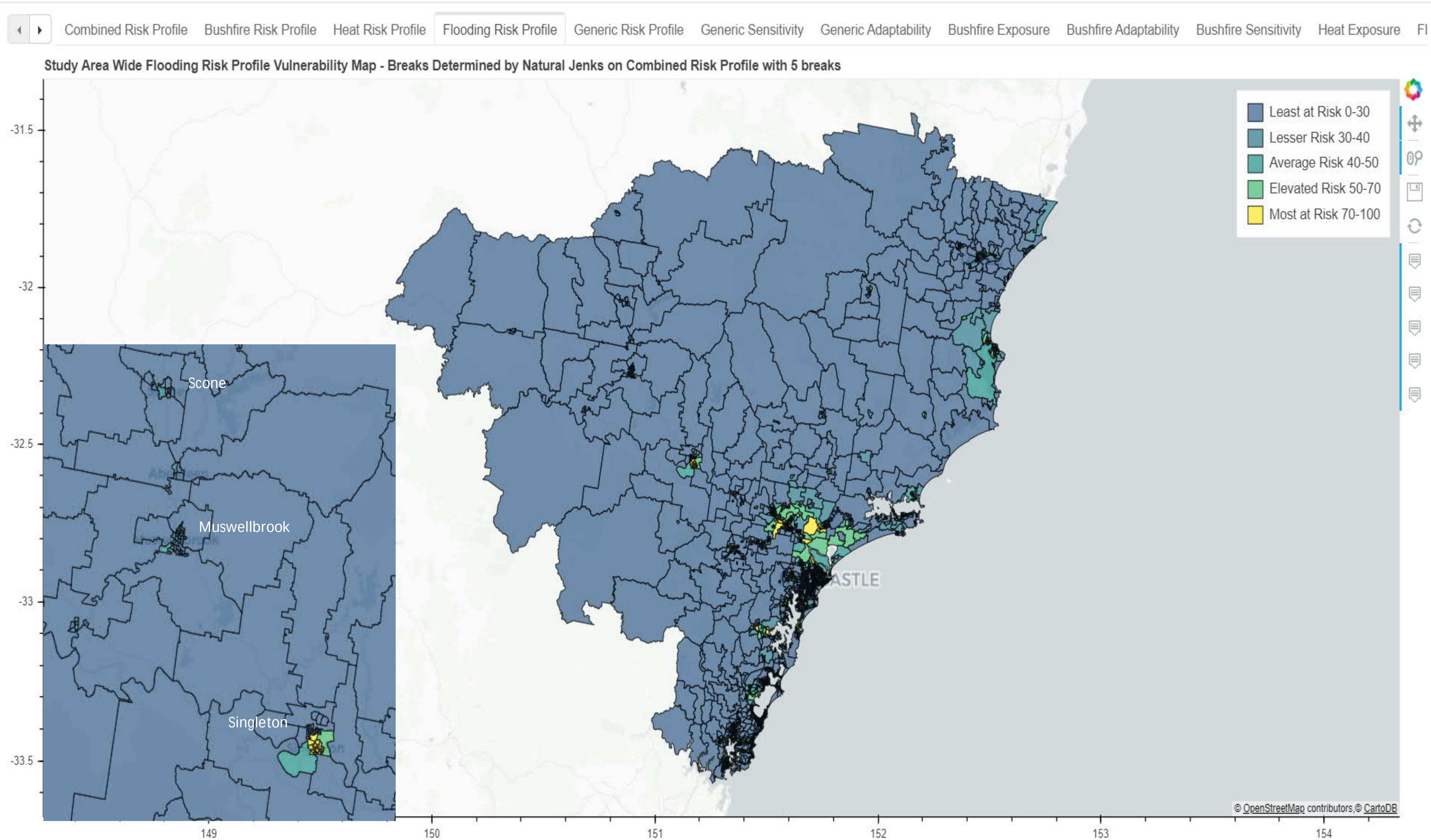

Figure 27 Relative Community Vulnerability – SA1 Level - Flooding Risk Profile with 5 Breaks

