WAGA 1:
Community Climate Change Project Report
ENVI1062 Client Based Research

This report must be considered a DRAFT as it has not yet incorporated comments by the supervisor nor client.
Completed 2019

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Executive Summary

The Western Alliance for Greenhouse Action (WAGA) is a partnership between eight local governments within the western suburbs of Melbourne. The aim of this partnership is to implement a regional greenhouse strategy and climate change adaptation strategy that involves various stakeholders within local communities (Western Alliance for Greenhouse Action n.d.b).

As part of this strategy, WAGA has produced a local data tool called How Well Are We Adapting (HWAWA). HWAWA is an online adaptation monitoring, evaluation and reporting tool that can be utilised within local government areas. Residents within WAGA and across Melbourne can use HWAWA to understand climate change impacts, as well as what their councils are doing and what they can do to take action on climate change (Western Alliance for Greenhouse Action n.d.a).

The purpose of this report is therefore to determine what principles and features are essential for local governments and organisations to incorporate into local data tools, such as the HWAWA tool used by WAGA, in such a way that communities and stakeholders engage with data and are then equipped with the knowledge to take effective climate action for themselves and their communities.

Key components of the report include:

- Analysis of existing literature surrounding localized data utilisation and community engagement
- Analysis of case studies wherein localized data tools have been utilised successfully to engage communities
- Development of key principles of creating successful data tools that engage communities based off the literature review and analysis of case studies.

Key principles that were developed based of analysis of literature and case studies are below:

- Transparent and meaningful participation from stakeholders during knowledge creation and decision making processes of local climate change data tools

- Communicative, locally relevant, and dialogue-enhancing engagement with local communities about climate change knowledge and local climate change data tools

- Creating data tools with interactive visualizations to enhance community knowledge of and engagement with local climate change data tools

- The creation of local climate change data tools that are accessible to people of all abilities and knowledge levels

Background

Internationally climate change has become a dominant threat to ecosystems and society. Methods of coping with climate change impacts have gradually shifted over the last decade from mitigation to adaptation, especially in the area of governance (Baker et al. 2012; Porter, Demeritt & Dessai 2015). However in order to effectively adapt as a society to the threat of climate change, adaptive capacity, especially in the form of community knowledge, needs to be developed. The Intergovernmental Panel on Climate Change (IPCC) (2014, pp. 118) defines adaptive capacity as ‘the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences’. Therefore a key element of adaptive capacity is building the knowledge of climate change amongst communities so they can more effectively enact adaptation strategies. A key stakeholder in developing this knowledge amongst local communities is local governments as many climate change impacts occur locally, and therefore require local governance and building of adaptive capacity (Pasquini, Cowling & Ziervogel 2013; Porter, Demeritt & Dessai 2015).

One way local governments can build climate literacy and adaptive capacity amongst communities is through the use of local data and data tools. In general, local governments have focused on developing localised information-based data tools. These include interactive mapping, indicator reporting tools, and adaptation monitoring and evaluation frameworks (Lieske, Wade & Roness 2014). Localised information-based data tools however are not just useful for building knowledge and adaptive capacity, but also allowing local governments to make linkages between knowledge and responsibilities within localities and therefore assist them with decision-making processes (Measham et al 2011).

It is also important for local governments to share local data tools, and decision-making frameworks on a regional level. Within Australia, and more specifically within Melbourne, some local governments have moved towards multi-level alliances and networks to share information between councils and help shape their adaptation plans (Maloney & Funfgeld 2015). One such alliance is the WAGA, which is made up of eight local councils to the west of Melbourne. WAGA aims to build adaptive capacity and regional climate change adaptation that involves both local governments and their communities (Western Alliance of Greenhouse Action n.d.b). In doing so they have created an online local data tool called HWAWA that monitors, evaluates and reports climate change data as well as council responses to various climate change impacts (Western Alliance for Greenhouse Action n.d.a). The overall goal of the tool is for councils within the alliance to share data, and equip communities with the knowledge they need to take action on climate change.

It is important to note that tools like HWAWA are still relatively new and that the development of local data tools to assist adaptive capacity is still a relatively new area of research. The aim of this project report is therefore to determine what principles and features are essential for local governments and organisations to incorporate into local data tools, such as the

HWAWA tool used by WAGA, in such a way that communities and stakeholders engage with data and are then equipped with the knowledge to take effective climate action for themselves and their communities.

Literature Review

The purpose of this literature review is to identify existing fields of knowledge in relation to the engagement and participation of the public in climate change adaptation. Thus, to effectively create a means of communicating information to the general public, theories of actions that can engage—or disengage—people should be examined. This is explored through a general, and more traditional method of scientific information to public communication, and also through a method of using data tools as a means of communicating to the public. The literature used within this review was chosen because they met high standards of credibility and the selected literature from journal articles were all peer-reviewed. The field of knowledge about climate change local data tools is still relatively new, and so search terms were expanded to include literature that talked about communicating scientific knowledge, with an emphasis on climate change.

When examining the literature around climate change knowledge, community engagement and local data tools, two dominant themes emerged. The first is that both participation and engagement are essential to communicating scientific knowledge to and engaging communities. There is a consensus that simply informing people about scientific knowledge does not engage or sufficiently teach them about science (Kollmuss & Agyeman 2010; Nisbet & Scheufele 2009). Creating a dialogue around climate change and involving stakeholders creates a collaborative learning environment that assists both local communities and local stakeholders, facilitating not only education but engagement with the knowledge itself (Kahan et al. 2012; Cone et al. 2013; Crawford et al. 2018; Monroe et al. 2017). Importantly, there is also consensus within the literature about the usefulness of participation within local decision making processes and data tools, to create better more resilient outcomes within communities. Leitch et al. (2019) writes that involving users in the creation process of decision support frameworks and other data tools, creates tools that better meet the needs and expectations of users; tools that are usable and useful. Involving stakeholders in the creation of such tools can also improve resilience outcomes within communities, with more robust and better functioning tools, planning, and frameworks being developed that also include local knowledge (Cloutier et al. 2015). Significantly, there is also consensus within the literature that involving communities in knowledge creation processes leads to increased trust in the final product as well as other stakeholders involved like governments; something that is integral to climate science (Cash et al. 2003; Crawford et al. 2018; Leitch et al. 2019).

The literature discusses that not only should communities and local stakeholders be involved in knowledge creation processes, but also highlights the importance of how to successfully engage them in those processes and with the knowledge created. There is a consensus that to encourage awareness and increase knowledge in communities, it is important to recognise the means in which knowledge is formed, especially in a community environment. The general public tend to interpret scientific knowledge through their established social ties, which reinforces both their connections to groups of like-minded people and creates a circular cycle of information within smaller communities (Kahan 2010). As the broader public is comprised of an interconnected web of different social groups, it is important to present information to these diverse groups and navigate through incorporating the effects of culture and social ties into risk communication (Kahan 2010). Sources within the literature concede that most people do not perceive climate change as something that will affect them personally, even considering the large amount of public awareness around the topic (Burke et al. 2018). They argue that this is largely due to the idea of climate change being seen as a 'statistical phenomenon', presented on timescales immeasurably greater than a human lifespan, disconnecting people from climate change (Burke et al. 2018; Hulme 2009). The literature therefore concludes that it is important to make the distant and global threat of climate change personal and local for people to understand and engage with (Monroe et al. 2017). Programs that also directly address misconceptions and promote the community to be directly involved with addressing climate change impacts, have been identified as useful tools in engaging the public and helping them to move past the basic understandings of climate science, especially in pushing them towards effective action (Monroe et al. 2017).

