Submission to the Chief Health Officer -
Inquiry into the impact of climate change on health

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Submission Purpose

The purpose of our submission is to:

1. Highlight the important role spatial information and spatial technology has in;
    a. identifying vulnerable populations due to climate change (i.e. risk profiling) and
    b. providing geospatially enabled decision support tools such as scenario planning for adaptation planning to mitigate risk due to climate change.
    (i.e. items 2 & 3 in the Inquiry Terms of Reference)
2. Highlight other activities/initiatives relevant to WA in considering a framework to evaluate future implications of climate change on health impacts.

Background/rationale

Many forward-thinking cities have been developing climate change action plans[2] or city resilience strategies[3] to help reduce the city's contribution to climate change and prepare for future unusual weather events associated with climate change through adaptation strategies. Much of the adaptation portion of these initiatives is aimed at elements of the built environment which can be referenced spatially e.g. buildings, trees, waterways and facilities.

In Western Australia these spatial factors are exacerbated by the population being dispersed over an area of 2.5 million square kilometres. Regions are not only faced with diverse geography and climate but social factors such as disparate income levels, food availability, health status and availability of health services which also vary with *time*. To be effective, surveillance of climate-related health vulnerabilities must consider a wide variety of factors influencing health outcomes, as well as their associated spatial and temporal aspects. Therefore, having the ability to view this information spatially and at a sufficient level of detail to enable effective decision making is critical for improved understanding of population vulnerability or the risk of adverse health outcomes as well as for developing and implementing mitigation initiatives.

- What do we Mean by Spatial Information?

  Spatial information is the digital connection between location, people and activities. This information can graphically illustrate what is happening (where, how and why) to show the insight and impact of the past, the present and the (likely) future. Traditionally spatial data have been uniquely characterized as geographic (e.g., longitude and latitude) or map-based coordinates.

  Spatial data therefore is data that has an x,y, and z coordinate as an attribute and will increasingly in the future be time stamped. These characteristics are required for the data to be 'spatially enabled'.

[1] Formerly the Cooperative Research Centre for Spatial Information

[2] Anguelovski I, Carmin JA. Something borrowed, everything new: innovation and institutionalization in urban climate governance. Curr Opin Environ Sustain. doi: 10.1016/j.cosust.2010.12.017.

[3] http://100resilientcities.org/strategies/

- How is Spatial Information used in health?

Spatial tools have been used for many years to explore environmental determinants of cancer, describe risk factors for chronic disease, investigate disease transmission, and plan for and respond to natural disasters, including in low-resource settings, where application to infectious disease surveillance and outbreak response predominates[4]. Indeed, modern public health, in the English-speaking world, was founded in the work of John Snow and his carefully drawn cholera maps in the London of the 1850s[5].

In the last decade, the mapping and spatial analysis of disease patterns has changed dramatically, as computer power and cloud storage has increased and become more accessible, and Geographic Information Systems (GIS) have emerged as individually accessible software, allowing for more widespread, complex and comprehensive analyses than previously. Such advances have made it possible for medical geographers, and others, to seek answers to questions that were previously overly complex and unfeasible. Through GIS analysis it is possible to understand why things are located where they are and, in combination with health and other sciences, how they are related. Obtaining disease and health data has been made easier by low-cost global positioning system (GPS) units and the improvement of the quality of Remote Sensing (RS).[6] Key insights can be discovered when we overlay health data with other seemingly disparate data sets such as transport, location of types of food supply, socioeconomic status and environmental data.

Aim 1: How can spatial information/technologies assist in addressing the specific terms of reference of this enquiry?

Specifically, spatial information and associated technologies will assist with addressing items 2 and 3 of the terms of reference.

- ToR # 2: Identify a program of work which will protect the public from the harmful health impacts of climate change
- ToR #3: Identify a program of work which will strengthen the preparedness and resilience of communities and health services against extreme weather events, with a focus on the most vulnerable in the community

Vulnerability to climate change must take into account many risk factors (income, diseases, handicaps, lack of social network, geographical location, presence of specific services in the district, etc.) and to be effective, be applicable at different levels of spatial resolution (e.g., street, suburb, city, region). The risk factors are also different for specific case studies (heat, water, air quality, vector borne disease etc.). To effectively assess climate change vulnerability (profile risk) the data sources for each indicator and each case study must be identified, obtained and integrated (as opposed to linked).