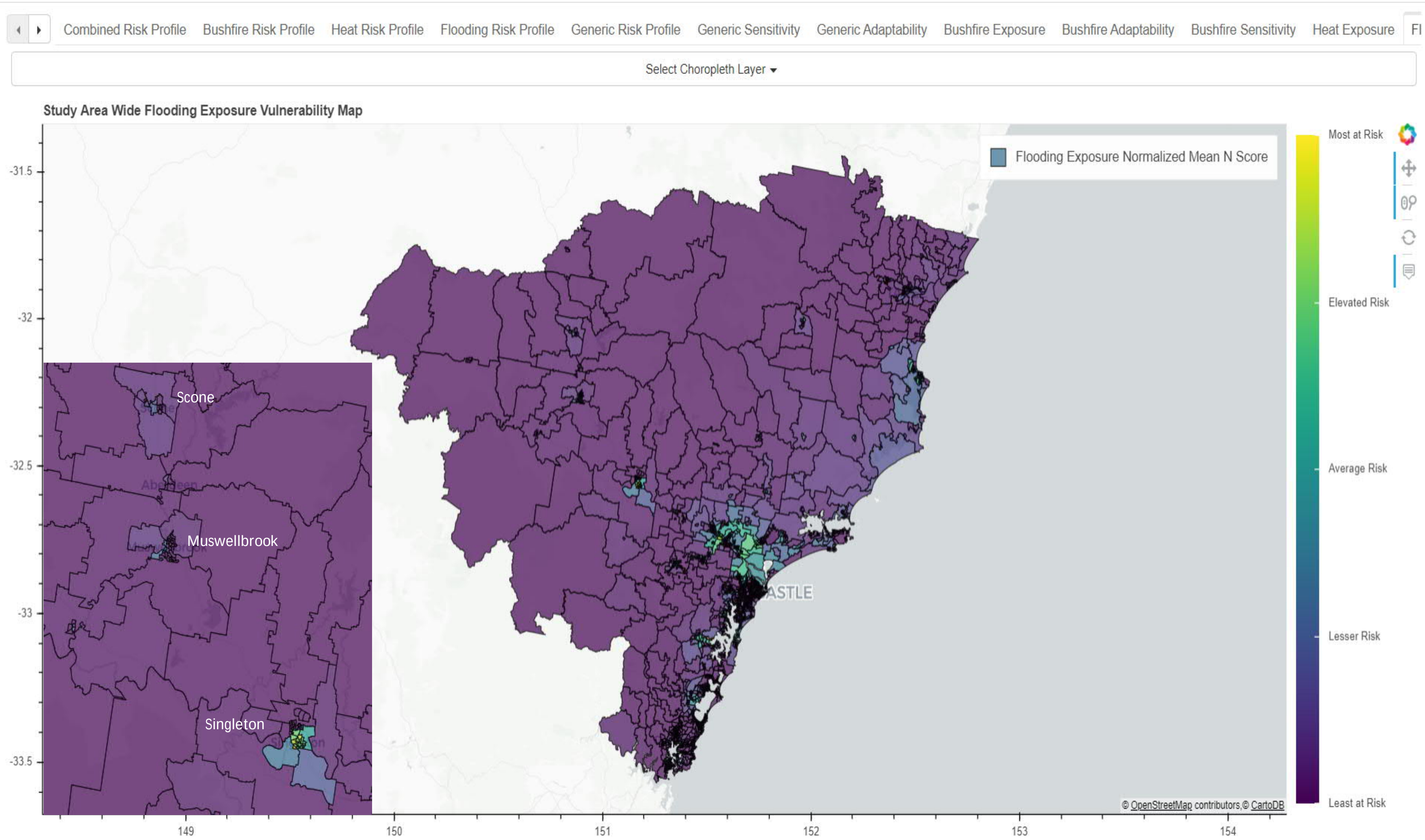

Figure 28 Relative Community Vulnerability – SA1 Level - Flooding Exposure

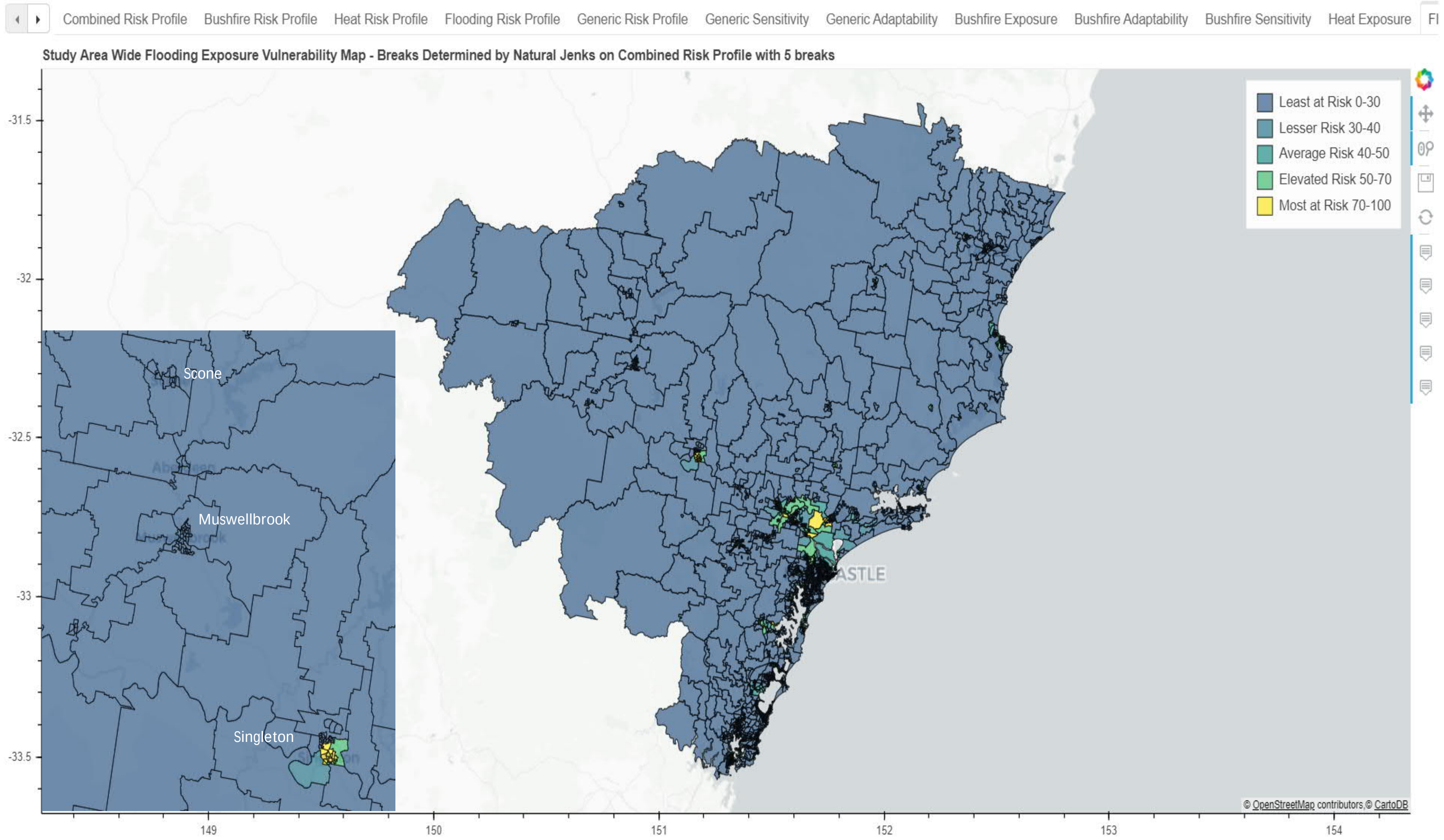

Figure 29 Relative Community Vulnerability – SA1 Level - Flooding Exposure with 5 Breaks

