

How perception shapes response?

The impacts of rising sea levels in an Australian coastal community

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Abstract— Sea levels have been rising over the past decade at a magnitude greater than ever before. It is crucial for Australians to respond to the impacts of rising sea levels as 85% of the population live within 50 kilometers of the coastline. A framework for environmental risk assessment commonly applied on climate adaptation strategies are based on the triad Pressure-State-Response (PSR). Although very useful and somewhat effective, it is argued here that PSR frameworks can be improved through the introduction of the concept of human perception. We believe that not only the pressure (P) itself, but the ‘perception of the impact of that pressure’ is a determinant in shaping how individuals respond to the pressure. This paper explores how the perceptions, described through the concepts of awareness, concern, and experience about the impact of rising sea levels, shape the response to it by different stakeholders within a coastal community. A case study in Ocean Grove/Barwon Heads region involving a survey with 24 participants indicated that significant correlations between perception and responses, variations of this relationship among different stakeholders, and also the different magnitude of the role of awareness, concern, and experience as drivers of responses. These results suggest the potential relevance of incorporating perception to the PSR frameworks if for more effective community responses to climate adaptation are expected.

Keywords— *Sea level rise, coastal communities, impact, perception, response, adaptation*

I. INTRODUCTION

Climate change is one of the greatest environmental challenges of our time and as a result of its dependability on agriculture and the prominence of its coast, ‘Australia has been designated as one of the most vulnerable countries to climate change’ [1]. According to the State Government of Victoria [2], since 1788, settlements have been built along the coast with the expectation that sea levels would remain unchanged. However, as a result of the changing climate, sea levels have significantly increased since the 1800’s [3] and are expected to continue rising in the 21st century at a rate unprecedented in human history [4]. According to the 2011 Australia State of the Environment Report [5] the rate of sea level rise has been ‘an order of magnitude greater than the average for several previous decades with an average rise of 3.1 mL/year between 1993 and 2003, compared to 1.8 mL/year between 1961 and 1993. The Intergovernmental Panel on Climate Change, in its fourth assessment report [6] has predicted

global sea levels to increase between 0.18 to 0.59 meters by 2099.

According to CSIRO [7], Australia is a predominantly coastal society with ‘85% of the population living within 50 kilometres of the coastline’. Therefore as sea levels rise, there is a significant increase in the threat and vulnerability of roads, buildings, infrastructure, and human lives. Australia’s native ecosystems, marine and coastal plants and animals also face potential detrimental harm.

Although uncontrollable effects of the natural environment contribute to the changing climate which then results in sea level rise, it is imperative that a number of measures are taken in order to ensure various stakeholders within Australian coastal communities can adequately respond to the man-made impacts which contribute to the effects of global warming.

These response measures will be required to minimise the magnitude of the effects of rising sea levels, and also adequately plan to adapt the coastline of Australia to the future change which will be experienced over the coming decades. In order to respond to the impacts and effects of climate change, ‘partnerships must be developed between science, government, business and community sectors’ [4].

Behavioural changes must also take place on an individual, local and national scales in order to reduce the impacts of global greenhouse emissions and global warming. As stated by the 2007 Independent Working Group Report of the Australian Prime Minister’s Science, Engineering and Innovation Council [8], ‘there is...no room for complacency in facing the challenge of climate change’. Depending on their circumstances, coastal communities will respond to the risk of inundation in different ways, according to a study by CSIRO [9]:

‘Likely response options are to build defenses to restrain the sea, adapt to occasional inundation, retreat from advancing seas, or some combination of these. Choice of strategy, and the details of the design, will have significant and widespread implications for the value and security of private property, the ecological values of coastal areas, the safety and resilience of settlements, and the cohesiveness of communities.’

Responding to the impacts of rising sea levels requires the design and development of environmental assessment frameworks in order to analyse the environmental pressure and therefore provide adaptation responses. The most common environmental assessment

frameworks include the Pressure-State-Response framework (PSR), Driving Force-State-Response framework (DSR) and the Driving Force-State-Impact- Response framework (DPSIR) which were all developed in the 1990s. Each of the three frameworks enables the assessment of environmental pressures which contribute to the state of the environment and allows for responses to environmental pressures which will in turn reduce the impact on the state of the environment. Alternatively, responses can be developed in order to adapt to the state of the environment. Despite these frameworks being similar in their assessment, each framework is respectively an advancement of the prior framework as the European Environmental Agency (EEA) saw the need to address 'the issues that plagued the [previous] frameworks' (Carr & Wingard, 2007). Although the EEA has elaborated and redefined the structure of environmental assessment frameworks (PSR, DSR and DPSIR) to address the 'root causes of... human activities' (Carr & Wingard), these frameworks still lack 'social inclusiveness' [11].