Geographical Information Systems (GIS) then provide a common platform in which to view and analyse these diverse data sets for an area of interest or for a specific use case. The value of a vulnerability assessment is that it allows health departments to understand the people and places in their jurisdiction that are more susceptible to adverse health impacts associated with the climate-related exposures modified by climate change. This assessment of people and place vulnerability can then be used to implement more targeted public health action to reduce harm to people. Several case studies are outlined below to demonstrate the value of spatial technologies and more are offered in Appendix 1.

[4] Lyseen AK, Nohr C, Sorensen EM, Gudes O, Geraghty EM, Shaw NT, et al. A review and framework for categorizing current research and development in health related geographical information systems (GIS) studies. Yearb Med Inform (2014) 9:110–24. doi:10.15265/IY-2014-0008

[5] Snow J. On the Mode of Communication of Cholera. London: John Churchill (1855). 162 p.

[6] Yearb Med Inform 2014:110-24 http://dx.doi.org/10.15265/IY-2014-0008 Published online August 15, 2014

- *Case study 1: Identifying vulnerable populations to an intense heat wave*
  The first example deals with a part of the population that is potentially more vulnerable to an intense heat wave, namely elderly people living alone or in isolated surrounds. In a GIS the user may spatially represent the proportion of people living alone at different levels of detail regardless of gender and age. Then, the user can get more insight by distributing this proportion according to population age and filter the older ones (e.g., 75–84 years; 85 years or older) by simply selecting these groups directly within the system. This analysis can be immediately enriched by adding additional measures, such as the proportion of the population with low income, cardiovascular, respiratory, neurologic and psychological diseases. This kind of information can be derived in minutes and combined with data on mitigation strategies or related health care facilities or services

- *Case Study 2: Identifying potential vector-borne disease outbreak*
  Climate change potentially expands the spatial reach of vector-borne diseases by increasing flooding, altering precipitation patterns, and raising temperatures. Forecasting where these outbreaks might occur enable health departments to target intervention programs. A robust earth observing system that monitors key climate variables is critical to predicting future disease outbreaks and has advantages for modelling vector borne disease spread. Geoscience Australia through its Digital Earth Australia platform now provides 30 years of satellite data (earth observation data) enabling users to access this data for use in numerous applications. Globally there is significant work being conducted to use remote sensing technologies in this manner, especially in relation to tropical or mosquito borne diseases. In the future disease modelling will increasing use ground based and satellite-based sensor information to effectively and economically forecast disease spread, as well as identify vulnerable populations.

- *Case Study 3: Identifying vulnerable populations to poor air quality due to landscape fires*
  GIS can also be used to identify areas at greatest risk of exposure from landscape fires based on new smoke trajectory models. These models ingest data such as PM2.5, remotely sensed aerosol optical depth, fire radiative power, venting index, vehicle emissions, weather conditions and smoke plume from earth observation imagery to forecast which geographical locations will be at greatest risk of poor air quality. When other people centred data (health conditions, socioeconomic factors, age) is then considered within the GIS platform vulnerable populations can be identified and subsequently warned through targeted interventions.

- *Case Study 4: Sea level rise decision tools*
  Sea level rise decision support tools which use spatial information such as LiDAR and aerial imagery surveys as model inputs toprepare for, and adapt to, sea level rise brought about by climate.

- *Case Study 5: Improving a city's infrastructure to better respond to heat waves*
  GIS together with thermal models which incorporate remotely sensed and weather data can be used to rapidly visualise the temperature over any geography at different levels of detail to detect hotter regions. From this representation, contextual spatial layers can instantly be displayed to provide additional information, whatever the level of detail being analysed. Public parks, natural waterways as well as private and public pools can be displayed over the temperature map. Such a representation can help local government plan new green spaces or install new public pools to better serve the population. As per other examples, additional information can be easily combined, such as the ratio of hospitalization for respiratory diseases or the ratio of the population living with incapacity to identify areas of greatest need.