Sensitivity and Adaptive Capacity

Hazard specific risk factors for both sensitivity and adaptive capacity could not be assessed based on insufficient data being available. As such, analysis of sensitivity was not conducted for flooding (refer Section 4.1). Potential future indicators to inform hazard specific risk profiles are provided in Figure 30 and Figure 31 respectively.

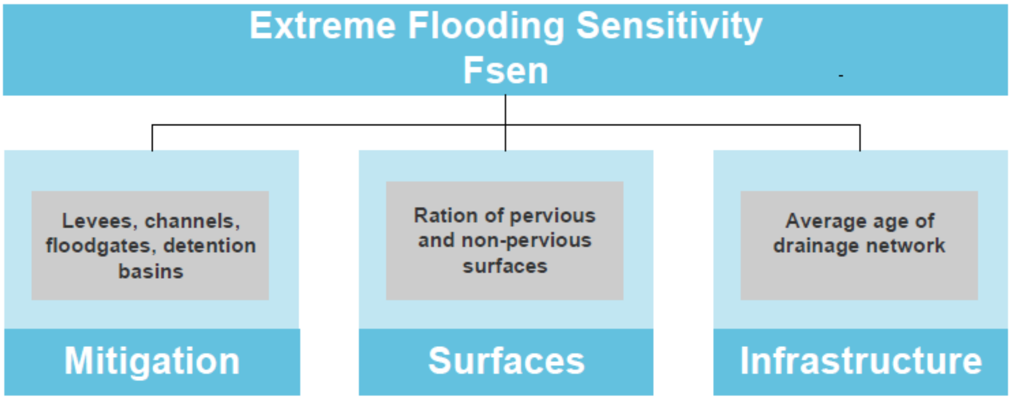

Figure 30 Extreme Flooding Sensitivity – Vulnerability Relationship Diagram

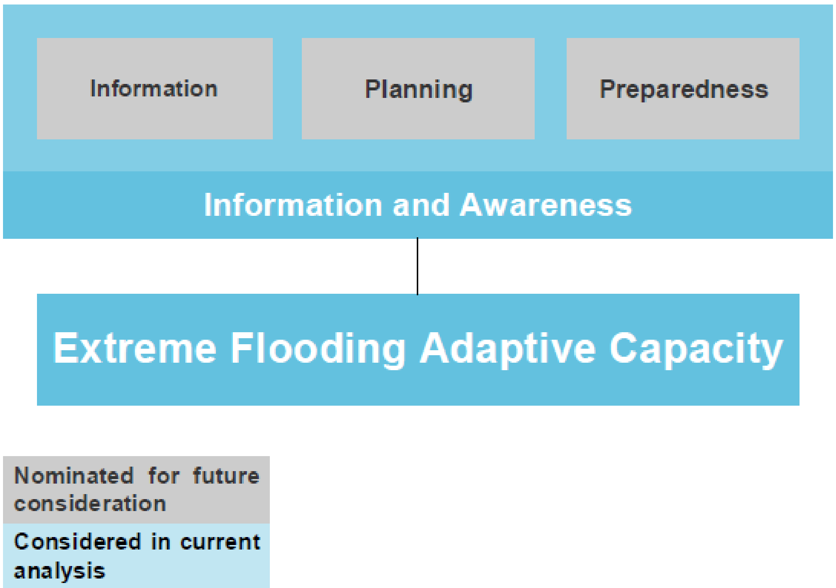

Figure 31 Extreme Flooding Adaptive Capacity – Vulnerability Relationship Diagram

4.4 Relative Community Vulnerability to Extreme Heat Events

Exposure

Communities '*most at risk*' from heat were typically located in the more inland areas of low canopy presence and high level of development (see Figure 33, Figure 34, Figure 35 & Figure 36). This trend is again noticeable through the 'corridor' from Newcastle to Muswellbrook, which was categorised '*most at risk*' and '*elevated risk*'. This reflects the urbanisation of this area and the lack of vegetation present, as vegetation can generally lower surface and air temperatures.

The areas '*least at risk*' were areas of high canopy presence, higher elevations or within coastal communities which receive cooling coastal winds.