'Several community surveys have been conducted to assess community perceptions of climate change in an Australian context' (for example, [11, 12, 13, 14, 15, 16, and 17].

At the time of conducting this research project (2013), we were not aware of any survey or publication which has specifically examined the relationship between the perception of various stakeholders within Australian coastal communities, about the impacts of rising sea levels, and their response. The aim of this research is to develop an understanding of how the perception of various stakeholders within Australian coastal communities, about the impacts of rising sea levels, shapes their response. We argue here that PSR frameworks can be improved through the introduction of the concept of human perception. We believe that not only the pressure (P) itself, but the "perception of the impact of that pressure" is a determinant in shaping how individuals respond to the pressure. Perception varies across different stakeholders, because they may experience impacts differently, and may also be harmed or benefit from them differently. If coastal communities are considered as a heterogeneous collective of stakeholders, the introduction of the concept of perception would allow a richer and more diverse investigation of the types of and motives for responses.

A literature review is used in order to explore the pressures of rising sea levels by providing an understanding of what makes sea levels rise as well as the impacts of rising sea levels. The literature review will then be used in order to provide an understanding of how Australian coastal communities can respond to the impacts of rising sea levels. The development and use of environmental assessment frameworks will then be further explored allowing for the emphasis of the need for responding to the gap in these frameworks by addressing the "perception" of various stakeholders.

In conjunction with the literature review, a case study of Ocean Grove/ Barwon Heads will be used which involves the implementation of a survey to assess the perception of various stakeholders within the coastal community about the impacts of rising sea levels as well as their response to the situation.

These stakeholders include local residents (property owners and those renting), building developers and the local council of the City of Greater Geelong. The survey results will better the understanding of how various stakeholders within Australian coastal communities may perceive the impacts of rising sea levels based on their awareness, concern and experience with the issue. The survey will also allow for an evaluation of the relationship between the perception of the impacts of rising sea levels and the response to the impacts of rising sea levels in order to understand how perception of various stakeholders shapes their response.

Tentative conclusions will be drawn from this research about how various perceptions within Australian coastal communities may influence responding to the impacts of rising sea levels. Evidence from the literature review and survey results will also be used in order to suggest that by refining environmental assessment frameworks to account for social considerations such as human perception, more effective responses to the environmental pressures as well as the state of the environment can be delivered by Australian coastal communities which will therefore result in adapting more resilient cities to the impacts of the rising sea levels phenomenon.

II. LITERATURE REVIEW

A. *The pressure: Rising sea levels*

Through extensive coastal observation and analysis over the past few decades various scientific research have confirmed sea levels are rising worldwide, and are detected to have been rising within Australia since 1920. Some of these research have been carried out by organisations such as NCCARF (National Climate Change Adaptation Research Facility), CSIRO (Commonwealth Scientific and Industrial Research Organisation), IPCC (Intergovernmental Panel on Climate Change), NASA (National Aeronautics and Space Administration) and SEC (State of the Environment Committee). There is enough evidence to affirm that sea levels are rising at a rate faster than ever before; however without understanding exactly what makes sea levels rise, as well as the impacts of rising sea levels, the success of delivering adequate adaptation responses is compromised.

There are various natural and anthropogenic factors which contribute to the rising of sea levels [18, 19]. Contrary to the over-publicised perception of climate change, the earth's atmosphere actually needs greenhouse gases; without them 'the average global temperature of the Earth would be about -17 degrees Celsius' [20]. However, human activities excessive in the production of carbon emissions contribute to global warming, and as a consequence, to impacts such as rising sea levels.

When humans add greenhouse gases to the atmosphere, the level where outgoing radiation can escape to space moves to a higher and colder location. Cold air does not emit as much outgoing radiation. Because the incoming solar radiation is unchanged, there will be less heat leaving the planet than coming in. the result will be a warmer lower atmosphere. This is known as the enhanced greenhouse effect which contributes

to the scientifically complex and politically controversial process of global warming.

As the temperature of the waters in the oceans rises and the seas become less dense, they expand and will spread, occupying more surface area on the planet causing inundation of low lying areas. Increased temperature will accelerate the rate of sea level rise.

The melting of the glaciers is 'occurring at an alarming rate with glaciers on five major continents disappearing rapidly' [18]. Since 1970 temperatures have increased by 2.1 degrees Celsius in locations such as the Alps which are already causing 90% of the world's glaciers to melt and some to disappear completely. The maximum melt of the Greenland ice sheet has increased on average by 16% from 1979 to 2002 and the warming of Greenland and the Arctic is already increasing the rate of sea level rises. For every degree increase in mean annual temperature near Greenland, the rate of sea level rise increases by about 10% [18]. Monitoring has shown that currently the oceans are rising around 5 cm every ten years. Both sea and glacier ice cool the earth which is extremely important to the global climate as it slows heat loss from the relatively warm ocean to the cold atmosphere and without the large sea ice masses at the poles to moderate the energy balance, global warming will escalate.