Aim 2: Highlight other activities/initiatives relevant to WA

1. **Development of Victoria Environmental Health Tracking System**
   Published in May 2019 https://www.mdpi.com/1660-4601/16/10/1748 this article outlines Victoria's (Australia) Environment Protection Authority (EPA), the state's environmental regulator, has recognized the need to develop an Environmental Health Tracking System (EHTS) to better understand environmental health relationships. To facilitate the process of developing an EHTS; a linkage-based conceptual framework was developed to link routinely collected environmental and health data to better understand environmental health relationships.

2. **FrontierSI formulation of the AusEnHealth Knowledge Hub**
   FrontierSI are currently exploring the development of 'major initiatives' of which an environmental health online portal **(AusEnHealth)** is one. This would pull together the key environmental health indicators, required data, relevant models into one platform powered by newly developed data infrastructure methods known as a Spatial Knowledge Infrastructure (SKI) for easier and more meaningful information to a range of end-users like the Australian Cancer Atlas (atlas.cancer.org.au). This would involve a multi-party, multi-disciplinary effort and require careful facilitation and project management which is FrontierSI's expertise. Our approach is well-aligned to the direction of the WA Department of Health's inquiry.

3. **New Zealand Environmental Health Indicators**
   The New Zealand Environmental Health Indicators web portal provides you information and statistics on how the environment affects the health of the New Zealand human and animal populations. http://www.ehinz.ac.nz/

4. **Development of Digital Twin projects for data integration, scenario planning**
   Several Australian state government departments (Vic, NSW, QLD) are commencing work in developing Digital Twins as a mechanism to create a digital replica of a physical entity eg. city, state, country. By bridging the physical and the virtual world, data can be transmitted seamlessly allowing the virtual entity to exist simultaneously with the physical entity. FrontierSI believe the City of Perth are developing a Digital Twin prototype which could potentially integrate environmental health indicators as a test case for environmental health monitoring.

5. **The Group on Earth Observations (GEO) – Ministerial Summit Nov 2019 Canberra**
   GEO is an intergovernmental partnership of 105 Member governments, 127 Participating Organizations and thousands of passionate individuals and businesses that improves the availability, access and use of Earth observations for a more sustainable planet. GEO promotes open, coordinated and sustained data sharing and infrastructure for better research, policy making, decisions and action across many disciplines. The GEO community focuses on three global priority engagement areas: the United Nations 2030 Agenda for Sustainable Development (including Sustainable Development Goals), the Paris Agreement and the Sendai Framework for Disaster Risk Reduction. GEO provides a unique forum where governments, businesses, the research community, non-profits and all other groups come together to create solutions, share, and cooperate.

   In November 2019, Ministers from GEO's 105 Member governments, business leaders, heads of international non-profits and passionate experts will meet in Canberra, Australia for GEO Week 2019 and the GEO Ministerial Summit. Building on the 2015 Mexico City Declaration, GEO Week will focus on accelerating the delivery of GEO's Strategic Plan and will bring the GEO community together to scale-up the impact of Earth observations.

   Paula Fievez, FrontierSI Health Lead is a member of the Geo Health Community of Practice who have jointly developed the 2020 Workplan. Paula has been keeping the WA Department of Health informed on this activity. The draft workplan can be found here:
   http://www.earthobservations.org/documents/gwp20_22/eo_for_health_ip.pdf

6. **US Centre for Disease Control & Prevention**
   The US CDC has developed the Building Resilience Against Climate Effects (BRACE) framework which is a five-step process that allows health officials to develop strategies and programs to help communities prepare for the health effects of climate change. Part of this effort involves incorporating complex atmospheric data and both short- and long-range climate projections into public health planning and response activities. Combining atmospheric data and projections with epidemiologic analysis allows health officials to more effectively anticipate, prepare for, and respond to a range of climate sensitive health impacts. The five sequential steps that comprise the BRACE framework can be found here: https://www.cdc.gov/climateandhealth/BRACE.htm

Recommendations for the Climate Health WA Inquiry

In addressing the Terms of Reference of the Climate Health WA Inquiry our recommended program of work is outlined below. The outcomes of each work package would equally benefit every state and territory health agency and should be considered as a part of a nation-wide initiative.

We recommend the development of an **Aus**tralian **En**vironmental **Health** Knowledge Hub (AUSEnHealth) an online environmental health information portal enabling users to access, visualise and analyse environmental health data, environmental health indicators, reports and models, and provide tools to support adaptation planning, vulnerability assessment and decision making. This would draw information together from existing sources to provide an integrated solution to empower a range of users including the public, media, policy analysts, and decision-makers, as well as researchers and scientists.