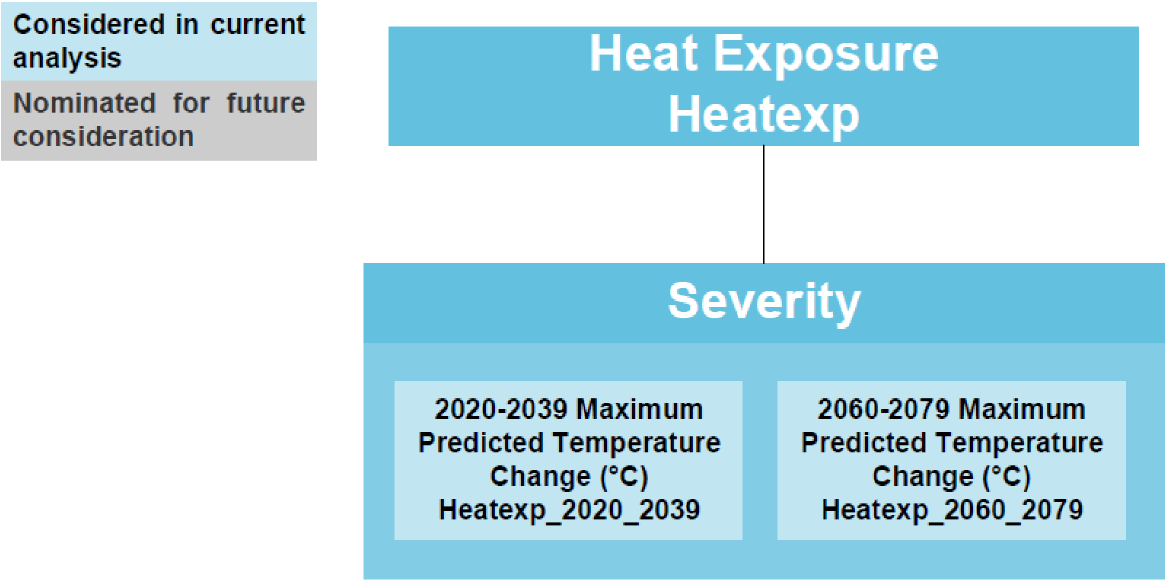

Figure 32 Heat Exposure – Vulnerability Relationship Diagram

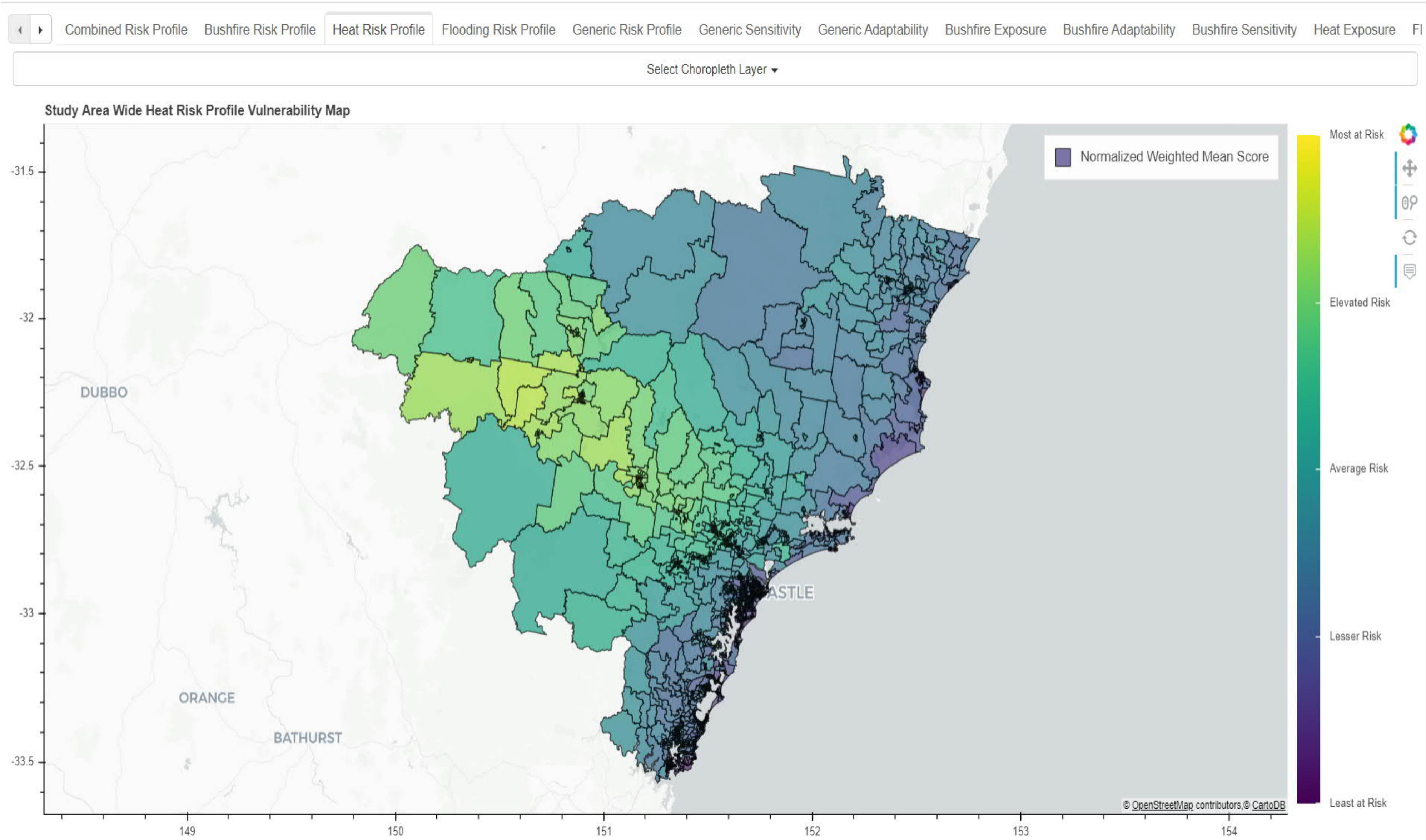

Figure 33 Relative Community