The second theme present within the literature is the importance of the functionality and design features of local data tools. There is a consensus within the literature that visualisation is a key aspect of data tools for both communication and relating information on a more personal and emotionally-engaging level (Herring et al. 2017; Wang et al. 2016). Displaying data on a local level through the use of visualization can overcome the 'psychological distance' people feel about climate change, through the visualization of direct impacts within their communities (Wang et al. 2016). There is also general agreement that eliciting a more emotional and personal response from people about climate change through the use of visual imagery can have a greater impact on behaviour and action taken by people (Wang et al. 2016; Sheppard 2005). Furthermore, sources argue that by communicating scientific information visually it can also be more easily understood by the average person (Brown et al. 2006; Sheppard 2005). The literature also highlights the need for visual interactivity within data tools, a feature that can make the data more personal and meaningful to individuals and also allows users to adapt information for their own expertise level (Neset et al. 2016a; Herring et al. 2017; Wang et al. 2016; Sheppard 2005). There was also a consensus within the literature on the importance of the accessibility of data and data tools, especially amongst individuals who struggle with computer literacy and data tools, as well as individuals with other barriers such as colour blindness (Kaye, Hartley & Hemming 2012; Neset et al. 2016a; Neset et al. 2016b).

From the literature it is clear that there is general consensus amongst academics on what improves the effectiveness of scientific education and community engagement with scientific knowledge. It is important however to emphasise that within the literature there is an acknowledgment that greater research is needed into the area of climate change data tools specifically, and not just science communication as a whole.

Case Study Research Design

Using case studies to categorise information and illuminate a decision or set of decisions within a real life example is a recognised way to present findings and recommendations in academic literature. This report utilises the linear case study planning process (Table 1) developed by Yin (1994) to ensure research provides valuable insight for the guiding organisation.

Table 1: Relevant Situations for Research Strategies (Yin 1994, pp. 6).

Research strategy	Form of research questions	Requires control over behavioural events	Focuses on contemporary events
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival analysis	Who, what, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

Case studies provide strength to a report through their representation of socio-political settings, cultural and historical narratives and response to place (Crowe et al. 2011). Yin (2009, pp. 129) writes that "the case study approach emphasises the distinctive need for understanding complex social phenomena". The use of case studies for this project is useful as the issues of climate change, adaptation, community and responsibility, are all deeply entwined within the complex systems mentioned above. The case studies chosen will provide examples of decision making processes and detail why action was required, how the action was implemented, and whether the outcome was effective (Schramm 1971, cited from Yin 2009, pp. 17). The selected case studies will also be current international examples that have been adapted using aspects of Yin's (2009) framework for case study research. These aspects include:

Design > Collect > Analyse > Share

Through a process of elimination and categorisation, case studies with related qualities were grouped together. Upon analysing the groupings the following themes represent overall findings within case studies and were of significant relevance to the research approach:

1. Local scientific data applied to visualisation and local planning method and frameworks
2. Participatory web-based tools influencing climate change perceptions and knowledge exchange

Within each of these themes a single case study was chosen that met all of the following criteria:

a) Similarity to the project scale and scope (ie. Local government, applicable on a regional scale)
b) Practicable for local government climate change adaptation
c) Utilising a form of data that translates an occurring natural phenomenon to an interactive web-based platform.

Referencing the 20 case studies against this criteria, only two cases were suitable for further research and analysis; The Kimberley Local Climate Change Visioning Process and the Surging Seas Risk Finder Tool by Climate Central.

Case Study 1: The Kimberley Local Climate Change Visioning Process by the University of British Columbia

This case study provides an overview of the Kimberley Climate Adaptation Project (KCAP), showcasing the community-focused three phase adaptation process and a background on the outcomes of visualisation for embedding personal experiences on the local level. The KCAP by The Collaborative for Advance Landscape Planning (CALP) at the University of British Columbia, provides a practical example of how a visioning project within the City of Kimberley can be completed during a restricted time frame, with budget and technical limitations, representing real constraints that planners might face (Schroth 2009).

As an alpine region, the community is vulnerable to a wide range of climate change impacts, such as rapid snowmelt, landslides due to Mountain Pine Beetle infestation, flooding and wildfires (Schroth 2009). To tackle the concerns facing Kimberley, the CALP piloted the LCCVP for climate change planning and community consultation. The LCCVP process was conducted from 2008-2009 in conjunction with the City of Kimberley over three phases for the purpose of developing a comprehensive guide to developing resilient local communities in the face of an uncertain climate change future.

Phase One: Participatory Scenario Building

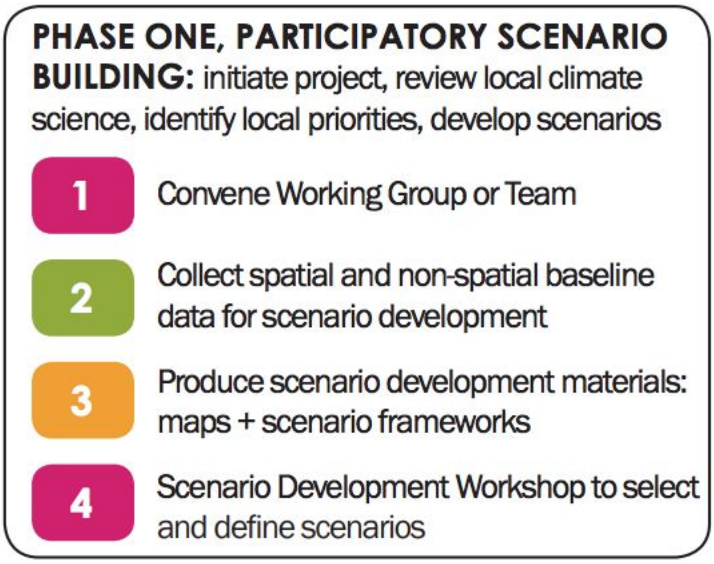

Figure 1. Phase one: Participatory scenario building steps 1-4 (CALP 2010).

The Kimberley adaptation scenarios were developed during three workshops to prioritise local environmental issues, and provide a comprehensive visualisation of the projected climate related impacts most relevant to Kimberley. These scenarios were based on the latest baseline GIS spatial data and the IPCC global emissions scenarios A1 to B2 which can be seen in Figure 2.

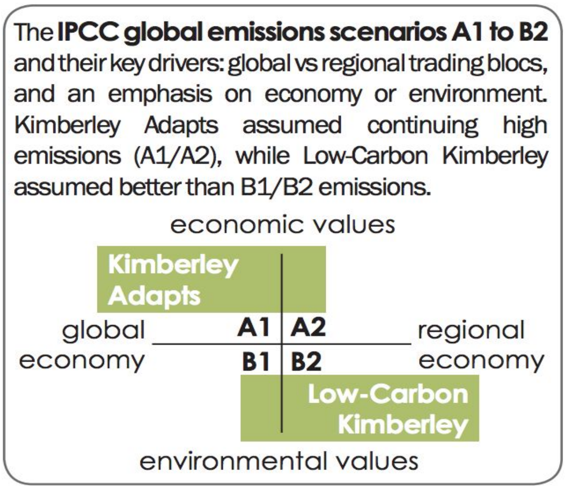

Figure 2. The relationship between the IPCC global emissions scenarios A1 to B2 and the Kimberley adaptation approaches (CALP 2010).

The workshops depicted the following two scenarios up to the year 2100.

