

# Exploring the role of climate change risk perceptions in informing climate services for adaptation in East Africa

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## Abstract

The specificities of the African decision context are not well understood and are often not considered in the development, tailoring and supply of climate services for Africa. Yet, the utility of climate services relies on them being suitable for the decision context, so an understanding of the decision context should be central to climate services development. One unexplored approach to deepening an understanding of the decision context for climate services is through climate change risk perceptions, because perceptions of climate change risk influence whether decision makers take action on climate change as well as what information they seek and use to take action.

Accordingly, this study uses data collected through a regional survey (N = 474) and semi-structured interviews (N = 36) to explore and better understand climate change risk perceptions amongst policy decision influencers in East Africa. The data informs three separate analyses. First, a climate change risk perceptions model is constructed, elucidating how various risk perception determinants interact to influence climate change risk perceptions and professional action on climate change in East Africa. This model shows that the pathway to climate change risk perceptions differs depending on individual value systems. Heightened climate change risk perceptions of those with primarily self-enhancing (inward looking) values are predominantly influenced by social norms, whereas heightened climate change risk perceptions of those with primarily self-transcending (outward facing) values are predominantly influenced by experience of extreme events and the psychological proximity of climate change.

Second, the identified climate change risk perception determinants are quantified and explored to better understand the specificities of the decision context in which climate services are used. Climate change risk perceptions are found to be heightened, driven by observance of social norms, perceptions of climate change as a proximal risk, frequent experience of extreme weather events and a predominantly self-transcending value system among policy decision influencers. Lastly, the relationships between determinants of climate change risk perceptions and the use of climate services information are quantified and explored to evaluate gaps in currently available climate services. The analysis reveals three main gaps, namely the lack of long-term climate change projections disseminated through National Meteorological Services, the limited locally ground-truthed delivery of impact-based forecasts and inadequate capacity development of climate services users to understand and use complex climate information. The study culminates in a proposed framework for the enhancement of climate services for East Africa, based on understanding gained through the study.

## Declaration

I declare that this dissertation is my own work. I declare that neither the substance nor any part of the dissertation has been submitted in the past, or is being, or is to be submitted for a degree at this University or at any other university.

I confirm that I have been granted permission by the University of Cape Town's Doctoral Degrees Board to include the following publications in my PhD dissertation, and where co-authorships are involved, my co-authors have agreed that I may include the publications:

1. **Steynor, A.** and Pasquini, L. 2019. *Informing climate services in Africa through climate change risk perceptions*. *Climate Services*. 15, 100112: DOI: 10.1016/j.cliser.2019.100112
2. **Steynor, A.**, Pasquini, L., Thatcher, A. and Hewitson, B. 2021. Understanding the links between climate change risk perceptions and the action response to inform climate services interventions. 41(10). *Risk Analysis*. DOI: 10.1111/risa.13683
3. **Steynor, A.** and Pasquini, L. Using a climate change risk perceptions framing to align climate services to the East African decision context. Under review. *Climate Services*
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# Chapter 1: General Introduction

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## 1. Introduction

Climate change, caused by anthropogenic greenhouse gas emissions, is a complex global hazard that has the potential to significantly affect the functioning of modern-day society. While climate change is likely to have widespread global repercussions, projections of change are not uniform across all regions of the world, with some regions projected to experience more extreme changes than others (Masson-Delmotte et al., 2021). For instance, in the African context, the 2021 Intergovernmental Panel on Climate Change (IPCC) report noted that, at 4°C global warming, annual maximum temperature increases over the African continent are projected to range between 3°C and 6°C depending on the location (IPCC, 2021, Africa regional fact sheet). Northern and southern Africa (the more arid zones) are expected to experience greater magnitude temperature increases than central Africa (IPCC, 2021, Africa regional fact sheet). Mean precipitation is projected to decrease in the southern parts of Africa, and increase in the Sahel region and parts of central Africa (IPCC, 2021, Africa regional fact sheet). These changes in temperature and precipitation are projected to be accompanied by a change in climatic extremes, such as extended dry spells (resulting in droughts) and heavy rainfall events (resulting in flooding). Droughts are likely to intensify, with a projected increase in drought events in west Africa, southern Africa and Madagascar (IPCC, 2021, Africa regional fact sheet), while flooding events are projected to increase in all regions in Africa, apart from western southern Africa (IPCC, 2021, Africa regional fact sheet).

Further compounding the physical climate changes, developing countries, such as those in Africa, have a heightened vulnerability in comparison to developed countries. This heightened vulnerability will result in them being disproportionately impacted by climatic changes (Collier et al., 2008). These impacts will unfold differently depending on the location, developmental context and international assistance. However, broad-scale examples of potential impacts from climate change may include: water shortages or restrictions, an increase in water-borne and vector-borne diseases, lower crop yield or total destruction of crops and loss of biodiversity, amongst many other impacts (Pörtner et al., 2022).

To address these projected impacts, there have been two high-level responses to climate change. These responses take the form of adapting to the unavoidable changes in climate and impacts that will occur as a result of climate change (adaptation) and decreasing greenhouse gas emissions to reduce the magnitude of future climatic changes and impacts (mitigation) (Parry et al., 1998; Zhao et al., 2018). It is recognised that a combination of both responses is required in order to address climate change (Laukkonen et al., 2009; Masson-Delmotte et al., 2021). However, while mitigation is a major focus of many developed nations, the focus, in Africa, is primarily on adaptation (African Union, 2015).

This difference in focus is largely due to the relatively small greenhouse gas emissions contribution of the African continent (Blanco et al., 2014) but also due to the (previously noted) disproportionate impacts that the developing world is projected to experience from climate change.

Adaptation to climate change requires deliberate and planned adjustments to social, economic and ecological systems in response to expected climatic changes (CARE, 2009). This planning, in part, relies on sound information regarding past, current and future climate conditions (Williams et al., 2015; Hansen et al., 2019). Providing this climate information is the remit of climate scientists, however, early attempts to integrate climate science into adaptation decision-making revealed a gap between what the climate science community were providing and the type of information the adaptation decision making community required for adaptation planning (Lemos et al., 2012). This gap has been identified as one major (and ongoing) barrier to the success of climate change adaptation (Kiem and Austin, 2013; Hansen et al., 2019; Vogel et al., 2019; Findlater et al., 2021).

In a formal attempt to bridge this gap, the field of climate services was officially established at the third World Climate Conference in 2009 (Hewitt et al., 2012). Climate services aim to provide tailored and contextualised decision-relevant climate information products (on all timescales) (Vaughan, Dessai, & Hewitt, 2018) alongside capacity support for their use (Vincent, Daly, Scannell, & Leathes, 2018) to enable science-informed adaptation decision making. As a relatively new initiative, the field of climate services is rapidly evolving and has been the subject of significant investment to date (Bhattacharya, A. et al., 2020).

Yet, despite investment in climate services, there has not been a commensurate level of uptake of climate information into adaptation planning processes in many African countries (Singh et al., 2018; Vincent, Daly, et al., 2018; Vogel et al., 2019; Trisos et al., 2022). There is varied literature regarding barriers to the uptake of climate information, including barriers such as how information is distilled (Jack et al., 2021), an underappreciation of the complexities of the decision making landscape (Steynor et al., 2016; Siders and Pierce, 2021) and inherent power differentials in how climate services are envisaged, funded, co-produced, disseminated and ultimately used (or not) (Daly and Dilling, 2019; Vogel et al., 2019; Vincent, Carter, et al., 2020).

Within this wider discourse, scholars have suggested that one of the reasons that climate services is not gaining traction in some African adaptation decision making processes is because African decision context specificities are not often considered in the development, tailoring and supply of climate services (Hewitson et al., 2017; Vogel et al., 2019), resulting in a mismatch between the way climate services are currently supplied and what is required for decision-making (Jones et al., 2015; Singh et al., 2018; Vincent, Daly, et al., 2018; Vogel et al., 2019). Instead, the way climate services are framed

and communicated are, often, biased towards the global north, where the majority of climate services originate (WMO, 2017).

Better understanding of the African decision context (broadly, the factors that influence decision making) would provide insights into the decision maker's competing priorities and influences (Ziervogel et al., 2011; Pasquini et al., 2013), what kinds of information is useful for decision making (Mabon, 2020) and how information gets used in making decisions (Flagg and Kirchhoff, 2018; Singh et al., 2018; Steynor, Lee, et al., 2020). These insights are critical when developing and delivering climate services because, for information to be effective, it should respond to the particular needs of those using it, while being packaged in a way that aligns with their context, preferences, values, beliefs and norms (Peattie and Peattie, 2009; Carlton and Jacobson, 2013).

In recognising this need, this study proposes to focus on this specific barrier in order to develop a novel approach to better understanding the decision context for climate services through the framework of climate change risk perceptions, because climate change presents a significant risk to society. Climate change risk perceptions are the subjective judgments of climate change risk and are important components of the decision context because they underlie both willingness to act on climate change (Spence et al., 2012) and influence the types of information people use or need to take action on climate change (Brügger et al., 2016). Despite the potential for climate change risk perceptions theory to contribute to the climate services field, the relationship has, to date, remained unexplored. Therefore, there is potential for novel research that seeks to inform climate services through an understanding of climate change risk perceptions.

While there is a reasonably good understanding of climate change risk perceptions in the developed country context (e.g. Leiserowitz, 2006; Capstick *et al.*, 2015; van der Linden, 2015) there is limited understanding of climate change risk perceptions in the African context, yet climate change risk perceptions may vary substantially between developed and developing countries (Poortinga et al., 2019). This limited understanding also extends to what factors influence or determine climate change risk perceptions in an African context. These risk perception determinants are an important part of the climate change risk perceptions framing because they provide further valuable insight into the climate change adaptation decision context. Therefore, this study aims to gain a holistic understanding of the decision context by exploring both climate change risk perceptions and its associated determinants in a region within Africa.

In summary, intensifying climate change impacts are creating an urgent need to increase the utility and effectiveness of climate services for African decision makers. In this regard, it is critical that



climate services respond to local needs by better understanding the specificities of the decision context. This study addresses this challenge by engaging with relevant actors in East Africa to elucidate critical decision context factors that help to inform the development and delivery of climate services, while simultaneously contributing to the theoretical discourses in both the climate change risk perceptions and climate services fields.

### **1.1 A commentary on situating this study within Africa**

It is acknowledged that positioning this study as “African” may incorrectly convey the representation of Africa as homogeneous in its people and culture by virtue, solely, of geography. It is important to dispel this notion and denounce this representation upfront in the research. Lack of homogeneity is true for any region in the world and even within countries. However, for research purposes, it is often necessary to refer to political or geographical groupings such as continents or the global South/North as a way of highlighting broad differences across regions in the world. For this purpose, there is precedent set (by organisations such as the African Union, the World Meteorological Organisation and the Intergovernmental Panel on Climate Change) to treat Africa with a reasonable amount of homogeneity due to similar challenges with regards to politics and post-colonial legacies. However, beyond the somewhat artificial geographical grouping, aspects such culture, economies and environments vary significantly across the continent. Therefore, where any reference to “Africa” or “developing countries” is made in this study, it should be construed as a mechanism for contrasting the broader differences with other parts of the world. Indeed, the choice to focus on one region within Africa for this study reinforces the acknowledgment of the heterogeneities across the continent.

### **2. Choice of study region and respondent group**

In order for the scope of the study to be tractable, the research was constrained to a single study region and climate services user class. The choice of region was aligned with the Weather and Climate Information Services for Africa (WISER) TRANSFORM<sup>1</sup> project, under which data for the study was collected. WISER was a programme funded by the United Kingdom Foreign, Commonwealth and Development Office to support sustainable development in Africa through delivering accessible weather and climate services. In WISER phase 2 (under which TRANSFORM was funded) a total of 12 projects were funded, focused on east Africa. The objective of the TRANSFORM project was to improve the supply of user-relevant weather and climate information through co-production and capacity development. The project consisted of six work packages. The research for this study fell

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<sup>1</sup> <https://www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser/transform>

under the second work package, which aimed to maximise user uptake and added value of climate information products through increased understanding of users' decision contexts.

TRANSFORM focused on five countries in the East African region, yet the research aimed to draw out lessons for delivering climate services that can be applied to Africa more broadly. This aim recognizes that East African countries share many similar characteristics with other African countries such as an economic focus on agriculture (Nkiaka et al., 2019; Carr et al., 2020), regular experience of climate extremes (Selormey et al., 2019) and limited human and financial resources to address climate change (Cullmann et al., 2019).

The study concentrated on the policy decision influencer community. This community was defined as those people who have an influence in informing, defining or developing development or natural resource management policy. It included government officials at different levels of government and individuals from non-governmental organisations, parastatals, international development agencies, trade unions, research institutions and private companies. This grouping of individuals is of particular interest to the climate services community because of their potential to use climate services in informing policy-level climate change adaptation initiatives, which may have a widespread positive impact on adaptation implementation.

### 3. Research aims and objectives

Noting the East African and policy decision influencer focus, the research aims is to explore and better understand East African climate change risk perceptions in order to contribute to academic discourses and practical developments in (i) climate change risk perceptions theory and (ii) the climate services field, from the perspective of the developing world.

Consistent with the aim set out above, the study includes the following objectives:

- 1) Identify and assess determined aspects of climate change risk perceptions among policy decision influencers, in five East African countries.
- 2) Explore, in greater detail, the underlying influences that inform these risk perceptions, in two East African countries.
- 3) Assess and explore the relationship between determined aspects of climate change risk perceptions and the current landscape of climate information use.

4) On the basis of the understanding gained through objectives 1-3, consolidate a framework for the enhancement of climate services, such that they better meet the risk perception specificities of East African policy decision influencers.

5) Integrate the above findings to inform the future development and practice of climate services by contributing to wider discourses around (i) climate change risk perceptions and (ii) the decision context for climate services.

#### 4. Scope and contribution of the study

In meeting the objectives set out for the study, this dissertation consists of seven chapters. These chapters comprise of a general introduction (this chapter), followed by a review of the current literature within the climate services field and the theoretical framework of climate change risk perceptions. These chapters are followed by four linked journal papers. The first of the four papers (Steynor and Pasquini, 2019) sets out the rationale for the work and its importance in an African context. The following three papers (Steynor et al., 2021; Steynor and Pasquini, 2022a, 2022b) address the empirical findings of the research, and each contribute a new facet towards the development of a framework for the enhancement of climate services for East Africa. The discussion chapter outlines the theoretical contributions of the study and presents the proposed framework together with a discussion on the generalisability of the framework to geographical areas other than the study region.

A chapter breakdown, outlining the logical flow of the dissertation, is presented below:

**Chapter two** lays the theoretical foundation for the research by providing a critical review of the current literature pertaining to climate services and climate change risk perceptions. This chapter serves to position the current research within the academic discourses and identify areas of unique theoretical contribution.

**Chapter three**, the first journal article, provides the detailed rationale behind the study by positioning climate change risk perceptions as a theoretical framing for better understanding context-specific climate services. It also demonstrates the importance of understanding how the context for climate services in Africa may be different from developed countries. The chapter goes on to discuss how determinants of climate change risk perceptions differ, or might differ, in the African context as compared to the developed world, thus emphasizing one of the important theoretical contributions of this study to the climate change risk perceptions literature.

**Chapter four**, the second journal article, primarily aligns to the first study objective to better understand what factors determine climate change risk perceptions in East Africa and how they interact together to influence climate change risk perceptions. Gaining this understanding is

fundamental for framing the research in the subsequent two chapters because it serves to identify the priority climate change risk perception determinants for further exploration and quantifies their relative importance in influencing climate change risk perceptions. The chapter results in a model of how climate change risk perception determinants interact together to influence climate change risk perceptions and resultant adaptation action in East Africa, thereby providing a new theoretical contribution to the literature and a structure by which a framework for the enhancement of climate services can be constructed.

**Chapter five**, the third journal article, primarily aligns to the second study objective by using a qualitative research method to explore and explain each of the climate change risk perception determinants (identified in chapter four) in the East African context. This better understanding of the East African climate change risk perceptions context not only provides a valuable theoretical contribution to the climate change risk perceptions literature but also provides the fundamental insight required to better align climate services to the East African decision context. With this better understanding of the decision context, the chapter closes with a set of suggestions as to how currently available climate services could be better aligned to the East African decision context. These suggestions go on to inform the proposed framework for the enhancement of climate services in the discussion chapter.

**Chapter six**, the fourth journal article, primarily aligns to the third study objective. This chapter draws on the climate change risk perception determinants identified in chapter four to determine the relationship between climate change risk perceptions and the current use of climate services information in East Africa. This relationship is further explored and explained through qualitative analysis. Exploring how climate change risk perceptions relate to climate services information use is proposed as a way of gaining insight into the climate services information use landscape and, in turn, what is currently missing from the landscape (the gaps in the landscape). Hence, this chapter contributes a novel methodology for evaluating climate services. The understanding gained with regards to the gaps in currently available climate services is used to propose a set of recommendations for filling these gaps. These recommendations inform the proposed framework for the enhancement of climate services in the discussion chapter.

**Chapter seven**, the discussion chapter, aligns to the fourth and fifth study objectives. It draws together the framework structure developed in chapter four with the recommendations for climate services enhancement from chapters five and six to present a consolidated framework for informing the development and delivery of climate services to East African policy decision influencers. The chapter goes further to discuss the generalisability of the framework for application in other geographical

regions. Critically, this chapter outlines the importance of the study's theoretical contribution to the climate change risk perceptions literature and climate services literature, the limitations of the work and suggestions for future avenues of research.

## 5. Research approach and study participants

This section provides a high-level overview of the research approach and study participants. All specific details regarding the research design, participant selection, data collection and analysis are provided, as appropriate, in chapters four, five and six.

The study employed an explanatory sequential mixed-methods approach (Creswell and Creswell, 2017). This approach starts with quantitative analysis and then builds on the results of the quantitative analysis to explore and explain them through qualitative research. This mixture of quantitative and qualitative approaches recognises their complementarity but also their differential explanatory power for answering specific research questions. For instance, quantitative approaches are useful for testing statistical/causal relationships, evaluating validity of relational hypotheses and investigating the underlying structure of data (Elliott et al., 1999). Qualitative approaches are more often concerned with developing underlying theory and gaining a richer understanding of participant perspectives, contexts and experiences (Elliott et al., 1999). However, while each approach can be used in isolation, there is significant power in combining them (as is done in this study), particularly as qualitative approaches provide an effective way of gaining a deeper understanding of quantitative findings (Baxter and Jack, 2008).

The quantitative methods used in this study consisted of a survey (see annex 1 for the full survey) while the qualitative methods consisted of semi-structured interviews (see annex 2 for the interview protocol). Each of these methods, the study objectives they informed (figure 1.1) and how they are appropriate for informing the study objectives are outlined in the following sections.

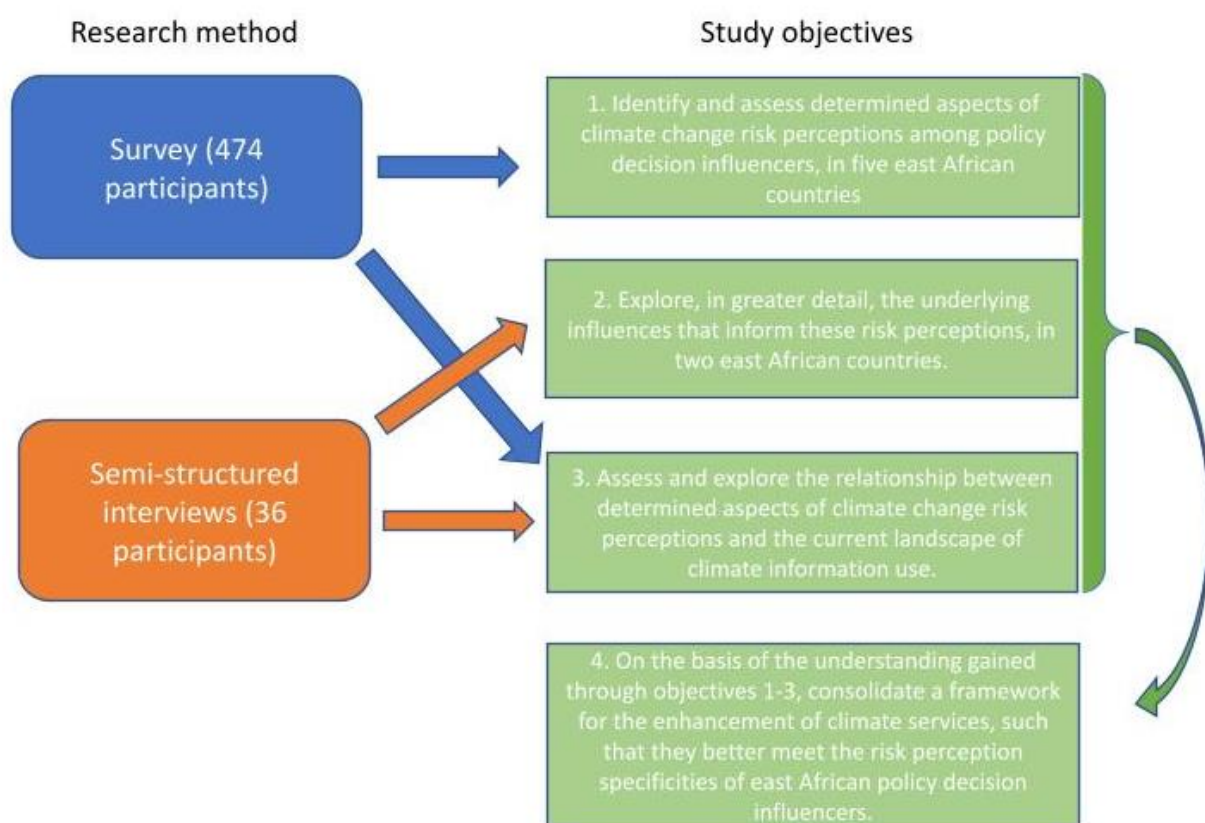


Figure 1.1: The research method used to inform each of the study objectives

### 5.1 Quantitative research method: Survey

A total of 616 respondents were approached to complete the survey, of which 474 fully completed responses were received and, therefore, considered suitable for analysis. Refer to chapter four and six for greater details regarding the survey design and implementation.

The survey component of the study was designed to include questions with regards to both climate change risk perceptions and its determinants as well as the uptake and use of weather and climate information services. As illustrated in figure 1.1, the outputs of the survey first enabled an assessment of each of the climate change risk perception determinants and how the climate change risk perception determinants interact together to influence risk perceptions (objective one). Second, including the use of climate information within the same survey allowed for an assessment of the relationships between climate change risk perception determinants and climate services information use (objective three).

As each of objectives one and three set out to ‘assess’ the wider climate change risk perception and climate information use context, a survey method was best suited to meeting these two study objectives because surveys are generally a good way of studying (or assessing) a portion of a population in order to infer generalisable conclusions for the wider population (Creswell and Creswell, 2017). Within psychological climate change research, survey methods are a way of broadening research beyond the laboratory to better understand the complexity of the challenges within which climate change sits (Gifford, 2008).

Survey studies are one of the most common research methods in environmental psychology (Steg et al., 2018) therefore, this study constructively builds on existing environmental psychological literature. Surveys have also been noted as a good method for studying relationships among and between psychological variables because they allow for a large number of psychological variables to be measured at the same time (Steg et al., 2018). The ability to assess the relationships between variables was important for this study because, not only did the study aim to understand how climate change risk perception determinants interact to influence climate change risk perception in the African context, but it also sought to understand the relationships between climate change risk perceptions and climate services information use.

Similar to all research methods, surveys have their shortcomings that should be noted. For instance, surveys collect self-reported information, often subject to psychological biases. One notable bias is social-desirability bias, which is an individual’s propensity to under-report behaviours or attitudes that could be seen as being social undesirable, leading to an over-report of more socially desirable attributes (Grimm, 2010). However, the effect of social desirability bias in environmental psychology survey research has been shown to be negligible (Vesely and Klöckner, 2020), suggesting that survey methods are still an appropriate method for gaining a high-level understanding of a population.

For this study, a more notable shortcoming of the survey method is its limitations to fully explain and interpret the quantitative results, which is particularly important in gaining the required understanding of East African climate change risk perceptions to inform climate services. Therefore, in this study, the survey approach was complemented by semi-structured interviews to provide a more comprehensive understanding of the research problem than provided by either a survey or set of interviews alone.

## 5.2 Qualitative research method: Semi-structured interviews

Based on the quantitative results of the survey, an interview protocol was developed that sought to further investigate particular areas of interest arising from the preliminary survey analysis. The interview protocol was developed by distilling four overarching exploration aims. These included: a)

exploring the risk perception determinants in more detail, b) exploring the current use of climate services in more detail, c) exploring how determinants of risk perceptions relate to risk perceptions and action and d) exploring the effect of current institutional/cultural/policy frameworks on the use of climate information and climate action. These interviews contributed to the achievement of the study's objectives two and three (figure 1.1). A total of 36 semi-structured interviews were conducted.