A project of this scale requires collaboration and support from a range of agencies, expertise and disciplines. It cannot be done by one agency alone. The problem is a shared one and thus the solution must also be shared. The result of this collaborative effort however will benefit WA and the nation.

To deliver the AusEnHealth Knowledge Hub we recommend a staged approach through the following work packages:

1: Data audit, review and collection (environmental health indicators)

Review current knowledge gaps, identify existing gaps and implement initiatives to enable data collection or data integration to enable effective vulnerability assessments to be undertaken in consultation with other state and territory health agencies. This would firstly:

a. identify environmental health indicators (e.g. air and water quality, UV, temperature, precipitation indicators)
b. identify health data relevant to environmental indicators
c. identifying data sources/custodians for data sources
d. undertake a data audit on gaps in required data
e. initiate data collection and/or data integration

2: Data integration and analysis software development

Once the data sources are identified and made accessible then they would need to be integrated through a spatial platform enabling query, analysis and reporting at various geographical boundaries (e.g. Local Government level, Primary Health Network level and SA2). This information will be a necessity for undertaking a Climate Change Vulnerability Assessment and subsequent Climate Change Adaptation Plans for the health sector and local governments. This stage will provide historical and current state information.

A framework (Integrated Geospatial Information Framework) developed by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) and the World Bank could be considered during this stage of development. This framework is an enabler for coordinating, developing, strengthening and promoting the effective sharing of geospatial information for policy formulation, decision-making and innovation. http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Part%201-IGIF-Overarching-Strategic-Framework-24July2018.pdf

3: Scenario planning tool development

Once current state is known then future state needs to be addressed through the development of a spatially enabled scenario planning tool. This will draw on gold standard modelling methods for predicting future health outcomes as well as forecast weather data available from https://www.climatechangeinaustralia.gov.au. There are numerous examples of scenario planning tools developed for other sectors that could be considered in such a development. This tool would be required in order to assist policy development and future Climate Change Adaptation Planning.

Conclusion

Many reports discuss 'new technologies' such as sensors and smart real time health applications as if they are not quite attainable, however this technology is available now and can be applied practically to meaningfully identify and mitigate climate change impacts on health As stated in *Location Matters – realising the potential of people-centred spatial information to inform policy*, a report commissioned by the Australian Institute of Health and Welfare and the Cooperative Research Centre for Spatial Information; "Indeed, this future is quickly becoming the present, and people-centred spatial information will become even more crucial not only for decision and policy makers, but for each one of us as we partner in navigating our well-being and our environments'.

The private sector is capitalising from acquiring such data and building new consumer applications, however there appears to be a lag in government uptake. Government need to work much closer with industry within a more innovative and agile framework if we are going to make a step change in combatting the health impacts of impending climate change.

It is our contention that spatial information and enabling technologies is an imperative for inclusion in any program of work addressing climate change. Omitting to include spatial information and technology in any future climate change mitigation strategy would be a costly oversight.

How can FrontierSI assist WA Department of Health?

FrontierSI brings together the best people to solve the most complex spatial problems and represents a partnership of over 40 organisations across Australia and New Zealand. Through our partnerships and collaborative model, our spatial expertise accelerates industry and economic growth, provides better government services and leads to improved environmental and social well-being. Our partners include research agencies, government departments and private sector companies who are global leaders in spatial information. In Western Australia we are currently partners with Landgate, WA Department for Health and Curtin University as well as a range of spatial industry technology companies. We have several projects underway with government environmental agencies across Australia and being more and more relied on to assist government with challenges of this scale. We are a trusted advisor and facilitator and have a depth of experience delivering multi-party, multi-disciplinary collaborative spatial research and development projects both local and internationally.

We have outlined some key recommendations in this submission in which we are well placed to facilitate for the WA Department of Health should they wish to pursue such research and development. FrontierSI welcome the WA Department of Health to connect with us to initiate early discussion about how we can assist in facilitating and coordinating a project of this scale.