In summary we can understand that sea levels are rising as a result of the changing climate. The reason for the changing climate is partly the result of natural environmental processes over time, but it is accelerated by human activities which lead to significant increases in greenhouse gasses.

B. The impacts of rising sea levels

Sea levels will continue to rise globally at varied magnitude across the globe. Areas such as Australia, experiencing exponential rises, are more at risk of effects such as storm surges and coastal erosion which in turn will have detrimental impacts on buildings, infrastructure and livelihoods [21]. According to CSIRO [7], within Victoria alone, a sea-level rise of 1.1 meters would put between 31,000 and 48,000 residential buildings at risk, which will result in losses between \$8 and \$11 billion. 3,500 km of roads as well as 135 km of railways, and 2,000 commercial buildings would be damaged in Victoria with an estimated value of up to \$9.8 billion, \$500 million and \$12 billion respectively [7]. Additional costs should be accounted for environmental damage on natural ecosystems.

As a country, Australia will experience social, economic and political implications with the threat of a significant decrease in tourism due to the increase in damage and danger posed on tourist attractions. There is also potential in the loss of residential housing which will ensure the relocation of local residents into more suburban or inland areas. In particular, various infrastructures imperative for Australian communities will be at risk, including 258 police, fire and ambulance stations, five power stations/sub stations, 75 hospitals and health services, 41 landfill sites, three water treatment plants, and 11 emergency services facilities which are located within 200m of the shoreline [22].

On a global scale, many islands such as Tuvalu, the Cook Islands and the Marshall islands are at risk of disappearing as sea levels rise. Tuvalu in particular may be the first large inhabited island to be 'lost forever with a prediction that the nation will be submerged in 50 years' [18]. A 1 m rise in sea level would inundate half of Bangladesh's rice land and cause severe flooding throughout nations such as China, India and Thailand. Other areas such as Egypt, Indonesia, the Philippines and the United States are particularly vulnerable to sea level rise [18].

C. The response: adapting to the impacts of rising sea levels

Delivering effective responses to the impacts of rising sea levels will involve addressing both mitigation and adaptation strategies amongst Australian coastal communities.

The American Psychological Association [19] has defined the process of mitigation as:

'...any human action that reduces the sources of or enhances the sinks of greenhouse gases. Emissions can be decreased by a variety of means such as lowering energy demands, making existing energy systems more efficient, increasing the contribution of renewable forms of energy production'

Mitigation can therefore be identified as a behavioural response to the impacts of rising sea levels which requires minimising the pressures on the environment which in turn will allow for a better state of the environment. Although mitigation and adaptation are generally contrasted and compared, it is important to acknowledge the overall difference between the two. According to the Intergovernmental Panel on Climate Change [6] adaptation is:

'...the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities'.

Adaptation responses can therefore be understood as a measure in order to respond directly to the existing or predicted impacts whereas mitigation differs in its approach with a focus on reducing the magnitude of the pressures in order to avoid the impacts from occurring. In the case of rising sea levels, mitigation responses aim in reducing man-made contributions towards climate change by developing response strategies in order to minimise the excessive production of greenhouse gas emissions. Sea levels are predicted to continue to rise 'for coming centuries, regardless of any future mitigation of greenhouse gas emissions' [23] and therefore it is absolutely crucial for Australian coastal communities to focus heavily on developing and implementing adaptation strategies which respond to the impacts of rising sea levels.

Adaptation strategies to rising sea levels must respond directly to the impacts of rising sea levels whereby such response strategies for Australian coastal communities, large and small, include the following [24]:

'...assuring effective governance, increasing the resilience of physical and linkage infrastructures, changing settlement locations over a period of time, changing settlement form, reducing heat-island effects, reducing emissions and industry effluents as well as improving water handling, providing financial mechanisms for increasing resiliency, targeting assistance programs for especially impacted segments of the

population and adopting sustainable community development practices.'

Existing literature delivers various adaptation responses which address property and infrastructure for coastal communities at risk of inundation due to rising sea levels [25]. These adaptation responses include: building hard and soft defenses to protect properties and infrastructure; building or modifying properties and infrastructure to cope with periodic or permanent inundation; removing or relocating properties and infrastructure as and when required; ensuring new structures are built out of harm's way.

Coastal communities are expected to continue to provide the scenery and recreational opportunities, and habitats for plants and animals that Australians currently value. Coastal wetlands, seagrasses, beaches and dunes may assist in the protection of buildings and infrastructure from the increasing risks of storm surges and coastal erosion [26, 25].