As objectives two and three set out to explore and understand the underlying influences behind climate change risk perceptions and the use of climate services information, qualitative methods such as interviews are an appropriate research method because they provide insight into the complex social context (DeJonckheere and Vaughn, 2019). The semi-structured interviews used in this study included aspects of both structured and unstructured interviews by being guided by a set of questions but, at the same time, allowing for additional questions to be asked to clarify or further expand on particular issues (Fox, 2009). This method allows for the interviewer or respondent to follow a particular train of thought in more detail if required (Britten, 2007). The ability to expand on certain topics or diverge from the original question allows for the discovery of information that may not previously have been thought of as pertinent by the researcher (Gill et al., 2008)

Interviews, while more time intensive than group discussions, offer particular benefits over forum/group discussion methods because participants are able to discuss topics that they may not feel comfortable discussing in group environments (Gill et al., 2008). Questions that seek to understand climate change risk perceptions (such as questions in this study with regards to social norms and values) could be considered sensitive topics and are therefore more suited to one-on-one interviews. Interviews also remove the possibility of group-think effect, in which individuals feel that their responses need to agree with the group (Janis, 1997). Therefore, interviews are beneficial for eliciting a wide range of responses that both illustrate the range of diversity in thinking as well as the areas of convergence. However, due to the time intensive nature of interviews, the respondent group is necessarily much smaller than can be achieved through the survey method (Creswell and Creswell, 2017), further confirming the value of adopting a mixed-method approach.

### 5.3 Study sample and participants

The survey and interviews were conducted with policy decision influencers in the East Africa region between September 2018 and September 2019. Respondents were sourced from national and local government ministries, non-governmental organisations, international development agencies, parastatals, trade unions, research organisations, and the private sector. The main criterion for inclusion was that the respondents' organizations should have a direct or indirect influence on a country's development or natural resource policy. Specific respondents at each organisation needed



to be in roles where they would be expected to use, or benefit from using, climate information in the achievement of their professional activities. The demographics for the respondents in both the survey and interviews are provided in tables 1.1 and 1.2 respectively. Eleven interview respondents had taken part in the initial survey. All respondents took part in both processes on a voluntary basis with no reward for their participation. Further details with regards to participant selection and data collection are available in chapters four, five and six, as appropriate.

*Table 1.1: Demographics of the 474 participants in the structured survey*

Characteristics	Categories	Percentage of the total sample
Resident country	Ethiopia	16%
	Kenya	29%
	Rwanda	25%
	Tanzania	20%
	Uganda	10%
Gender	Male	70%
	Female	30%
Educational attainment	School leavers certificate	2%
	Diploma	10%
	Bachelor degree	47%
	Post-graduate degree	35%
	Doctorate	6%
Age	20 - 29	23%
	30 - 39	40%
	40 – 49	24%
	50 – 59	12%
	60 - 69	1%
Type of institution	Local government	4%
	National government	34%
	Private sector	18%
	NGO	11%
	International development agency	4%
	Research/academic	16%
	Parastatal	8%

	Federation/union	5%
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*Table 1.2: Demographics of the 36 participants in the semi-structured interviews (age was not recorded)*

Characteristics	Categories	Percentage of the total sample
Resident country	Ethiopia	41%
	Kenya	59%
Gender	Male	66%
	Female	34%
Educational attainment	School leavers certificate	0%
	Diploma	0%
	Bachelor degree	29%
	Post-graduate degree	54%
	Doctorate	17%
Type of institution	Local government	8%
	National government	19%
	Private sector	8%
	NGO	19%
	International development agency	6%
	Research/academic	25%
	Parastatal	14%
	Federation/union	0%

## 6. Positionality statement and ethical considerations

Positionality outlines the position that the researcher holds within a research study and describes the researchers perspective in relation to those of the study participants (Savin-Baden and Howell Major, 2013). A statement of positionality acknowledges that researchers are seldom neutral bystanders in research and their views and positions will have a direct or indirect influence on the design, implementation and interpretation of the research results (May and Perry, 2017). A statement of positionality requires the researcher to locate their personal position within the study, locate their position in relation to the participants in the study and locate themselves with respect to the research

context (Savin-Baden and Howell Major, 2013). The following sections explore each of these positionalities as I reflect on my position within this study.

With respect to my personal position within the study and the beliefs I hold that may influence the research, it is important to acknowledge some of my fundamental beliefs that inspired this research. Firstly, I believe that increasing the uptake of climate services will, on balance, have a net positive impact on addressing climate change. Therefore, I believe it is ethically justified to encourage the uptake of climate services into decision making – a belief that has undoubtedly shaped the resulting recommendations made in the study which aim to increase the uptake of climate services. I also believe that an African perspective is underrepresented in both the literature and the practical design and delivery of climate services. I am a strong advocate for the African voice in academic discourses and include my own voice in that grouping. My aspiration is that, by helping to fill this void in the climate services discourse, the unique African perspective will be better accounted for in the design and development of climate services. This positionality will have shaped the research in as much as I actively sought to highlight the unique African perspective.

It is also important to note my intellectual positionality with respect to this study. As a mature doctoral student, I have been active in the field of climate adaptation, impacts and services for eighteen years. The majority of this activity has been focused on the African context; however, for five years I was based in the United Kingdom and focussed on climate change adaptation in Britain. The experience in both countries has exposed me to the dichotomy between developed and developing countries' approaches to climate change, including resourcing, priorities and governance arrangements. This familiarity with the deep difference in contexts is primarily what inspired a focus on context-specific climate services as I have experienced (personally and from those around me) a growing discontent towards research agendas that are designed in a void of understanding of the African context.

A further particular issue of positionality is whether, as a researcher, I am an insider or outsider in relation to the research context and research participants (Holmes, 2020). However, there is an argument that insiders and outsiders are not clear opposites of each other because it is possible to embody elements of both an insider and an outsider in a research process (Herod, 1999). For instance, the fact that I grew up and currently live in Africa makes me familiar with and sympathetic to the complexities of the African developmental context, rendering me somewhat of an insider to the research context. In addition, my time to undertake this work and the data collection was funded through a project under the Weather and Climate Information Services for Africa programme (WISER). The WISER programme is a research programme that some of the study participants may have been familiar with, and some participants may even have been involved in other WISER projects. While the

connection of this study to the WISER programme may have encouraged participation in the study, it is my belief that it did not otherwise influence the analysis of the results. In addition, due to my long-standing presence in the climate services field, it is possible that my networks and relationships within the field may have enabled easier access to participants for the study. It certainly enabled introductions to initial interview participants, who then identified further participants. However, since the survey was conducted by enumerators in the field, without any introductions from me, I believe that this “insider advantage” was ameliorated to some degree.

With respect to the participants in the research, apart from the fact that I live in Africa and have a profession in the climate change field, I share few commonalities with the study participants. I have neither lived in East Africa, nor do I have any expertise or experience in policy development. I am embedded in a Western family culture and I am a Caucasian. None of these attributes are true of the majority of the study participants. Therefore, I largely deem my role as an ‘outsider’ in this study, which positions me well to be able to reflect on the results with more objectivity than someone embedded within the community.

My tertiary education to date has been predominantly focused on the natural sciences. This natural science focus included a Masters thesis employing solely quantitative techniques, with which I am most familiar. From a natural science training I have progressively moved towards the social sciences over the course of my career, culminating in an intellectual home between the two sciences. My qualitative analysis skills are less developed than my quantitative analysis skills and, it is partly for this reason, that I employed a mixed-method approach in this study, which enabled me to draw on skills I am comfortable with (quantitative analysis) while simultaneously building new skills (qualitative analysis).

Research for this study was conducted in an ethical manner and governed by research ethics clearance from the University of Cape Town Science faculty ethics committee. Study participants voluntarily consented to their involvement in the study, their personal information was kept confidential at all times and participants were aware of their right to withdraw from the study at any time. Throughout the data collection, the respondents were made aware that the results of the research would be shared with them. To this end, research results were personally shared with them, both as a high-level policy brief and as a longer technical report. These same outputs were also shared as part of the WISER programme and are freely available online. The underlying research data are not publicly available in accordance with personal data protection commitments.

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## Chapter 2: Literature Overview

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## 1. Introduction

The aim of this chapter is to, first, provide an overview of the climate services field and the current debates within the field. This is achieved by outlining a short background to climate services and how climate services were formalised through a global framework. The chapter goes on to describe the disagreement in approaches to climate services under the framework and where this study positions itself within this debate.

Second, the chapter introduces the theoretical framing of climate change risk perceptions by first tracing the origins and evolution of thinking within risk perceptions theory. The focus of the chapter then turns to climate change risk perceptions, as a sub-set of risk perceptions, in order to outline the current approaches to understanding climate change risk perceptions and to highlight theoretical gaps. Finally, the chapter narrows its focus to approaches to understanding climate change risk perceptions in Africa, as the study's region of focus. Current research on climate change risk perceptions in Africa is outlined and research gaps are highlighted.

The chapter concludes by highlighting key research priorities that have emerged from the literature review and how this study intends to contribute to the discourses through addressing some of these gaps. The literature review in this chapter is intentionally a concise overview, with more specific literature further developed, as applicable, in chapters three, four, five and six.

## 2. A background to climate services

The concept of sharing climate information is not new (Vaughan and Dessai, 2014). Creation of a framework for institutional cooperation on climate information exchange was established by the World Meteorological Organisation (under its predecessor the International Meteorological Organisation) in the late 1800s (Vaughan and Dessai, 2014). This framework was followed by a series of World Climate Conferences aimed at advancing research and observational capacity within the climate community, the first of which took place in 1979 (Zillman, 2009). However, the first societally focused climate research activity resulted from the World Climate Conference 1 where the World Climate Programme was established to improve understanding of the climate system and how it may impact society (Bruce, 1990).

Since the origins of formalised climate research cooperation, conversations about the changing climate have come a long way. Individuals in society have become sensitised to the climate change rhetoric and are becoming increasingly aware of the impacts that a changing climate may have (Selormey et al., 2019). This awareness naturally led to questions about how to better integrate climate information into practice in order to more effectively mitigate climate change and adapt to its impacts (Vaughan and Dessai, 2014).

However, the process of mainstreaming climate information into decision making exposed a fundamental gap between what was produced by climate science and what was required for decision-making (Lemos et al., 2012; Kiem and Austin, 2013; Cvitanovic et al., 2015). In an attempt to address this gap, key users of climate information, government officials and climate experts were again brought together at the 2009 World Climate Conference 3 to discuss the user requirement from climate information and to enhance coordination between climate information suppliers and the user community (Hewitt et al., 2012). What emerged from this conference was a formal framework developed to facilitate the exchange of knowledge between climate information producers and intended users of climate information. This knowledge exchange framework was called the Global Framework for Climate Services (GFCS) and has since become a prominent World Meteorological Organisation framework for attempting to address the identified gap between the societal need for climate information and producer supply (Hewitt et al., 2020). Within the framework, climate services is defined as *“the provision of climate information in such a way as to assist decision-making”* (Hewitt, Mason and Walland, 2012; pg 831).

To structure the provision of this climate information, the GFCS was designed around five core components. The five components of the GFCS are illustrated in the green inner circle in Figure 2.1 and can be broadly divided into data-provision and user-focused activities. Data-provision activities include the collection of historical climate data (observations and monitoring component), research into climate forecasting and climate change modelling (research modelling and prediction component) and the mechanism through which climate information is archived, analysed, processed and exchanged (the climate services information system). User-focused activities include the structured means through which users and scientists interact (User Interface Platform) and the development of user capacity to use climate information (capacity development component).

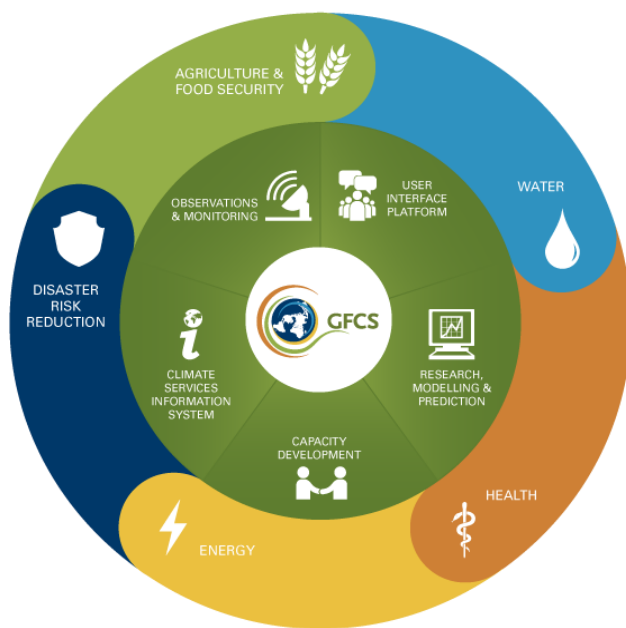


Figure 2.1 Schematic showing the components of the WMO Global Framework for Climate Services (GFCS: <https://gfcs.wmo.int/about-gfcs>)

While this framework appears logical in its presentation, there remains a varied understanding of how climate services should be implemented in practice (Vogel et al., 2019; Visscher et al., 2020). This varied interpretation is particularly acute in the User Interface Platform (UIP) component because, aside from a recent opinion publication which introduces three activities within the UIP, namely websites and tools, interactive group activities and focused relationships (Hewitt et al., 2017), there is little consensus on how best to implement these activities or, indeed, which activity should receive the most focus. Understanding the current lack of consensus in implementing the User Interface Platform is helpful in situating the debate around approaches to climate services that currently divide the climate services community. These varying approaches are explored in the next section to situate this study within the current scholarly debate.

### 2.1 Varying approaches to Climate Services

Implementation of the UIP component of climate services range from approaches focused on climate services as primarily a climate data delivery activity (the data-first approach) (World Meteorological Organization, 2011; Van Den Besselaar et al., 2015) to approaches to climate services that focus on understanding the decision context in order to support and inform the development of decision-relevant climate data (the user-first approach) (Kruk et al., 2017; Vincent, Daly, et al., 2018).

Those adopting a data-first approach focus primarily on the data provision activity of climate services, such as providing an early warning system. The dominant rationale behind this data-first approach is



that there is a knowledge deficit with regards to the availability of climate data (Hulme, 2009). If this gap is filled with climate data, then the barrier to action on climate change will be overcome (Vogel and O'Brien, 2006). Under this data-first approach, descriptions of climate services in the literature focus on a one-way flow of data delivery with users noted as targets or recipients of information only. An example description of a data-first approach is "*the timely production and delivery of useful climate data, information and knowledge to decision-makers*" (Hidalgo and Taddei, 2014: pg 1). The prevalence of this approach was acknowledged during a workshop of the Global Framework for Climate Services when it was noted that most past and ongoing work on climate services in Africa focused primarily on data delivery with limited stakeholder engagement to understand the needs of the climate information users (WMO, 2017).

The data-first approach has resulted in a proliferation of public-facing web-based climate information portals (Hewitson et al., 2017). Often these data portals result in a stream of data being fed to users, but with limited attempts to translate it into information that is relevant for the decision context. These data portals are premised upon assumptions made by climate information producers of the needs of the users while, in reality, user needs are poorly defined, and much more diverse than those accounted for by climate information producers (Hewitson et al., 2017). The climate services community are increasingly recognising the shortcomings of this data portal approach because it does not result in the kind of user-tailored services envisaged by the Global Framework for Climate Services. To quote Filipe Lucio (Director of the Global Framework for Climate Services) the time has come to move beyond provision of data and move towards providing services that speak more to the user need (WMO, 2018).

*"I would like to highlight the word services [in climate services] because we have for many years been providing data and information, but we have not made great advances in providing climate services. This is because to provide effective climate services we have to link the users and providers of climate services together to identify the needs and the best solutions or options in terms of products and services."*

— Filipe Lucio (2018), Director of the Global Framework for Climate Services World Meteorological Organisation, speaking at the stakeholder consultation workshop on the National Framework for Climate Services in Ethiopia

In recognition of the shortcomings of data portals, there has been a conceptual shift in much of the climate services community towards the idea of climate services as a value chain (Giuliani et al., 2017; Harvey et al., 2019; Hewitt et al., 2020). The value chain approach envisages climate information being fed down a chain of actors from provider to user. While the value chain approach is still a data-first

approach, it importantly acknowledges that there can be several Intermediary actors (between producers and users) that are involved in transforming or tailoring the climate data into a product that is more context and decision relevant, hence adding 'value' to the product (World Meteorological Organisation, 2015). As such, the value chain approach begins to recognise the need to add value to the information by understanding the decision context which enables contextualisation of the climate information (Lourenço et al., 2015). This need to understand the decision context is made explicit in the White Paper on Climate Services Ethics which states *"We believe that the value systems and decision frameworks of users should be central to climate service delivery"* (Adams et al., 2015, p.1). Understanding the decision context is important because it provides insight into what information is useful for decision making and how the information is likely to be used (Flagg and Kirchhoff, 2018; Singh et al., 2018; Steynor, Lee, et al., 2020). In addition, climate services are more likely to be used when they effectively integrate aspects of the decision context such as cognitive, experiential and normative aspects of human behaviour (Carlton and Jacobson, 2013; Lee et al., 2015; van der Linden, 2015).

Taking into consideration the need to understand the decision context, a more explicit user-first approach to climate services is supported by a part of the climate services community. This approach stands in contrast to the two types of top-down approaches outlined above, particularly as it pushes back against the conceptualisation of climate information as singularly important in adaptation decision making. The user-first approach recognises the importance of understanding the multitude of place-based, structural and institutional influences on decision making and takes a more integrative approach to collaborative risk management.

The user-first approach to climate services holds a conceptualisation of climate services that is fundamentally intertwined with transdisciplinary co-production. Transdisciplinary co-production of climate services is the process of bringing together knowledge holders from across science and society to develop a shared understanding of the decision context and the principles that guide decision making in particular contexts (Taylor et al., 2016). In turn, this understanding serves to inform the co-development of decision relevant climate services and, ultimately, increase the integration of climate information into the decision-making process (Steynor, Lee, et al., 2020). Those who adopt a user-first approach argue that the need for and development of climate products needs to emerge from these focused user-led engagements (Daniels et al., 2020). In this way, the users determine what and how climate products are developed, standing in contrast to the data-first value chain approach of transforming or tailoring (already available) climate products to a superficially understood user need.

As an illustration of the user-first approach, Stegmaier, Hamaker-Taylor and Jiménez Alonso, (2020, p.4) state that *“the value of the service is not just determined by the quality of the output but rather the interactions between user and provider”*. Vincent et al. (2018, p.1) reiterate this stance by stating that *“producing climate services requires a shift in the knowledge system – from a one-way “push” of scientific information, to a two-way collaborative process of knowledge construction-known as co-production”*. In addition Daniels et al. (2020, p.3) argue for a reconceptualization of climate services *“We propose deliberately moving away from a narrow focus on delivery of tailored products and specific outputs, and instead, moving towards a transdisciplinary, process-centric approach in which collaboration purposefully seeks to bring about wider, long-term benefits.”*

Despite the benefits of designing climate services based on a better understanding the decision context, the user-first approach to understanding the decision context for climate services does not come without limitations. A key limitation of the user-first approach is its resource and time intensity (Lemos et al., 2018). In addition, the user-first approach is limited in its ability to reach as many climate service users as the data-first approach because the user-first approach involves intensive engagement with a small number of users in order to inform bespoke climate products, whereas the data-first approach can result in the generation of widely available climate products (Steynor et al., 2016). Therefore, the user-first approach suffers from a limited amount of scalability. Conversely, the data-first approaches, although widely available, are often found to be inadequate for context-specific decision-making because of their limited understanding of the decision context (Vogel et al., 2019). Therefore, while all approaches attract critique, they also each have their relative points of merit, so it is important to situate this study within the landscape of the current approaches to climate services when attempting to find a middle ground between the data-first and user-first approaches.

## 2.2 Situating this study within the climate services debate

As a constantly evolving field, nuanced approaches to climate services are always welcomed, especially if they seek to reconcile some of the limitations outlined in the purely data-first versus purely user-first approaches. There is also a growing call for interdisciplinary study in understanding the decision context for climate change decision making (Lee et al., 2015) and interdisciplinary study in informing the design and development of climate services (Brasseur and Gallardo, 2016).

Understanding the polarised tension in the approaches to climate services is particularly helpful in situating this study within the debate about the most appropriate approach to climate services. This study proposes a nuanced approach to climate services that draws on an understanding of climate change risk perceptions theory to blend some aspects of the user-first approach, specifically a deeper understanding of the decision context, with aspects of the data-first approach, particularly the tailoring of existing climate services where appropriate. In this way, the proposed approach seeks to

draw on the relative points of merit in both the user-first and data-first approaches. However, it is important to note that this nuanced approach does not replace either the user-first or data-first approaches but rather proposes a complementary approach that might be employed alone or alongside the other approaches.

The next section introduces why the climate change risk perceptions approach is useful for understanding the decision context and goes on to provide a background to the evolution of risk perceptions theory, the current approaches to understanding climate change risk perceptions theory and, finally, the current approaches to understanding African climate change risk perceptions.

### 3. Moving towards a new approach to understanding the decision context

The decision context can be broadly defined as the circumstances in which decisions are made including the internal and external influences on decisions. Colloff et al. (2021) further refine these internal and external influences to include knowledge, personal values and rules (including institutional guidelines as well as social norms or behaviours). Therefore, when exploring the decision context, it is useful to think about what Maibach et al. (2007) refer to as the 'fields of influence' within the decision context. These fields of influence can be separated into people-based fields of influence and place-based fields of influence. Broadly, the people-based field of influence incorporates the attributes of people at the individual, social and community level (Maibach et al., 2007). The place-based field of influence incorporates the attributes of place such as physical structures, policy frameworks and availability of products and services (Maibach et al., 2007). These two fields of influence are closely linked to each other (Maibach et al., 2007), meaning that an understanding of the decision context could be approached by either a people-based or place-based entry point.

This study chose to adopt a people-based entry point to understanding the decision context which requires understanding the attributes of people, their social referents and the community in which they sit. Climate change risk perceptions offer a promising framework for understanding these people-based fields of influence within the climate change decision context because climate change poses a significant risk to individuals and their immediate community. Climate change risk perceptions also have established relationships with important aspects of the decision context that influence the use of climate services. For instance, climate change risk perceptions have been shown to influence both willingness to act on climate change (Lo & Chan, 2017; E. K. Smith & Mayer, 2018; Spence, Poortinga, & Pidgeon, 2012; Xie, Brewer, Hayes, McDonald, & Newell, 2019) and actual action on climate change (Blennow, Persson, Tomé, & Hanewinkel, 2012; Fahad & Wang, 2018; van Valkengoed & Steg, 2019). Heightened risk perceptions have also been shown to increase individual information seeking behaviour (Kahlor, 2007) and the desire for climate information amongst natural resource

planners when acting on climate change risk in the workplace (Peters et al., 2018), while the perceived proximity of climate risks has also been shown to influence the kinds of information people use in making decisions (Brügger et al., 2016). For instance, if climate change is perceived as a currently occurring risk, then decision-makers might prioritise the use of near-term forecasts that provide them with concrete information such as potential impacts.

Despite the value that climate change risk perceptions theory provides for informing climate services, there is no prior research that attempts to bring the two fields together. In recognition of this theoretical gap in the literature, this study adopts a climate change risk perceptions approach to understanding the decision context which, in turn, informs the development and delivery of climate services.

The next section begins by first providing a background to the overarching field of risk perceptions before introducing the theoretical framework of climate change risk perceptions and finally climate change risk perceptions in Africa.

### 3.1. Introducing approaches to understanding risk perceptions

A narrow definition of risk describes the combination of the probability/likelihood of an event and the magnitude of its consequences (Kasperson et al., 1988; Hulme, 2009). Therefore, in a quantitative risk assessment, when the probability of an event is high and the magnitude of the consequences are severe, the event would be defined as “high risk”. This assessment is based on objective facts and analysis. However, the outcomes from a quantitative risk assessment may vary significantly from how the same risk is perceived by an individual. These perceptions of risk (or risk perceptions) are the subjective beliefs or judgments about the potential for harm or possibility of loss (Darker, 2013). In other words, they are the personal judgement of the probability and magnitude of an adverse event (Carlton and Jacobson, 2013). The complexities of what shape these subjective judgements have been the focus of the evolving risk perceptions literature. The following section documents this evolution to provide a historical background to risk perceptions theory.

#### 3.1.1 *The cognitive approach*

Early research on risk perceptions focussed on the model of rational choice, which hypothesises that humans judge risk in an analytical manner by mentally calculating the odds of the risk and basing choices on the outcomes of those calculations (Leiserowitz, 2006). The primary theory on which this approach was based was Expected Utility theory (Von Neumann and Morgenstern, 1944). Expected Utility theory gained its popularity in the field of economics as an explanation for how people make decisions based on risk information (Helgeson et al., 2012). It theorises that humans analytically appraise risky prospects by comparing expected utility values (produced through a mathematical

formula laid out in expected utility theory). In other words, a person's perception of risk is informed by a rational, objective analysis of available data.