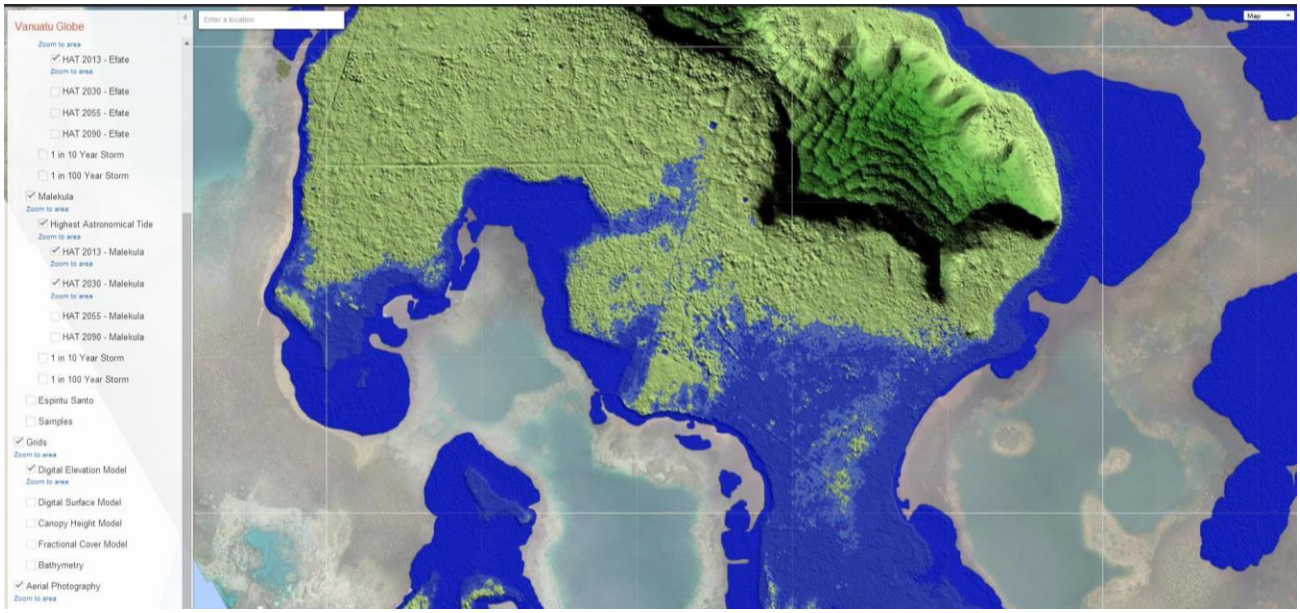
Appendix 1: FrontierSI Case Studies

Pacific Island Sea Level Rise Planning Capacity Building

The Australian Department of the Environment and FrontierSI completed a four-year project working with Tonga, Samoa, Vanuatu and Papua New Guinea, to build capacity in spatial modelling and decision making through LiDAR and aerial imagery surveys, GIS training and the provision of hardware and software. The project team completed the project in 2015 enabling these countries to prepare for, and adapt to, sea level rise brought about by climate change by providing the fundamental data, skills and tools for planning decisions.

The project achieved excellence in the Pacific Island coastal inundation and capacity building project by including locals in every stage of the project. This project was showcased by Google at the White House Climate Data Initiative launch as a leading example around the world for increasing climate change awareness and enabling communities through the use of spatial information and mapping. The project has won a number of awards including:

- United Nations COP21 Momentum 4 Change Lighthouse Activity 2015
- 2016 Asia Pacific JK Barrie Award. The J.K. Barrie Award is the apex of achievement in the spatial industry and is the highest award the national panel of judges can confer.



Google Maps web tool developed for the Pacific Island Project showing sea level rise in the Maskelyne Islands, Vanuatu

