Australian Urban Observatory

# FAQs

## Heat Vulnerability Index

### How has the Heat Vulnerability Index been developed?

The Heat Vulnerability Index (HVI) is a composite index developed for the 21 largest cities in Australia to identify areas and populations most at risk from heat-related impacts. It includes three core components based on the Intergovernmental Panel on Climate Change's (IPCC) vulnerability framework:

- **Heat Exposure** – derived from satellite-based Land Surface Temperature (LST) data;
- **Heat Sensitivity** – based on socioeconomic indicators that influence how severely populations may be affected by heat;
- **Adaptive Capability** – reflecting the capacity of communities to respond to and manage heat risks.

The Heat Vulnerability Index supports targeted local planning, climate adaptation strategies and can be updated or customised for different applications.

### How are Heat Vulnerability Index scores interpreted?

Each area is assigned a vulnerability score from **1 (low vulnerability) to 5 (high vulnerability)** with lower scores indicating lower vulnerability. These scores are calculated from quartile rankings of the combined indicators described above. A score of 0 is reserved for areas with no recorded residential population in the census. The same rating scale is used for the overall Heat Vulnerability Index and the 3 sub-components of Heat Exposure rating, Heat Sensitivity rating and Adapative Capability rating that are used to calculate the overall Heat Vulnerability Index.
A simple way of understanding and interpreting results according to colours of the Australian Urban Observatory (AUO) map is provided below.

- **Heat Vulnerability Index** – heat vulnerable locations are coloured pink and less heat vulnerable areas are coloured green.
- **Heat Exposure rating** – hotter areas are coloured pink with higher Land Surface Temperatures.
- **Heat Sensitivity rating** – areas more sensitive to heat are coloured pink and include more people vulnerable to heat (older, younger, care needs) and areas with less vegetation and more buildings.
- **Adaptive Capability rating** – areas with populations less able to adapt to heat are coloured pink and include higher proportions of socioeconomic disadvantage.

## What is the purpose of the Heat Vulnerability Index?

The purpose of the Heat Vulnerability Index is to understand the relative distribution of heat-vulnerable neighbourhoods at a single point in time. The technical workflow follows the IPCC framework (Figure 1), incorporating the conceptualisation of heat exposure, sensitivity, and adaptive capability (Figure ). By combining heat, vegetation, and demographic data, the HVI provides an holistic view of the underlying drivers of heat vulnerability. These outputs support the identification of locally appropriate responses to help protect and empower heat-vulnerable communities.

## How can the Heat Vulnerability Index be used in policy and planning?

The HVI helps identify communities most at risk from extreme heat by integrating environmental, social and health-related factors. The HVI can be used to:

- benchmark neighbourhoods to identify relative heat vulnerability;
- inform heatwave preparedness;
- guide greening and cooling infrastructure investments;
- target vulnerable areas for action;
- support equitable climate adaptation planning.

Decision-makers can use the HVI to understand the heat vulnerability of different areas and target urban planning and public health interventions where they are needed the most.

The City of Greater Bendigo provides a great example of how the HVI can be applied in practice. The HVI was used by council to inform the development of the city's first urban forest strategy—Greening Greater Bendigo 2020–2070. Trees were planted in neighbourhoods identified as heat vulnerable areas to reduce heat exposure and improve community resilience.

## How should I use Heat Vulnerability Index results in practice?

We recommend using the AUO map portal and three levels of HVI analysis to guide the development of targeted heat mitigation strategies for areas:

- **Level 1** begins with interpreting overall Heat Vulnerability Index scores at suburb and neighbourhood level to provide high-level insights into areas that are more vulnerable to heat;
- **Level 2** disaggregate the HVI into its three subcomponents of Heat Exposure rating, Heat Sensitivity rating, and Adaptive Capability rating to interpret and understand the underlying dimensions contributing to heat vulnerability in different areas;
- **Level 3** consider further investigation of the individual variables included in the HVI and three subcomponents (Table 2) including land surface temperature, NDBI and NDVI (available here) and demographic variables (available in the AUO map portal and ABS Census).