While expected utility theory is typical in economic modelling, it has been shown to have limited value in the psychology field (Tversky, 1975; Kahneman and Tversky, 1979). The evolving field of risk perceptions research revealed that human judgement is much more nuanced and rational choice alone does not explain risk perceptions (Carlton and Jacobson, 2013). Studies in social and cognitive psychology showed that the human brain relies on two different information processing systems (Sloman, 1996; Chaiken and Trope, 1999). The first kind of information processing system is analytical, effortful and rational while the second processing system is experiential, automatic and fast. Both of these processing systems work together to guide judgement, however, experiential thinking emerged as more dominant than analytical thinking (Slovic, Peters, M. L. Finucane, et al., 2005; Marx and Weber, 2012). Given this understanding of dual processing systems, it was clear that the drivers of risk perception were more complex than originally thought.

### *3.1.2 The experiential approach*

In alignment with the idea of information being processed experientially, Simon (1955) extended the academic discourse beyond the model of rational choice proposed by Von Neumann and Morgenstern (1944) to introduce the idea of heuristics. Heuristics are mental shortcuts that people employ in order to make quick judgements of how risky something is. Heuristics are grounded in experience rather than in analytical reasoning. An example of one of these heuristics is the concept of 'availability'. Availability, in this context, refers to how easily an event is remembered or imagined. If an event is readily 'available' people tend to overestimate its chance of recurrence (Tversky and Kahneman, 1973). Heuristics influenced by experience, such as availability, appear to have a large part to play in how people judge risks (Pachur et al., 2012).

It is within this heuristics context that the 'risk as feelings' theory was introduced (Loewenstein et al., 2001). Risk as feelings was described through the affect heuristic (a reliance on good or bad feelings experienced in relation to a stimulus) (Slovic, Peters, M. Finucane, et al., 2005). The 'risk as feelings' theory proposed that affective reactions to risks often diverge from analytical assessments of those risks and, when this divergence happens, the affective response to the risk often overrides the analytical response (Loewenstein et al., 2001). In fact, some researchers went as far as to suggest that risk information will not be acted on unless it is given affective significance (Slovic et al., 2004).

At a similar time to the development of the 'risk as feelings' theory, Liberman and Trope (1998) proposed Construal Level Theory as a way of understanding how people perceive and think about risk (Liberman and Trope, 1998). Construal Level Theory proposed that a person's mental representation

of an object or an event is determined by the psychological distance of that object or event (Liberman and Trope, 1998; Trope and Liberman, 2003). Psychological distance describes the personal experience of something that is either close or far away from oneself in both the here and the now (Pahl et al., 2014). Construal Level Theory proposed that psychological distance is linked to and, in fact, influences affect, providing a unifying framework that explains variations in affect (Liberman et al., 2007). This initial proposal has seen support in the ensuing literature, as evidence continues to suggest that psychological distance has a significant influence on affect (Williams and Bargh, 2008; Williams et al., 2014; Chu and Yang, 2019). These evolving arguments demonstrate the continuous growth in understanding with regards to the experiential factors that influence risk perceptions.

### *3.1.3 The socio-cultural approach*

While the experiential approach to risk perception has been rapidly evolving in the literature, Mary Douglas (a cultural anthropologist) and Aaron Wildavsky (a political scientist) criticised the experiential and cognitive approaches for not including social and cultural factors as influences of risk perception. Thus in 1982, Douglas and Wildavsky introduced the cultural theory of risk (Douglas and Wildavsky, 1982). The cultural theory of risk is based on the premise that each culture encompasses different ways of understanding one's place in the world and upholds different assets and lifestyles as determinants of value. It follows that culture will also influence the importance assigned to different risks depending on where the risk lies within the cultural framework (Hulme, 2009). Cultural theory of risk proposed a conceptual typology of cultural types, categorising risk culture into four broad groups along the axes of group (the degree to which people feel bounded by being part of a group) vs grid (the degree to which individuals maintain control and structure within their social roles) (Douglas and Wildavsky, 1982). Evidence for the cultural theory of risk continued to strengthen in the literature, with subsequent empirical studies demonstrating that people can perceive the same risk in different ways depending on their assumptions of the nature of society (Slovic et al., 1998; Steg and Sievers, 2000).

Subsequent theories such as the "social representations theory" (Moscovici, 1984) and the "social amplification of risk framework" (Kasperson et al., 1988) built on the idea of risk perceptions being influenced by one's social surroundings. Social representations theory introduced the concept of group thinking influencing individual thinking, whereas, Kasperson (1988) went on to present the idea of the social amplification of risk in which risk signals interact with psychological, cultural and institutional processes to either attenuate or amplify an individual's perception of risk (Hulme, 2009).

In short, cultural and social factors are becoming increasingly recognised as having a role to play in risk perceptions. However, there is ongoing work to understand how cultural and social factors

interact with cognitive and experiential factors and, indeed, the role that additional individual socio-demographic factors may play in influencing risk perceptions.

#### *3.1.4 The influence of socio-demographic factors*

A final component of risk perceptions noted in the literature are individual socio-demographic factors. For instance, risk perceptions have been shown to be influenced by factors such as gender, age and educational attainment. The differences in risk perceptions based on gender are well documented. Research has suggested that risk perception tends to be higher amongst women than men (Davidson and Freudenburg, 1996; Sundblad et al., 2007; Henwood, Parkhill, et al., 2008), but risk perceptions have been inconsistently linked to age and educational attainment. For instance, advancing age has been linked with both higher risk perceptions (Lazo et al., 2000) and lower risk perceptions (Ballew et al., 2019). Similarly, higher educational attainment has been inconsistently linked to either increased (Sundblad et al., 2007) or decreased risk perceptions (Brody et al., 2008; Akerlof et al., 2013).

This section has introduced the four groupings or factors that influence risk perceptions. While each of these groupings are presented independently here, it should be recognised that they are all interconnected in influencing risk perceptions. Therefore, it can be concluded that risk perceptions are a cumulative result of cognitive, experiential, socio-cultural and socio-demographic factors. Having discussed the fundamental principles of risk perceptions, the next section turns to reviewing current approaches to understanding and explaining risk perceptions within the climate change field.

### *3.2. Approaches to understanding climate change risk perceptions*

Research on climate change risk perceptions grew out of the wider field of environmental risk perceptions (O'Connor et al., 1999) and is a relatively new field of research, emerging in the literature approximately twenty years ago. Since the commencement of climate change risk perceptions research there have been several attempts at understanding the combination of factors that account for the greatest variance in climate change risk perceptions and, therefore, provide the best understanding of the factors that determine climate change risk perceptions. Table 2.1 provides an overview selection of the types of risk perception determinants that have been included in recent climate change risk perceptions studies. The table is divided into the broad groupings of cognitive, experiential, socio-cultural and socio-demographic factors (as identified in section 3.1) as well as additional factors that some studies have included in attempts to further explain climate change risk perceptions.



Table 2.1: An overview of climate change risk perception determinants included in recent climate change risk perception studies

	Included climate change risk perception determinants																						
	Cognitive		Experiential			Socio-cultural		Socio-demographic											Additional factors				
	Knowledge of climate change	Beliefs about climate change	Affect	Personal experience	Psychological distance of	Values	Social norms	Age	Gender	Education	Political affiliation	Political ideology	Marital status	Income	Wellbeing	Children	Ethnicity	Place attachment	Religion/religiosity	Communication	Climate policies	Trust in information	Perceived efficacy to respond
Akerlof <i>et al.</i> , 2013																							
Elshirbiny and Abrahamse, 2020																							
Etana, van Wesenbeeck and de Cock Buning, 2020																							
Hitayezu, Wale and Ortmann, 2017																							
Lee <i>et al.</i> , 2015																							
Lewis, Palm and Feng, 2018																							
Milfont, 2012																							
Ndamani and Watanabe, 2017																							
Poortinga <i>et al.</i> , 2019																							
Smith and Leiserowitz, 2012																							
Spence, Poortinga and Pidgeon, 2012																							
van der Linden, 2015																							
van Eck, Mulder and van der Linden, 2020																							
Xie <i>et al.</i> , 2019																							

Table 2.1 illustrates the ongoing debate in the literature about the combination of climate change risk perception determinants that best explain climate change risk perceptions. No one study has been able to account for 100% of the variance in climate change risk perceptions. However, as the first study of climate change risk perceptions to take into account determinants from all of the cognitive, experiential, socio-cultural and socio-demographic groupings, van der Linden (2015)'s study (which resulted in a multi-variate climate change risk perceptions model) appeared to account for more of the variance in climate change risk perceptions (68%) than any previous study. Van der Linden's climate change risk perceptions model became the template by which further studies were conducted amongst Australians (Xie et al., 2019), Egyptians (Elshirbiny and Abrahamse, 2020) and within the blogosphere (van Eck et al., 2020).

While van der Linden's model provides a solid methodological foundation for future studies, it was developed based on data from United Kingdom respondents (a developed country). It is likely that the model's explanatory power and the proportional contribution of each climate change risk perception determinant to overall climate change risk perceptions may vary between countries and, in particular, between developed and developing country contexts (Poortinga et al., 2019) because of varying experience with extreme weather/climate events (Steynor, Leighton, et al., 2020) and differences in socio-cultural contexts (Corner et al., 2014) amongst other reasons. The model's varied explanatory power was confirmed by those who applied versions of van der Linden's model in other countries. While Xie *et al.*, (2019) found a similarly high explained variance of climate change risk perceptions in Australia (a developed country), Elshirbiny and Abrahamse (2020) found a much lower explained variance in Egypt (a developing country), although social norms were not included in the Elshirbiny and Abrahamse study.

The potential differences in explanatory power and proportional contribution of each risk perception determinant between the developed and developing country contexts is particularly important to note because the majority of research on climate change risk perception determinants hails from developed countries, leaving developing countries understudied and underrepresented in the literature. Therefore, there is scope for further research to investigate the explanatory power and proportional contribution of each of the determinants of climate change risk perceptions in additional developing country contexts. There is also potential to incorporate additional climate change risk perception determinants that may be of importance to the developing country context. For instance, it is noteworthy that Spence, Poortinga and Pidgeon (2012) focused on the psychological distance of climate change as a determinant of climate change risk perceptions, yet psychological distance has not been incorporated into any multi-variate climate change risk perceptions models/studies to date. The psychologically distant nature of climate change has been well documented in the literature from

the global north, often attributed to limited exposure of people to extreme weather events that they perceive to be related to climate change (e.g. Spence, Poortinga and Pidgeon, 2012; McDonald, Chai and Newell, 2015; Jones, Hine and Marks, 2017). However, evidence on the psychological distance of climate change in Africa is largely lacking in the literature, yet, there is widespread experience of extreme weather events perceived to be related to climate change (Selormey et al., 2019). Therefore, psychological distance is likely an important climate change risk perception determinant in the developing country context and should be considered for inclusion in climate change risk perception studies in Africa.

Moreover, within the experiential grouping of risk perception determinants, Liberman, Trope, and Stephan (2007) argued that psychological distance provides a unifying framework that explains variations in affect (section 2.2.1.2). In the climate change field, this argument was confirmed by Chu and Yang (2019) who found that emotions (affective responses) vary in response to the psychological distance of climate change. Therefore, psychological distance may account for affect in a more holistic manner than inclusion of the affect variable alone, suggesting that if psychological distance were substituted for affect in a climate change risk perceptions model, the model may be able to account for more of the variance in climate change risk perceptions than inclusion of affect alone. It is on this basis that chapter three thoroughly explores the added value of the psychological distance of climate change as a climate change risk perception determinant in Africa.

In summary, the following areas have been identified as novel areas for further research to contribute to climate change risk perceptions theory:

- i) understanding the ability and proportional contribution of selected determinants to explain climate change risk perceptions in a developing country context and,
- ii) understanding the contribution offered by including the psychological distance of climate change in a multi-variate climate change risk perceptions model in Africa.

In response to these novel research areas, this study sets out to explore and understand a suite of climate change risk perception determinants of relevance to Africa. The selection of climate change risk perceptions determinants for this study, and their relevance to the African context, are discussed in detail in chapters three and four, and hence are not further discussed here. However, given that the contextual nuances of the African context are important for informing this study, the next section provides an overview of the current literature on climate change risk perceptions in Africa.

### 3.3 Approaches to understanding climate change risk perceptions in Africa

As noted in the previous sections, there has been less attention focused on understanding the multiple determinants of risk perceptions in the African context than the developed world context. Instead, in

Africa, climate change risk perception studies primarily focus on personal experience (within the experiential grouping) as the only determinant of climate change risk perceptions. Before, reviewing the climate change risk perceptions literature in Africa, it is first necessary to note that there is a general conflation of the concepts of climate change ‘perceptions’ and climate change ‘risk perceptions’ in the literature.

Perceptions are distinct from risk perceptions because one can perceive a change in the climate but not believe the change to be a risk. However, much of the literature available from the African context focuses on perceptions of climate change in general, with the assumption that climate change is deemed a risk by those who are perceiving it. This is likely a reasonable assumption, especially as recent Africa-wide survey data found that 67% of Africans feel that climate change is making their quality of life worse and 71% think that climate change should be stopped (Selormey et al., 2019). While Selormey *et al.* (2019) did not measure risk perceptions explicitly, the results do suggest that climate change is likely perceived as a risk by a large portion of Africans. Therefore, to gain a comprehensive understanding of the literature, both studies on climate change risk perceptions and climate change perceptions have been included in this review.

Taking this conceptual conflation into account, Table 2.2 presents the summary results of a meta-review of academic literature that contained assessments of either risk perceptions or perceptions of climate change in each country in Africa. The review was undertaken by searching Google Scholar and Web of Science with all combinations of the key words: climate change, perception/s, risk perception/s, Africa and individual country name. The search was bounded to the period 2010 – 2021 in order to capture the most recent research. Articles returned through the first 20 pages of the search (after 20 pages the returned results offered diminished returns) were then screened for relevance based on their title, abstract, methods and results sections. Studies that provided results for more than one country (e.g. Lee et al., 2015) were captured multiple times in the table, under each individual country they studied. Therefore, the total number of country-level studies differs from the overall number of papers reviewed.

Table 2.2 Summary of a meta-review of academic literature focused on climate change (risk) perceptions. A blank square denotes zero studies. (The data in this table resulted from of a literature review undertaken in Simpson et al., (2021), to which this dissertation’s author contributed

		Perceived climatic changes											Number of studies linking perception to adaptive response	Farmers (commercial and subsistence)
		Number of studies	Decreased precipitation totals	Increased precipitation totals	Rainy season changes (shorter, shifts)	Increased rainfall variability	More severe or frequent droughts or dry spells	Increased flooding	Increased heavy rainfall	Increased temperature	Extreme heat / Heatwave / Longer hot periods	Increased cold or frosts		
<b>TOTAL</b>	<b>AFRICA-WIDE</b>	<b>211</b>	<b>84</b>	<b>11</b>	<b>84</b>	<b>99</b>	<b>97</b>	<b>58</b>	<b>27</b>	<b>118</b>	<b>31</b>	<b>5</b>	<b>121</b>	<b>133</b>
<b>Northern Region</b>														
	Algeria	1												
	Egypt	4	1				1			1			2	
	Tunisia	2					1						1	1
<b>Central Region</b>														
	Cameroon	5	2	1	3	3	2	1	1	3	1		4	
	Central African Republic	1			1		1	1						
	Chad	2				1	1	1		1			1	1
	Congo, Democratic Republic of the	1	1		1	1	1		1	1			1	1
<b>Eastern Region</b>														
	Burundi	1												
	Comoros	1						1						
	Djibouti	1												
	Ethiopia	17	13		6	7	5	1	1	14	2		13	16
	Kenya	15	9	2	7	9	9	4	2	10	2	1	8	11
	Madagascar	2	1		1	1				1			1	1
	Rwanda	2			1	1				1			1	1
	South Sudan	2			1	1	1	1		1			1	1
	Sudan	1												

	Tanzania	12	6		2	10	9	3	1	10	2		6	4
	Uganda	6	1	1	4	3	4	2	3	3	1		5	5
<b>Western Region</b>														
	Benin	11	5	1	7	5	4	6	1	8	1		9	10
	Burkina Faso	7	3	1	5	4	5	4	3	6	1		5	6
	Côte d'Ivoire	2	1		2	1	2			1			2	2
	Equatorial Guinea	1			1	1				1			1	1
	Ghana	20	9		6	11	4	4	3	12	3		13	16
	Guinea	1												
	Liberia	1												
	Mali	3	2		2	2	2			2	1		2	2
	Mauritania	2	1		1		1	1		1				
	Morocco	1												
	Niger	3	2		2	2	3	2		2	1		2	2
	Nigeria	22	8	4	8	9	9	7	3	15	4		18	19
	Senegal	1												
	Sierra Leone	1												
	Togo	2	1							1			1	1
<b>Southern Region</b>														
	Angola	1												
	Botswana	6	3		2	3	4	1		2	2		3	3
	Lesotho	1					1		1		1	1	1	1
	Malawi	8	2	1	4	6	6	4	2	4	2	1	4	5
	Mozambique	3	1		1	2	1	1	1	2			1	1
	Namibia	3	1		1		2	1		1			1	1
	South Africa	19	4		4	5	5	3	2	7			4	10
	Swaziland / eSwatini	2	2		1	1	2	2		1			1	2
	Zambia	4			3	2	3	2	1	1			2	3
	Zimbabwe	10	5		7	8	8	5	1	5	7	2	7	6

All the studies reviewed (164 individual papers) reported that their target audience had perceived a change in the climate. Most of these studies then went on to document what climatic variables (specifically) were perceived to have changed. Most prevalent amongst these perceived changes were increased temperatures (e.g. Berhanu and Beyene, 2015; Egeru, 2016), increased rainfall variability (e.g. Ayal and Leal Filho, 2017; Mekonnen *et al.*, 2018) and more frequent or severe droughts/dry spells (e.g. Ayanlade, Radeny and Morton, 2017; Chepkoech *et al.*, 2018). The review revealed that the literature is currently dominated by studies focused on the farming sector with a total of 123 individual papers (75% of the papers reviewed) reporting on either commercial or subsistence farmers perceptions.

The focus on the agriculture sector is likely driven by the economic importance of agriculture in many African countries (Nkiaka et al., 2019; Carr et al., 2020), thereby likely resulting in both research interest and research funding priorities. This biased sectoral focus in the literature undoubtedly skewed the literature, particularly in terms of the perceptions around what climate variables have changed, because participants in the studies were likely to focus on variables of importance to them. The focus on increased temperatures, increased rainfall variability and more frequent or severe droughts/dry spells can therefore likely be explained by the particular importance these changes have for agriculture: increased temperatures are particularly important for agriculture because individual crops have particular temperature thresholds for optimal growth (Porter and Semenov, 2005) and any unusual variability in rainfall or lengthy dry spells within the season, has significant effects on crop yield (Agaba, 2019). This bias suggests a gap in knowledge regarding the climate variables of greatest importance to other sectors or professions.

The review further revealed a link between the experience of climatic changes and reported adaptation action. While not all reviewed studies sought to assess the relationship between climate change experience and adaptation, those that did (109 individual papers) found there to be adaptation actions taken because of the perceived changes in climate, although those actions varied in magnitude. Examples of these actions ranged from seemingly smaller actions such as increasing the diversity of herd species (towards more drought-tolerant animals such as camels and goats) (Berhanu and Beyene, 2015) to seemingly larger actions such as totally switching crops (Chichongue et al., 2015) or permanent relocation to less drought-prone areas (Below et al., 2015). While the wider literature documents a relationship between climate change risk perception determinants (including experience of extreme weather events) and willingness to take pro-environmental action both on a personal (Lo and Chan, 2017; Smith and Mayer, 2018; Xie et al., 2019) and professional level (Ture and Ganesh, 2014; Inoue and Alfaro-Barrantes, 2015; Madsen et al., 2019), this evidence sets a solid basis for confirming that experience of climate change has an established relationship with action on climate change in Africa, a relationship that underpins the research in this study.

Of the studies reviewed, only three focused on the perceptions of climate change amongst policy decision makers (the audience of focus of this study) in a workplace setting. However, wider literature notes experience of extreme weather events (Madsen et al., 2019) as well as other individual climate change risk perceptions determinants such as social norms (Lee et al., 1995; Andersson et al., 2005; Scherbaum et al., 2008; Lo et al., 2012; Ture and Ganesh, 2014), values (Ture and Ganesh, 2014) and gender (Wehrmeyer and McNeil, 2000) as having an influence on pro-environmental behaviour in the workplace. The paucity of studies focused on policy decision makers reveals a gap in the academic discourse with regards to understanding climate change perceptions amongst policy

influencers/decision makers in the majority of African countries, including that of East Africa (the region of focus of this study).

The studies focused on policy decision makers included one in the Central African Republic (Brown et al., 2013), one in Tanzania and Malawi (Pasquini, 2019) and one in Zimbabwe, Malawi and Botswana (Steynor, Leighton, et al., 2020). In the Central African Republic, Brown et al. (2013) focused their study on institutions with relevance to climate change and development. These included government institutions, regional and national institutions, research institutions, NGOs and some relevant civil society actors. The research found that there was a heightened awareness of climate change amongst these institutional respondents, and that they all felt that the impacts of climate change were already being experienced in the country. Explanations for these heightened perceptions of climate change were primarily related to the agricultural sector, with respondents describing changes to the agricultural calendar driven by changes in the timing of the rainy season and the length of the dry season. The study's respondents also noted the displacement of urban residents during a recent flooding event, the effect of long dry seasons on increased wildfires, and the increased distances that people needed to travel to access water (affecting women and children in particular).

In Tanzania and Malawi, Pasquini (2019) reported results of interviews with government actors in the cities of Dar es Salaam (Tanzania) and Karonga (Malawi). The research found that most respondents felt they were already experiencing the effects of climate change, citing experiences with flooding, changes in rainfall patterns, drought, rising temperatures and heatwaves as evidence for the changing climate. They also highlighted adaptation actions that were being taken to ameliorate the effects of climate change on their city.

Finally, in southern Africa, Steynor et al. (2020) focused their research on institutions involved in climate/natural resource policy decisions in the three cities of Blantyre (Malawi), Gaborone (Botswana) and Harare (Zimbabwe). They found that climate change was perceived as a risk amongst all the study's respondents, with the majority of study respondents noting that they were already experiencing the impacts of climate change in their cities through changes in rainfall patterns leading to flooding events and extended droughts. These climatic changes were noted as having multiple negative impacts including, for instance, damage to infrastructure, health impacts and disruption to transport routes.

Common across all these policy decision-maker studies (and all the studies reviewed in table 2.2) is the perception that the impacts of climate change are already being felt. While the exact climate variables mentioned in each study differed depending on region, target audience or sector of focus, it is evident that the experience of climate change as a currently occurring phenomenon appears to be



common across all countries in Africa. This conclusion is important to highlight as it further strengthens the importance of studying experiential factors (personal experience and the psychological distance of climate change) as potentially important determinants of climate change risk perceptions in Africa.

#### 4. Key research priorities emerging from a review of the literature

This chapter has revealed that there are still theoretical gaps in the academic discourses. Firstly, there is an absence of literature that draws on an understanding of climate change risk perceptions to inform the development and delivery of climate services. Understanding the relevance of each of climate change risk perception determinants and their relative contribution to climate change risk perceptions in Africa is central to gaining a better understanding of the decision context within which climate services are being delivered and used. This is a critical gap in the climate services literature, particularly as scholars have identified the need for climate services to be informed by interdisciplinary knowledge (Carlton and Jacobson, 2013; Alexander and Dessai, 2019) and by context-specific understanding (Carlton and Jacobson, 2013; Adams et al., 2015; Vogel et al., 2019).

A second theoretical gap has been identified in the climate change risk perceptions literature with regards to understanding i) the ability and proportional contribution of selected determinants of climate change risk perceptions to explain climate change risk perceptions in a developing country context and ii) the contribution offered by including the psychological distance of climate change in a multi-variate climate change risk perceptions model in Africa. Without such understanding, there remains a, potentially incorrect, assumption that there is homogeneity in what determines and explains climate change risk perceptions across developed and developing countries.

Finally, the climate change perceptions/risk perceptions literature in Africa is predominantly focused on the agricultural or farmer sector. In particular, only three studies focused on the policy-level decision maker audience. However, policy makers, and those who influence policy decisions, are an important group to understand because they are in a position of autonomy and authority to take actions on climate change (Mohamed, 2016) such as developing climate change adaptation policies or allocating government funding for climate change adaptation actions.

In response to these identified gaps in the literature, this study advances climate change risk perception theory and climate services scholarship by developing an approach that uses the theoretical framework of climate change risk perceptions to better understand the decision context for climate services amongst East African policy decision influencers. This better understanding of the decision context is used to inform the development and delivery of context-specific climate services.