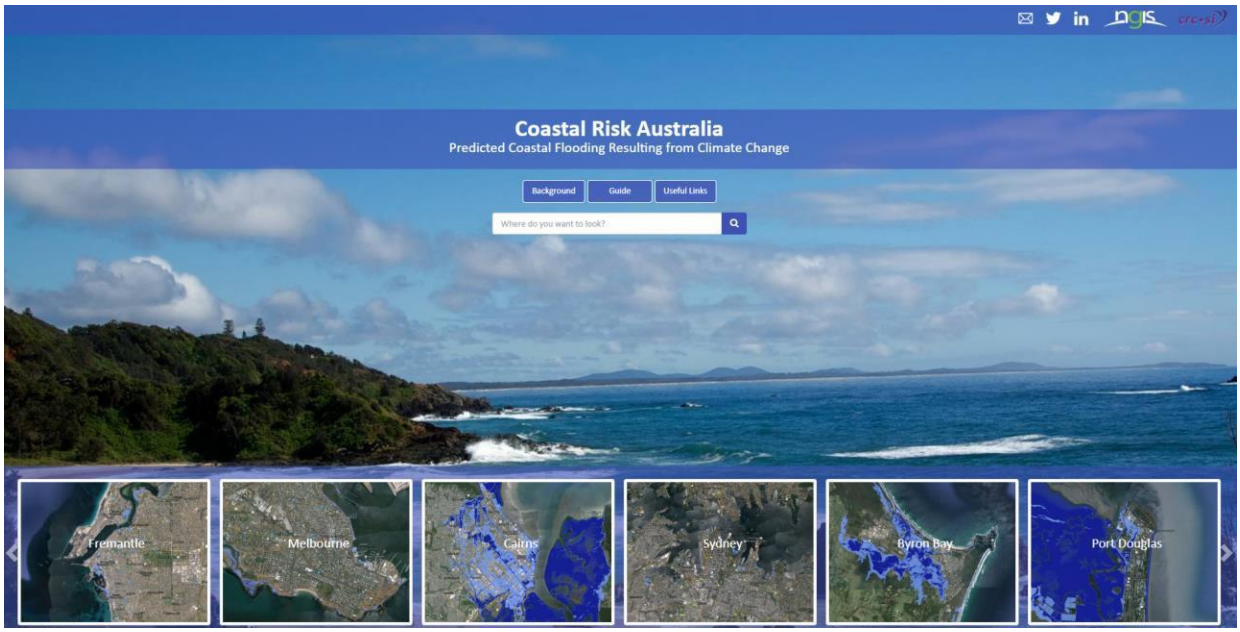
Coastal Risk Australia and Vanuatu

Coastal Risk Australia (CRA) and Coastal Risk Vanuatu (CRV) are world first website that empowers coastal communities to take action regarding climate change. For the first time Australians and ni-Vanuatu can visualise how their homes and neighbourhoods could be vulnerable to rising sea levels driven by climate change.

Coastal Risk Australia charts the majority of Australia's enormous coastline, including all major cities. It is freely available at http://coastalrisk.com.au/ and http://coastalrisk.com.vu/. It incorporates cutting edge Google technology and local tidal data to accurately map how rising sea levels could encroach on cities, towns and beaches under three internationally recognised scientific scenarios.

More than 80 percent of Australians live near the coast and future sea level rise could put more than $200 billion of infrastructure at risk. Across the globe, sea levels have risen an average of 17cm over the course of the 20th century. Scientists are forecasting sea levels will rise between 0.4–1.1m over the remainder of this century depending on emissions.

The website shows that iconic beaches like those along the Gold Coast and famous coastal spots such as Cairns will be among the most vulnerable places to rising seas. Over 100,000 users from every state in Australia and 100 countries worldwide have already used CRA.