D. The gap: Incorporating 'perception' into assessment frameworks would facilitate more effective responses

As environmental issues such as rising sea levels are becoming more of a concern over recent years, there has been a significant increase in regulations which has therefore led to a boom in environmental assessment reports [27]. They have become common place in planning and evaluation at all scales of decision making, particularly due to the capacity of environmental assessment reports leading to the identification of environmental indicators which may aid in providing 'a sign or signal that relays a complex message... in a simplified and useful manner' [28].

The Pressure-State-Response framework (PSR), Driving Force-State-Response framework (DSR) and the Driving Force-State-Impact-Response framework (DPSIR) were developed in the 1990s 'as a tool for the reporting and analysis of environmental problems' [10]. Although it may seem as though there is a wide variety of frameworks to choose from, each framework is respectively a further development based upon the limitations of the previous framework. The need to continue updating the structure and implementation of frameworks seems to be a viable solution towards better analysing and responding to environmental problems.

The PSR framework developed by the Organization for Economic Co-operation and Development [29] and the European Environmental Agency [30] which is 'an extension of Rapport's [31] Stress-Response Model has been used by various scientific research bodies including the Intergovernmental Panel on Climate Change [32] 'as a framework for the integrated assessment of climate change'. The structure of the framework is based on the understanding that human activities impose pressures on the state of the environment. Such pressures due to human activities will induce changes in the state of the environment which may then lead to a response to reduce pressures which will therefore reduce the environmental damage. Alternatively, a response measure may also be delivered by improving the state in some other manner.

Despite the continuous advancements on PSR, through the addition of driving forces and impacts (DPSIR) into the whole systems approach to environmental problems, the US National Commission on Science for Sustainable Forestry [11] stated that:

'...the reliability of identified measures is frequently questioned, at least in part because selection of indicators often has lacked... social inclusiveness.'

This indicates another weaknesses in the current environmental assessment frameworks: lack of social inclusiveness. It is argued here that 'perception of impacts by stakeholders involved in an environmental problem', and only the impact itself, can strongly affect the level and effectiveness of responses to the problem.

In 2012, a study was published by CSIRO titled "Perceptions of Sea-Level Rise and Managed Retreat: An Exploratory Survey" [9] expressed the importance of community perception towards rising sea levels. In 2011 NCCARF published a report, "Public risk perceptions, understandings, and responses to climate change and natural disasters in Australia, 2010 and 2011" [17]:

'This report presents and discusses the findings of a second Australian national survey examining and monitoring public risk perceptions, understandings, and responses to climate change and natural disasters, undertaken between 15 July and 8 August of 2011.'

Between 2005 and 2013, international environmental researchers including [10], [11], and [27], have heavily critiqued the lack of focus on human in environmental frameworks such as the PSR, DSR and DPSIR frameworks. Moreover, CSIRO and NCCARF have recently released studies which respectively explore Australian's perception of policies designed for rising sea levels and disasters of climate change [9, 17]. Therefore this evidence suggests that there has been an increase in emphasis on the importance of understanding how people perceive such events, yet the PSR framework has still not been developed in order to deliberately accommodate for, and assess, human perception.

III. RESEARCH DESIGN

A. Case study

This research has been developed in order to understand how the perception of various stakeholders within an Australian coastal community, about the impacts of rising sea levels, shapes their response. The research explores this through the implementation and discussion of results from a survey completed by various stakeholders within the coastal community of Ocean Grove/Barwon Heads, in Victoria. This location has been selected due to the already existing expression of vulnerability to the impacts of rising sea levels.

In 2010 CSIRO published a set of maps showing how sea level rise would affect the Australian coast in the period 2030-2100, considering three scenarios: 0.5, 0.8 and 1.1 metres, relative to the levels in 1990 [33]. The low scenario (0.5 m) considers sea level rise in the context of a global agreement which brings dramatic reductions in global emissions and

represents what is likely to be unavoidable. The medium scenario (0.8 m) represents the application of projections suggested by the IPCC's 4th Assessment Report. The high-end scenario (1.1 m) consider the high end risk identified by the IPCC's 4th Assessment Report and also reflects the impacts of recent warming trends beyond those already included in the IPCC's projections. Even in the context of the low scenario, rising seas would submerge large parts of Australia's coast.

Figure 1 illustrates the potential flood area in Ocean Grove/Barwon Heads in 2100 for the high-end scenario.