In this way, the study directly contributes to the each of the theoretical gaps identified in the academic literature as well as contributes to the practical advancement of climate services.

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## Chapter 3: Informing climate services in Africa through climate change risk perceptions

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This chapter consists of the following published paper (further revised based on examiner comments):

**Steynor, A.** and Pasquini, L. 2019. *Informing climate services in Africa through climate change risk perceptions*. Climate Services. 15, 100112: DOI: 10.1016/j.cliser.2019.100112

**Lead author (student)** Anna Steynor      **Role:** Conceptualised the paper, obtained the underlying data, undertook the data analysis, interpreted the results and drafted the paper.

**Co-Author:** Lorena Pasquini.      **Role:** Thesis supervisor, guidance, review of draft paper

This chapter is composed of a positionality paper that was published early in the development of the doctoral research to establish a premise for the work. As such, it draws on data collected through previous studies that are not detailed in the methodology section of Chapter 1. The paper serves to further introduce the literature and rationale for the study by drawing a relationship between climate change risk perceptions and the design and development of climate services. The formal establishment of the theoretical linkages between climate change risk perceptions and climate services sets the stage for the research in the rest of the study. The chapter also serves to highlight the importance of understanding aspects of climate change risk perceptions in the understudied African context. In particular, through presentation of preliminary data, the chapter positions aspects of climate change risk perceptions in Africa as potentially different from that of a developed country context.

### **Abstract:**

*The context for climate services in Africa is significantly different from that of developed countries, in some part due to the disproportionate impacts of climate variability already being experienced on the*

*African continent. One approach to deepening contextual knowledge for climate services is through an understanding of climate change risk perceptions, because they have been shown to be strong drivers of pro-environmental behaviour. Climate change risk perceptions in Africa are likely to differ significantly from those of developed countries but, to date, the understanding of climate change risk perceptions is highly underdeveloped in Africa. This paper goes some way towards addressing this knowledge deficit by providing preliminary evidence with regards to the psychological distance of climate change, which is one determinant of climate change risk perceptions. We posit that climate change is reasonably psychologically close in Africa. In addition, we emphasise the importance of studying a suite of determinants of risk perceptions in order to better inform climate services. Each of the determinants of climate change risk perceptions can provide value in informing climate services, whether it be through appropriate mechanisms for collaborative practitioner engagement, timelines of relevance, the most appropriate content and format of climate information products and services and/or suitable communication and dissemination mechanisms. Through a better understanding of climate change risk perceptions, there is scope to design climate services that more readily fit the specific decision contexts of the African continent.*

## 1. Introduction

It is widely acknowledged that the African continent is highly vulnerable to both climate variability and climate change (IPCC, 2014). This inherent vulnerability has attracted a sense of urgency in the need to supply climate services that assist in developing adaptation action to address the impacts of climate change (Lourenço et al., 2015). Too often, these climate services are developed with a superficial understanding of the target audience, are data-driven and are dominated by the western assumptions and cultural norms of those developing them (WMO, 2017). The contextual nuances inherent in the developing world are often not fully considered or are dismissed as inconsequential to the uptake of information (Hewitson et al., 2017). However, the latter is a false supposition, because outreach has been shown to have a greater utility when it resonates with the personal situation and values of those being engaged (Vogel and O'Brien, 2006; Maibach et al., 2008; Clayton et al., 2015; Hine et al., 2016).

Therefore, if climate services are to be effective in building capacity to prepare for future adverse climate conditions in Africa, understanding the African context for climate services will be central to designing climate services that are effective for motivating adaptation action. While there are many frameworks that could be used to better understand the decision context, attempts to better understand decision contexts through an environmental psychology lens is an emerging area of interest (Spence et al., 2012; Brügger et al., 2015; Lourenço et al., 2015). User risk perceptions are one area of focus, due to the significant risk that climate change poses to society, and the messages of climate-related risk that result from climate services.

Risk perceptions are important to understand because they underlie both willingness to act on climate change (Spence et al., 2012) and the types of information people use or need to take action (Liberman and Trope, 1998). While there is a relatively good understanding of climate change risk perceptions (and what influences them) in a developed country context (e.g. Capstick et al., 2015; Leiserowitz, 2006; van der Linden, 2014), there is a rudimentary understanding with regards to climate change risk perceptions in the African context. In addition to the gaps in understanding with regards to climate change risk perceptions in Africa, there is no literature, globally, that uses risk perceptions as a basis for informing the provision of climate services for adaptation. A better understanding of climate change risk perceptions may necessitate a reconsideration of how climate services are carried out, particularly in Africa.

As the study of risk perceptions has evolved, there has been a shift in theoretical understanding. Early research on risk perceptions focussed on the model of rational choice, which hypothesises that humans judge risk in an analytical manner by mentally calculating the odds of the risk and basing choices on the outcomes of those calculations (Leiserowitz, 2006). For instance, deciding whether to

take out house contents insurance based on crime statistics. However, the evolving field of risk perceptions research reveals that human judgement is far more nuanced and rational choice alone does not explain risk perceptions (Carlton and Jacobson, 2013). For example, one's perceptions of the crime rate may be influenced by having been a recent victim of crime. This evolved understanding acknowledges risk perceptions (including climate change risk perceptions) as complex, with the need to consider multiple different factors that influence human behaviour, as predictors of risk perceptions (Hulme, 2009). Various studies have identified differing but, often, connected determinants of climate change risk perceptions (e.g. Brody et al., 2008; Menny et al., 2011; Spence, Poortinga and Pidgeon, 2012; Akerlof et al., 2013; Carlton and Jacobson, 2013; Asiyanbi, 2015; Lee et al., 2015; van der Linden, 2015). No one study is able to identify the predictors that explain 100% of the variance in climate change risk perceptions (van der Linden, 2015). However, drawing on the existing literature provides a basis for selecting determinants of climate change risk perceptions that may help inform climate services. Based on some of the determinants that offer potential utility in informing climate services, the foci of this paper include: the psychological distance of climate change, personal experience of extreme weather events, cultural values and norms, and socio-demographic characteristics.

For the purposes of this perspective piece, we focus primarily on the aspect of psychological distance, because there is sufficient preliminary data to inform a commentary on the current psychological distance of climate change in an African context. Therefore, the paper begins with a review of the literature on the psychological distance of climate change (section 2) and is followed by a preliminary assessment of the psychological distance of climate change in Africa context (section 3). We consider the other identified determinants of climate change risk perceptions (personal experience of extreme weather events, cultural values and norms and socio-demographic characteristics) as similarly important for informing climate services, so each are briefly reviewed in section 4. However, as stated, they are only discussed theoretically here because there exists no data, yet, to inform a more empirically-focused discussion. Finally, in section 5 we discuss how better understanding the determinants of climate change risk perceptions may inform the design of climate services that are more contextually appropriate for the African<sup>2</sup> decision space.

## 2. The psychological distance of climate change

Psychological distance provides a measure of a person's personal perception of something as either close or far away (Pahl et al., 2014). Psychological distance comes from Construal Level Theory, developed by Liberman and Trope (1998). Construal Level Theory defines a relationship between the

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<sup>2</sup> See paper reviewer comment number 1 (annex 3) with regards to the aggregation of the findings to "Africa"

psychological distance of an event and the way people construe (i.e. mentally represent) the event and, hence, the types of information they may use to act on the event.

The principles of psychological distance are defined with respect to four dimensions (Trope and Liberman, 2003, 2011; Liberman and Trope, 2008), namely:

- (i) whether an event is close (proximal) or remote (distal) in time (temporal dimension);
- (ii) whether an event is close or far away in space (spatial dimension);
- (iii) whether an event refers to ours or other people's experiences (social dimension); and
- (iv) whether it is certain or uncertain to occur (hypothetical dimension).

Construal Level Theory also states that when there is a change in distance in one of these dimensions, the other dimensions also change in the same direction i.e. become closer or more distant, irrespective of the context (Trope and Liberman, 2011). For instance, if an event is perceived as unlikely to occur then it also brings to mind people other than oneself (social distance), a distant future (temporal distance) and remote locations (spatial distance). Therefore, each of the four psychological dimensions have been shown to significantly correlate with each other (Fiedler et al., 2012), even if they have little or nothing else in common (Trope and Liberman, 2011).

When an event is psychologically close, it promotes emotional and cognitive engagement with the event (Lorenzoni et al., 2007; Spence and Pidgeon, 2010). For instance, the imminent threat of a flood may bring to mind images of wading through one's house to rescue sentimental objects and evacuate vulnerable family members. These types of psychologically proximal threats are typically associated with "low-level" construal, which is a type of comprehension composed of concrete thinking and specific detailed features (Trope and Liberman, 2011; Spence et al., 2012) where feasibility, safety and the attainability of a good outcome become the primary areas of focus (Sagrignano et al., 2002; Trautmann and Van De Kuilen, 2012).

On the other hand, when a threat is psychologically distant it can be more difficult to relate to and more effort is required to mentally construe it (Brügger et al., 2015). For instance, the anticipation of a future flood, without recent experience of a flood, does not provide any direct specifics of the situation or sensory detail. Therefore, psychologically distant events are typically associated with "high-level" construal, which results in a type of comprehension composed of abstract and general features (Liberman et al., 2002; Spence et al., 2012).

There are numerous studies that have explored the individual dimensions of psychological distance in the developed world. Based on much of the literature to date, climate change is typically thought of as an abstract phenomenon, rendering it fairly psychologically distant. The psychologically distant

nature of climate change has been widely applied, in developed countries, to explain the lack of action on climate change (Spence et al., 2012; McDonald et al., 2015; C. Jones et al., 2017). However, there appears to be no literature that gains a systematic understanding of the psychological distance of climate change within or from an African context, and how this may, therefore, affect action on climate change in the African continent.

To investigate documented perceptions of climate change further, we now consider each of the four dimensions of psychological distance in greater detail, discussing them in the context of the relevant literature and evidence base<sup>3</sup>. We highlight, again, that the majority of literature on psychological distance in relation to climate change comes from developed-country researchers with a focus on developed-country decision frameworks and perceptions.

### 2.1. Hypothetical distance

Hypothetical distance refers to the perceived certainty of a future occurrence/event. This perceived certainty may encompass both perceptions about whether climate change is occurring (scepticism) as well as perceptions about the direction and magnitude of change that is likely to occur (climate projection uncertainty) (Wakslak and Trope, 2009; Poortinga et al., 2011a; McDonald et al., 2015). In general, the hypotheticality of climate change is widely noted as an obstacle to intentions to engage with climate change (Lorenzoni et al., 2007; Nisbet, 2009; Whitmarsh, 2011).

It is important to clearly distinguish between the concepts of scepticism and climate projection uncertainty (Spence et al., 2012). Both concepts have a hypothetical component to them so they are often used interchangeably (Spence et al., 2012). Climate projection uncertainty refers to varying perceptions around what is knowable of the future, given current scientific understanding (Spence et al., 2012) leading to varying magnitudes of change projected from different climate modelling centres (Taylor et al., 2012). Hence, greater uncertainty in climate change projections may lead to climate change being perceived as more psychologically distant. However, the predominant interpretation of the hypothetical distance of climate change in the literature refers to the concept of scepticism (Spence et al., 2012; McDonald et al., 2015). This is, perhaps, because the majority of the general population do not engage with climate data enough for projection uncertainty to alter their perceptions.

Scepticism refers to the inherent belief in (or refutation of) climate change as a concept and whether it will have serious adverse effects (Brügger et al., 2015). Greater scepticism of climate change leads to it being perceived as psychologically distant. If one is sceptical about the existence of climate change one is, in turn, unlikely to take action on it (Brügger et al., 2015). Thus, an understanding of

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<sup>3</sup> See paper reviewer comment number 2 (annex 3) with regards to the dates of the cited literature



the predominance of belief with respect to climate change is important because people who are not sceptical about climate change are more likely to take adaptation action (Floyd et al., 2000; Nicholson-Cole, 2005).

There have been many large-scale country-based surveys around belief (scepticism) in climate change in recent years which provide insight into the current hypothetical distance of climate change. The most recent survey conducted by Gallup in 2018 revealed that belief in human-induced climate change in the United States had dropped from 68% in 2017 to 64% in 2018 (Gallup, 2018b). Another recent survey undertaken by IPSOS MORI in 2016, assessed belief in human-induced climate change across a mix of 22 developing and developed countries (Taylor et al., 2014; IPSOS MORI, 2016). Results showed that participants from developing countries displayed the greatest belief in human-induced climate change. For instance, in Indonesia, 93% of the participants believed in human-induced climate change, followed by Argentina (88%), India (88%), Peru (87%) and Mexico (86%). Conversely, participants from developed countries had a lower belief in human-induced climate change. For instance, Japan had the lowest belief in human-induced climate change (63%) followed by Australia (73%), United Kingdom (74%), Sweden (76%), Canada (77%), France (79%) and Belgium (79%). Therefore, in the developed country context, it seems plausible to conclude that climate change is still perceived by many (as much as more than a quarter of the population in Japan, United States, United Kingdom and Australia) as uncertain. This uncertainty is expected to have the effect of increasing the hypothetical distance of climate change.

## 2.2. Temporal distance

By its very nature, climate change is gradual and manifests incrementally over time in a chaotic pattern (Alexander et al., 2013). In addition, while it is possible to provide projections of possible changes in extreme events, it is very hard to scientifically link causation of a particular climatic event to climate change (van Aalst, 2006). Therefore, tangible current impacts from climate change are often difficult to distinguish from climate variability (Spence et al., 2012) unless the individual believes that a particular event is due to climate change (Weber, 2010). This may be a reason behind climate change often being perceived as a temporally distant phenomenon in developed countries (C. Jones et al., 2017). This conjecture is corroborated by a study conducted in the United Kingdom in which the participants noted that they could not see the effects of climate change in the United Kingdom, so were less likely to act on climate change concerns (Nicholson-Cole, 2005). More recent global polls have been undertaken to assess whether respondents feel that climate change is already harming people. The Pew Research Center global attitudes survey (2015) found that 60% of Europeans, 41% of North Americans and 49% of Chinese believed that climate change was already harming people (Pew Research Center, 2015). This low recognition of climate change impacts was further documented

in polling evidence from 2018 which suggested that more than two-thirds (69%) of Americans thought they were not being personally impacted by climate change and 41% thought that their local area was not being affected (Pew Research Center, 2018). Therefore, it seems plausible that general public perceptions in some developed countries might still be that climate change is temporally distant, as suggested by Leiserowitz et al. (2013).

### 2.3 Spatial distance

Some studies have investigated people's perceptions with regard to the spatial distance of climate change. In a systematic survey of the perception of climate change as a local problem, 52.6% of the population of the United Kingdom agreed or strongly agreed that their local area is likely to be affected by climate change and 45.8% of those surveyed agreed or strongly agreed that climate change will predominantly affect those in developing countries (Spence et al., 2012). Therefore while there was an acknowledgment, by the UK population, that climate change will affect their local area, there is still a perception that the impacts of climate change will be more severe and serious in developing countries, which distances the impacts from their local geographical area (Spence et al., 2012). Admittedly this evidence is somewhat dated and predates the latest IPCC report in 2014, which could plausibly have changed these perceptions somewhat. However, this distancing effect was, again, shown in a recent poll in the United States where 63% of respondents thought that climate change would harm the United States but 69% of respondents thought that climate change would harm developing countries (Ballew et al., 2019). These findings correlate with an earlier 18-nation study (of primarily developed countries) studying spatial bias in the expected future state of the environment. Although studying environmental perceptions more generally (rather than specifically climate change), the study found that people predominantly believe that future environmental conditions will be worse in more distant places (Gifford et al., 2009).

### 2.4. Social distance

Perceptions of climate change as a personal threat are important, because people are not likely to support climate change adaptation initiatives unless they see the problem as something that is likely to affect them personally (Lorenzoni and Pidgeon, 2006). Thus, the extent to which people perceive climate change as a personal threat, or as an important threat to the society they are embedded in, determines how 'socially distant' they are from the issue.

Survey findings from the developed world suggest that, while people consider climate change as a problem, they are divided as to whether it will pose a significant personal risk. In 2012, in the United Kingdom, 44.6% of respondents agreed or strongly agreed that climate change will affect people like themselves, while 32.3% strongly disagreed that it would affect people like themselves (Spence et al., 2012). In a poll undertaken in the United States in 2017, 49% of the population believed that climate

change would personally affect them either moderately or a great deal, while 43% of people believed it would only affect them a little or not at all (Leiserowitz et al., 2017). In the same poll, 55% of the American population believed that climate change will harm people in their community either moderately or a great deal, while 37% believed that climate change will only affect their community a little or not at all (Leiserowitz et al., 2017). These findings suggest that a sizeable proportion of people in the United Kingdom and United States think that climate change will affect them or their communities very little or not at all, which points towards the perception of climate change as a socially distant threat for many people in these developed countries.

The predominantly developed country context, presented in this section, provides a useful backdrop against which to contribute preliminary findings from the African context. In the following section we present preliminary evidence to inform a discussion with regard to the psychological distance of climate change in Africa, through evidence presented for the sub-Saharan region.

### 3. Preliminary evidence informing the psychological distance of climate change in Africa

Consistent with the nature of a perspective paper, the evidence for the assertions set forth here have not resulted from a discrete project studying the psychological distance of climate change in Africa, but rather from a body of evidence resulting from surveys, structured interviews and semi-structured interviews conducted through a variety of our (the author team's) projects involving users of climate information (Table 3.1). Using this accumulated data, we explore evidence that allows some inference to be made on each of the dimensions of psychological distance in Africa. It should be noted that, although we attempt to discuss each of these dimensions separately here, they are sometimes hard to distinguish from each other because of their interdependence (Trope and Liberman, 2011).

We acknowledge that the evidence focus is on sub-Saharan Africa and perceptions may not be uniform across all African countries or sectors of society. However, African countries are uniform in their designation as developing countries and are, therefore, treated as a fairly homogeneous socio-economic group by international bodies. This means that the differences within countries in Africa are likely to be lower than the inter-continent differences (e.g. between Africa and Europe). Given this caveat, we note that this evidence is exploratory only, with a need for further research that extends this analysis to all African countries. In addition, the data does not randomly sample the general population, being representative for the most part of professionals, government staff and sectoral experts (refer to Table 3.1). However, the data reflects our general experience of climate

change perceptions and provides a preliminary illustration of how African climate services users' may compare against those of their developed country counterparts.

### 3.1 Sources of information

From each of the projects outlined in Table 3.1, data relating to each dimension of psychological distance were extracted in order to draw potential inferences about the psychological distance of climate change within Africa (drawing on experiences from six different African countries). These, together with literature evidence for other countries, have informed the following discussion.

*Table 3.1: Project sources used to inform the discussion on the psychological distance of climate change in an African context*

Project reference number and name	Funding source and year	Country of focus	Number of survey participants	Data collection method	Demographic focus	Questions used to inform discussion on psychological distance
<b>1</b> Psychology of decision-making under uncertainty	USAID under the Climate Change Adaptation, Thought Leadership and Assessment (ATLAS) programme: 2017/18	Mozambique and South Africa	105	Online survey	Health and WASH sector professionals, academic researchers and civil society	Which of the following statements do you personally believe?  1) Climate change is happening now, caused mainly by human activities.  2) Climate change is happening now, but caused mainly by natural forces  3) Climate change is not happening now.  4) None of the above
<b>2</b> African Water Adaptation through Knowledge Empowerment (AWAKE)	African Development Bank: 2017	Malawi, Zimbabwe, Botswana	27	Structured interviews	Municipal staff, academic researchers and civil society	What do you understand by the term climate change?  Do you think climate change is affecting <insert city name>?  (If yes, how?)
<b>3</b> Urban Africa Risk Knowledge	DFID/ESRC: 2015-2018	Tanzania and Malawi	25	Semi-structured interviews	Municipal staff, local councillors, national-level government staff, civil society	Broad topics focussed on in the interview guide:  • beliefs and perceptions about whether the climate is changing

						<ul style="list-style-type: none"> <li>• experience of climate impacts</li> <li>• level of concern/worry about a changing climate</li> </ul>
4 Malawi rural vulnerability assessment	USAID under the African and Latin American Resilience to Climate Change (ARCC) programme: 2012	Malawi	9	Semi-structured interviews	Rural communities	Broad topics focussed on in the interview guide: <ul style="list-style-type: none"> <li>• beliefs and perceptions about whether the climate is changing</li> <li>• experience of climate impacts</li> </ul>

### 3.2 Preliminary evidence regarding the psychological distance of climate change in Africa

The African continent has high sensitivity to a changing climate because of the prevalence of factors that increase the degree to which stress is experienced by the system, such as widespread poverty, overdependence on rain-fed agriculture, inequitable land distribution and poor governance (Watson, 1998; Jones et al., 2015). In addition, many of these as well as other factors, such as budgetary constraints, lead to an inability of the system to adjust to climatic changes, resulting in limited adaptive capacity (Spires and Shackleton, 2018). This combination of heightened sensitivity to climatic changes and limited adaptive capacity leaves Africa very vulnerable to climatic variability (IPCC, 2014). As such, it would be reasonable to expect that more Africans may perceive climate change as a greater threat than do residents of developed countries.

A starting point for investigating African perceptions of climate change is investigating the hypothetical distance of climate change. For the purposes of this perspective piece, we employ a predominant interpretation of hypothetical distance used in the literature, which is the extent to which people inherently believe in human-induced climate change as a concept. Drawing upon the data from the projects listed in Table 3.1, we suggest that scepticism around climate change is low in Africa, amongst those with knowledge of climate change as a scientific phenomenon. An illustrative example of this assertion is provided through Project 1, in which an online anonymous survey (N = 105) was conducted. Through the survey, professional, academic and civil society individuals from Mozambique and South Africa were asked to choose one of four options indicating their belief in climate change. The overwhelming majority of respondents (n = 103; 98%) believed that climate change is occurring, and the majority of these respondents (n = 99; 94%) believed that climate change is primarily as a result of human actions. These quantitative results are also confirmed indirectly through project 2, in which structured interviews were conducted with municipal staff, academics and

civil society in cities in Malawi, Zimbabwe and Botswana in 2017 (N = 27). In response to a question asking what they understood by the term climate change, none of the participants refuted the notion of climate change or thought it was caused by natural causes. In fact, eight respondents explicitly mentioned the human influence on climate change through emissions.

While these projects indicate a high belief in human-induced climate change amongst survey participants, the target respondents were educated professionals and civil society members, so it is not possible to directly compare these results against studies undertaken in developed countries, where random samples of the general population have been undertaken. However, it is still interesting to note the strong contrast between the results of this survey and that of the broader sampling polls conducted in developed countries (refer to section 2.1).

With regard to the temporal distance of climate change, the project data suggests that climate change is perceived as a current and imminent threat in the African context. As evidence to support this notion, data collected through Project 2 confirms that climate change appears to be perceived as temporally close amongst the study participants. Interviewees were directly asked whether they thought that climate change was affecting their city. The majority of respondents (n = 23; 85%) confirmed the belief that climate change was already impacting their city and provided examples of changing climatic patterns that they had observed.

The data from Project 2 suggests that the main reason for respondents' belief that climate change is already impacting their city is tied to their experiences of rainfall variability. Across all the cities, 16 of the total 27 respondents (9 of 13 in Blantyre, 5 of 7 in Harare and 2 of 7 in Gaborone) indicated that they perceived changes in rainfall to have occurred, expressed variously as changes in rainfall timing (an unpredictable start to the rainy season), and/or more intense rainfall events and/or longer dry spells. In addition, 14 respondents across the cities (5 in Blantyre, 4 in Harare and 5 in Gaborone) expressed a perception of decreasing overall rainfall resulting in decreasing availability and access to water.

The findings from Project 2 also align with the findings from Project 4, which show that the perception that climate change is a current threat is not solely evident amongst professionals in an urban setting. Representatives from rural Malawian villages (N = 9) were asked whether they perceived the climate to be changing for their location and, if so, the associated impacts for in their village. All representatives reported a perceived change in climate for their village, citing reasons for this perception to include: increases in extended high temperatures and/or drought conditions together with changing rainfall patterns, characterised as unpredictable seasonal patterns and/or periods of intense or erratic rainfall.

Again, this finding is not broadly comparable to developed world countries, because Project 2 and 4 only sampled a sub-set of society, but it aligns with broader research conducted by the BBC World Service Trust in 2010. This research aimed to assess public understanding of climate change in 10 countries in Africa (Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa, Sudan, Tanzania and Uganda) through citizen focus groups and interviews, and was disseminated through a series of country reports. While knowledge of climate change as a scientific phenomenon was low amongst the general population, there was an almost universal perception that weather is currently changing in the sampled countries (Godfrey et al., 2010). When this perception was combined with an understanding of climate change, a changing climate was cited to explain the observed changes (Daniel et al., 2010). These findings align with literature that suggests that personal experiences with extreme weather is an influencer of climate change risk perceptions (Krosnick et al., 2006; Brody et al., 2008; Akerlof et al., 2013; van der Linden, 2015). The connections between personal experience of extreme weather and climate change risk perceptions are discussed further in section 4.