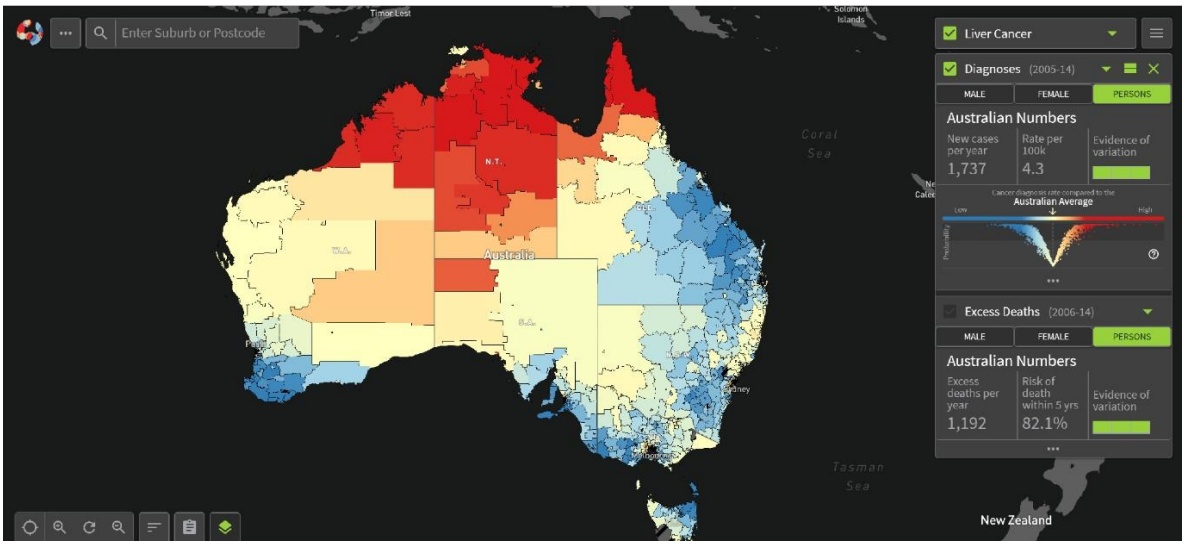


Australian Cancer Atlas

The Australian Cancer Atlas project was an Australian-first research study to understand national patterns in cancer incidence, survival and screening practices based on where people live. The project was a partnership between Cancer Council Queensland (CCQ), Queensland University of Technology (QUT), the Australian Institute of Health and Welfare and FrontierSI (then the CRC for Spatial Information).

The output of this project was an online, interactive digital tool providing small area estimation of cancer incidence, survival and screening without jeopardising privacy and confidentiality. The Atlas was underpinned by complex statistical models developed by award-winning statisticians from CCQ and QUT. Launched in September 2018, the National Cancer Atlas has enabled health agencies, policy makers and the community to understand the location and resource requirements for the most common cancers in Australia. The Atlas will be the foundation for investigations into the causes of geographical inequalities in Australia offering critical insights into patterns of cancer and outcomes in Australia, depending on where people live.

- The Challenge: Data access across multiple jurisdictions, the need for diverse expertise and disciplines, multiple end-users and stakeholders.
- Our Role: FrontierSI successfully managed the project in close collaboration with an outstanding team. We were able to connect our networks to ensure the best possible expertise were available for the project, develop multiple party contracts and contract variations in an agile manner and maintain fluent communication throughout the duration of this project.