Vulnerability – SA1 Level - Heat Risk Profile

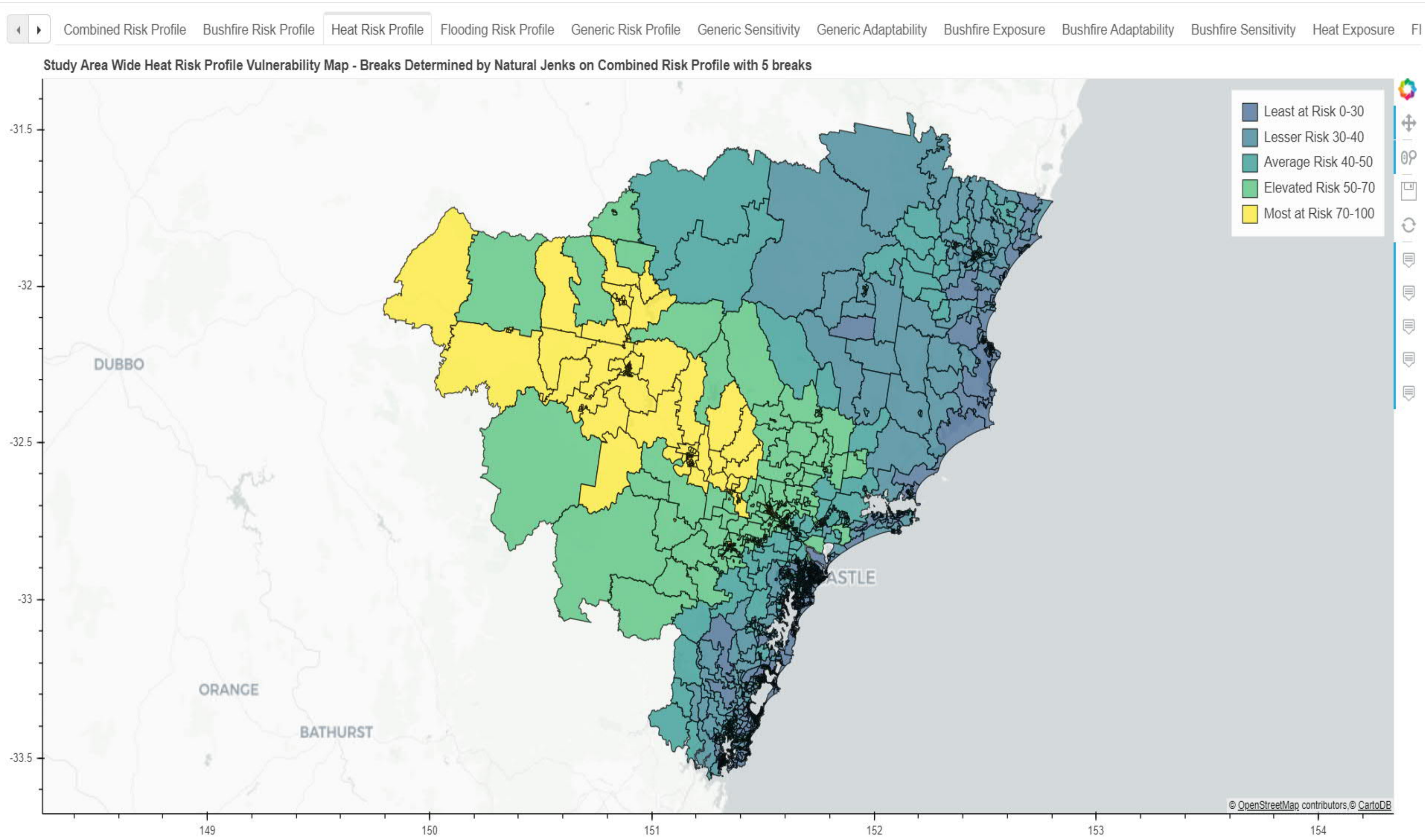

Figure 34 Relative Community Vulnerability – SA1 Level - Heat Risk Profile with 5 Breaks