Reflecting on the data from Projects 2 and 4, as well as from the various country reports from the BBC World Service Trust project, it is important to note that this data strongly contrasts with findings from developed countries, where, as previously noted in section 2.2., climate change is often seen as a temporally distant threat with the impacts only being felt in the decades to come (e.g. Spence, Poortinga and Pidgeon, 2012; Leiserowitz et al., 2013, 2017).

While there is less explicit evidence from our projects to support a commentary on the social and spatial distance of climate change, the reported impacts of the observed changes in climate provide insight into these dimensions. Many of the urban respondents in Project 2 (n = 13; 48%) not only reported a perceived change in climatic patterns but voluntarily added examples of the local and/or personal impacts of these changes. Some of these impacts included a perceived increase in climate-related health problems, a decrease in water supply and quality and inadequate dam recharge leading to electricity black-outs from hydro-electricity failure.

Similarly, all the rural village representatives (N = 9) interviewed in Project 4 reported having observed an increase in personal crop failure, damage to village infrastructure from flooding and an observed increase in disease-related illness and death, from climate-dependent illnesses such as cholera, malaria and diarrheal disease. In situations of crop failure or low yield, the majority of representatives (n = 8; 89%) reported an increase in malnutrition, food insecurity or reliance on food aid. The majority of village representatives (n = 8; 89%) also reported an increase in personal housing damage due to

flooding and were forced to diversify their crops to often less-profitable or less-desirable crops in order to adjust to the altered climatic conditions.

Further evidence of the perceived temporal, social and spatial closeness of climate change can be drawn from the semi-structured interviews conducted in Project 3, in which respondents discussed their perceptions regarding the effects of climate change. Respondents from Karonga (Malawi) and Dar es Salaam (Tanzania) volunteered information pertaining to how they perceived climate change to already be impacting them personally and/or their local community. The majority of respondents (n=24; 96%) provided numerous examples of their perceived effects of climate change. These included flooding and drought-related impacts such as: personal property damage, poor crop yields, food insecurity, displacement of community members, coastal erosion and illness (for a full presentation of the results, refer to Pasquini, 2019). Finally, these findings all align with the various country reports from the BBC World Service Trust project, in which less predictable rainy seasons, increases in temperature and more intense and frequent drought and flood events were reported across ten countries in Africa, leading to migration, crop failure, infertile soils and unreliable water sources (Godfrey et al., 2010).

Taken together, these project findings imply that climate change may be socially and spatially close in the African context. These results again contrast with studies undertaken in developed countries where, as noted in section 2.3 and 2.4, around half to two-thirds of the respondents (a much lower proportion than in the African cases) felt that their local area was likely to be affected by climate change and/or that climate change would personally affect them.

Data relating to all four dimensions of psychological distance, analysed above, point towards climate change being psychologically proximal in Africa. Psychological proximity has been shown to be directly related to concern about climate change (Spence et al., 2012). Therefore, if climate change is psychologically closer in Africa then we would expect a heightened level of concern about climate change. In this respect, Project 3 provides some insight into how concerned African residents are about climate change. Seven of the interviewees from Malawi (n = 5) and Tanzania (n = 2) were explicitly asked whether they felt worried about climate change. Six of these respondents confirmed that they did indeed feel worried about climate change. The one respondent who was not concerned about climate change was in a position of considerable authority in the city and stated that it is *“difficult to see the impact of climate change because we are eating every day”*. This response might be explained through Trope and Liberman (2011)’s proposal, that people in positions of power see themselves as more distant from risks than those who have less power. However, given the exploratory nature of the work, the data does not allow further investigation of this notion.



While the data presented here points towards climate change as a psychologically proximal threat in Africa, psychological distance is one of many determinants of climate change risk perceptions that offer value in informing climate services (as noted in the introduction). The following sections outline some of the other determinants of climate change risk perceptions and the value they can provide for informing climate services.

#### 4. Additional determinants of risk perceptions that should be considered in informing climate services

Other major determinants of climate change risk perceptions selected from the literature because they provide value in informing climate services include: personal experience of extreme weather events<sup>4</sup>, cultural values and norms and socio-demographic characteristics. Although these determinants of risk perceptions are documented separately here, they are inextricably linked together and influence each other. This means that, in practice, they cannot be treated as standalone determinants of risk perceptions but should always be considered in relation to the other determinants, including psychological distance.

##### 4.1 Personal experience of extreme weather events

Personal experience of climate change is hard to objectively measure because it is very hard to formulate a causal relationship between a particular climatic event and climate change (van Aalst, 2006). Despite this, personal experience of climate change related events and psychological distance have been shown to correlate with each other (McDonald et al., 2015) and personal experience of individual extreme weather events has been shown to increase climate change risk perceptions (Krosnick et al., 2006; Brody et al., 2008; Akerlof et al., 2013), *if* the extreme weather events are believed to have been caused by climate change. Personal experience of an adverse event tends to elicit a visceral response and strong emotions, therefore, if one is able to personally experience negative impacts of climate change, strong responses should be triggered resulting in a heightened perception of climate change risk (Weber, 2006). This is particularly the case if the individual has a sense of meaning attached to the place and things that are at risk (Brügger et al., 2015).

Corroboration for these effects has been demonstrated through the discussion in the previous section, which highlights how personal experience of devastating extreme weather events appears to have influenced respondents' perceptions of climate change as a psychologically close phenomenon in Africa. As Africa routinely experiences extreme weather events, associated with significant socio-

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<sup>4</sup> See paper reviewer comment number 3 (annex 3) with regards to separating experience of extreme weather events from psychological distance

economic impacts (WMO, 2014), personal experience of extreme weather events may have a significant influence on climate change risk perceptions in the African context.

#### 4.2 Cultural values and norms

The influence of culture and values is an important driver of climate change risk perceptions (Smith and Leiserowitz, 2012; Akerlof et al., 2013; van der Linden, 2015). Culturally-constructed beliefs can strongly influence people's perceived experiences of climate change events, their interpretation of how climate change will manifest, their view of nature and ultimately their overall perception of climate change risk (Akerlof et al., 2013). Therefore, it can be expected that socio-cultural influences may have a significant bearing on climate change risk perceptions in Africa.

People from similar cultures are likely to share the same values because values are shaped by social experiences and cultural contexts (Schwartz and Sagiv, 1995; Schwartz, 1999), therefore, van der Linden (2015) suggests that broad value orientations may be a way of incorporating cultural influences into risk perception studies (a better way than Douglas and Wildavsky, 1982's cultural theory of risk, he suggests, because of the theoretical controversy surrounding the cultural theory of risk). Values underlie the moral make-up of a person and are concepts and beliefs that transcend specific situations (Schwartz and Bilsky, 1990). For instance, honesty, as a value, applies universally at work, at home, in sport, with family, with close friends and with strangers.

Studies have shown that values strongly condition people's perceptions of climate change risk, as well as policy options to address it. For example, people with predominantly self-transcending values (i.e. those focussing outside the individual self, such as altruism and benevolence) are more likely to perceive climate change as a greater risk, be supportive of climate change policies and less sceptical about the realities of climate change (Nilsson, von Borgstede and Biel, 2004; Leiserowitz, 2006; Poortinga et al., 2011; Whitmarsh, 2011; Smith and Leiserowitz, 2012; Poortinga et al., 2019). People with self-enhancing values (i.e. those focussing on the self, such as personal achievement and power) are likely to perceive climate change as a low risk (Smith and Leiserowitz, 2012). Therefore, values lead to a nuanced interpretation of climate change risk messages and the same climate information may have a different effect, dependent on the values of the person receiving the information.

In addition to values, much literature has shown that normative social factors likely influence risk perceptions (Griskevicius et al., 2008). Social norms can be defined as "expectations of how people are supposed to act, think or feel in specific situations" (Popenoe, 1983). An example of a social norm, in a Western context, is shaking hands when first meeting someone. The focus theory of normative conduct (Cialdini et al., 1990a) introduces two types of norms: (a) injunctive (prescriptive) norms, which describe what most people approve or disapprove of; and (b) descriptive norms, which refer to

what most others do (Cialdini et al., 1990a). For instance, if climate change is viewed as a high risk by the social groups to which an individual feels a sense of belonging, then it is likely that the individual's perception of climate risk will also be high (van der Linden, 2015). This similarly applies to the actions and behavioural norms of the group. For instance, a carbon-intensive lifestyle, which contributes to climate change, has become a socially-acceptable way of behaving in the West. This lifestyle includes activities such as driving to work, flying to overseas holidays and importing food from foreign countries (Lorenzoni et al., 2007). Therefore, it is important to consider social norms in the study of climate change risk perceptions.

Cultural values and norms are documented as important influencers of risk perceptions (van der Linden, 2015) and there is no reason that this relationship would not hold true in both developing and developed countries. However, research towards understanding predominant values and norms and their bearing on climate change risk perceptions in Africa is lacking in the literature (Corner et al., 2014). A better understanding of these influences would provide greater insight into how people engage with climate change issues and climate services in Africa.

#### 4.3 Socio-demographics

Risk perceptions are also influenced by socio-demographic factors such as gender, age and educational attainment. The differences in risk perceptions based on gender and age are well documented (Davidson and Freudenburg, 1996; Lazo et al., 2000; Sundblad et al., 2007; Henwood, Anne Parkhill, et al., 2008). Psychometric risk perceptions research suggests that risk perceptions tend to be higher amongst women than men and are often found to be higher amongst younger than older people, however, there are cross-country nuances to these general rules (Poortinga et al., 2019). The reasons behind these differences are still debated in the literature (Xiao and McCright, 2015).

Further, higher educational attainment and socio-economic status has been inconsistently linked to either increased (Sundblad et al., 2007) or decreased risk perception (Brody et al., 2008; Akerlof et al., 2013). Where decreased levels of risk perception exist amongst higher socio-economic groups, the reason might be explained through Trope and Liberman (2011)'s proposal, that people in positions of power see themselves as more distant and more immune to climate change effects than people who have less power. These socio-demographic differences in risk perception are important to consider, particularly as they can provide insight into the risk perceptions of those governing a climate change adaptation decision space when their socio-demographic characteristics are known.

## 5. From an understanding of the determinants of risk perceptions to designing climate services for Africa

Since the implementation of the Global Framework for Climate Services in 2009, climate services have evolved from a primary focus on climate data access to one of user-informed and user-driven activities (Lourenço et al., 2015). In fact, the term “climate services” has a spectrum of definitions, ranging from that of a data provision activity to one which embraces the model of transdisciplinary co-exploration and co-production (Hewitt et al., 2012; Lourenço et al., 2015; Taylor et al., 2016). All of these ‘co’ techniques require sustained interactive processes over an extended timeframe. They strive to foster collaborations across knowledge holders and to collaboratively produce tangible knowledge products for climate services. For the purposes of this paper, we adopt the latter broader definition of climate services, which incorporates both collaborative engagements related to how climate considerations can be incorporated into planning as well as the scientifically-driven provision of weather and climate data.

Adopting this broad definition of climate services requires recognising the need to better understand the context in which climate information is being used, in order to inform the development of effective climate services (Clayton et al., 2015). The study of climate change risk perceptions in an African context may reveal that Africans perceive the threat of climate change differently from that of the developed world. Therefore, understanding the context for climate services in Africa through a risk perceptions lens provides an opportunity to inform more appropriate collaborative engagements, relevant timelines for climate-related decision-making, the most appropriate content and format of climate information products and services, and suitable communication and dissemination mechanisms. Each determinant of risk perceptions can provide insights in this regard, as we discuss further below.

An assessment of psychological distance provides insights into the type of climate information (e.g. time periods) that should be communicated because the psychological distance of climate change determines people’s construal level – as abstract (high-level construal) or concrete (low-level construal). The level of construal, in turn, determines the type of information used to make decisions (Trope and Liberman, 2011; Brügger et al., 2016). For instance, situations of psychological proximity may require near-term climate information (daily, seasonal or annual forecasts). In addition, studies have concluded that the way climate change is communicated could be more intentionally matched to the assessed level of construal of the audience (Berson et al., 2015; Brügger et al., 2016) by matching abstract, goal-oriented information to situations of high-level construal and concrete, solution-oriented information to situations of low level construal (Spence and Pidgeon, 2010; Brügger et al., 2016). Concrete information may include, for instance, cost options for implementation of flood

relief measures. In addition, matching low-level construal with visual information framed in terms of losses and high-level construal with verbal information framed in terms of gains, has been shown to lead to greater intentions to engage with the information (Chang et al., 2015; Yan et al., 2016). In cases of low-level construal, for instance, an infographic describing the potential negative impacts of climate change may be an appropriate communication format. When information is intentionally matched to the assessed construal level, the audience are better able to process it and will perceive the information as more salient and persuasive (Brügger et al., 2016).

An understanding of personal experience of extreme events offers value to climate services because the kinds of extreme weather events that routinely impact specific locations provides valuable information about the kinds of climate information (e.g. dry spell duration for analysis of persistent droughts) to focus on in the provision of climate services. It also provides relevant topics for location-specific engagement on climate change. For instance, if an area routinely experiences devastating floods, the topic of flooding could be used as a discussion starter in collaborative decision-maker engagements, to draw decision-makers into a conversation around climate change.

Finally, an understanding of the socio-cultural and socio-demographic context provides insight into the dominant socio-cultural/demographic elements governing the decision space and influencing climate change risk perceptions. This knowledge can feed back into the development of climate services both in collaborative engagement activities and the development of content, format and dissemination techniques for discrete climate data/information products. While data provision is traditionally thought of as a culture and value-neutral activity, in reality, data are often embedded in descriptive reports which include culture-specific, value-laden language. Additionally, there is a recent drive towards disseminating climate data via stories or visions of changing risk, for instance the climate change risk narratives developed under the Future Climate for Africa programme (Scott and Jack, 2017). These stories of change are, by necessity, couched in a particular socio-cultural context. Therefore, it is necessary to interrogate that socio-cultural context in light of the audience for which it is intended.

Designing climate information products based on an understanding of socio-cultural context may include, for instance, matching climate messages to the values of an audience, such as prioritising potential changes to traditional customs that might result from climate change, when designing messages for an audience that prioritises traditional values. An understanding of the socio-cultural context may also inform the use of culturally appropriate language such as using language that remains sensitive to the social position of pastoralists in many cultures. There is also scope to leverage social norms, particularly descriptive norms, if the audience shows a propensity for influence by social

norms (van der Linden et al., 2015). For instance, amongst urban policy decision makers, highlighting the increasing number of African cities joining climate alliances (such as C40) may increase their willingness to engage with climate services for urban planning.

In the case of collaborative engagements, the element of trust between parties is an essential component of a successful engagement (Lacey et al., 2018). In the absence of contextual socio-cultural/demographic knowledge, contrasting perceptions and cultural contexts or approaches can undermine this trust development process, resulting in a perpetuation of the science-society divide (Steynor et al., 2016). More readily understanding the socio-demographic context also has potential to inform more fundamental issues such as the use of accessible language when the language used in the climate information product differs from the predominant first language of the audience.

There are, of course, additional important socio-cultural and demographic elements that require further consideration but for reasons of brevity, cannot be discussed further here. These include activities such as framing messages within a particular social construct (Peterson et al., 2010) or designing age- and gender-appropriate climate messages.

## 6. Conclusion

This paper supports the growing call for interdisciplinary study in the field of climate services, to understand the underlying contextual factors that influence the implementation of climate services in Africa. Africa currently experiences disproportionate impacts resulting from climate variability (WMO, 2014). This means that the context for climate services in Africa is very different from that of developed countries.

One approach to deepening contextual knowledge for climate services is through an understanding of climate change risk perceptions. Currently, climate change risk perceptions in Africa are not well understood, however, it is likely that they differ significantly from the developed country context. This paper goes some way towards addressing this knowledge deficit by providing preliminary evidence with regards to the psychological distance of climate change, which is one determinant of climate change risk perceptions.

Through preliminary evidence gathered across different studies, we posit that climate change is reasonably psychologically close in the African context, at least closer than it is in developed country contexts, where the majority of studies theorise that the psychologically distant nature of climate change is a barrier to engagement with climate change (Spence et al., 2012; McDonald et al., 2015; C. Jones et al., 2017). However, we acknowledge that the evidence presented in this paper does not represent a general public audience and is more representative of professionals/government staff and sectoral experts, so a wider study would be required for a more robust comparison to developed

country findings. In addition, we suggest that more recent research in the developed world is required on the psychological distance of climate change, and that research is required, also, that examines the climate change risk perceptions of decision-makers in this context, as there appears to be a gap in the literature in this regard.

In addition, we emphasise the importance of studying a suite of determinants of risk perceptions in an African context in order to better inform climate services. Relevant determinants include (amongst others): the psychological distance of climate change, experience of extreme weather events, socio-cultural influencers such as values and norms, and socio-demographics. The psychological distance of climate change and socio-cultural influencers on climate change risk perceptions in Africa are, in particular, not well understood currently. There is a need for further exploration and understanding of these risk perception determinants in an African context.

Each of the determinants of climate change risk perceptions can provide value in informing climate services, whether it be through appropriate mechanisms for collaborative engagement, timelines of relevance, the most appropriate content and format of climate information products and services and/or suitable communication and dissemination mechanisms. Through a better understanding of climate change risk perceptions, there is scope to design climate services that more readily fit the specific decision context. While designing climate services based on a better contextual understanding will not overcome all barriers to action on climate change (Corner and Randall, 2011), it will likely increase the salience of climate services for an African audience.

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# Chapter 4: Understanding the links between climate change risk perceptions and the action response to inform climate services interventions

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This chapter consists of the following published paper (further revised based on examiner comments):

**Steynor, A.,** Pasquini, L., Thatcher, A. and Hewitson, B. 2021. *Understanding the links between climate change risk perceptions and the action response to inform climate services interventions*. 41(10). Risk Analysis. DOI: 10.1111/risa.13683

**Lead author (student)** Anna Steynor      **Role:** Conceptualised the paper, obtained the underlying data, undertook the data analysis, interpreted the results and drafted the paper.

**Co-Author:** Lorena Pasquini.      **Role:** Thesis supervisor, guidance, review of draft paper

**Co-author:** Andrew Thatcher      **Role:** Situating the research within the psychology field, statistical methodology advice, review of draft paper.

**Co-author:** Bruce Hewitson      **Role:** Thesis co-supervisor, statistical advice, review of draft paper

The paper serves to identify and better understand the interactions between factors that influence climate change risk perceptions in the African context, with a view to informing climate services. To establish this understanding, the paper develops a model of how climate change risk perception determinants interact to influence climate change risk perceptions and resultant adaptation action. The model structure and climate change risk perception determinants identified in this paper are fundamental for establishing the framework for the remainder of the study. In the following chapters the study uses this framework to a) further investigate each of the climate change risk perception determinants to gain an understanding of the East African decision context (chapter five) and b) relate each of the climate change risk perception determinants in the framework to the use of climate services information to evaluate potential gaps in currently available climate services (chapter six).



### **Abstract:**

*Understanding what motivates people to act on climate change provides an opportunity to design more effective interventions, in particular, climate services interventions, by aligning them with factors that strongly influence action. Climate change risk perceptions have been shown to underlie action on climate change. Therefore, this study performs exploratory research to understand how various determinants of risk perceptions contribute and interact to influence climate change risk perceptions and professional action on climate change in East Africa, in order to inform the context-specific design of climate services. Using data collected through a region-wide survey, a model to risk perceptions and professional action was constructed through structural equation modelling. The model elucidates the cascading effects of variables such as age, gender, education, and personal values on action. In particular, it highlights a split in motivating factors amongst individuals with higher levels of self-enhancing values versus those with higher levels of self-transcending values. The model also highlights the prominent role that experience of extreme weather events, psychological proximity of climate change, climate change risk perceptions, and social norms play in motivating action. The model, therefore, offers a framework for prioritizing the various factors that motivate people to take adaptation action, which, in turn, provides a basis for informing climate services development going forward.*

## 1. Introduction

Given the growing need to proactively prepare for a changing climate through adaptation, it is increasingly necessary to understand what factors drive people to act on climate change, what the relative contributions of these factors are and how they interact to motivate action (van Valkengoed and Steg, 2019). This topic is particularly pertinent in the African context due to the disproportionate impact that climate change is likely to have in Africa (IPCC, 2014). Understanding what motivates people to take action on climate change provides an opportunity to identify and design effective adaptation action interventions (van Valkengoed and Steg, 2019) by aligning interventions with factors that strongly influence action. Of prominence in the suite of intervention activities for promoting adaptation action are climate services.

Climate services include the tailoring, delivery and contextualisation of decision-relevant climate information products (Vaughan et al., 2018) together with user engagement and co-production of information as part of the service delivery activity (Vincent, Daly, et al., 2018). Understanding what drives motivation to act on climate change provides potential to improve the design of climate services such that they align to key motivating factors for adaptation action (Steynor and Pasquini, 2019). This may include, for instance, designing climate services engagements or messages to align with location-specific experience of extreme events, if these experiences are shown to increase people's motivation to act.

To inform climate services, which are generally targeted at people in their professional capacity, it is important to understand what drives work-related adaptation action amongst people who have an ability to influence natural resource policy. In this study, these individuals are referred to as 'policy decision influencers' and are defined as people who directly or indirectly influence the development of principles, plans and courses of action around natural resource management at the local or national level. Examples of such individuals include government officials, researchers, trade union representatives, NGO practitioners, and others. These individuals are an important community because they are an accessible group for introducing adaptation-oriented interventions and are in a position of leadership to drive social adaptations around climate change (Mohamed, 2016). Therefore, an understanding of what factors are key in driving adaptation action in this community could provide the knowledge required for substantial innovation in climate services.

In light of the significant risks posed by climate change, risk perceptions provide a valuable entry point for understanding the factors that motivate climate change action, especially as risk perceptions have been shown to underscore both willingness to act on climate change (Spence et al., 2012; Lo and Chan, 2017; Smith and Mayer, 2018; Xie et al., 2019) and actual action on climate change (Blennow et al.,

2012; Fahad and Wang, 2018; van Valkengoed and Steg, 2019). There is also a significant body of literature from the global North that outlines various antecedent determinants of risk perceptions, providing a basis from which to select factors for inclusion in an adaptation action model (van der Linden, 2015; van Eck et al., 2020)<sup>5</sup>.

On this basis, this study sets out to perform exploratory research to understand how antecedent determinants of risk perceptions interact to influence: a) climate change risk perceptions and b) professional action on climate change amongst policy decision influencers in East Africa, in order to inform c) the development of more contextually-appropriate climate services. To this end, a selection of risk perception determinants was chosen for inclusion in the construction of a causal model (section 2). These risk perception determinants were then investigated through structured surveys with policy decision influencers in East Africa (section 3). The results were statistically analysed using structural equation modelling in order to construct a model to professional action through climate change risk perceptions (section 4) and the results are discussed in light of how they could be used to design more effective climate services (section 5).

## 2. Exploring climate change risk perceptions and their determinants

The literature regarding the ways in which risk perceptions can be measured is abundant and characterized by widespread disagreement about the “best” way to measure risk perceptions (Wilson et al., 2019). While some researchers have taken a general approach to measuring risk perceptions by asking “how risky is X activity?” (e.g. Safi, Smith and Liu, 2012), others take the approach of dividing risk perceptions into the components of affect, probability, and consequence, choosing to focus on one or more of the components as a measurement of risk perceptions (e.g. van der Linden, 2015; Elshirbiny and Abrahamse, 2020). In light of this debate, Wilson, Zwickle and Walpole (2019) performed a meta-analysis of climate change risk perception studies and concluded that “worry about climate change” was an appropriate measurement of climate change risk perceptions. Therefore, worry about climate change was chosen as a measure of climate change risk perceptions for this study. This selection is supported by previous studies taking a similar approach (e.g. Spence, Poortinga and Pidgeon, 2012; Carlton and Jacobson, 2013; Lujala, Lein and Rød, 2015).

In addition to the debate about how to measure climate change risk perceptions, there are also various explanatory factors (or determinants) of climate change risk perceptions documented in the literature (e.g. Akerlof et al., 2013; van der Linden, 2015; Poortinga et al., 2019). While explanatory factors are various, no one set of factors purports to identify 100% of the variance in climate change

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<sup>5</sup> See paper reviewer comment number 4 (annex 3) with regards to the influence of climate change risk perceptions (and their determinants) in the workplace

risk perceptions (van der Linden, 2017), although some models claim higher levels of explained variance than other models (van der Linden, 2015). In addition, previous models mostly hail from the global north, leaving the developing country context understudied in this respect.