Kimberley Adapts:
This scenario was determined by the working groups assessing and reflecting on current carbon emissions and development pathways. The climate change impacts projected are of extreme risk to the population and substantial adaptation is needed. Under this situation, the high energy fossil fuel economy will begin transitioning to renewable energy, protection will focus on flooding and wildfire management, and there will be focus on a build-out adaptation plan. The findings of the workshops can be characterised as falling within this scenario.

Low-Carbon Kimberley:
This scenario was developed preliminary from drastic reductions in carbon emissions towards a mostly renewable energy dependency, localised food production, and reconsideration of development pathways. These development pathways in particular utilise sustainable design, car redundancy, public transport and take into concern the planning capacity of increased population due to climate refugees. The findings during the workshops recommended current processes in the development pathway, such as local energy generation, electric car share network, and community water development (Liepa 2009).

Phase Two: Data & Modelling

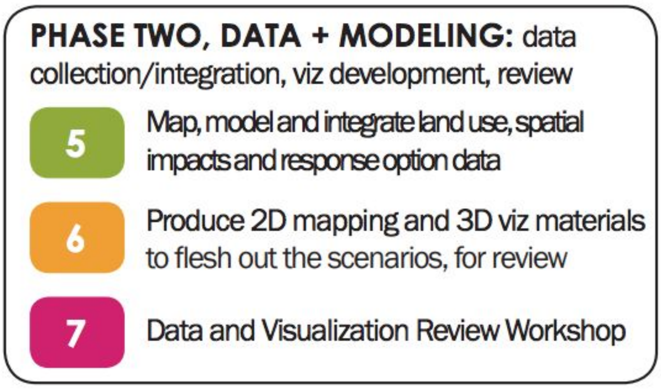

Figure 3. Phase Two- Data and Modelling, steps 5-7 (CALP 2010).

For the Kimberley project, developing digital visualisation tools to communicate the climate change impacts recognised in each scenario was undertaken through using both gathered and generated GIS data. Phase Two was started in Step 5, with evidence base building and baseline data collection. This was then followed by generated GIS data including figure-ground 2D mapping of all buildings in the community to illustrate current development and land use patterns, as outlined in Figure 3. The visualisation production begins in Step 6 through a process of storyboarding and narrative in order to represent the scenarios effectively and ethically, which can be seen in Figure 4.

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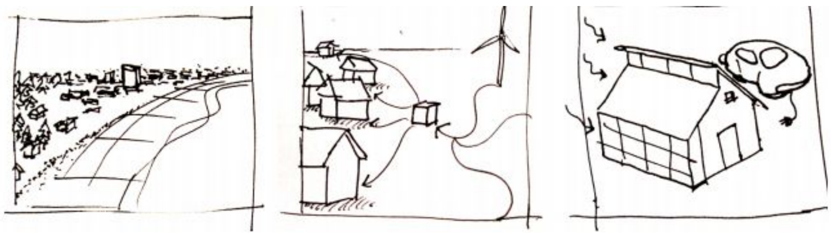


Figure 4. Storyboarding visualisations from visioning phases (CALP 2010).

This process follows the “Three D’s” of ethical visualisation (Sheppard 2001).

- **Disclosure:** Are scenario expectations and data sources transparent?
- **Drama:** Is the data visually represented accurately?
- **Defensibility:** Are the visualisations created from evidence-based, peer-reviewed scientific data and local knowledge?

The visualisation teams compiled the storyboards into a visualisation scenario using numeric, spatial, 3D and hybrid modelling in CommunityViz, Google Earth, Biosphere 3D and Visual Nature Studio (CALP 2010). The visualisations of the scenarios were reviewed in a ‘Big Viz’ workshop in March 2009 by working group members, representatives of the community, and council experts over two days in order to identify data issues, and revise visual communications and models for the next phase (Schroth 2009).

Phase Three: Final Visioning Package

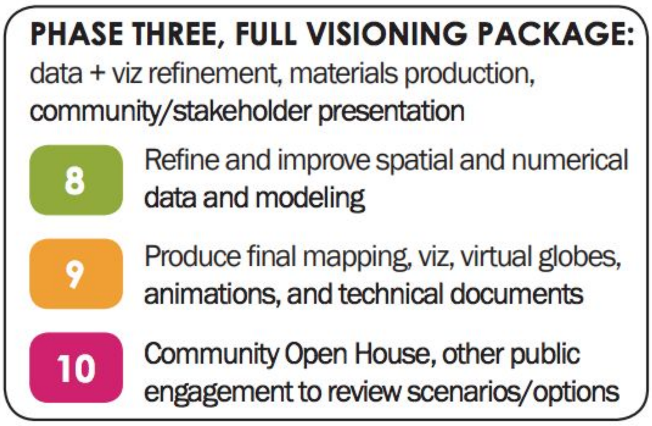


Figure 5. Phase three- Full visioning package, steps 8-10 (CALP 2010).

The feedback received informed the subsequent stages of the visualisation work, resulting in refined development of the final visioning package of 3D visualisations.

The Local Climate Change Visioning Process in Practise

Mountain Pine Beetle infestation contributing to increase fire risk and runoff in the Kimberley watershed:

Using the projected regional climate data, the visualisation team were able to create a spatial modelling of two climate related impacts; Mountain Pine Beetle infestation and fire risk. This was based on the existing forest stands with advice from forest experts to model the high-risk areas in the Kimberley watershed, which can be seen in Figure 6.

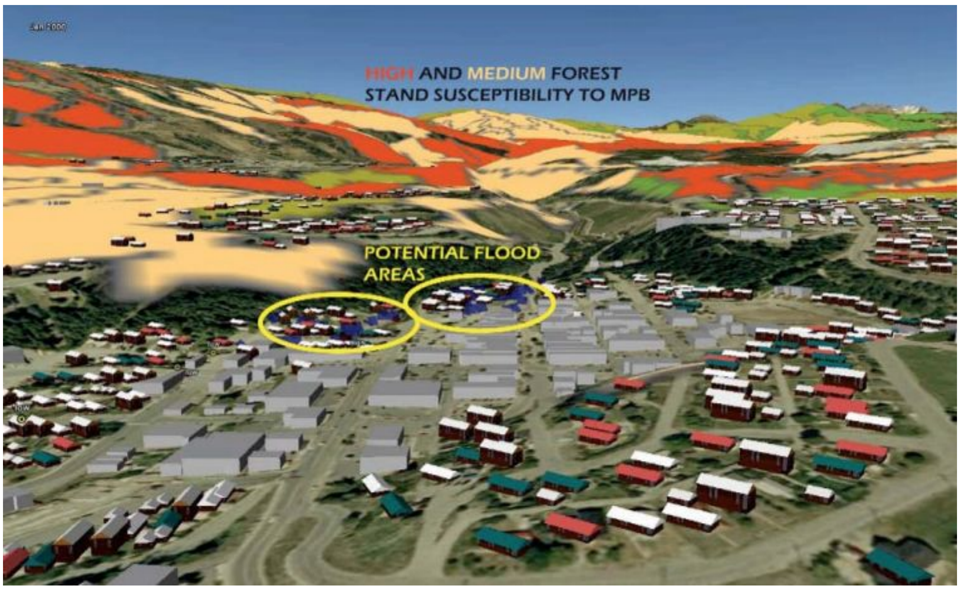


Figure 6. Flood mapping for the City of Kimberley showing Mountain Pine Beetle susceptibility, fire risk and downstream flooding, from climate-related deforestation in the Kimberley watershed (Schroth 2009)

While this issue is known amongst experts, the purpose of this visualisation was to explain to the public the reasoning behind any major interventions needed in the watershed (Schroth 2009). The Mountain Pine Beetle epidemic represents the first wave of climate change impacts in Kimberley that have potentially devastating risks to exacerbate flooding and wildfires; an impact that is perceived as uncertain risk within the community. The deforestation of trees due to the disease spread by the Mountain Pine Beetle subsequently increases snowpack and water runoff into the town watershed, causing a considerable risk of flooding in the potential flood areas, as seen in Figure 6.