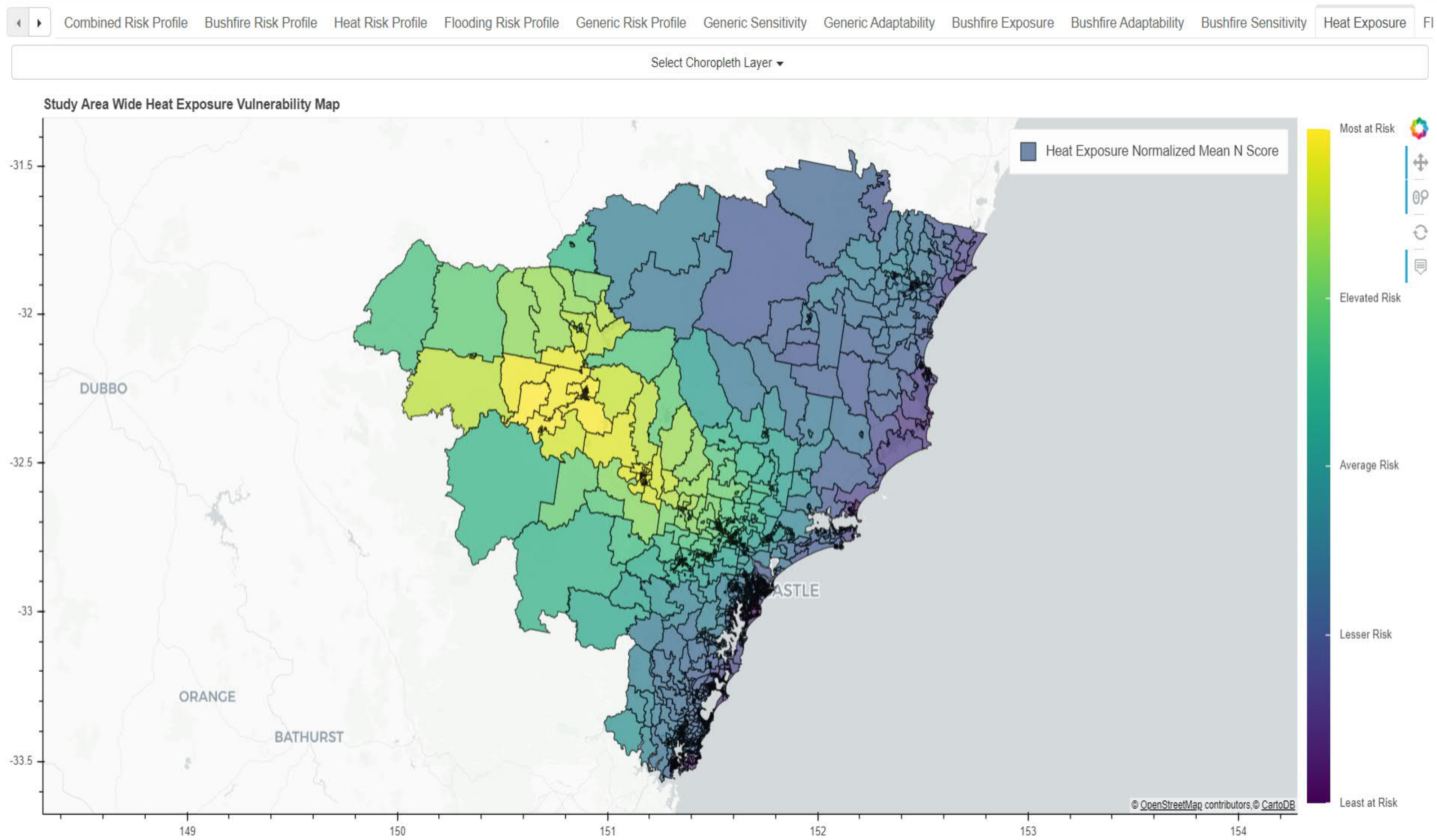

Figure 35 Relative Community Vulnerability – SA1 Level - Heat Exposure

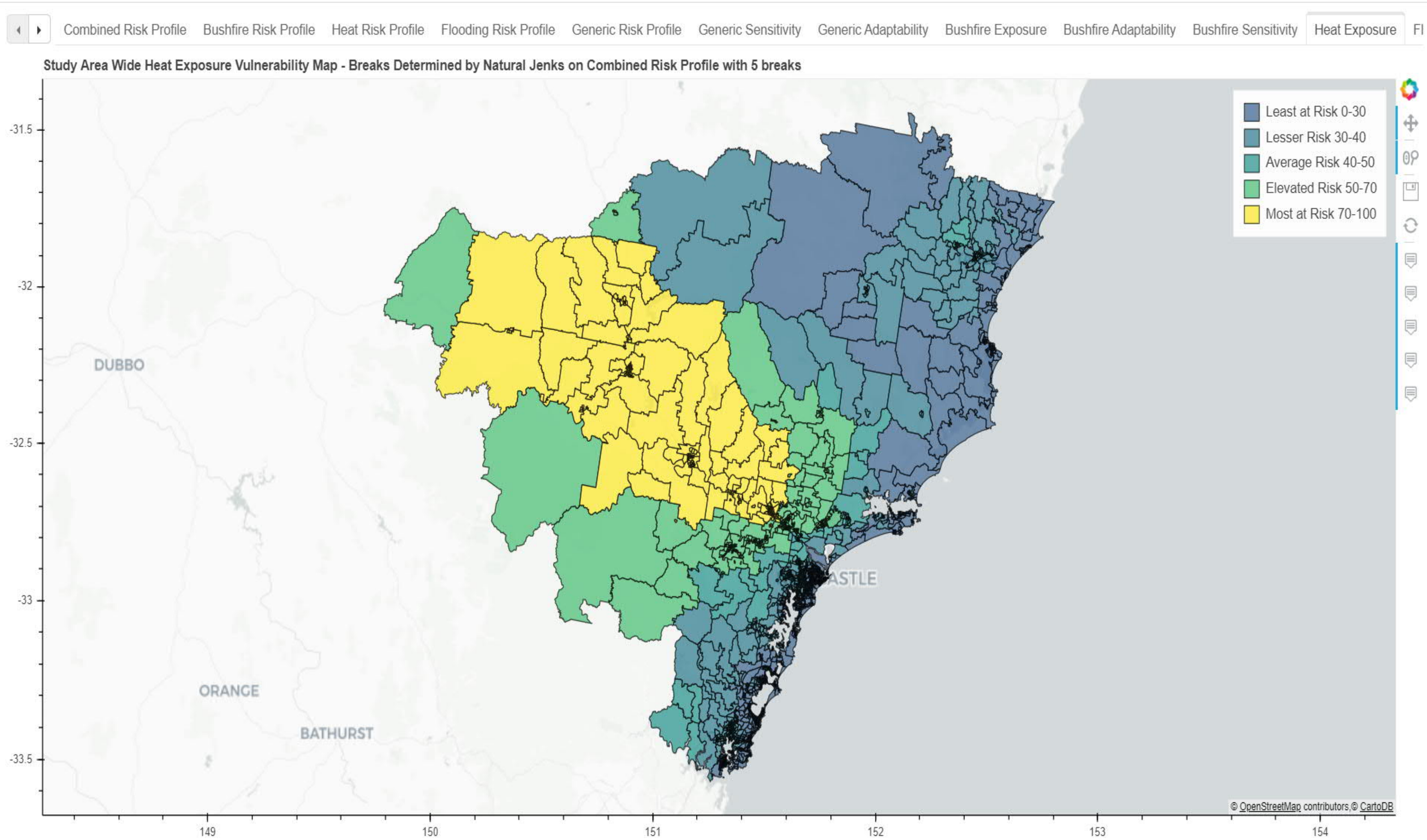

Figure 36 Relative Community Vulnerability – SA1 Level - Heat Exposure with 5 Breaks

4.5 Combined Risk Profile - Relative Vulnerability to Natural Hazards

As described in Section 3.0, a combined risk profile was also established based on the hazard specific risk profiles for bushfire, flooding and heat. This combined risk profile is shown in Figure 37 & Figure 38 and illustrates the '*average risk*' scores recorded against each of the three hazards considered. The combined risk profile aligns well to the bushfire and heat profiles as each of these hazards shared similar results.