Given the bias towards studies focused on developed countries, it is necessary to consider that the developing country context may display somewhat different characteristics, particularly when it comes to the determinants of risk perceptions. In order to tailor this study to the African context, a bespoke set of climate change risk perception determinants have been selected for inclusion, drawing from a suite of climate change risk perception determinants used in the literature. The selection of each risk perception determinant was based on appropriateness to the African context (as will be illustrated in the following sections). As a result, the following climate change risk perception determinants were selected for inclusion: psychological distance (closeness) of climate change, experience of extreme weather events, social norms, values (self-enhancing and self-transcending) and demographic variables (age, gender and education). Each of these determinants are explained in further detail in the following sections.

### 2.1 Psychological distance (closeness) of climate change

Psychological distance is a measure of an individual's perception of a threat as either proximal and real, or distant and abstract (Pahl et al., 2014). It is measured taking into account four components of a threat, namely spatial distance (geographical proximity of the threat), temporal distance (the imminence of the threat), social distance (proximity of the threat to oneself or immediate social groupings), and the likelihood/certainty of the threat (Trope and Liberman, 2011).

The psychologically distant nature of climate change has been well documented in the literature from the global north. In fact, it is often cited as a barrier to action on climate change (Spence et al., 2012; McDonald et al., 2015; C. Jones et al., 2017). There is less evidence on the psychological distance of climate change in developing countries, however, recent studies have posited climate change as psychologically proximal in the African context, substantially more so than in the global north (Steynor and Pasquini, 2019; Steynor, Leighton, et al., 2020). The psychological proximity of climate change in a developing country setting might be a significant driver of climate change risk perceptions and, hence, is likely to be an important factor to consider within risk perceptions models in Africa. Therefore, psychological closeness was considered to be a relevant and appropriate variable for inclusion in this study.

### 2.2 Experience of extreme weather events

While it is scientifically challenging to attribute any one extreme weather event to climate change (van Aalst, 2006), personal experience of extreme events has been documented to increase climate change

risk perceptions by invoking a concrete understanding of the effects of climate change in reality (Akerlof et al., 2013; Reser et al., 2014a; Demski et al., 2017). There is a growing body of evidence that suggests a belief, within Africa, that extreme and erratic weather events are increasing, primarily as a result of climate change (Sutcliffe et al., 2016; Ayal and Leal Filho, 2017; Ayanlade et al., 2017; Mahl et al., 2020). These events, in East Africa, include increased average temperatures, decreased and/or more variable precipitation resulting in heavy rainfall events and flooding, a shorter or delayed rainy season, and longer dry spells and droughts (Gross-Camp et al., 2015; Egeru, 2016; Chepkoech et al., 2018; Mubiru et al., 2018). This growing awareness of changing weather events attributed to climate change suggests that the experience of extreme weather events in Africa may be an important factor in determining climate change risk perceptions.

While experience of extreme climatic events and the psychological distance of climate change have been viewed as interconnected or even inter-changeable in the literature (McDonald et al., 2015), we treat them as separate entities for the purposes of this study. Motivation for this is primarily due to the prominence of the experience of extreme weather events in the African context in comparison to the developed world, which may render it an important variable in determining climate change risk perceptions. In addition, a previous study has noted the possible additional effect that exposure may have on mental construal (strongly linked to the role played by psychological distance in construal level theory) (Förster, 2009). The separation of the two concepts therefore allows us to test the validity of the assertion, from recent literature, that experience of extreme weather events and psychological distance are interchangeable (McDonald et al., 2015; McDonald, 2016).

### 2.3 Observance of social norms

Social norms are external expectations about how one is supposed to feel, behave, or think in particular situations (Popenoe, 1983) and can be divided into descriptive norms (observing what others do) and prescriptive norms (what is generally socially approved / disapproved of) (Cialdini et al., 1990b), for instance, whether a carbon-intensive lifestyle is socially acceptable behaviour (Lorenzoni et al., 2007). This social legitimacy often overrides cognitive knowledge of the damage that carbon-intensive lifestyles cause, aptly demonstrated by the carbon emissions from the air travel of many academics (Wynes et al., 2019), including those in fields related to sustainability and climate change (this study's authors included).

Observance of social norms has been shown to be a powerful influencer of human behaviour, including different environmentally sustainable actions both personally (Griskevicius et al., 2008) and in the workplace (Ture and Ganesh, 2014; Inoue and Alfaro-Barrantes, 2015) as well as of climate change risk perceptions (van der Linden, 2015). As such social norms warrant study in the context of

the current research, because there is no reason why social norms should not be powerful influencers of action on climate change in the African context as well.

#### 2.4 Values

Values are standards or criteria that guide individual action, judgement, choices, attitudes and evaluations (Rokeach, 2008). They transcend specific situational contexts and underlie the moral composition of a person (Schwartz and Bilsky, 1990). For instance, if loyalty is a core value of a person, they will apply this principle universally in their workplace, at home, in friendships, and even with strangers.

The values of self-transcendence and self-enhancement have been shown to link to greater/lesser acceptance and action on a variety of environmental behaviours, including climate change. Previous literature has shown that people with predominantly self-transcending values show greater support for climate change policies and more easily accept the realities and risks of climate change (Poortinga et al., 2011b, 2019; Whitmarsh, 2011). In contrast, predominantly self-enhancing values are associated with a lower perceptions of climate change risk (Smith and Leiserowitz, 2012). Therefore, a person's values are important in informing climate change risk perceptions and action on climate change, yet there is a paucity in research on the values landscape in Africa and their influence on climate change perceptions (Corner et al., 2014).

#### 2.5 Demographics

Socio-demographic characteristics such as age, gender, and educational attainment have all been shown to influence climate change risk perceptions (van der Linden, 2014) and are, therefore, important to consider in the African context. For instance, women are more likely to exhibit elevated perceptions of climate change risk when compared to men (Sundblad et al., 2007; Henwood, Parkhill, et al., 2008). Educational attainment is inconsistently linked to either higher (Sundblad et al., 2007) or lower risk perceptions (Brody et al., 2008; Akerlof et al., 2013). Similarly, age is inconsistently linked to climate change risk perceptions in the literature, with advancing age linked with both higher perceptions of climate change risk (Lazo et al., 2000), lower perceptions of climate change risk (Gallup, 2018a; Ballew et al., 2019), or no effect on climate change risk perceptions (Shi et al., 2016).

Using the outlined risk perception determinants, the following section presents a methodology for exploring the relationship between each of these selected risk perception determinants and how they influence two outcomes: risk perceptions (worry about climate change) and professional action on climate change.

### 3. Materials and methods

#### 3.1 Procedure and participants

Data to inform the study were collected through structured surveys and subjected to University ethical clearance procedures. Consent forms acknowledging anonymity of the responses were collected from all participants. All respondents took part in the project on a voluntary basis with no reward for their participation.

The targeted participant group for this study consisted of policy decision influencers in the East Africa region. The majority of respondents (38%) were sourced from national and local government ministries. Other organisations included the private sector (18%), research organisations (16%), non-governmental organisations (11%), parastatals (8%), trade unions (5%) and international development agencies (4%). The main criterion for inclusion was that the respondents' organizations should have a direct or indirect influence on a country's development or natural resource policy. Specific respondents at each organisation needed to be in roles where they would be expected to use, or benefit from using, climate information in the achievement of their professional activities. During the design phase for the structured survey, the draft survey was pilot tested with academics from various African countries (N=7) whose first language was not English. In response to the pilot phase, the survey was revised based on feedback, particularly with regards to clarifying ambiguous language and unclear questions.

Through a competitive process, in-country enumerators were selected to undertake surveying in their home countries (Ethiopia, Kenya, Rwanda, Tanzania and Uganda). Prior to surveying, each enumerator was trained and provided with a detailed instruction sheet, in order to ensure that each country's data were collected in a consistent manner. Enumerators were supplied with a proposed list of organisations to approach (which had been co-developed with stakeholders in the region at a prior workshop based on the broader research project). Additional participants were then further identified through a snowball approach. Surveying took place between September 2018 and January 2019. Each survey was conducted in a one-on-one dialogue format between the respondent and the enumerator, with the exception of the values section, which is particularly susceptible to social desirability bias. This section was completed by the respondent, independent of the enumerator (i.e. the respondent filled in this section of the survey themselves), in order to minimise this potential bias.

The dataset comprised of a total of 474 complete surveys (representing a participant response rate of 77%) across the five East African countries. Given that the general guidance on sample size is to have at least 10 participants for each included parameter (professional action, social norms etc) (Schreiber et al., 2006), the minimum criteria of 100 respondents was more than adequately met. The final

sample consisted of 70,3% male and 29,7% female respondents with an average age of 30-39 years and an average educational level of an undergraduate university degree.

### 3.2 Measures for the structured survey

As the data collection activities formed part of a wider funded project on assessing climate change information use in decision making<sup>6</sup>, only the constructs relevant to the findings reported here are detailed in this section.

#### 3.2.1. Professional action on climate change

One item was included with respect to whether the participant reported taking general action, as part of their job activities, to prepare for the impacts of climate change. This item was designed to elicit a response based on actual reported action as opposed to a willingness to act by asking the respondent to rate how strongly they agreed with the statement “As part of my job activities, I do things (at least sometimes) that help to prepare for the impacts of climate change”. This self-report single measure was chosen because the study was focused on the "internal landscape" of respondents, and therefore on which risk perception determinants play a greater/lesser role in respondents' perceptions of risk, and their consequent effects on professional action. Therefore, this simple self-report measure about whether respondents perceive themselves to be taking action at work is more important for the purposes of this investigation than the details of the actions taken. For the purposes of this analysis, responses to this item were referred to as ‘professional action’ on climate change<sup>7</sup>. The response was recorded on a five-point Likert scale from ‘strongly disagree’ to ‘strongly agree’.

#### 3.2.2. Climate change risk perceptions

As detailed at the outset, worry about climate change was used, in this study, as a measure of risk perceptions. Many previous studies have referred to the term ‘concern’ when measuring this variable. However, it is important to draw a distinction between the terms ‘concern’ and ‘worry’. It is possible to be concerned about something without being actively worried about it. When assessing action on climate change, previous studies have suggested that ‘worry’ is a better indicator to use than ‘concern’ (van der Linden, 2017) because if someone is worried about something (as opposed to generally concerned) they are more likely to act on it (van der Linden, 2017). Therefore, for this study, items were phrased in terms of ‘worry’ about climate change. Three items were used to assess overall worry about climate change, namely general worry about climate change, as well as worry at a personal and community level. These were measured on a five-point Likert scale from ‘not worried’ to ‘very

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<sup>6</sup> This work was funded under the WISER TRANSFORM project (<https://www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser/transform>)

<sup>7</sup> See paper reviewer comment number 5 (annex 3) with regards to the measure of professional action on climate change



worried'. The responses from the three items were combined into a construct ( $\alpha = 0.739$ ) for analytic purposes.

### *3.2.3. Psychological distance (closeness)*

Building on items developed by Spence et al. (2012), a total of seven items were proposed to represent the spatial, temporal, social, and hypothetical dimensions of psychological distance, as described by Trope and Liberman (2011). The social distance component was disaggregated into two questions regarding a) whether climate change will have a big impact on the respondent personally and b) whether climate change will have a big impact in the respondent's local area. The spatial distance component was similarly disaggregated into two questions regarding a) whether the respondent's local area is likely to be affected by climate change and b) whether climate change will mostly affect areas far away. Hypothetical distance was measured through two questions regarding a) whether climate change is happening and b) whether the effects of climate change are certain. Lastly the temporal component was measured through a question eliciting responses as to when the effects of climate change will be felt. Participants were asked to rank their response along a five-point Likert scale from 'strongly disagree' to 'strongly agree', except for the temporal distance question, which included timescales from "never" to "the effects are already being felt" as five response options. For analysis, a construct of psychological distance was created from six of those items ( $\alpha = 0.679$ )<sup>8</sup> with higher values representing increasing psychological closeness (therefore this construct is henceforth referred to as psychological closeness).

The one excluded item pertained to whether the participants thought that climate change would mostly affect areas that are far away from their location (one measure of spatial distance). This item was excluded because it resulted in reduced internal reliability of the scale. The exclusion of this particular item of spatial distance is supported by previous literature which finds that perceptions pertaining to the distant impacts of climate change can be anomalous in direction when compared to the other dimensions of psychological distance (e.g. Gifford et al., 2009; Spence, Poortinga and Pidgeon, 2012; Schultz et al., 2014). For this reason, the exclusion of this item was considered justifiable.

### *3.2.4. Experience of extreme weather events*

Four items were used to measure experience with extreme weather events. Survey participants were asked to recall how often, in the last five years, they had experienced a) flood events, b) droughts, c) high temperatures/heat events, and/or d) change to the rainy season pattern. A five-point Likert scale was used to record responses from 'never' (zero times) to 'very often' (more than ten times) and

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<sup>8</sup> Cronbach's Alpha ( $\alpha$ ) denotes the internal consistency of the construct.  $\alpha$  of greater than 0.6 generally denotes acceptable internal consistency (Ursachi et al., 2015)

assigned a value of one to five for analysis purposes. Each participant's scores were combined into an additive scale in order to provide a total value relating to overall exposure to extreme weather events. Since experience with one type of extreme weather event is not necessarily related to experience of a different extreme weather event, an internal reliability measure is not sensible.

A further item was posed in order to assess whether those extreme weather events were personally attributed to climate change. The vast majority (96.42%) of the participants attributed their experience of either some or all of the extreme weather events to climate change. Therefore, as asserted by Akerlof et al. (2013) it can be assumed that personal experience of extreme events broadly equates to personal experience of climate change.

### *3.2.5. Social norms*

Six items were used to measure the observance of social norms. Three items were designed to assess descriptive norms: two measured the level of observance of social referents (friends/family and colleagues respectively) taking action on climate change. A third item measured the level of observance of colleagues using weather/climate information in a work environment. A further three items were designed to measure prescriptive norms: two measured the respondent's perceptions as to whether family/friends and colleagues expect them to take action on climate change themselves (respectively in a personal and professional capacity). The third item measured the respondent's perceptions as to whether colleagues expect them to use weather/climate information themselves in their work capacity. Responses were measured on a five-point Likert scale from 'strongly disagree' to 'strongly agree'. For analysis, a construct of social norms was created from all six items ( $\alpha = 0.761$ ).

### *3.2.6. Values*

Values were assessed using the Schwartz (2003a) Portrait Values Questionnaire on a seven-point Likert scale from 'not like me at all' to 'very much like me'. The 21-item modification of the original 57-item questionnaire (Schwartz, 1992) was used for the purposes of this study because the 21-item modification is designed to be more accessible across educational levels than the original Portrait Values Questionnaire. This questionnaire is based on Schwartz's (1992) theory of values which breaks down human values into ten fundamental categories.

Using the guidance from Schwartz (2003b), responses for each of the ten basic values were converted to centred value scores. Due to the documented link between self-enhancing and self-transcendent values to acceptance and action on climate change (described earlier), a focus was placed on the results of these two higher-order values for the purposes of this study. Therefore, combined centred scores for self-transcending values (benevolence and universalism) ( $\alpha = 0.735$ ) and self-enhancing values (achievement and power) ( $\alpha = 0.644$ ) were used for analytic purposes.

### 3.2.7. Socio-demographics

A range of socio-demographic information was collected including gender (male, female and non-binary), age range (in ten-year bands, e.g. 20 to 29, etc.) and educational level. Educational level data were arranged into an ordinal scale from 1 to 5 with, 5 representing a doctoral degree and 1 representing a school leaver's certificate.

### 3.2.8. Use of weather and climate information services

Finally, in order to undertake a post-hoc analysis that drew linkages between professional action and the design of climate services, a further question on the use of weather and climate information services was included. This question assessed the frequency of weather or climate information use as part of the respondent's job. Responses were measured on a five-point frequency scale from 'never' to 'very frequently'.

### 3.3. Analysis

Using the data collected through the structured survey exercise, a series of statistical analyses were performed in order to construct a conceptual explanatory model for professional action. Firstly, descriptive statistics were generated for each of the dependent and independent variables using Spearman's correlation analysis, due to the ordinal nature of the Likert scale data as well as the non-normality of many of the data distributions. Secondly, a multiple linear regression analysis was performed to better understand the predictors of climate change risk perceptions and professional action on climate change. In order to perform this regression analysis, where there was non-normality in the data, a reflect and logarithm or a reflect and square root procedure transformation was used, depending on the degree of skewness. Finally, a conceptual model was constructed and the validity and robustness of the model was tested through structural equation modelling. To examine the model fit, Schreiber et al.'s (2006) proposed cut-off criteria for fit were used. These include:  $\chi^2/df \leq 3$ , Goodness of fit index (GFI)  $\geq 0.95$ , Adjusted GFI (AGFI)  $\geq 0.95$ , Comparative fit index (CFI)  $\geq 0.95$ , Tucker-Lewis index (TLI)  $\geq 0.95$  and the Root Mean Square Error of Approximation (RMSEA)  $\leq 0.05$ .

## 4. Results

### 4.1 Intercorrelations and descriptive statistics

Table 4.1: Intercorrelations between model variables

<i>N</i> = 474	1	2	3	4	5	6	7	8	Mean	SD
1. Professional action	--								4.18	0.80
2. Climate change risk perceptions	.251**	(0.739)							13.24	1.67
3. Social norms	.366**	.179**	(0.761)						22.45	3.80
4. Psychological closeness	.232**	.409**	.170**	(0.679)					27.18	2.49
5. Experience of extreme events	.149**	.194**	.080	.218**	--				12.44	3.12

6. Self-enhancing values	-.010	-.074	.103*	-.065	-.121**	(0.644)			-0.50	0.70
7. Self-transcending values	.068	.049	-.024	.100*	.112*	-.545**	(0.735)		0.51	0.49
8. Age	-.004	-.016	.100*	-.003	.063	-.022	.052	--	2.27	1.00
9. Education	.065	.019	-.099*	.072	.070	-.164**	.173**	.134**	3.33	0.81

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

Bracketed numbers represent the Cronbach Alpha value

Through correlation analysis it was found that social norms, psychological closeness and experience of extreme events were all significantly and positively correlated ( $\rho = 0.01$ ) to both risk perceptions and professional action ( $r = .149$  to  $r = .366$ ). Social norms were most strongly correlated to professional action ( $r = .366$ ) and psychological closeness was most strongly correlated to risk perceptions ( $r = .409$ ) (Table 4.1).

As a categorical variable, gender was analysed separately through a Mann Whitney test. The only statistically significant difference between the genders was found in self-enhancing values. Males had significantly higher self-enhancing values than females ( $\rho = .02$ ,  $r = .11$ ).

#### 4.2 Regression analysis

As an initial multi-collinearity test confirmed a lack of multi-collinearity within the data, multiple linear regression was used to explore which of the independent variables explained the greatest variance in 1) climate change risk perceptions and 2) professional action on climate change.

##### 4.2.1 Climate change risk perceptions

The multiple linear regression revealed a statistically significant model, explaining a total of 18.4% of the variance in climate change risk perceptions ( $F(8, 465) = 14.302$ ,  $\rho < .001$ ,  $Adj R^2 = .184$ ). The regression revealed that psychological closeness ( $t = 8.734$ ,  $\rho < .001$ ), social norms ( $t = 2.327$ ,  $\rho = .020$ ), and experience of extreme events ( $t = 0.040$ ,  $\rho = .040$ ) were significant predictors of climate change risk perceptions while psychological closeness was the dominant predictor ( $\beta = 0.380$ ) (Table 4.2).

##### 4.2.2 Professional action on climate change

For professional action, climate change risk perceptions were included as an additional independent variable because of the known positive influence that risk perceptions have on action, shown through the descriptive statistics (Table 4.1) and supported by the literature (Spence et al., 2012; Singh et al., 2017). Again, the multiple linear regression revealed a statistically significant model, explaining a total of 18.1% of the variance in professional action ( $F(9, 464) = 12.615$ ,  $\rho < .001$ ,  $Adj R^2 = .181$ ). The regression revealed that social norms ( $t = 7.403$ ,  $\rho < .001$ ) and risk perceptions ( $t = 2.936$ ,  $\rho = .003$ )

were both significant predictors of professional action, while social norms was the dominant predictor ( $\beta = 0.321$ ) (Table 4.3).

*Table 4.2: Regression of risk perception determinants on climate change risk perceptions*

<b>Independent variables</b>	<b>B</b>	<b><math>\beta</math></b>	<b>t</b>	<b><math>\rho</math></b>	<b>95% confidence interval for B bound</b>	<b>95% confidence interval for B upper bound</b>
Psychological closeness	.338	.380	8.734	.000	.262	.415
Social norms	.040	.100	2.327	.020	.006	.074
Experience of extreme events	.008	.088	2.056	.040	.000	.015
Self-enhancing values	-.021	-.055	-1.100	.272	-.059	.017
Self-transcending values	.004	.007	.142	.887	-.050	.058
Education	-.006	-.017	-.400	.689	-.034	.022
Gender	.028	.047	1.109	.268	-.021	.077
Age	-.013	-.017	-.392	.695	-.081	.054

*Table 4.3: Regression of climate change risk perceptions and its determinants on professional action*

<b>Independent variables</b>	<b>B</b>	<b><math>\beta</math></b>	<b>t</b>	<b><math>\rho</math></b>	<b>95% confidence interval for B bound</b>	<b>95% confidence interval for B upper bound</b>
Social norms	.088	.321	7.403	.000	.065	.111
Climate change risk perceptions	.094	.136	2.936	.003	.031	.156
Psychological closeness	.056	.092	1.946	.052	-.001	.112
Experience of extreme events	.004	.075	1.745	.082	-.001	.010
Self-enhancing values	.003	.012	.238	.812	-.023	.029
Self-transcending values	.019	.049	.997	.320	-.018	.056
Gender	-.031	-.077	-1.805	.072	-.065	.003
Education	.018	.080	1.862	.063	-.001	.038
Age	-.036	-.064	-1.513	.131	-.082	.011

### 4.3 Conceptualising a model to professional action on climate change

Using this preliminary analysis, a conceptual model was constructed to map the interactions between each variable included in the analysis and how they lead to professional action on climate change. The model was then theoretically checked to simplify pathway interconnections and ensure that a sensible argument could explain each individual pathway.

As a final step, the conceptual model was tested through structural equation modelling (SEM) in AMOS 26. SEM is an appropriate technique for testing causality because it tests the measurement and structural model simultaneously, thereby testing direct and indirect effects of the model variables on the outcome while adjusting for measurement error (Dietz et al., 2007). The model was estimated based on maximum likelihood with 1000 bootstrap samples and 95<sup>th</sup> percentile confidence intervals. The final causal model and fit statistics are presented in Figure 4.1. Based on the Schreiber et al.'s (2006) accepted fit statistic criteria, the model represents a very good fit, therefore no post-hoc tests were performed.

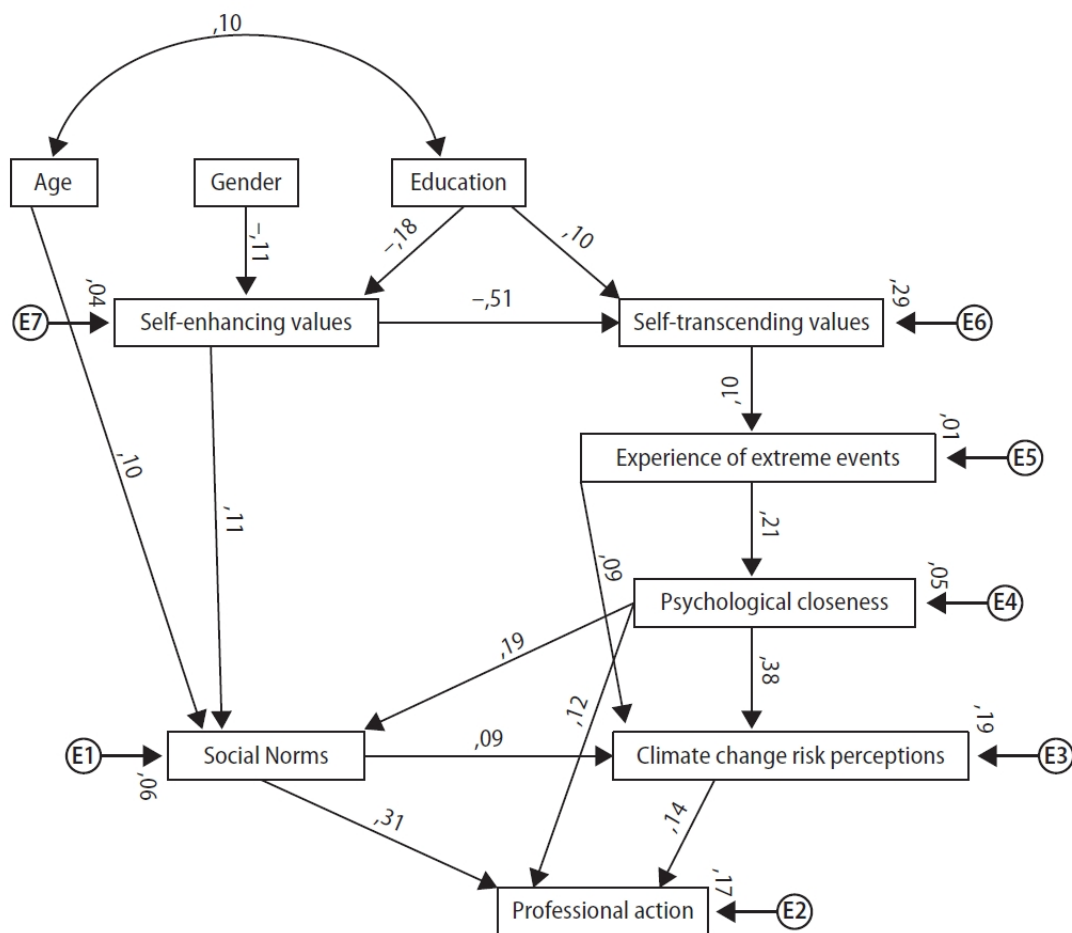


Figure 4.1: Model showing the pathways from risk perception determinants to risk perceptions and professional action on climate change. The standardised regression weights are represented numerically on each pathway line and are all statistically significant. E1 to E8 refer to the error

terms. Model fit statistics:  $\chi^2/df$ : 1.441; GFI = 0.983; AGFI = 0.968; CFI = 0.970; TLI = 0.953; RMSEA = 0.031; RMR = 0.029.