Mapping wildfire spread and evacuation across a timeline in Forest Crowne, Kimberley

Additional visualisations in the final visioning package included using existing modelling in Google Earth to overlay GIS fire-spread mapping into a Fire Area Simulator Model (Farsite), as seen in Figure 7.

1 hour after ignition | 3 hours: First evacuation is cut off | 8 hours: Second evacuation is cut off

Figure 7. The progression of the Farsite fire spread model showing the possible speed of the spread of a forest fire with an ignition point southeast of Kimberley (Schroth 2009).

The Farsite map depicts that within four hours a fire will cover the exit route of Kimberley at Forest Crowne. In eight hours, the fire has overtaken the town centre making evacuation impossible. During the final visioning workshop, there was an audible and emotional response given by the audience at the presentation of this model (Schroth 2009). The visualisation induced emotional reactions, with comments such as "the fire viz was most powerful – could feel it in the room", and "caused major unrest in the audience for that moment' (Schroth 2009, pp. 25). While the purpose of this 4D visualisation was to locate potential fire spots and predict the spread over an 8-hour period, the visualisations viceral communicative capacity has since provided a tangible dimension to Kootenay fire management and FireSmart homeowner education in Kimberley (Schroth 2009).

Outcomes of Visualisation

The visioning package emphasises the importance of translating climate change impacts through modelling to create vivid imagery that represents the experiences of those on the local level (Schroth et al. 2015). The meaning of the data becomes explicitly clear, when community members see a visualisation of their own homes and community spaces, understanding the relevance climate change will have on their lives and making its effects less ambiguous and impersonal (Schroth et al. 2015). Presenting the visualisations contributed to two outcomes across the community in regards to enhancing community engagement and influencing local council decision making in Kimberley (Schroth et al.

2015). The first was in respects to influencing community engagement. During the community open house, 90% of local residents expressed that they found engagement with visualisations to be highly beneficial and helpful (CALP 2010), as seen in Figure 8.

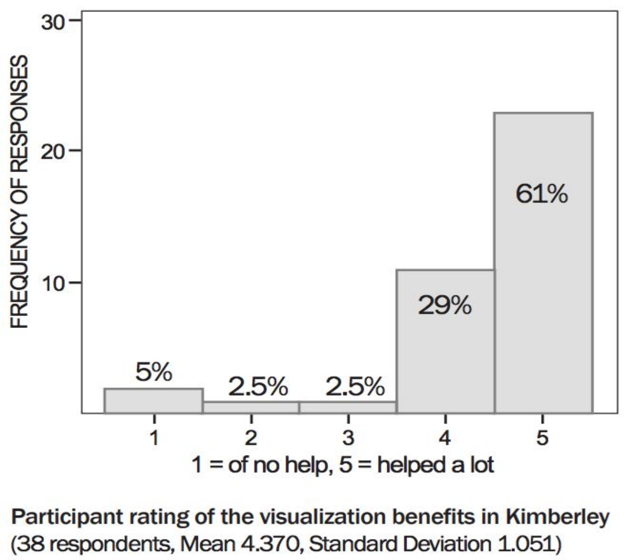


Figure 8. Participant rating of visual benefits in the Kimberley public meeting (CALP 2010).

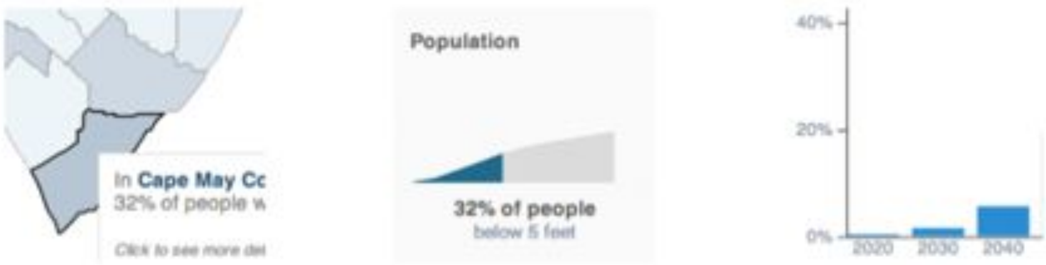
Participants found that the presentation material was easily understood and facilitated meaningful communication between stakeholders, as the visualisations provided shared points of interests and connection due to the impacts envisaging scenarios "in people's backyards" (CALP 2010b, para. 84). The second outcome that the visualizations achieved was influencing council decision making. Due to the increased awareness of climate change adaptation within the community, the City of Kimberley echoed the sentiment for championing efforts to tackle the region's most sensitive issues, with council members stating that after the KCAP, "the Council is now more proactive" (Schroth et al. 2015).

In summary, the LVCCP project demonstrates how data tools can effectively present local data visually as a means of educating and engaging stakeholders of a community. It achieves this by creating a connection between climate change on the local level and personal experiences to facilitate climate change adaptation planning and community consultation. Through its three phases, KCAP has outlined its method of communicating risks through visualisation to create emotional impact in making climate change issues personal. The result of this project has been an increase of community education and awareness around local climate change impacts which has helped to facilitate meaningful communications between community stakeholders. This has in turn promoted council decision making with an increased awareness of adapting to climate change.

Case Study 2: Surging Seas Risk Finder Tool by Climate Central - Productive usability of Iterative decision making tools:

As the mechanisms for professionals to engage and utilise scientific climate change data continue to become more popular, web-based adaptation decision aids are providing greater transparency for citizen participation in planning (Lieske, Wade & Roness 2014). This case study provides an overview of the design and development of Climate Central's Surging Seas Risk Finder (SSRF), an interactive sea level rise viewer (ISLRV) for planning professionals to access open source data maps, visualisations and reports for the use of communicating the predicted effects of coastal inundation (Richards 2016).

In partnership with web design consultancy Bocoup and Stamen Design, Climate Central, an organization that provides reputable data analysis, sought to address its communications problem by creating a tool that incorporated presenting their latest scientific data across multiple future scenarios and timescales (Ros 2013). Through prototyping using D3.js, an interactive data visualizations javascript for web browsers, Bocoup was able to build multi layered graphics of a singular data set with various presentation formats to achieve different results (Figure 9).



Map and text format | Simplified Area Chart | Bar Chart

Figure 9: Multiple data presentation formats of population in Cape May County, NJ created for Climate Central Surging Seas Risk Finder by Becoup during web design consultations (Ros 2013).

Support from Stamen Design enables displaying the risk of sea level rise across geographies over time and comparing that risk with its impact on critical areas such as infrastructure and education. Figure 10 depicts Climate Central's surging seas risk finder, shown in its initial design (upper image) and as a revised version after iterative testing (lower image).