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## What variables are included in the Heat Vulnerability Index?

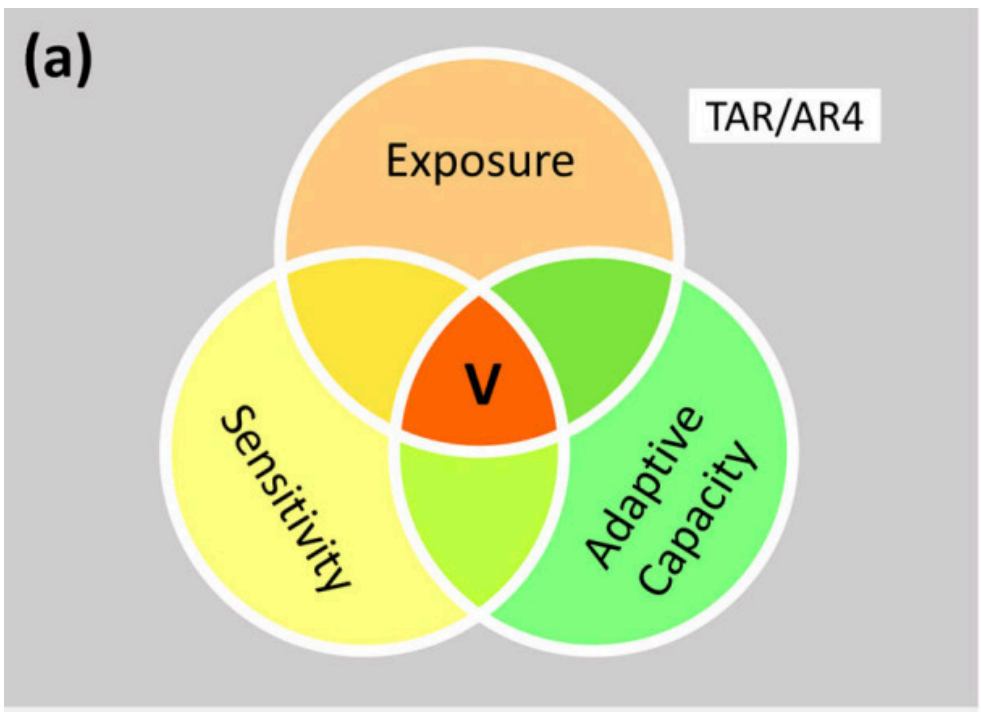
The HVI integrates remote sensing datasets including the Normalized Difference Built-up Index (NDBI), Normalized Difference Vegetation Index (NDVI) and socioeconomic data. It is spatially aggregated to the Australian Bureau of Statistics (ABS) Statistical Area Level 1 (SA1) scale. All variables included in the HVI are presented in Table 1 below.

**Table 1**: Variables included in the Heat Vulnerability Index

| | |
|---|---|
| LST | SA1 mean LST (land surface temperature) for a defined year (Nov – Mar summertime), calculated from satellite thermal imagery (Landsat) on Google Earth Engine |
| NDBI | SA1 mean NDBI (Normalized Difference Built-up Index) same period as LST, calculated from satellite imagery (Sentinl-2) on Google Earth Engine |
| NDVI | SA1 mean NDVI (Normalized Difference Vegetation Index) same period as LST, calculated from satellite imagery (Sentinl-2) on Google Earth Engine |
| Population Density | SA1 population density (per square kilometres), calculated based on the ABS Census of Population and Housing: General Community Profile (Table G01), which includes total population and area size for each SA1. |
| Age_65_Above | SA1 percentage of older population (aged 65 and above), calculated based on the ABS Census of Population and Housing: General Community Profile (Table G06), which provides age-specific population data. |
| Age_4_Below | SA1 percentage of very young population (aged 4 and below), calculated based on the ABS Census of Population and Housing: General Community Profile (Table G06), which provides age-specific population data. |
| Population need care | SA1 percentage of persons who need care, derived from the ABS Census of Population and Housing: General Community Profile (Table G18), which includes data on the need for assistance with core activities. |
| Education level | SA1 education score: Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), SEIFA-IEO |
| Income level | SA1 education score: Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), SEIFA-IER |
| HVI | Heat Vulnerability Index combining Heat Exposure Score, Heat Sensitivity Score, and Adaptive Capability Score to represent overall heat vulnerability. |
| Heat exposure rating | Heat exposure rating, derived from LST |
| Heat sensitivity rating | Heat sensitivity rating, representing population sensitivity to heat based on age, population density, and care needs, and land use characteristics (vegetation coverage: NDVI and built-up intensity: NDBI) |
| Adaptive capability rating | Adaptive capability rating, measuring the population's ability to adapt to heat based on socio-economic factors, derived from the SEIFA dataset in the Census of Population and Housing. |