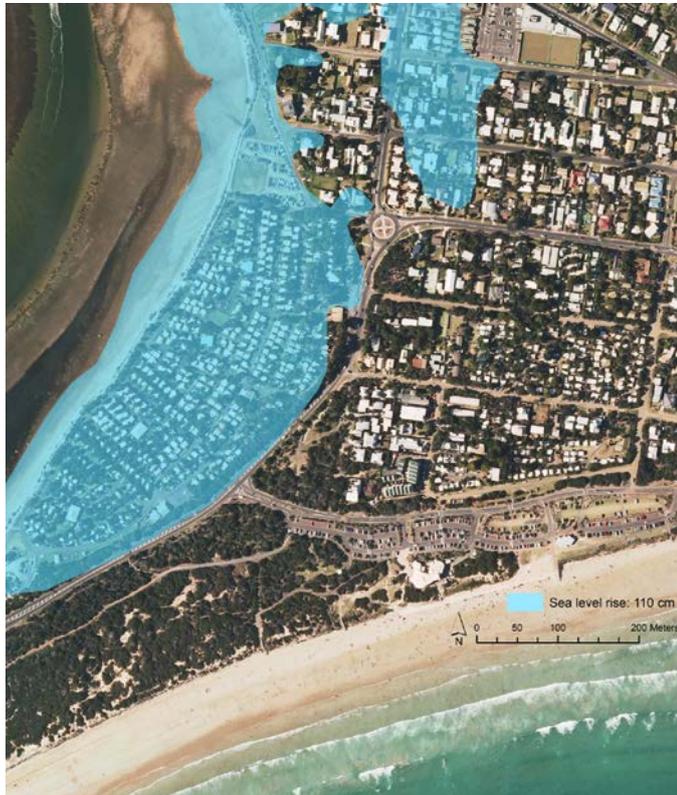


Fig. 1. Sea level rise in 2100 in Ocean Grove/Barwon Heads area for the high-end scenario

B. Survey method: measuring perception

Borrowing concepts from psychology, perception of a risk is described here through three components: awareness, concern, and experience [19]. This means that the level of perception would depend on how aware someone is in regards to the risk they are exposed to; it would also be affected whether the person is concerned or not about the risk; and

finally, perception would also be influenced if the person has experienced the risk.

A questionnaire was designed to arise a sense of these components through questions with multiple-choice responses using a likert scale (1: strongly disagree, 2: disagree, 3: unsure, 4: agree, 5: strongly agree.). For example; where participants had answered "strongly agree" in response to a question, they would receive a score of 5/5 for this question. Had they answered strongly disagree, this would have received a score of 1/5. The overall mark for each component would be the sum of the questions for that component, scaled to %. For example, someone may have a "level of awareness" of 80% (one knows well about the risk), a "level of concern" of 50% (one is not overly concerned about the risk), and a "level of experience" of 20% (one has a minimum experience with the risk). As an average of the three components, the total perception of this individual would be 50%. These are later correlated to the "level of response" to investigate their relationships. The level of response use the same % scheme based on questions with the likert scale.

Stakeholders used in this survey included local residents (renting or property owners), building developers and members of the local council. As the term 'coastal community' does not describe a homogeneous entity, it is important to disaggregate the community into a group of various stakeholders, with different roles and interests, and potentially different perceptions and patterns of responses.

Level of awareness:

The term awareness can be understood as ones' 'knowledge of a situation or fact' [34], this is how well-informed someone is on a particular situation or development. Therefore in order to best understand each of the participants' level of awareness to the impacts of rising sea levels, questions were designed to explore whether participants had heard of the impacts of rising sea levels, where they learnt or heard about the impacts and to what extent they agree with the following statements: (a) Sea levels have risen over the past decade; (b) Sea levels will continue to rise in the coming years; (c) There are various physical impacts as a result of rising sea levels, such as loss of property or land, fluctuations in land values on rental property prices; (d) I believe the impacts of rising sea levels are not emphasized enough through the media; (e) I believe creating awareness and education on the issue of rising sea levels is important.

Level of concern:

In order to best understand participant's perception, it is crucial to analyse their level of concern to the impacts of rising sea levels as this is a measure of how 'anxious or worried' [34] a person may be with respect to a certain situation. The questionnaire assessed concern by exploring the following questions: (a) How concerned are you about the impacts of rising sea levels?; (b) Do you believe people in general should be concerned about the impacts of rising sea levels?; (c) Within your local community, who do you believe should be most concerned about the impacts of rising sea levels?; (d) Do you believe you may be more concerned about the issue, if you experienced the impacts first hand?; (e)

Whether or not you experience the impacts of rising sea levels, are you still concerned about the issue?; (f) Do you believe you may one day be affected by the economic, social or physical impacts of rising sea levels?

Level of experience:

A person's experience indicates contact with the risk itself of its consequences. The questionnaire assesses experience of the impacts of rising sea levels by asking participants to what degree do they agree with the following statements: (a) I have heard of other people who have experienced the impacts of rising sea levels; (b) I have experienced the impacts of rising sea levels first hand; (c) I expect that I will one day have to deal with the impacts of rising sea levels; (d) My home or a building/ region I work in have been affected by rising sea levels; (e) I have seen the impacts on rising sea levels on a building before.