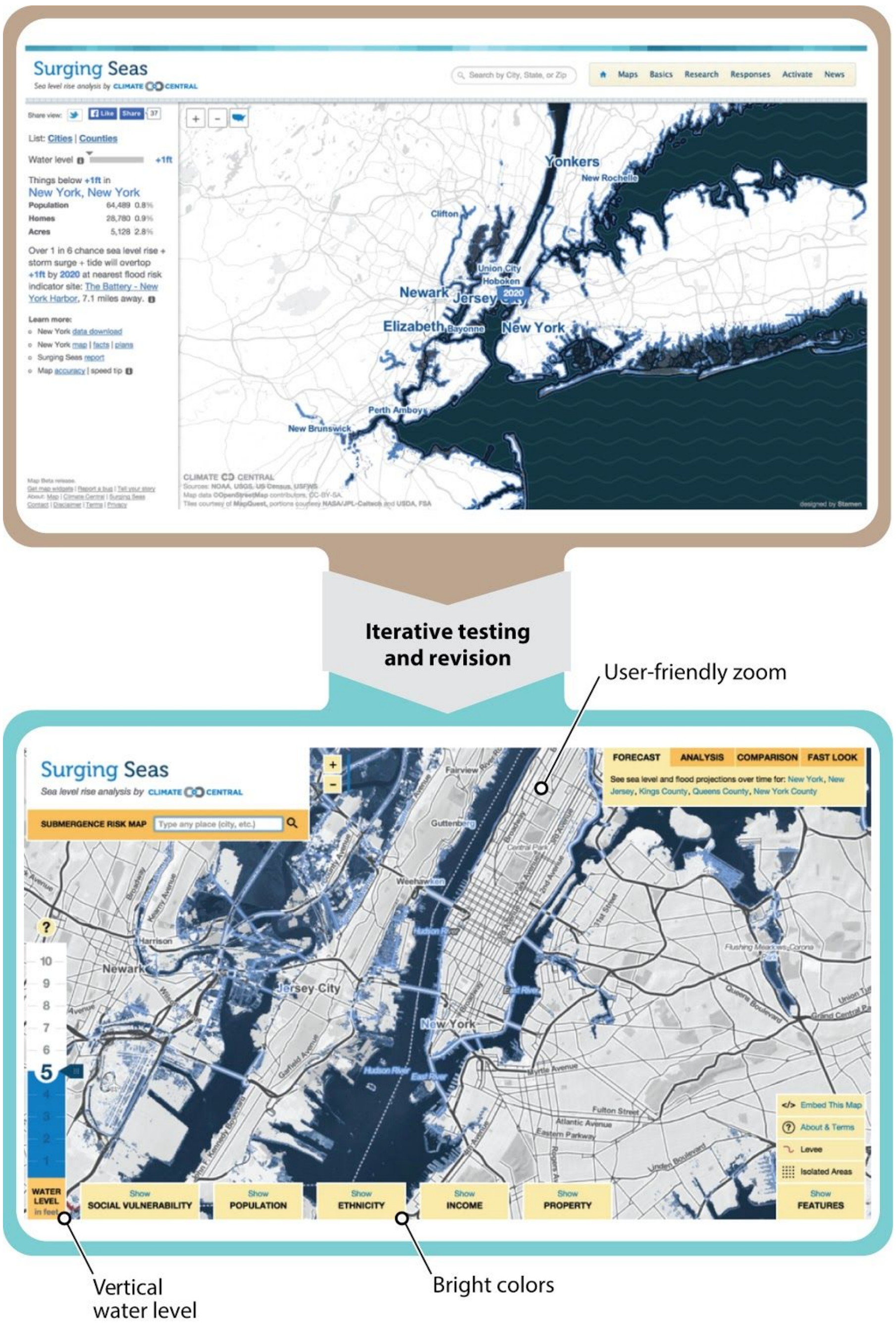


Figure 10: The Surging Seas Risk Finder web interface revision during visual design consultations and iterative testing (Mach & Field 2017).

In response to structured interviews, changes included bright colors for key features, vertical orientation of water level, and a welcoming initial screen with reduced clutter and zoom. Recognising the strong communicative capacity that visual design can make in connecting users to information in a simple manner, the design consultation allowed policymakers to identify potential futures for familiar places in the community by presenting these places in a variety of adaptation scenarios. In 2015, a research team from Old Dominion University

Virginia began a 'productive usability' study of SSRF to understand "the motivations and choices users assign for themselves when using the tool" (Richards 2016, para 7). This is highlighted in how the homepage encourages self-inquiry to provide users with a highly informative experience to locate themselves within various inundation scenarios, as seen in Figure 11.

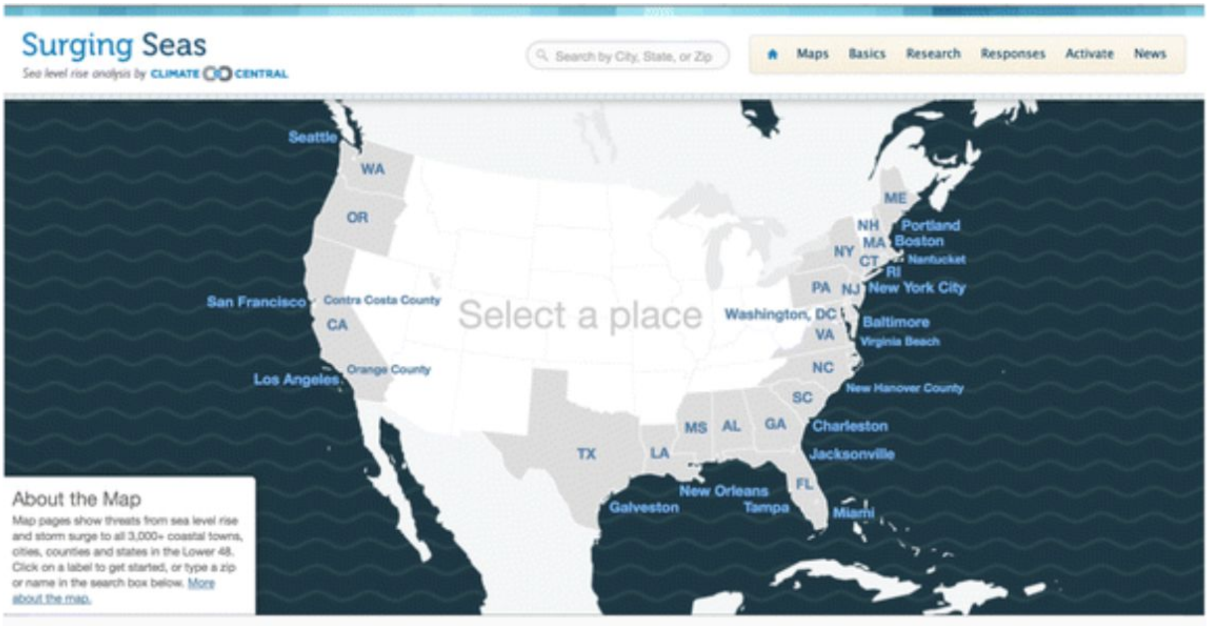


Figure 11: The Surging Seas Risk Finder Tool home interface, displaying a search by city and state map to target specific locations and their sea level risk (Climate Central 2019).

The UX study was focused on a highly vulnerable population of residents in Hampton Roads region, Virginia. Out of 258 residents, 12 were chosen to participate and represented a high diversity in regard to age and time spent in the region, and an equivalent range in climate literacy and computer proficiency (Richards 2016). Aside from these differences, each member had experienced multiple direct complications and disturbance from flooding or sea level rise at some point.

Following a brief overview and study introduction, 75% of participants stated the tool would provide useful from where to buy property to navigating roads under flooding conditions (Richards 2016). The procedure of the study replicated natural user interaction, starting at the home page selection of five tabs including: Maps, Forecast, Analysis, Comparison and Fast Look Reports (Figure 12).