#### 4.3.1 Statistical interpretation of the model pathways

Tables 4.4 and 4.5 break down the effects of each of the predictor variables into direct and indirect effects.

##### 4.3.1.1 Climate change risk perceptions (Table 4.4)

The psychological closeness of climate change had the biggest direct effect on risk perceptions ( $\beta = .38$ ). Experience of extreme climatic events also had a large effect on risk perceptions, however, this was shared between direct ( $\beta = .093$ ) and indirect ( $\beta = .085$ ) effects. Experience of extreme events had a comparatively large direct effect ( $\beta = .214$ ) on psychological closeness, which explains its indirect effect on risk perceptions. However, the direct pathway from experience of extreme events to risk perceptions was also important, and statistically significant, in the model, signifying that experience of extreme climate events was important in influencing risk perceptions in its own right. Observance of social norms also had a small but direct effect ( $\beta = .09$ ) on risk perceptions.

##### 4.3.1.2 Professional action (Table 4.5)

The observance of social norms had the largest direct effect on professional action on climate change ( $\beta = .311$ ). The second largest effect on professional action came from risk perceptions ( $\beta = .142$ ) through direct effects. A third major contributor towards professional action came from the psychological closeness of climate change. However, approximately half of this effect was indirect ( $\beta = .115$ ), through risk perceptions and the observance of social norms, while the remainder was from a direct effect on professional action ( $\beta = .122$ ).

While the other antecedent variables of risk perceptions in the model did not have direct effects on risk perceptions or professional action, they were, nevertheless, important in influencing the antecedents of both. For instance, education had a direct effect ( $\beta = .096$ ) on the presence of self-transcending values and a negative effect ( $\beta = -.176$ ) on self-enhancing values. In turn, the presence of self-transcending values had a direct effect ( $\beta = .104$ ) on the reported experience of extreme climatic events and self-enhancing values had a direct effect on the observance of social norms ( $\beta = .11$ ).

Table 4.4 Direct and indirect effects on climate change risk perceptions

<i>Climate change risk perceptions</i> ( $R^2 = .191$ )	B	$\beta$	SE	$\rho$
<b>Direct effects</b>				
Experience of extreme events	.008	.093	.004	.028
Psychological closeness	.338	.380	.038	.000
Social Norms	.037	.092	.017	.028
<b>Indirect effects</b>				

Education	.001	.002
Age	.008	.010
Self-enhancing values	.000	.001
Self-transcending values	.010	.019
Experience of extreme events	.007	.085
Psychological closeness	.016	.018

Table 4.5: Direct and indirect effects on professional action

<b>Professional action</b> ( $R^2 = .175$ )	<b>B</b>	<b><math>\beta</math></b>	<b>SE</b>	<b><math>\rho</math></b>
<b>Direct effects</b>				
Psychological closeness	.074	.122	.028	.009
Climate change risk perceptions	.097	.142	.032	.002
Social Norms	.085	.311	.012	.000
<b>Indirect effects</b>				
Gender	-.001	-.003		
Education	-.001	-.005		
Age	.019	.034		
Self-enhancing values	.009	.032		
Self-transcending values	.003	.007		
Experience of extreme events	.004	.064		
Psychological closeness	.070	.115		
Social Norms	.004	.013		

## 5. Discussion

### 5.1 Conceptual interpretation of the paths

While the statistical interpretation of the model has been presented above, it is also important to theoretically check the model to ensure it makes conceptual sense. To this end, we start with the beginning of the pathway to action, which consists of the socio-demographic variables (age, gender and education). Socio-demographic variables, particularly age and gender, are stable variables with limited influence from external stimuli so are, by necessity, represented as initial variables in the pathway to action. There was a positive correlation amongst the socio-demographic variables of age and education. This suggests that higher education levels are associated with advancing age, likely because advanced age affords greater opportunity (in terms of time) of enrolling and completing studies, particularly tertiary education, that may be progressively undertaken over the course of an individual's lifetime.

Also, near the beginning of the pathway, yet significantly influenced by the level of education of an individual, are self-enhancing and self-transcending values. As education increased, so did levels of



self-transcending values. This relationship was reversed for self-enhancing values, i.e. as education decreased, self-enhancing values increased. This finding supports studies such as the meta-analysis undertaken by Hyman (1979) documenting the effect that education has on promoting more self-transcendent values; it also aligns with the findings of Post and Meng (2018), who document that more education increases pro-environmental priorities over economic priorities. Conceptually, as an individual becomes more educated, they have an increased knowledge and understanding of the wider world and their place within it. As noted by Stevenson and Peterson (2015) this may, in turn, stimulate a focus to outside of themselves, underpinning a self-transcendent value system. The converse would then hold true for self-enhancing values resulting from lower education. Since self-enhancing and self-transcending values were found to be negatively correlated (as expected, based on being opposing values within Schwartz et. al.'s (2012) multi-dimensional values structure), they are represented on either side of the model in Figure 4.1, signifying the beginnings of a split and dual pathway to action.

The first pathway to action (represented on the left-hand side of the model in Figure 4.1), applies mainly to those with higher levels of self-enhancing values. In one prior study, norms have been shown to be mediators between self-transcending values and policy support for climate change action (Nilsson et al., 2004). However, our model showed that individuals with higher levels of self-enhancing values were also likely to observe social norms, presumably because such observance may best aid their individual achievement (as opposed to being motivated by the collective good). Traditionally seen as the bread-winners of society, males are more likely to have higher levels of self-enhancing values than females (Schwartz and Rubel-Lifschitz, 2009). The relationships between gender, values and norms are reflected in Figure 4.1 by a direct effect of gender (males) on self-enhancing values and a direct effect of self-enhancing values on observance of social norms. Social norms were the single most important driver of professional action on this side of the pathway. The positive relationship between social norms and climate change action has been documented in the literature (Lo, 2013; Fielding and Hornsey, 2016; van Valkengoed and Steg, 2019).

The second pathway to action (represented on the right-hand side of the model) applies to individuals holding higher levels of self-transcending values. Individuals with higher levels of self-transcending values were more likely to report experience of extreme weather events that were linked to climate change, perhaps due to a heightened awareness of the world around them (as self-transcending values are those that focus outward of the individual). This experience of extreme events was found to bring climate change psychologically closer and increase climate change risk perceptions, as noted before in the literature (e.g. Spence, Poortinga and Pidgeon, 2012; Steynor et al., 2020). In our model,

risk perceptions and psychological closeness were both important drivers of professional action on climate change.

Additional pathways to action were found from psychological closeness through social norms, and from social norms through risk perceptions. This pathway supports van der Linden's (2015) positioning of social norms as a driver of risk perceptions. However, these links are likely context-specific to areas where the social norm is to take action on climate change. If the social norm was for inaction, the positive correlations between psychological closeness, social norms and risk perceptions would likely break down because of a logically incompatible response to the risk.

### 5.2 The generalisability of this model to other contexts

While the individual links between the different model variables are supported by current literature (refer to section 5.1), they have not, before, been analysed in concert with each other in the context of reported climate change action, as done here. This model, therefore, fills a gap in understanding that was noted by van Valkengoed and Steg (2019) as critical to properly determining the effect sizes of each variable in influencing climate change adaptation behaviour. While this model was developed within the context of East African policy decision influencers, the fact that each of the individual links has support in international literature, suggests that these connections may not be unique to the East African region. Therefore, the model presented here not only offers a model for how various risk perceptions determinants may link together to motivate climate change action in the wider African context but might be widely applicable to other international contexts too.

One situation in which the model presented here may not be generalisable elsewhere is in contexts where the social norm is for inaction on climate change. In this case, as noted above, the links from psychological closeness to social norms and from social norms to risk perceptions may differ. The relationship between social norms and risk perceptions is particularly complex because, while our model shows social norms influencing risk perceptions, it could be argued that risk perceptions may also influence social norms (Lo, 2013). Therefore, there could be a bi-directional relationship that is not explored through the current model because the data is cross-sectional in nature.

### 5.3. The relationship between psychological closeness and experience of extreme events

The experience of extreme events and the concept of psychological closeness has previously been conflated in the literature (McDonald et al., 2015; McDonald, 2016). By separating them in this study, we are able to provide commentary on the validity of conflating these two concepts. The African context is a particularly good setting in which to test this interconnectivity because experience of extreme events is documented as being high (Below et al., 2015; Sutcliffe et al., 2016; Ayal and Leal Filho, 2017; Ayanlade et al., 2017).

Counter to current arguments, the relationship between experience of extreme events (thought to be due to climate change) and psychological closeness was not as high as one might expect, with a correlation coefficient of 0.218 (Table 4.1). Based on effect size guidance from Gignac and Szodorai (2016) and Funder and Ozer (2019), the relationship between the two variables falls into the medium effect range ( $r > 0.2$ ). This shows that the psychological distance variable was influenced by more factors than solely past experience of extreme events thought to be due to climate change. These additional factors may include personal values and education, as shown through this study, but also potentially other unexplored variables. This is an important finding from the study and supports the decision to separate the variables of experience of extreme events and psychological closeness in our model.

#### 5.4. Using an understanding of the drivers of climate change action to inform the development of climate services

In support of evidence-based decisions, one would expect there to be a positive correlation between professional action on climate change and the frequency of use of weather and climate information. However, the correlation analysis revealed a small ( $r = 0.219$ ;  $p = 0.01$ ) correlation between the two variables in this study, meaning that the frequency of use of weather and climate information in taking action on climate change was lower than one might expect.

Much literature suggests that the lack of climate information use (amongst those who would be expected to use it) is because of poorly designed climate information that is not accessible, understandable, or context-specific (Vogel and O'Brien, 2006; Dilling and Lemos, 2011; Lemos et al., 2012; Porter and Dessai, 2017; Vogel et al., 2019). A better understanding of the factors that influence risk perceptions and action on climate change provides insight into the context-specific needs of climate services users. Therefore, this understanding helps to facilitate the design of climate services that better align to the underlying influencers of action amongst such users. In other words, the more climate services can account for factors that influence risk perceptions and actions, the more they will be used when taking action.

While the model presented here elucidates the cascading effects of variables such as age, gender, education, and values on action, it importantly highlights the prominent role that experience of extreme weather events, psychological proximity of climate change, climate change risk perceptions, and social norms play in motivating action. The model, therefore, provides a framework for prioritising the different factors that motivate adaptation action, suggesting which factors could be of focus for informing climate services development. For example, observance of social norms stands out as a prominent motivating factor for action, and, therefore, could offer low-hanging fruit for climate services interventions that leverage or align to the current social norms. Such interventions may

include, for instance, interventions designed to highlight the frequency of desired climate information use behaviours, e.g. messages such as “80% of urban planning professionals are using climate information in their planning”. As another example, an understanding of an audience’s psychological proximity to climate change would allow for an appropriate matching of climate information framings. Previous literature has suggested that if climate change is psychologically close then audiences may respond better to concrete, solutions-orientated information (Spence and Pidgeon, 2010; Brügger et al., 2016). Using the model developed in this study as a foundation, future research can usefully undertake detailed investigations into the ways in which individual action-motivating factors could be used as a basis for informing the development of climate services.

## 6. Conclusion

This study advances our understanding of the relative contributions of various risk perception determinants to professional action on climate change by providing a model to professional action through risk perceptions. While individual linkages between each of the determinants in the presented model are documented in the literature, the developed model responds to the call for the determinants to be examined in concert with each other (van Valkengoed and Steg, 2019). The results highlight a dual pathway to action on climate change, dependent on individual value systems, and demonstrate the importance of experience of extreme weather events, psychological proximity of climate change, climate change risk perceptions, and social norms in motivating action.

The findings in this study offer a springboard for further investigating interventions that align with motivating factors for action on climate change. In particular, the model presented here informs the, currently, high profile intervention of climate services. Understanding the prioritisation of factors that motivate action on climate change allows for the design of climate services that better align to priority factors and are, therefore, better suited to the East African context and the specific audience of policy decision influencers.

It is acknowledged that further research is required to address some of the limitations of this study and fully elucidate the reasons behind the linkages within the pathway. For instance, this study took place amongst a very specific sample of people (policy decision influencers) who were purposefully identified rather than randomly sampled. The characteristics of this group may differ from the general population, for example policy decision influencers have a consistently high climate change literacy, likely higher than the general public, so climate change literacy was not included as a climate change risk perception determinant. While it is never possible to include all possible variables in a single study, further research may also reveal significant variables that have been excluded from the current model, such as the explicit inclusion of affect or emotions and other psychological heuristics. The

inclusion of additional variables may, in turn, have the effect of increasing the explained variance in comparison to the current model. Furthermore, while this model investigates the individual action context, there are likely to be additional structural factors that affect professional action on climate change such as institutional priorities, shared decision-making or resource capacities.

However, the current model can be viewed as a robust model for the individual action context from which further research could emanate and provides exciting possibilities for leveraging understanding of what drives action on climate change to encourage behaviour change among policy decision influencers in Africa. These findings are valuable given that the majority of the current literature on climate change risk perceptions and adaptation action is rooted in the developed world.

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## Chapter 5: Using a climate change risk perceptions framing to align climate services to the East African decision context

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This chapter consists of the following submitted paper (further revised based on examiner comments):

**Steynor, A.** and Pasquini, L. Using a climate change risk perceptions framing to align climate services to the East African decision context. Under review. Climate Services

**Lead author (student)** Anna Steynor      **Role:** Conceptualised the paper, obtained the underlying data, undertook the data analysis, interpreted the results and drafted the paper.

**Co-Author:** Lorena Pasquini.      **Role:** Thesis supervisor, guidance, review of draft paper

This paper serves to better understand the East Africa decision context for climate services by qualitatively exploring and explaining each of the climate change risk perception determinants determined in in the previous chapter (chapter four). Using this understanding, and drawing on known psychological principles, the paper goes on to identify particular interventions that climate services could employ to better align climate services to the East African decision context. These suggestions form an integral part of the final consolidated framework for the enhancement of climate services, proposed in the final discussion chapter (chapter seven) of this study.

### **Abstract:**

*A better understanding of the decision context within which climate services are used is likely to be central to designing user-relevant climate services for adaptation action. As climate change presents a risk, one entry point to better understand the decision context is through an exploration of the perceptions of climate change risk. How risky climate change is perceived to be will influence whether action is taken on climate change, what decisions are made and the types of information that are used when taking action, providing valuable insights into the decision-context. This study quantifies and*

*explores climate change risk perceptions, and its determinants, amongst policy decision influencers in East Africa. Climate change risk perceptions are found to be heightened, driven by observance of social norms, perceptions of climate change as a proximal risk, frequent experience of extreme weather events and a predominantly self-transcending (outward looking) value system among policy decision influencers. By drawing on known principles from environmental psychology, the study's results lead to a set of suggestions about how currently available climate services could be better aligned to the East African decision context. This alignment is recommended for enhancing the utility and uptake of climate services in decision making.*

## 1. Introduction

Climate services are widely regarded as the key to building capacity to adapt to climatic changes (Lourenço et al., 2015). They include the production of contextualised climate information, tailored delivery of climate messages and associated user engagement activities (Vincent, Daly, et al., 2018), all aimed at enhancing the integration of climate information into decision making. Despite their relative infancy, climate services are burgeoning in response to a need from the decision-making community to plan for the impacts of climate change (Hewitson et al., 2017). However, they are growing alongside a decision context that is generally not yet well understood, including what influences decisions and the types of information used in decision making. Furthermore, the contextual specificities of the developing world are not often considered in the development, tailoring and supply of climate services to Africa (Hewitson et al., 2017). Instead, climate services are, often, biased towards the specific contexts of the global north, where the majority of climate services originate (WMO, 2017). This limited understanding of the African decision context has led scholars to suggest that there is a mismatch between the way climate services are supplied and what is required for decision-making in Africa, thereby limiting the use of climate information in decision making (Jones et al., 2015; Singh et al., 2018; Vincent, Daly, et al., 2018; Vogel et al., 2019).

The low level of climate information use in decision making was confirmed by Steynor et al. (2021) who found that, despite high levels of reported action on climate change, the frequency of weather and climate information use amongst policy decision influencers in East Africa was lower than expected. Policy decision influencers are defined (in this context) as people with a direct or indirect influence on natural resource management through principles and plans at the national to local level, such as individuals from national and local government ministries, non-governmental organisations, research institutions, trade unions, international development agencies, parastatals and the private sector.

The proposition that the lack of alignment to context-specific needs is rendering climate services less salient for decision-making is supported by the principles of social marketing (an approach widely used to develop activities aimed at changing or maintaining people's behaviour for the benefit of individuals and society as a whole). Social marketing principles assert that simply providing information is not enough for people to use it (Maibach, 1993). In order for information to be effective it should align with the needs of the people to whom it is aimed, to deliver a "product" that appeals to them (Peattie and Peattie, 2009). This alignment requires a deep understanding of the audience for which products or services are developed, in order to tailor related messages to an audience's existing values, beliefs, and preferences (Peattie and Peattie, 2009), as well as other factors that make up their decision context.



Taking these insights into consideration, designing enhanced climate services for Africa requires a better understanding of the decision context within which climate services are used (Steynor and Pasquini, 2019). This understanding is likely to be central to designing climate services that are more effectively taken up and used in adaptation action. As climate change presents a risk, one entry point to better understanding the decision context is through an exploration of the perceptions of climate change risk and its associated determinants (Steynor and Pasquini, 2019). How risky climate change is perceived to be will influence whether action is taken on climate change (van Valkengoed and Steg, 2019) as well as what information is best suited for taking action (Brügger et al., 2016), providing valuable insights into the decision context. Furthermore, the determinants of climate change risk perceptions are an important part of the climate change risk perceptions framing because have been shown to provide insight into pro-environmental behaviour at the individual level (van Valkengoed and Steg, 2019) and in the workplace (Ture and Ganesh, 2014; Inoue and Alfaro-Barrantes, 2015).

To this end, this study uses the model proposed by Steynor et al. (2021) (described in section 2) as a framework in order to systematically quantify each climate change risk perception determinant amongst East African policy decision influencers, providing improved granularity to the quantification of each individual risk perception determinant in East Africa (section 4). But importantly, this paper furthers the work of Steynor et al (2021) by exploring each determinant through qualitative analysis, in order to better understand the climate change risk perception factors that have an influence on the professional decision context in East Africa (section 4). The resulting understanding from the qualitative analysis is then used to inform recommended interventions for the development of context-specific climate services that better align to the decision context, through the lens of climate change risk perceptions (section 5).

## 2. Theoretical framework

To date, the majority of the literature documenting climate change risk perceptions, and the factors that determine them, comes from the developed world and focuses, primarily, on general public audiences (e.g. Smith and Leiserowitz, 2012; van der Linden, 2015; Poortinga et al., 2019; Xie et al., 2019). However, the drivers of climate change risk perceptions can vary between different audiences. For instance, Taylor, Bruine De Bruin and Dessai (2014) reported on the different conceptualisations of climate change risk between expert and lay audiences in the United Kingdom, with expert audiences drawing more on analytical or technical data and lay audiences drawing more on their experiences of negatively-impacting extreme weather events as a determinant of their perceived risk of climate change.

To fill a gap in the current general public, developed nation understanding of climate change risk perceptions and their determinants, Steynor et al (2021) recently proposed a suite of factors relevant to determining climate change risk perceptions amongst a policy decision influencer community in the East African context. These selected climate change risk perception determinants included: observance of social norms, psychological distance of climate change, experience of extreme weather events, personal values and socio-demographic variables (age, gender and education). Each of these determinants are briefly discussed below, together with their motivation for use in the African context.

### 2.1 Selected climate change risk perception determinants

*Social norms* refer to the external expectation of how one is supposed to think, feel or act (Popenoe, 1983) and have been shown to have a very powerful influence on how people perceive risks (van der Linden, 2015) as well as to influence pro-environmental behaviour in the workplace (Lee et al., 1995; Andersson et al., 2005; Scherbaum et al., 2008; Lo et al., 2012; Ture and Ganesh, 2014). Given that there is no reason to assume that this influence would be diminished in an African setting, social norms are considered an important climate change risk perception determinant.

*Psychological distance* measures personal perceptions of a threat as either near or distant (Pahl et al., 2014). This perception is measured on four dimensions, namely whether a threat is close or distant: amongst one's social circle (social dimension); in one's geographical area (spatial dimension); in time (temporal dimension); and in certainty regarding the threat (hypothetical dimension) (Trope and Liberman, 2011). While climate change has been noted as psychologically distant amongst some general public cohorts in the developed world, representing a barrier to increased risk perceptions and action (C. Jones et al., 2017), recent studies have posited that climate change is psychologically close for many people in the African context (Steynor and Pasquini, 2019; Steynor, Leighton, et al., 2020), possibly resulting in increased risk perceptions. This potentially psychological proximal nature of climate change in the African context renders it an important factor to include as a determinant of climate change risk perceptions in Africa.

*Experience of climate variability and extreme weather events* is more widely documented in the African literature than other determinants of climate change risk perceptions. The vast majority of studies focus on the experience of climate variability or extremes (and their perceived link to climate change) as the sole determinant of climate change risk perceptions (e.g. Mengistu, 2011; Berhanu and Beyene, 2015; Chichongue et al., 2015; Mubiru et al., 2018). Commonly-cited perceived changes include increased temperature, increased rainfall variability and more severe droughts (e.g. Chepkoech et al., 2018; Kimaro, Mor and Toribio, 2018; Mekonnen et al., 2018). In addition, changes to the duration (onset and cessation) of the rainy season are often highlighted as observed impacts of

climate change (e.g. Bryan et al., 2013; Egeru, 2016; Chepkoech et al., 2018). Given this heightened awareness of perceived climatic changes in Africa, experience of climate variability and/or extreme weather events is likely an important determinant of climate change risk perceptions.

*Values* are personally-held criteria that govern individual priorities, actions and choices (Rokeach, 2008). They can be broadly categorised into ten basic values and four higher-order values (Schwartz, 1992). The four higher-order values include self-transcendence (focusing outside the individual self for the greater good of humanity and the environment) versus self-enhancement (focusing on the achievement and prosperity of oneself), and conservatism (a focus on maintaining tradition and the status quo) versus openness to change. The literature has linked predominantly self-transcending values to increased perceptions of climate change risk (Poortinga et al., 2011b, 2019), while predominantly self-enhancing values have been linked to lower perceptions of climate change risk (Smith and Leiserowitz, 2012). Individual values have also been shown to influence pro-environmental behaviour in the workplace (Ture and Ganesh, 2014). There is no reason to assume that these established relationships would not hold true in the African context too.

Finally, *socio-demographic characteristics* such as age, gender and education have all been shown to link to climate change risk perceptions. Women are more likely to have higher climate change risk perceptions than men (Henwood, Parkhill, et al., 2008) and exhibit more involvement in environmental behaviour in the workplace (Wehrmeyer and McNeil, 2000), while age and educational attainment have been both inconsistently linked to either increased (Lazo et al., 2000; Sundblad et al., 2007) or decreased climate change risk perceptions (Akerlof et al., 2013; Ballew et al., 2019).

## 2.2 A model for prioritising climate change risk perception determinants

Using the selected climate change risk determinants described above, Steynor et al. (2021) developed a model of how these determinants are organised in a causal manner to elucidate their relative priority in determining climate change risk perceptions and, in turn, action on climate change. The model showed that the pathway to climate change risk perceptions differs depending on individual value systems. Heightened climate change risk perceptions of those with primarily self-enhancing values are predominantly influenced by social norms, whereas heightened climate change risk perceptions of those with primarily self-transcending values are predominantly influenced by their experience of extreme events and their psychological proximity to climate change. However, as people very rarely encompass just one value system, these influences are not mutually exclusive. The model contributed towards filling a gap in the understanding of how climate change risk perception determinants interact in concert to influence climate change risk perceptions in the East African context.