Level of response:

The questionnaire analyses participants' response by asking them whether they have already taken action in responding to the impacts of rising sea levels, and if so, how they have responded to these impacts. Participants were also asked who they thought was most responsible for responding to the impacts of rising sea levels and how much they agree with the following statements: (a) I would be more encouraged to respond to the impacts of rising sea levels if the entire community was willing to do the same; (b) Responding to the impacts of rising sea levels is a big responsibility; (c) There is not much I can do to respond to the impacts of rising sea levels because the issue does not involve me.

Relation between perception and response:

In developing information regarding various stakeholders' perception and response to the impacts of rising sea levels, relationships and trends can be analysed between the two in order to understand how the perception of various stakeholders within Australian coastal communities, about the impacts of rising sea levels, shapes their response. Correlations and graphical analysis are used in order to unravel the influences and dependencies.

IV. RESULTS

The survey involved 24 participants: 5 residents renting their dwellings in the study area; 10 residents owning the dwellings in the study area; 5 building developers from a local construction firm; and 4 members of the local city council in positions related to urban design, project management and planning. Table 1 summarises the levels of awareness, concern, experience, total perception, and response for all participants, and the average for each stakeholder type.

Figure 2 shows the mean level of perception, including awareness, concern and experience, for the four stakeholders included in the study based on the survey in the Ocean Grove/ Barwon Heads community. It suggests significant variations among the stakeholders in relation to the different components of perception. The implications of these variations are discussed in the following section.

TABLE 1: RESULTS FROM OCEAN GROVE/ BARWON HEADS SURVEY

| Group | P | Awareness % | Concern % | Experience % | Total Perception % | Response % |
|---------------------|-------------|-------------|-----------|--------------|--------------------|------------|
| Residents renting | | 57 | 56 | 48 | 54 | 20 |
| | | 86 | 72 | 80 | 80 | 50 |
| | | 63 | 80 | 80 | 73 | 50 |
| | | 91 | 100 | 80 | 91 | 60 |
| | | 60 | 40 | 32 | 46 | 20 |
| | Mean | | 71 | 70 | 64 | 69 |
| Residents owner | | 91 | 88 | 80 | 82 | 40 |
| | | 57 | 96 | 60 | 47 | 60 |
| | | 86 | 88 | 88 | 87 | 40 |
| | | 74 | 80 | 68 | 74 | 40 |
| | | 77 | 68 | 56 | 68 | 30 |
| | | 77 | 88 | 56 | 74 | 30 |
| | | 80 | 76 | 56 | 72 | 50 |
| | | 83 | 92 | 64 | 80 | 40 |
| | | 100 | 80 | 100 | 94 | 100 |
| | | 86 | 88 | 88 | 87 | 60 |
| Mean | | 81 | 84 | 72 | 77 | 49 |
| Building developers | | 86 | 96 | 100 | 93 | 100 |
| | | 74 | 80 | 80 | 78 | 60 |
| | | 100 | 100 | 100 | 100 | 80 |
| | | 80 | 80 | 88 | 82 | 60 |
| | | 97 | 100 | 100 | 99 | 80 |
| | Mean | | 87 | 91 | 94 | 90 |
| Local Council | | 97 | 96 | 100 | 98 | 100 |
| | | 94 | 84 | 60 | 79 | 100 |
| | | 91 | 64 | 68 | 74 | 53 |
| | | 57 | 32 | 40 | 43 | 50 |
| | Mean | | 85 | 69 | 67 | 74 |

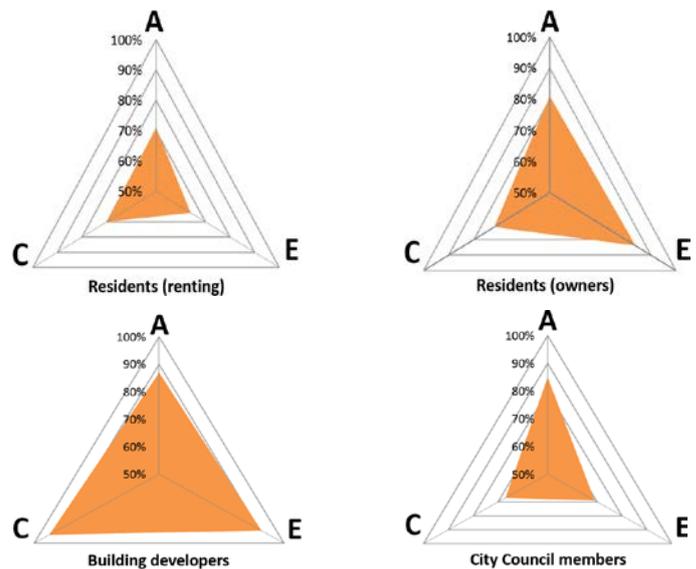


Fig. 2. Level of perception about the impacts of rising sea levels for multiple stakeholders; A: awareness, C: concern, E: experience.