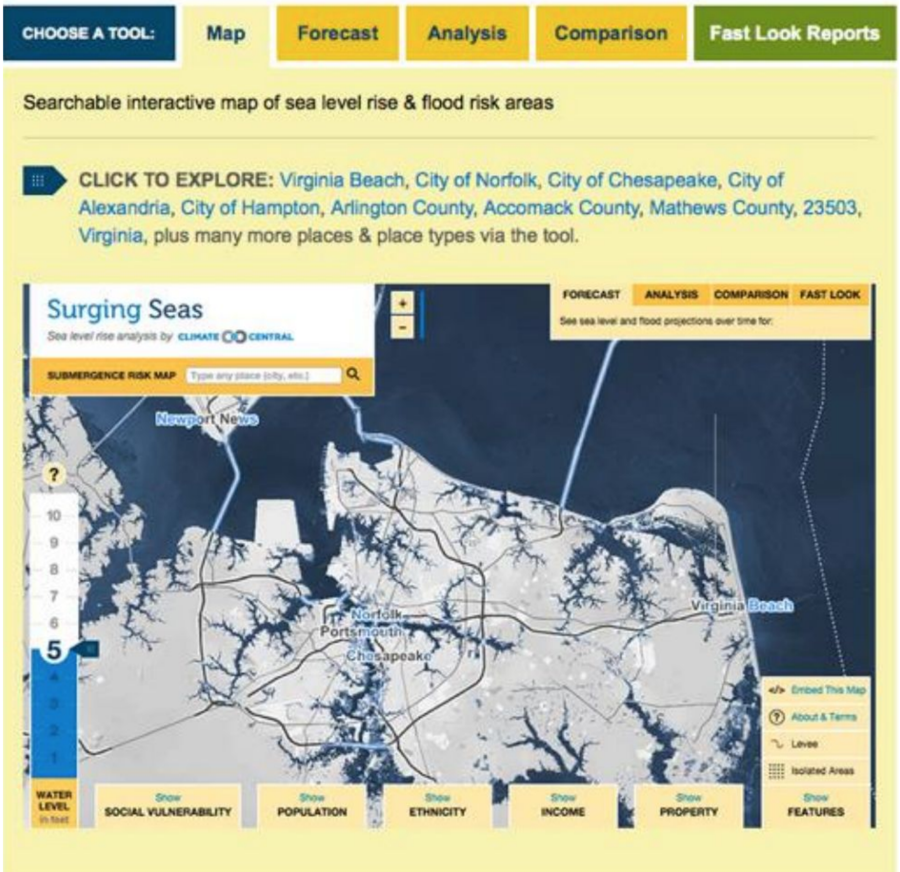


Figure 12: Selectable tool display on the searchable interactive map of sea level rise and flood risk in Virginia (Climate Central 2016)

From here, 83% of participants selected the Map tool first on the basis of locating personal property and due to the ordering materials of the site from left to right. This strategic organisation is a considered feature of the UX design, as a way to imply users to follow a defined narrative towards a final resolution or outcome (Strauss 2016). During the 20 minutes of use, the researchers determined three patterns of participation through observation and interviews:

EXPLORATION

SELF- DIRECTED INQUIRY

TUTORIAL

Exploration:

The nature of the exploratory direction can be summarised under the responses of the post-test questions which stated five participant's would have engaged with the Risk Finder "for curiosity's sake" or "no specific reason" (Richards 2016, para 22). These participants encountered data on the community or regional scale rather than specified locations, such as a home, work, or place. While observed to utilise all of the layer sets, they did not encounter technical interruptions in their search and proceeded with continued interest (Richards 2016).

Self- Directed Inquiry:

The Direct Inquiry participants progressed through all stages of the tool, engaging in all of the tools functions. Participants also were observed comparing locations with those of family members and other participants, to formulate a refined assessment of the potential impacts of sea level risk. The tool overall with the highest usage was the water level slide, which shows the predicted sea level rise scenarios from 1 ft-10 ft, with the data and map changing live (Figure 13).

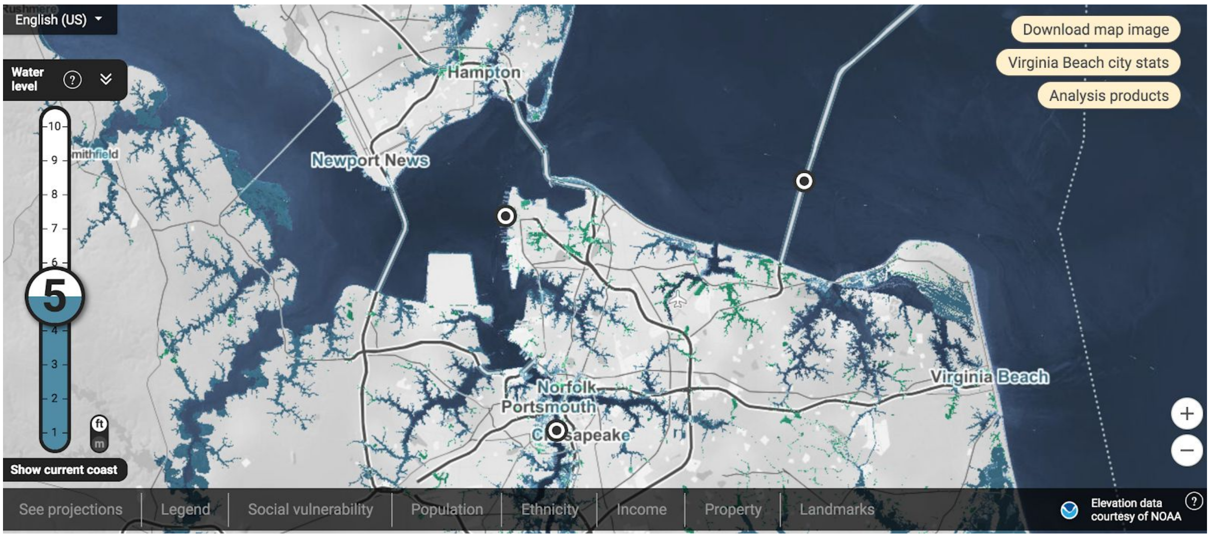


Figure 13: Water Level Slide Tool depicting the land below water level (Climate Central 2019).

The water level tool provides users with the ability to visualise how changes in sea level will affect a location and identify impact pathways between the layer sets. For example, one user recognised that combining the "slider tool" (water level scenario) with the projections of social vulnerability and income, identified that the communities with the lowest incomes percentiles of 0-20% & 20-40% (Figure 14), were those with the highest social vulnerability (Figure 15).