The 'corridor' from Newcastle to Muswellbrook, along the Hunter River was identified with generally *'most at risk'* and *'elevated risk'.* This is due to the higher scores for flooding and extreme heat in this area from low canopy density and high population density. The areas located along the inland project boundary were also subject to *'most at risk'* due to higher scores for bushfire exposure and extreme heat. The remaining areas subject to *'elevated risk'* were generally well distributed across the project area.

Areas identified as '*lesser risk*' were generally coastal and well distributed across the coastal LGAs and the areas identified as '*least at risk*' were the urban areas directly along the coast as these areas have low exposure to bushfire and extreme heat as well as have a higher level of adaptive capacity given investment in these more populated areas.

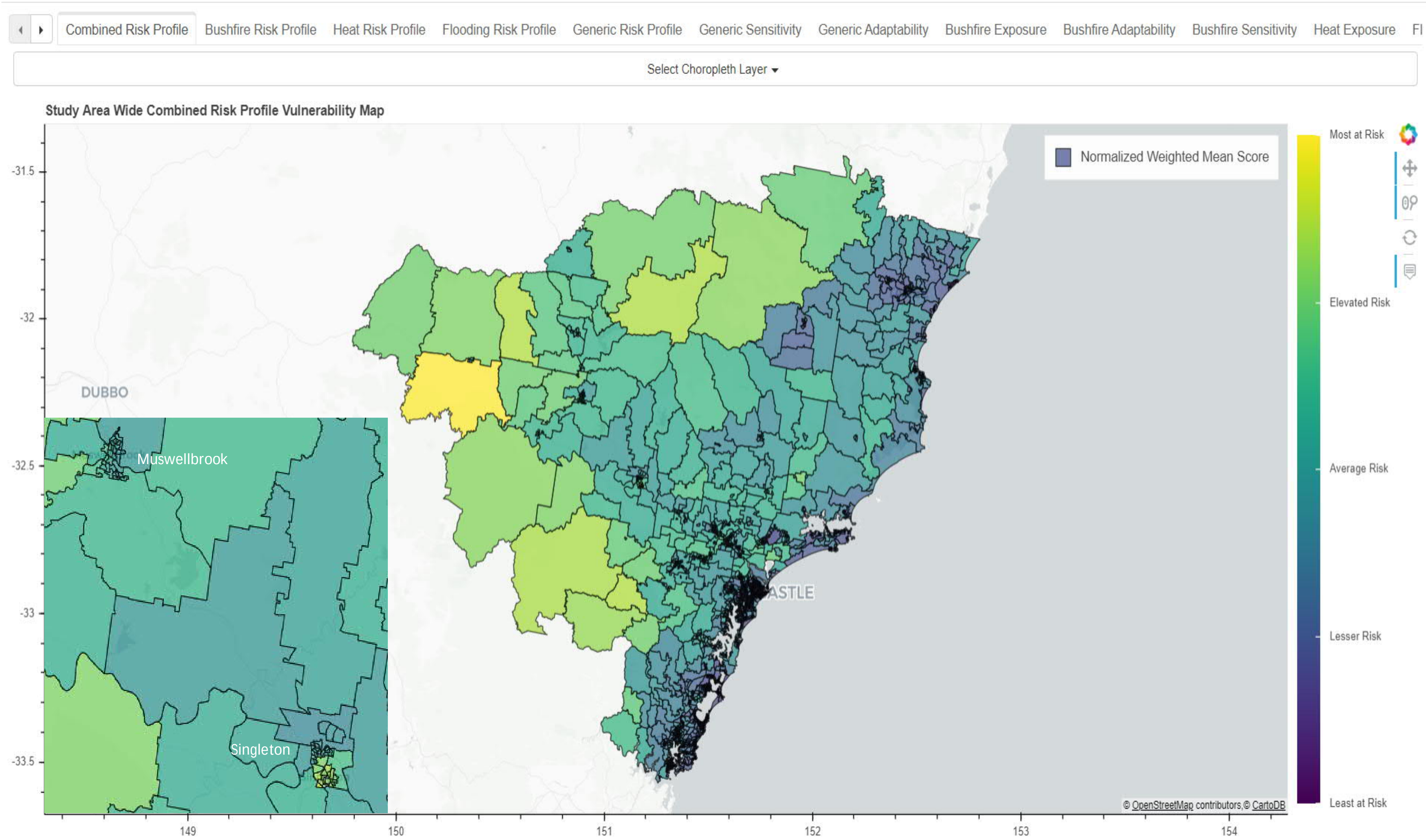

Figure 37 Relative Community Vulnerability – SA1 Level - Combined Risk Profile

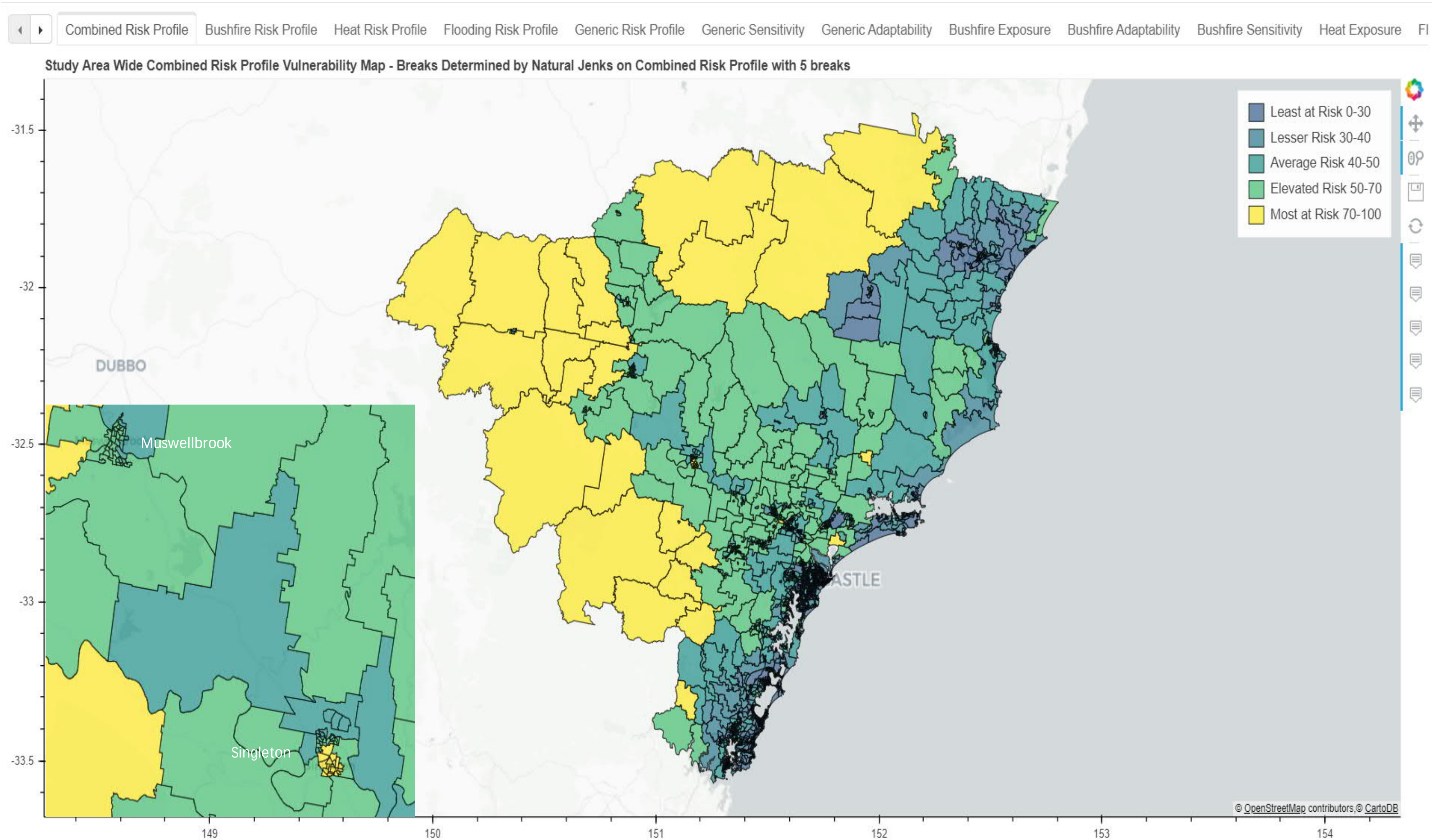

Figure 38 Relative Community Vulnerability – SA1 Level - Combined Risk Profile with 5 Breaks

5.0 Conclusion

This summary report provides an overview of how existing spatial data can be used to improve our understanding of the interface between 'at risk' communities and natural hazard exposure. As the summary of results (Section 4.0) makes clear there are many different factors to consider when assessing the risk hazards pose to communities. In general, the spatial datasets reviewed during the course of this project identified generic sensitivity and adaptive capacity risks adequately. The overall vulnerability of communities within the project area is therefore well represented.

However, some information gaps remain where exposure information is not readily available (e.g. sea level rise exposure). Similarly hazard specific measures of sensitivity and adaptive capacity were more apparent for bushfire than any of the other hazards considered. Such gaps were often a result of the scale, accuracy or completeness of available data as some factors are simply poorly represented in a spatial sense during common use. For example, it is common for the location of flood control structures (e.g. block banks, flood levees) to be identified. However, it is less common for the same data to define the extent of the community which they protect outside of a more detailed study. This limits the data in terms of measuring its effect on a given community.