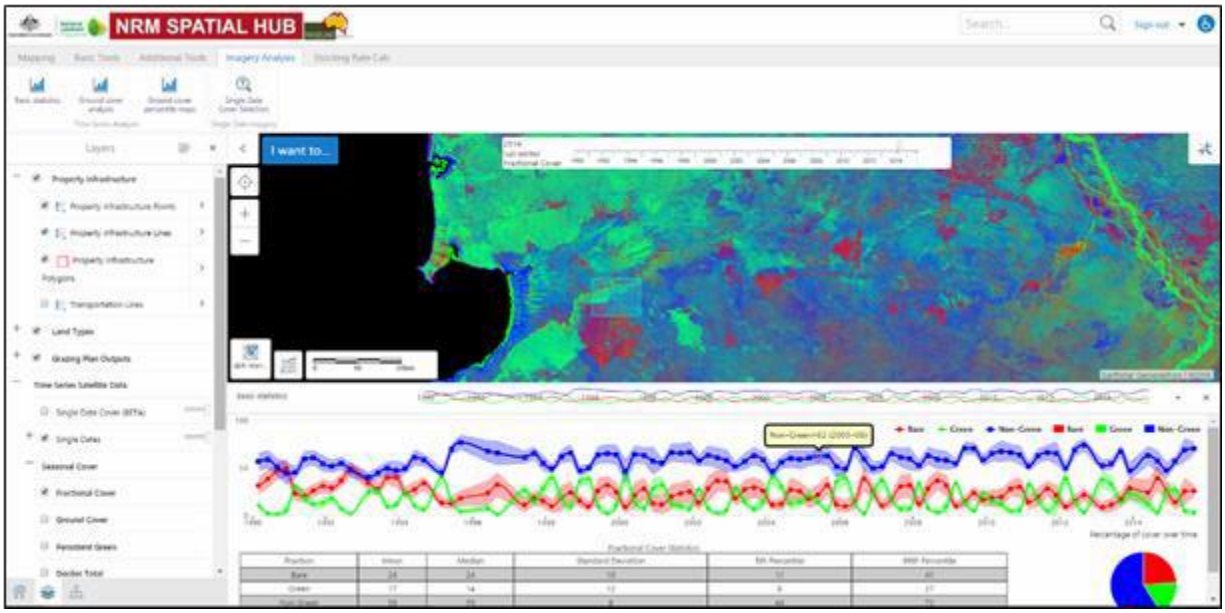


NRM Hub and Farm Map 4D

The NRM Spatial Hub (the Hub) gives rangeland managers the capability to map, plan, analyse and monitor their properties infrastructure, land resources and ground cover to improve pastoral and natural resource management. The world-first technology underpinning the Hub will contribute significantly to the profitable and sustainable management of Australia's rangelands. In addition to property infrastructure mapping, planning and analysis, the platform provides intuitive access to nearly 30 years of 30m resolution satellite data, and tools for simple analysis and interpretation of this information. With local knowledge, the products can assist in understanding current land condition and the impacts of management or investment decisions over time. This is an Australian first and has been acknowledged by members of the global scientific community as a breakthrough in sustainable agriculture. In January 2016, the Hub was the focus of a front page article by NASA titled "*Satellite data helps Australian ranchers meet the rising demand for meat in a changing world*".

The summary factsheet can be found at http://www.nrmhub.com.au/. The NRM Hub has spun out as a company, and is now known as Farm Map 4D (https://www.farmmap4d.com.au/). FrontierSI is part owner of Farm Map 4D. Farm Map 4D aims to give the opportunity for every agricultural property in Australia to have a trusted environment for creating, managing, analysing, accessing and sharing their digital farm map using satellite imagery to help improve productivity and sustainability.

- The Challenge: Rangeland managers faced ongoing pressures of climate change, increasing costs and uncertainty on how their land assets could be optimised to provide productivity and sustainability within the grazing industry. Lack of actionable information about their land has sustained ongoing uncertainty within the sector.
- Our Role: FrontierSI (then the CRC for Spatial Information) coordinated and managed Rangelands NRM Alliance partners; the Australian Government National Landcare Program, Meat and Livestock Australia, State Government Primary Industry, NRM agencies to develop the NRM Hub blueprint, a roadmap linked to the Australian Rangeland Initiative. We also managed the development of the NRM Hub, in collaboration with private partner AAM Group, in consultation with land managers to provide them with systems, tools, data and skills needed to dramatically improve access to property-scale information and knowledge.



Atlas of Environmental Health (Medical Entomology)

The Atlas of Medical Entomology forms part of the Atlas of Environmental Health, which provides a central repository for environmental health data, facilitates sharing of data between all levels of Government and enables Local Government Authorities to assess environmental health risks within their jurisdictions.

The Environmental Health Atlas is currently designed to assist groups specifically involved in mosquito management. The Atlas can be used to input and review mosquito surveillance data including adult and larval mosquito collections as well as producing reports on human cases of mosquito-borne diseases. The field guide is a valuable resource that will assist users in correctly identifying mosquito species and fine-tuning surveillance efforts. Further, a public complaint register allows users to record details of public complaints and provides mapping tools to view cases within real-time to further assess the need to take appropriate action.

Medical Entomology is focussed on mosquitoes, specifically around efforts to control them, and the diseases that they carry. This is the flagship of the modules, as it's had the most attention from the team. This module actually has three components;

- The web site which has data entry forms, reports and a field guide,
- The mobile tool, for remote offline data entry, and
- The web based help manuals.

The mobile app allows Environmental Health Officers (EHO) to undertake adult and larval mosquito monitoring (as well as to lodge public complaints) in the field, out of mobile reception. The whole app is designed to be a useful addition to the EHO's day, where they can lodge these records from the field. One EHO can set the traps in the evening, synchronise the mobile tool, and another EHO can synchronise the next morning, and then go and collect the deployed traps afterwards.

The web site component replicates the forms in the mobile tool and allows for on-line entry of the same data. There is also a field guide on the web site so that there is a solid reference base for the EHOs to use to learn more about the mosquitoes in their area. The field guide is built upon information from published sources.