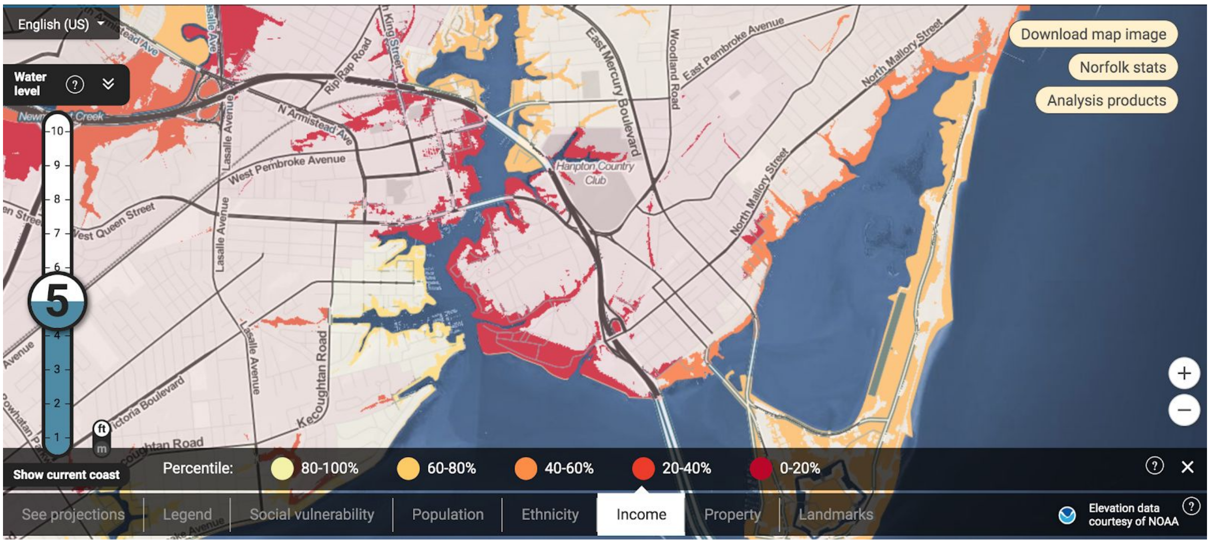


Figure 14: Projection showing the lowest incomes percentiles of 0-20% & 20-40% (Climate Central 2019)

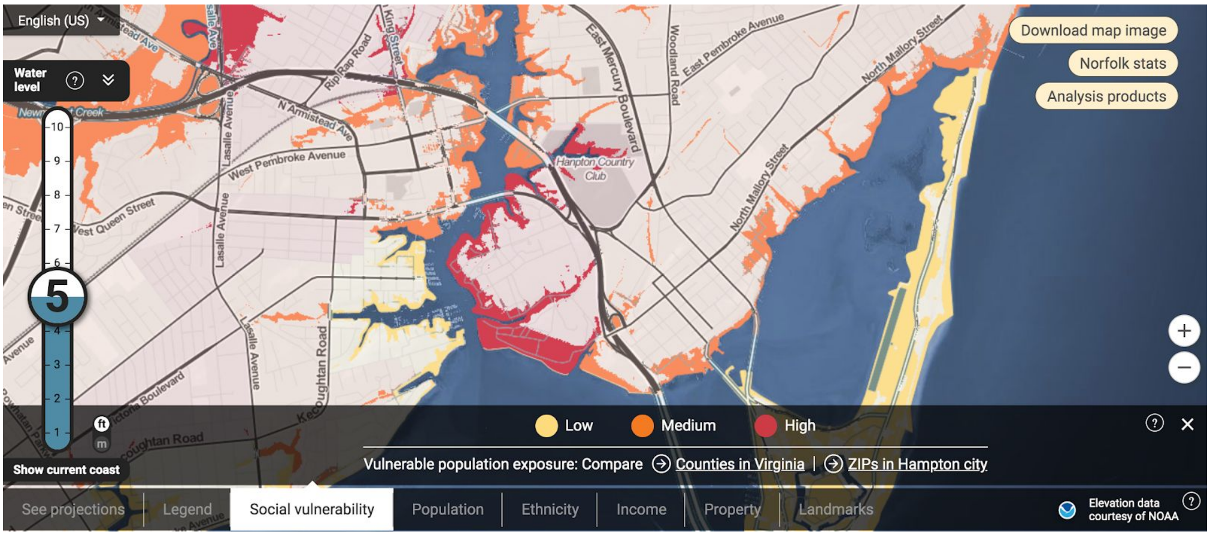


Figure 15: Social vulnerability projections combined with sea level rise of 5ft. The classification of vulnerability is classified in the legend from 'Low', 'Medium' and 'High' (Richards 2016).

Through the use of visualisation, the participants determined that the predominantly black and hispanic residents of West County would be practically unable to recover from a flooding event of 5ft, as seen in Figure 16 (Richards 2016).

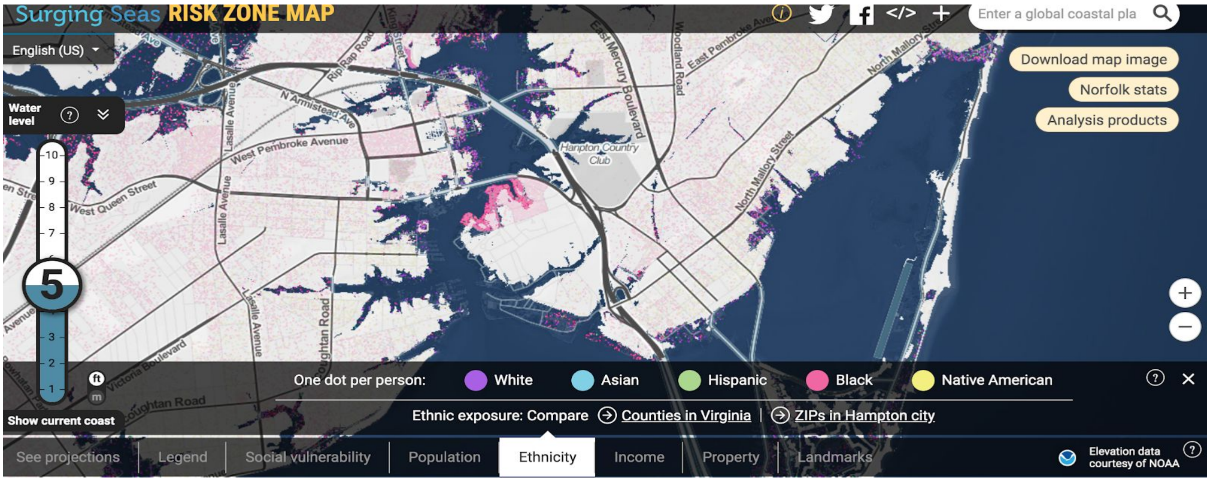


Figure 16: Ethnicity projection highlighting the communities in West County, VA (Climate Central 2019).

As highlighted, the participants with self-directed inquiry successfully undertook a risk assessment of a specific location using a variety of the tools features to form a calculated conclusion and were more likely therefore find data relevant to the community at large (Richards 2016).

Tutorial

In contrast, the single Tutorial participant encountered regular frustration with the combination of loading times, managing the toolbar and understanding icon functions. The participant reasoned the experience as “going in blind”, “like playing dice” and being “not sure to trust the website”, overall deciding to never use the tool again (Richard 2016, para 24).

Results

This emotional drawback was common across several of the participants who directed negative comments at themselves using the tool. Exploring the interface made users feel “dumb” at stages and insecure about the ability of the tool to provide essential and practical information (eg. moving safely out of a flooded area) (Richards 2016, para 31). Moreover, the visualisation exercise highlighted their vulnerabilities of sea level rise and climate change as whole, which is reflected in the studies participants perceptions of flood risks pre and post testing and evaluation (Table 2).

Table 2: Participant's perceptions of flood risk Pre-Test and Post-Test (Richards 2016)

Category	Pre-Test	Post-Test
Alarm	3	3
Concern	7	7
Sceptical	1	1
Other	1	1

To summarise, the Surging Seas study enhanced a process of social learning by deriving a scenario exercise of critical thinking centred on understanding initial experiences through open observation (Richards 2016). This case study highlights that self-directed participation exercises is demanding of participants, is typically available to only relatively small groups and is an inherently open-ended—and thus a risky—methodology for scenario practitioners (Stephens et al. 2015).