Review of the project data suggests that there may be potential to develop additional data inputs based on existing Geographical Information System resources in use and maintained by project partners and other government departments for other purposes. It is also likely that the involvement of additional project partners would provide greater access to spatial data. It is anticipated that as additional data sources become available or existing data is refined the framework outlined here may be updated to provide a more detailed or comprehensive analysis.

Further statistical analysis of these results is also likely to further improve our understanding of the interface between 'at risk' communities and natural hazard exposure by quantifying the relationships between different risk factors, identifying correlations between different hazards and providing quantitative certainty in the results. Additional spatial analysis may also be employed to highlight concentrations or clusters within the results and consider the spatial relationship between overall risk and available community resources.

There is also potential for the geospatial framework to not only identify those communities '*most at risk*' but also identify potential refuge spaces and available community resources within the context of building community preparedness. Exposure to bushfire, flooding and heat typically occur within finite limits. For example, a given community is typically inundated or avoids the impacts associated with flooding completely as it is limited to areas of a given low elevation. As a result, unaffected areas are often located in proximity to those areas most exposed. This information could also be used to identify these interfaces and prioritise initiatives to build community resilience.

Ultimately it is anticipated that the geodatabase provides a platform on which to build the effectiveness and efficiency of interagency efforts in raising community awareness and preparedness towards natural hazards. This may involve analysis at a local scale; identifying relevant risks and delivering tailored programs to meet the specific requirements of each community and target audience. Further statistical analysis is likely to be useful in determining the best placement and overall effectiveness of these resources.