## Who developed the indicator and is there an academic paper that can be cited?

Development of the HVI was led by A/Prof Qian (Chayn) Sun at RMIT University:
Sun, Q., Das, S., Wang, K., Tao, Y. Amati, M., Hurley, J., Choy, S. & Duckham, M. (2022). iHVI: An Open-Source Toolkit for Constructing Integrated Heat Vulnerability Index in Australia. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* 48, 175-182.
Additional resources are available on the GitHub repository and IGEE web application.




**Vulnerability (V)** (IPCC 2007, p. 883)
"The degree to which a system is susceptible to, and [**or** in IPCC 2001] unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation [**climate variation** in IPCC 2001] to which a system is **exposed**, its **sensitivity**, and its **adaptive capacity**." (bold emphasis added)

**Exposure** (IPCC 2001, p. 987)
"The nature and degree to which a system is exposed to significant climatic variations."
(not defined in IPCC 2007)

**Sensitivity** (IPCC 2007, p. 881)
"The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)."

**Adaptive capacity** (IPCC 2007, p. 869)
"The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences."

**Figure 1**: IPCC vulnerability assessment framework in TAR/AR4: Estoque, R.C. et al. Has the IPCC's revised vulnerability concept been well adopted?. Ambio 52, 376–389 (2023). https://doi.org/10.1007/s13280-022-01806-z



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**Table 2:** Indicators included in the calculation of Heat exposure rating, Heat sensitvity rating and Adaptive capability rating

| | Indicators | Justifications |
|---|---|---|
| **Heat Exposure** | **A:** Mean UHI based on meshblocks | provides an exposure indicator for heat. |
| **Heat Sensitivity** | **B:** NDVI (Normalized Difference Vegetation Index) | provides a sensitivity indicator for the retention of heat in the urban environment, lower NDVI, reduced cooling capacity and greater sensitivity to heat retention. |
| | **C:** NDBI (Normalized Difference Built-up Index) | provides a sensitivity indicator for the retention of heat in the urban environment, higher NDBI, increased heat absorption and retention. |
| | **D:** Population density (persons per square km) | prevents the generation of spatial biases induced by very large/small census tracts. high number corresponding with a high sensitivity score, as denser of population are more sensitive to heat related health complications. |
| | **E:** % of over 65 years old person | with high number corresponding with a high sensitivity score, as elderly people are more sensitive to heat related health complications. |
| | **F:** % of 4 and below person | with high number corresponding with a high sensitivity score, as very young kids are more sensitive to heat related health complications. |
| | **G:** % of persons needing care | with high number corresponding with a high sensitivity score, as more persons needing care indicating more sensitive to heat related health complications |
| **Adaptive capability** | **H:** (SEIFA-IEO) Education score | more advantaged populations have more resources to respond to heat. |
| | **I:** SEIFA-IER (Economic score) | more advantaged populations have more resources to respond to heat. |