Discussion

Although climate change is a well-discussed and analysed scientific subject, as discussed there is a lack of awareness amongst the general public about the effects of specific climate change impacts to their local communities. Local climate change data tools are an essential ingredient going forward to informing and empowering people with knowledge about climate change impacts, and what can be done to mitigate and adapt to them. It is therefore essential that data tools are well researched and designed. The aim of the discussion within this paper is to identify key principles, based off the analysis of both the literature review and the case studies, that are essential to good and engaging local climate change data tools.

Principle One: Transparent and meaningful participation from stakeholders during knowledge creation and decision making processes of local climate change data tools

The first principle that was identified within this report is that transparent and meaningful participation is needed for stakeholders during both knowledge creation and decision making processes of local climate change data tools. As discussed involving stakeholders and community members in knowledge creation processes, can lead to a higher degree of engagement with the finished data tool, as well as create higher levels of trust in the finished tool. Cash (et al. 2003) writes that stakeholder involvement in knowledge creation processes leads to higher trust in the knowledge that is produced from those processes. This is extremely integral to the success of local climate change data tools in informing communities, as due to the highly contentious nature of debate around climate change, the general public holds varied levels of trust about climate science as well as governments and their policies to deal with climate change (Buys et al. 2014; Myers et al. 2017). Involving various stakeholders and local community members in decision making processes around local climate change data tools also has the benefit of creating more robust and successful data tools and decision making processes (Leitch et al. 2019).

Participatory practices were used during both case studies to better enhance each project. During the Kimberley local climate change visioning process, members of the community were included within both Phase One and Phase Two of the project, providing input on both local environmental knowledge as well as the visualizations themselves, leading to better overall visualizations with less data and user issues (Schroth 2009). Similarly during the SSRF development phase members of the community were included in consultations, to give feedback on user issues, allowing the identification of any user issues, as well as providing information as to the usefulness of the tool (Richards 2016).

This principle can be applied to HWAWA in a variety of ways. Feedback can be sought from members of the local community about the user experience of the tool as well as the specific information found on the tool itself. This could help improve the tool through both an improvement in user experience, as well as providing information that is more successful at engaging local communities.

Principle Two: Communicative, locally relevant, and dialogue-enhancing engagement with local communities about climate change knowledge and local climate change data tools

The second principle that was identified, was the need for communicative, locally relevant and dialogue-enhancing engagement with local community members about data tools and climate change knowledge. As discussed people often feel psychologically distant from climate change, and so simply informing the public about climate change is not enough to engage them with the issue and adaptive actions (Wang et al. 2016; Nisbet & Scheufele 2009; Kollmuss & Agyeman 2010). Instead community members must engage with climate change knowledge in ways that create meaning for them. Instead engaging members of the community in a dialogue about climate change can create circulatory and collaborative learning processes, facilitating engagement with the knowledge and data tool itself (Kahan et al. 2012; Cone et al. 2013; Crawford et al. 2018; Monroe et al. 2017).

This principle was also seen within the case studies. As discussed the first phase of the Kimberley local climate change visioning process involved workshops with members of the community to provide input that could be used to develop visualizations. These workshops involved dialogue that created connections between climate change and the lived personal experiences of the community members present, creating meaning and leading to the development of scenarios that the visualizations could be based off of (Schroth 2009). Within the SSRF case study, users were left to navigate the SSRF data tool by themselves, leaving them feeling demotivated, emotionally drained and insecure about using the tool, highlighting the need for effective engagement with climate change data and not just a presentation of knowledge (Richards 2016).

This principle could also be applied to HWAWA. It is important to acknowledge that in just presenting information to members of the community, information is left to interpretation. Utilising workshops, in which people can directly engage, create discussions and negotiate meaning about knowledge, could be a useful means of engagement.

Principle Three: Creating data tools with interactive visualizations to enhance community knowledge of and engagement with local climate change data tools

The third principle that was identified was the need for interactive visualisations within local climate change data tools. As discussed, visualizations within data tools are integral to reaching members of the community with all ranges of knowledge about climate change. Visual images can be more easily understood by all members of the public, and including interactive features means users can alter data tools to suit their own knowledge levels (Neset et al. 2016a; Herring et al. 2017; Wang et al. 2016; Sheppard 2005). Importantly visualizations can also play a key role in creating meaning for users. By displaying local impacts locally, emotional responses can be elicited from users of data tools making climate change knowledge more personally connected and engaging (Herring et al. 2017; Wang et al. 2016). This emotional engagement with science data can also lead to a greater impact on individual's behaviour (Wang et al. 2016; Sheppard 2005). This can be particularly important as the role of local climate change data tools are not just to inform communities, but also to inspire action.

This principle was once again represented within both case studies. Within the Kimberley local climate change visioning process visualization created an emotional response from local members of the community being described as both powerful and useful (Schroth 2009). The visualizations within the SSRF allowed local residents to examine the local impacts of climate change as it resulted to themselves, as well as their friends and family (Richards 2016).

This principle is already seen within the HWAWA tool. Interactive visualizations are available to provide locally relevant visual information to users. It may be helpful to review current visualizations to see if there is room for improvement.

Principle Four: The creation of local climate change data tools that are accessible to people of all abilities and knowledge levels

The last principle that was identified was the need for local climate change data tools to be accessible to people of all abilities and knowledge levels. As discussed data tools can be difficult to use amongst people who are not computer literate or colour blind, among other disabilities (Kaye, Hartley & Hemming 2012; Neset et al. 2016a; Neset et al. 2016b). Targeting all communities of climate change is of the utmost importance especially vulnerable communities. As identified by Wolf (2011), one of the most vulnerable communities identified is elderly people, as they are likely to be severely impacted by climate change impacts such as frequent heat waves; which increases mortality and morbidity rates in elderly people (Sampson et al. 2013). Elderly people may not be as computer literate as younger people and thus may struggle to access information provided over technology.

This principle was particularly seen within the SSRF case study. As discussed when people were left on their own with that particular data tool, they had a lot of difficulty navigating the tool, which led to doubts about its ability to be useful and informative (Richards 2016).

It is therefore important when considering the HWAWA tool that vulnerable populations, such as elderly people in the community, are provided the same information as other users. Elderly people may not be able to directly find information from the tool to better equip themselves to adapt to climate change impacts, however the adaptation information can still be delivered to elderly people through their social networks (Leyva et al. 2017). HWAWA could be a potential educational tool for families or organisations that provide care directly to elderly people to understand how to best mitigate the impacts elderly people may experience from climate change impacts. Furthermore, currently the HWAWA tool does not have a colorblind mode — something that could be considered for the future of the tool.

Conclusion

It is important to acknowledge that while this report analysed and explored a vast range of knowledge in relation to climate change adaptation and local data tools, there are limitations to this approach. Using local data tools as a means of communicating climate change adaptation strategies is still a new area of knowledge and information on the area is relatively limited. The examined literature and case studies were chosen on the basis of it being relevant to HWAWA, however other general insights and applicable local data tools should be acknowledged for the insights they may provide.

Through the analysis of existing literature, a consensus around the effective uses of theories of engagement and participation strategies and the usefulness of data tools to communicate and visualise scientific information to the general public was established and explored. The case studies examined provided existing examples of how local data tools were effectively utilised to engage communities and communicate scientific knowledge that was personal and relevant to people on a local scale. Through the knowledge that the literature review and case studies explored and unveiled, four principles were developed in response. The four principles—of participation, engagement, visualisation and accessibility—are the foundations in which local climate change data tools can be utilized to effectively engage and equip communities and stakeholders with the knowledge to take climate change adaptation actions for themselves and their communities.

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