Figure 3 compares the average perception to the average response for each stakeholder. The impacts of the variations identified are discussed in the following section.

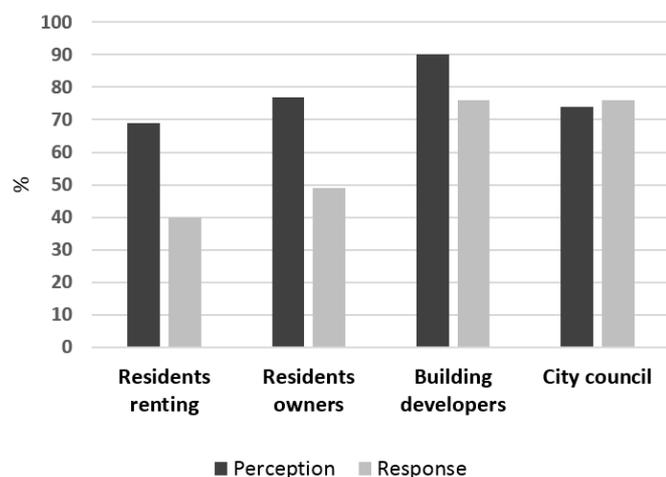


Fig. 3. Comparison of various stakeholders' level of perception vs. response about the impacts of rising sea levels

Table 2 consists of data which portrays the statistical correlation between components of perception, overall perception and response for all 24 respondents. This table contains the data most relevant to understanding how the community's perception about the impacts of rising sea levels, shapes their responses. The coefficients ranges between 0.5 to 0.73, indicating a significant correlation and a positive pattern for all relationship's (both factors increase or decrease together).

TABLE 2: CORRELATION BETWEEN AWARENESS, CONCERN, EXPERIENCE, PERCEPTION AND RESPONSE OF THE IMPACTS OF RISING SEA LEVEL

| | Awareness | Concern | Experience | Perception |
|------------|-----------|---------|------------|------------|
| Awareness | | | | |
| Concern | 0.61 | | | |
| Experience | 0.72 | 0.73 | | |
| Response | 0.63 | 0.50 | 0.68 | 0.62 |

V. DISCUSSION

A. How does the perception of various stakeholders within Australian coastal communities, about the impacts of rising sea levels, shape their response?

Table 2 shows the correlation between awareness, concern, experience, perception and response of the impacts of rising sea levels. The data in this table shows that the correlation between perception and response is 0.62 which indicates that there is a positive correlation between participants' perception about the impacts of rising sea levels and their response. Therefore as stakeholders' perception increases, so should do their response. Figure 3, however, suggests that the relationship between perception and response vary among stakeholders. City Council members and building developers seem to have a more similar level of perception and response; while residents have a lower level of response regardless their significant level of perception.

Table 2 presents specific correlations between the components of perception which are made up of the awareness, concern and experience of the stakeholder about the impacts of rising sea levels. Experience showed higher correlation to response (0.68) than awareness (0.63) and concern (0.50). If everyone would need to have some significant level of experience with sea level rise in order to respond to it, it may be too late to get some effective improvement or mitigation. The best scenario would be to increase the role of awareness and concern, regardless experience with the environment risk, as stimuli to responses.

The data in table 2 also shows that the strongest correlations exist between awareness and experience which have a positive correlation of 0.72, as well as concern and experience with a positive correlation of 0.73. This suggests that as individuals are more exposed to the impacts of rising sea levels and have a greater level of experience, the more aware and concerned they are likely to be. This suggestion can be affirmed by the 86% of residents (total of those renting and those who own their own home) who said they would respond to the impacts of rising sea levels if the impacts directly affected them.

Participants were asked to state where they had first learnt or heard about the impacts of rising sea levels. The results from this question show a comparison between sources which are influential on contributing to the way in which various individuals perceive the phenomenon of rising sea levels. Amongst the population who participated in the survey, 68% of the total participants stated that they had heard or learned about the impacts of rising sea levels through the media. 18% had heard or learned about the impacts through the conversation and 9% had been educated about these impacts in school or university. Hence, this data suggests that the media provides the most exposure about the impacts of rising sea levels and by doing so; the perception of individuals is most likely to be influenced by this source.