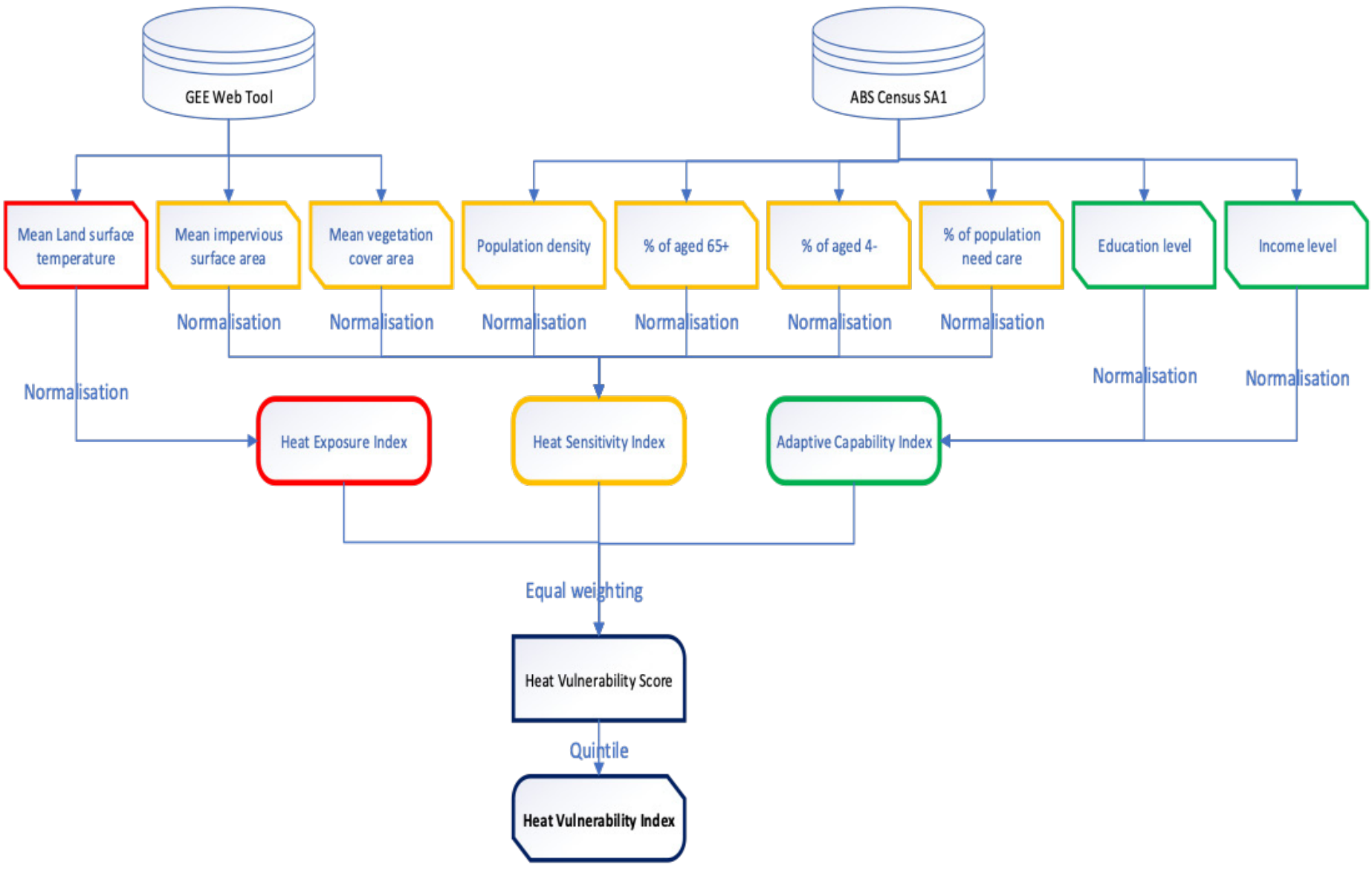


**Figure 2:** Workflow of development of the Heat Vulnerability Index which is comprised of the Heat Exposure + Heat Sensitivity + Adaptive Capability (Sun, Q., et al., 2022).

**suggested citation for this document:** Davern, M. & Sun., Q. (2025). Heat Vulnerability Index FAQs. Australian Urban Observatory, RMIT University, auo.org.au. DOI: 10.25956/5dcb85fa3bdfc.



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