Despite the media's ability to significantly influence the perception of individuals about the impacts of rising sea levels, perceptions amongst participants may vary. One of the participants who had answered that the media was where they had first heard about the impacts of rising sea levels, made further comments below their response stating that "because they cannot trust the media, they are not sure what to perceive" about the impacts of rising sea levels. It is therefore important to acknowledge that although the media is the most influential source in shaping individual's perception about the impacts of rising sea levels, it is not necessarily the most effective measure of delivering information. With this taken into account, the figure of only 9% of participants hearing/ learning about the impacts of rising sea levels in school or university is very low considering the effectiveness of education within Australia of learning about national and global issues. As the entire 9% of participants who stated they had learned about the impacts of rising sea levels through school or university were between the ages of 18-25 this may suggest that as the impacts of rising sea levels have become more evident in recent times, younger generations in educational systems

are starting to be educated about the rising sea levels phenomenon. Regardless of this belief, it is important that Australian schools and universities continue to educate students about the rising sea levels phenomenon.

B. The difference between perception and response to the impacts of rising sea levels amongst various stakeholders

Figure 2 shows that of all the stakeholders, building developers have the greatest level of awareness concern and experience to the impacts of rising sea levels (awareness: 87% , concern: 91% , experience: 94%). Figure 3 shows both the local council and building developers as having the greatest level of response (both of which are 76%). Figure 2 also suggests that local residents who are renting have the least level of perception and response to the impacts of rising sea levels (69% and 40% respectively). In contrast, building developers have the greatest level of both perception and response (74% and 76% respectively), which may be the result of having the greatest level of experience (94%). In this case, building developers may have a the highest level of experience due to working in numerous coastal communities as well as having to abide by standards of building and construction in coastal regions.

C. Responsibility of responding to the impacts of rising sea levels

86% of residents believe it is predominantly the responsibility of the local council to respond to the impacts of rising sea levels. Of these participants, all 4 members of the local council who participated in the questionnaire agreed with this. One member in particular included additional comments in the survey stating that it 'can't be done by local government alone – it requires state and federal responses as well'. 67% of residents also strongly agreed that they would 'be more encouraged to respond to the impacts of rising sea levels if the entire community was willing to do the same'. Members of the local council stated that they were already responding to the impacts of rising sea levels by 'developing planning policies and strategies to minimize risk and support resilient building and design responses' and through the 'careful design of infrastructure close to the coast'. Therefore it is clear that the local council is already responding to the impacts of rising sea levels, however by making the local residents aware of this action, there will be increases in resident's perception and therefore more effective responses can be delivered from the entire community.

VI. CONCLUSION

The aim of this research was to find out how the perception of various stakeholders within Australian coastal communities, about the impacts of rising sea levels, shapes their response. The results of this research may provide future opportunities for developing environmental strategies and assessment frameworks which incorporate human perception which will therefore result in more effective community responses to the impacts of rising sea levels, and

in turn, help coastal communities adapt to become more resilient to these impacts.

This research indicates that the importance based upon responding to factors of human perception such as awareness, concern and experience is reflective of the thought that perhaps there are more factors of 'response' than just the physical adaptation measures which are the responses most commonly and consistently delivered in both environmental research and assessment reports. Therefore after analysing the results of this research, it was necessary to explore adaptation responses further in order to suggest that further research in this field could also be conducted in order to better understand how to ensure more effective community responses.

According to the APA [19], 'social adaptation' involves 'continually adjusting group or community level responses to concerns and perceptions of environmental of threats and changing circumstances'. Therefore after retrieving the results of this research and conducting further research on the definition of social adaption we can see that this research can actually be considered as an insight into social adaptation as the main intention of this project was to emphasise the importance of 'adjusting responses to the perceptions of environmental threats', which is the exact definition of 'social adaptation'. In contrast, 'psychological adaptation' in the context of climate change encompasses 'how the phenomenon... is perceived, understood, and responded to' and involves changes in 'risk perception, threat appraisal and associated cognitive, emotional and motivational responses to the threat' [17]. Therefore, these definitions make it clear that both social and psychological adaptation responses are heavily influenced by perception. So then why does the research conducted by environmental research bodies and the design of environmental assessment frameworks predominantly focus on only physical adaptation? This observation is reinstated by the deliberation of environmental assessment frameworks such as PSR, DSR and DPSIR which over many years have been continuously redeveloped and refined to focus on human activity and physical adaptation responses. Perhaps the fault in redevelopment as well as the existing weakness in these frameworks is the lack of incorporation of social adaptation and psychological adaptation responses. In order to strengthen these frameworks attention must be given to the physical, psychological and social adaptation responses. By doing this, researchers will be achieving the initial contention of this research project – incorporating human perception into environmental assessment frameworks which will therefore aid Australian coastal communities in delivering more effective responses to the impacts of rising sea levels.

This project was approved by Deakin University' Ethics Committee (Faculty of Science, Engineering and Built Environment) on the 19 September 2013 (STEC-45-2013-SAMUEL).

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