The current paper uses the Steynor et al (2021) model as a framework in order to systematically quantify and explore (through qualitative analysis) each of the identified climate change risk perceptions determinants. This analysis yields the detailed understanding required to suggest ways to align the delivery of climate services to a better understanding of the East African decision context.

### 3. Method and procedure

This study took place amongst a targeted respondent group consisting of policy decision influencers in five East African countries (Ethiopia, Kenya, Rwanda, Tanzania and Uganda). Policy decision influencers are an under-researched grouping, yet are an important focus of climate services because their position of leadership enables them to be drivers of social change (Mohamed, 2016). Data that informed the study were collected through surveys (the same survey data used to construct the Steynor et al. (2021) model) and semi-structured interviews, representing an explanatory sequential mixed-methods approach (Creswell and Creswell, 2017). In this way, the results from the qualitative research sought to explore and explain the quantitative results. A full description of the survey design and its piloting is available in Steynor et al. (2021) so only a brief description of each of the survey measures informing this paper are provided in section 3.2. Section 3.3 details the design and analysis of the semi-structure interviews, which informed this paper's novel qualitative analysis.

#### 3.1 Survey participants

A total of 474 completed survey responses were used for analysis. The respondents ranged from 20 – 70 years old with most participants (87%) falling into the 20 – 50-year age bracket and 40% into the 30 - 39 age group. The gender split was 70% male and 30% female and most of the respondents (88%) had at least a university bachelor's degree, while all had school leavers certificates.

#### 3.2 Measures in the survey

As data collection took place within a wider data collection activity focused on assessing determinants of risk perceptions together with assessing the current and desired use of climate information in decision making, only the constructs relevant to this analysis are presented here.

##### 3.2.1 Social norms

Six questions were used to measure social norms, on a five-point Likert scale. These were divided into three questions designed to measure descriptive norms (what most people in a group feel, think or do) and three questions designed to measure prescriptive norms (what most people in a group approve of).

##### 3.2.2 Psychological distance of climate change

Six questions were used to measure the psychological distance of climate change, on a five-point Likert scale. These were largely based on measures used in Spence et al. <sup>(2012)</sup> and cover the four dimensions of psychological distance as described by Trope and Liberman (2011).

### *3.2.3 Experience of extreme weather events*

To measure experience of extreme weather events, participants were asked to recall how often they had experienced four types of events in the previous five years, on a scale from “never” to “very often” (more than ten times). These extreme events included: flooding, drought, high temperatures/heat events and changes in seasonal rainfall patterns. While changes in seasonal rainfall patterns may not be strictly classified as “extreme weather events” they have been grouped under this variable for ease of terminology and because the impacts of seasonal rainfall pattern changes can, similar to the other extreme events grouped here, have devastating impacts in the region, particularly on agriculture (Kotir, 2011).

To assess the perceived relationship of these events to climate change, a further question was asked as to whether the respondents felt that these events were made worse, or happened as many times as they did, because of climate change. Responses were measured as ‘yes’, ‘no’, ‘some’ or ‘don’t know’.

### *3.2.4 Values*

Steynor et al.’s (2021) model only considered the higher order values of self-transcendence and self-enhancement in their model. However, the survey measured respondent’s value orientations across all ten basic values, using Schwartz’s (2003a) established 21-item Portrait Values Questionnaire (PVQ). The responses were converted to centred scores using the standard guidance from Schwartz (2003b). Centred scores show the relative priority of different value systems by representing them as a deviation from the mean across all values questions.

### *3.2.5 Climate change risk perceptions*

Three questions, phrased in terms of “worry” about climate change, were used as a proxy for climate change risk perceptions, with responses recorded on a five-point Likert scale. A measure of either “worry” or “concern” has been used by previous studies as a proxy for climate change risk perceptions (e.g. Spence, Poortinga and Pidgeon, 2012; Carlton and Jacobson, 2013; Lujala, Lein and Rød, 2015), because, as Wilson, Zwickle and Walpole’s (2019) meta-analysis of climate change risk perception measures concluded, while risk perceptions are multi-dimensional, they are primarily driven by an individual’s emotional reaction to the risk. The specific word “worry” was used in the survey because worry is more likely to result in action than general concern (van der Linden, 2017).

## *3.3 Interview design and participants*

The results of the survey were further explored through in-depth semi-structured interviews, meaning that they were guided by a set of questions but, at the same time, allowed for additional questions to be asked to clarify or further expand on particular issues (Gill et al., 2008). The ability to expand on

certain topics or diverge from the original question allows for the discovery of information that may not previously have been thought of as pertinent (Gill et al., 2008).

Data collection consisted of 36 semi-structured interviews. These interviews were conducted in person with 20 respondents from Kenya and 16 respondents from Ethiopia during August and September 2019. Participants were offered no rewards for their participation and were selected on a targeted basis from the same institutional groupings as the survey. Each interview lasted approximately one hour, was recorded and later transcribed for analysis. Care was taken to include participants from a wide spectrum of policy decision influencer organisations and to ensure a gender representative sample. While the interviews covered a range of topics, the questions of relevance for this analysis aimed to gain a deeper understanding and explanation of overall climate change risk perceptions and their determinants.

Analysis of the interviews took place through a multi-step approach in NVivo. Initially the interviews were deductively coded into the pre-defined categories of climate change risk perception determinants including responses related to experience of extreme events, social norms etc. These categories were then further divided into sub-categories such as (for social norms) observation of colleagues taking action on climate change. Repeated patterns were then identified as emerging from the data such as (for social norms) that their colleagues are taking action on climate change because of an awareness of the impacts climate change is having on them. Finally, these sub-categories were used to detect linking themes across categories in the data which served to further explain the quantitative results.

#### 4. Results and discussion

Figures 5.1 to 5.5 show the quantitative findings from the survey. The results of the qualitative interview analyses are presented alongside the results of the quantitative analysis, to explore and explain some of the underlying drivers behind the quantitative results.

##### 4.1 Social norms

From the regional survey results, observance of social norms for action on climate change and the use of weather and climate information was high, with an average (across the six statements measuring norms) of 67.6% of the respondents agreeing or strongly agreeing with the statements posed (Figure 5.1). However, observance of social norms was higher in the workplace (on average 72.2% of respondents agreed or strongly agreed with the statement posed) than in their personal lives (on average 55.1% of respondents agreed or strongly agreed) and was marginally stronger for prescriptive norms (on average 68.2% of the respondents agreed or strongly agreed) than descriptive norms (on average 64.9% of respondents agreed or strongly agreed).

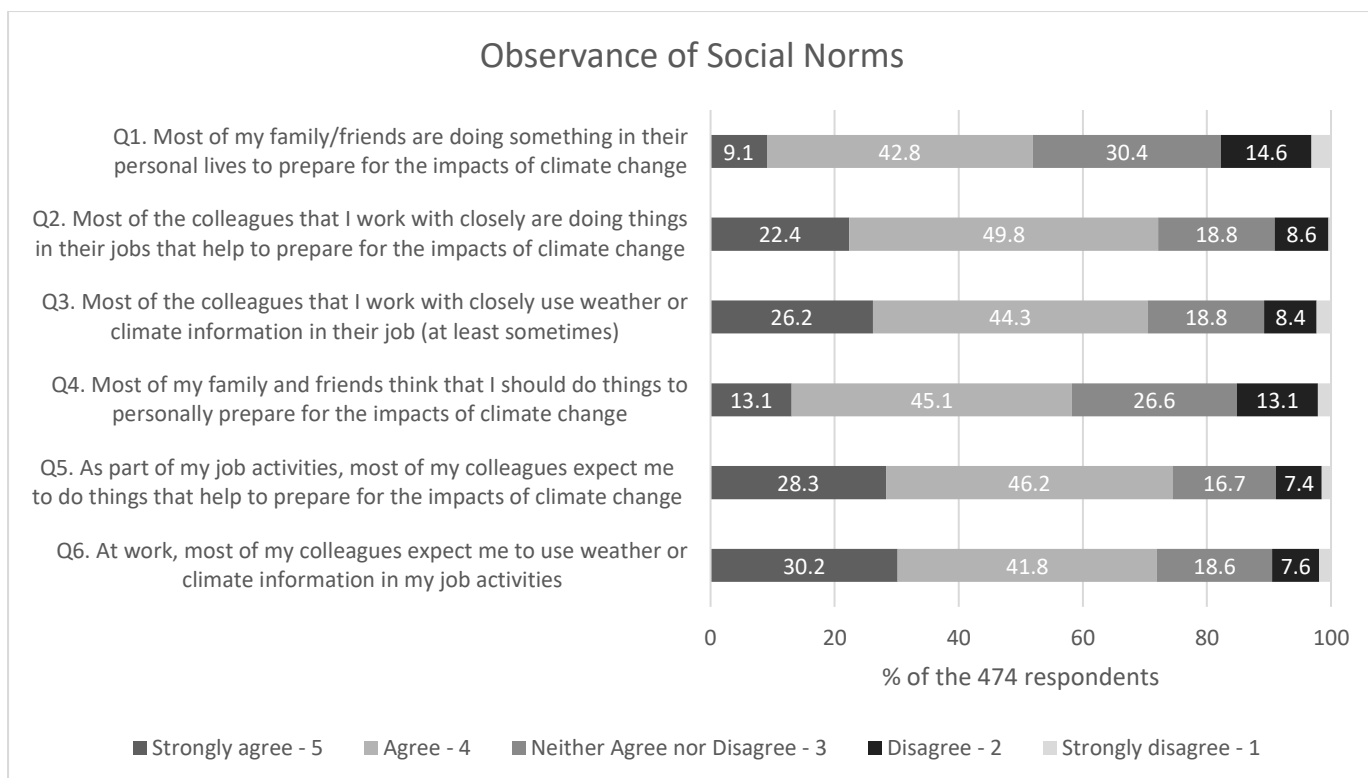


Figure 5.1: Questions assessing the observance of social norms amongst the 474 survey respondents. Descriptive norms are assessed through questions 1 to 3 and prescriptive norms are assessed through questions 4 to 6.

The interview analysis provided a basis for further investigating what may be driving this observance of social norms. When asked if they observed their colleagues taking action on climate change and/or whether they were expected to take action on climate change themselves at work, 23 participants replied in the affirmative and further explained this to be due to a high level of awareness of the impacts that climatic changes were already having or could have in the future. For instance, when asked if there was a strong expectation, in the workplace, to prepare for climate change, a participant confirmed that preparation for climate change was generally expected and attributed it to the link between their experience of climatic variability and the impacts they had seen on wildlife, as an example.

“Yes [there is a strong expectation to act on climate change], because we realise, for example, if I speak for the wildlife aspect, because of the prolonged droughts or rainfall patterns, it actually affects even the movement of the animals. . . . So, we really need to strengthen mainstreaming, climate change is becoming more and more evident.” Respondent K16, NGO, Kenya

While awareness of impacts seems a reasonable explanation, it stands in contrast to previous literature which suggests that simple awareness/knowledge of the impacts of climate change, even

when combined with concern, is unlikely to result in significant engagement on climate change (Lorenzoni et al., 2007; Tam and Chan, 2017). However, Lorenzoni, Nicholson-Cole and Whitmarsh (2007) suggested that climate change action can be enabled when awareness of climate change is twinned with an enabling environment and Vincent et al. (2020) reiterated the need for an enabling environment to increase the use of climate services when acting on climate change. This enabling environment might take the form of more supportive infrastructure and institutions or could go further to include policy frameworks (Vincent, Conway, et al., 2020). This also aligns with previous studies that have investigated social norms through the lenses of corporate commitment to sustainability issues (Lee et al., 1995; Andersson et al., 2005) and companies environmental policies (Ramus and Steger, 2017).

With this academic basis in mind, further interrogation of the interviews revealed three additional factors which, together with the heightened awareness of climate change impacts, may be creating the supportive (enabling) environment for acting on climate change in the workplace. These three factors noted by respondents consisted of:

- a) A professional expectation to take action on climate change, i.e. the majority of respondents were expected to act on climate change as part of their job portfolio (n = 27);
- b) the presence of local or national policy regulations which provided the structures within which to act on climate change (n = 16); and
- c) access to or the acquisition of (usually international) funding targeted at addressing climate change impacts (n = 13).

This confirms that the social norm for action on climate change was likely enhanced by the enabling structural environment in which they find themselves. Amongst this group of respondents, these three enablers are likely to be inter-linked in many cases. For instance, one could imagine a scenario in which a local government official is expected to implement climate change policy, while that implementation is funded through a climate-financed project.

As an example of the recognition of these enabling factors in the workplace, when one respondent was asked why they thought they were expected to act on climate change, they made reference to the enabling environment provided by their organisation and of the enabling policy environment in which they worked.

“I think most of it [the expectation to take action on climate change] is because of the work I do, or the organisations that I work for . . . I think generally the country, as in Kenya, there is a lot of expectations and of course there are a lot of initiatives and policy and frameworks to



really try to address the climate change impacts today and in the future.” Respondent K1, NGO, Kenya

This strong enabling environment likely explains why, while the descriptive norm to take action on climate change was high (Q1-Q3, figure 5.1), the prescriptive norm was marginally higher (Q4-Q6, figure 5.1), because respondents felt that taking action on climate change was expected (or socially prescribed) in their professional role, even when not specifically mandated.

#### 4.2 Psychological distance

Climate change was shown to be psychologically close amongst these East African respondents, across all four dimensions of psychological distance. An average of 92.9% of the respondents agreed or strongly agreed with the statements posed in questions 1, 2, 3, 5 and 6 (Figure 5.2) and 91.8% of the respondents believed that they were already experiencing the impacts of climate change (question 4, Figure 5.2).

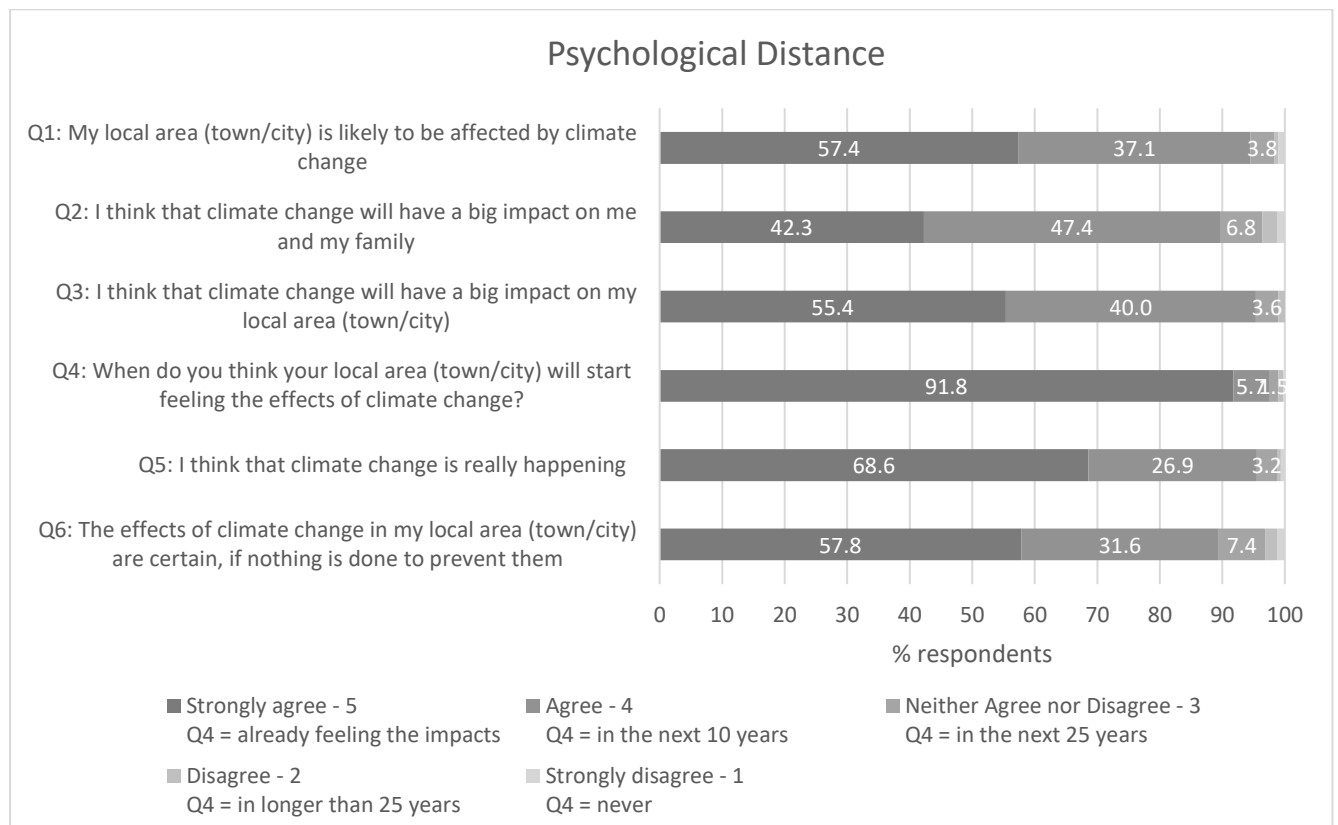


Figure 5.2: Questions assessing the psychological distance of climate change amongst the 474 survey respondents. The spatial dimension of psychological distance is represented through Q1, the social dimension through Q2 and Q3, the temporal dimension through Q4 and the hypothetical dimension through Q5 and Q6. Note that for Q4, participants were asked when they thought their local area would experience the effects of climate change on a five-point Likert scale from “never” to “already feeling the impacts”.

The interviews allowed for deeper insight into the underlying reasons why climate change may be psychologically close in East Africa. In this regard, two prominent themes emerged from the analysis. The first theme centred around the alignment between the significance of rain-fed agriculture in the region and the perceived personal experience of climate change through agricultural impacts. The second theme focused on the vulnerability of the current developmental context to climate variability and change.

Agriculture (and its association to food security) has previously been documented as a major economic activity in many African countries (Nkiaka et al., 2019; Carr et al., 2020). This importance has resulted in the sector becoming a focus for climate-related funding and initiatives (Nkiaka et al., 2019). While agriculture is of obvious importance to economies and livelihoods in rural areas, it was interesting (in the interviews) to note its ascribed importance, even to city-dwelling policy decision influencers (all the interview respondents were residing in cities). The economic importance ascribed to agriculture may be one reason why climate change was psychologically close amongst this cohort. The qualitative results revealed two interlinking reasons to support this hypothesis. Firstly, some of the respondents explicitly mentioned having personal links to the agricultural sector, whether it was because their families farmed and/or they originally came from predominantly farming areas (n = 6). This personal connection appeared to make the impacts from climate variability (believed to be due to climate change) concrete and real to them, therefore likely bringing climate change psychologically closer. For instance, one respondent explicitly linked the climatic impacts on their family farm to climate change and described this as an impact on a personal level.

“At a personal level, my family has a farm, and we realise that we plant crops, they don’t do as well because it rains too much when the seedlings have not sprouted, so they kind of rot. So, we don’t get enough produce. And then other times, it’s dry, so, there’s no balance. So, as a family, I would say we are experiencing [climate change] at a personal level” Respondent K16, NGO, Kenya

Secondly, even those who did not express a personal link to the agricultural sector, referred to the effect that climatic changes were already having on them personally (or to their local area/community), through the knock-on effects that climate impacts on the agricultural sector had on the economy and societal wellbeing (n = 9). These knock-on effects included increased food prices, food relief efforts, food deficits and health impacts through malnutrition (or other nutrition-related illnesses). For instance, when one respondent was asked whether they felt that they were personally experiencing the effects of climate change, they responded that they were feeling the effects of

climate change on both the social (individual and family) and spatial (country) dimension, and then went on to explain this answer by providing an example of how they experienced increased food prices because of climate-related agricultural impacts.

“From my individual level, yes. Family level, yes. Organisational level, yes. Country level, yes . . . [when] there was delay in planting, there was delay in getting produce from the farm, there was increasing prices, which is basically as a result of the delay in rains.” Respondent K18, NGO, Kenya

The second theme emerging from the interviews, that may also contribute to explaining the psychological closeness of climate change, related to the vulnerable development context of most African regions, meaning that there is very little buffer to withstand the impacts of weather events that do not fall within the normal range (IPCC, 2014). All of the respondents (n = 36) made note of direct or indirect impacts of weather-related events that had affected them or their local area. These impacts included water shortages during dry spells (n = 13), flooding from intense rainfall events (n = 34) and health risks resulting from extreme rainfall (n = 12) such as malaria and water-borne diseases like cholera and diarrheal disease. Exposure to these impacts invokes an emotional response, making them very real and concrete (Weber, 2006), bringing all the dimensions of psychological distance closer.

#### 4.3 Experience of extreme weather events

The regional survey responses reflected a similarly widespread experience of extreme weather events (Figure 5.3) to that discussed in the preceding section (4.2). Perceptions of changes to rainy season patterns was noted most often from the survey. The second most frequently experienced events were floods and high temperature and/or heat events. Finally, droughts were noted as the least frequently experienced event.

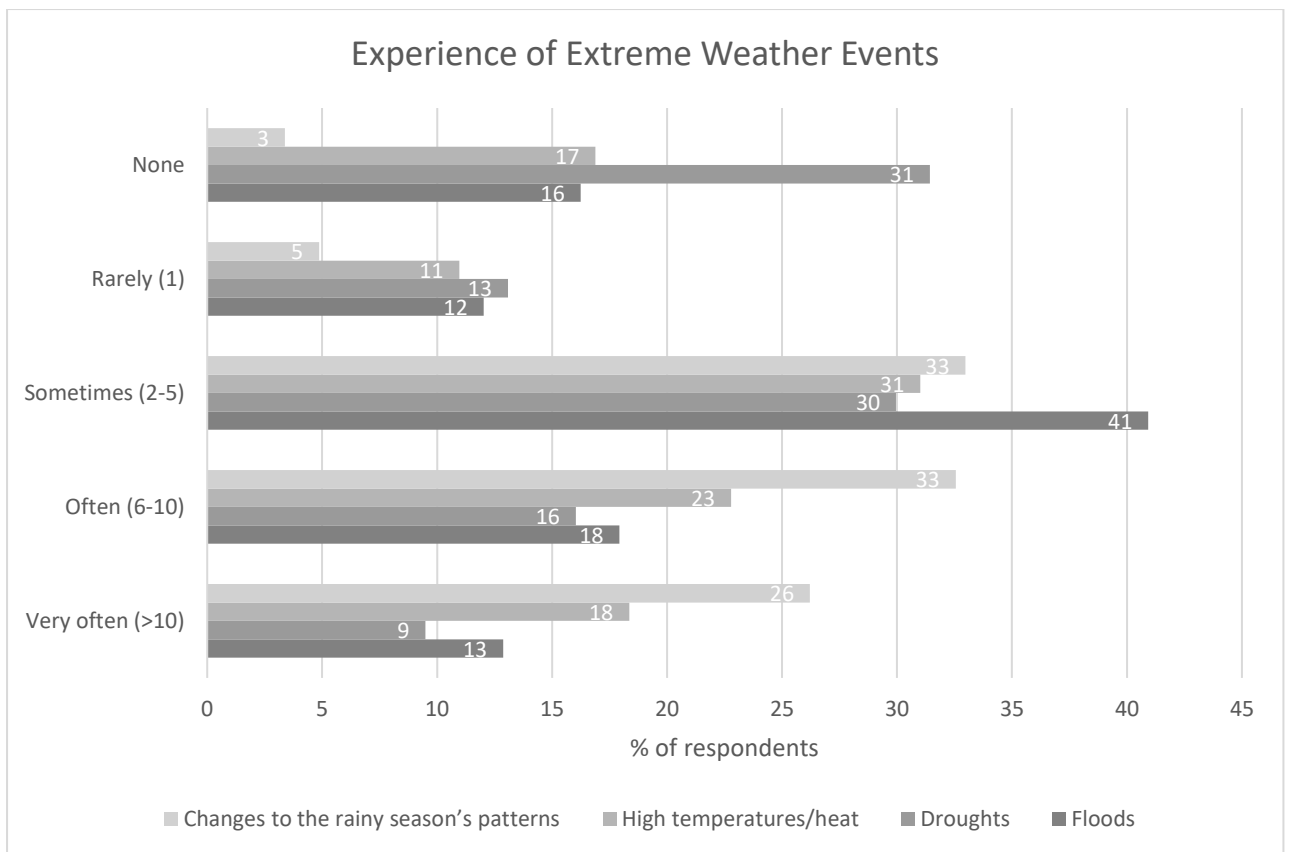


Figure 5.3: Recalled experience of extreme weather events in the previous five years amongst the 474 survey respondents.

All interview respondents (n = 36) noted experiencing extreme weather events. The types of events noted in the interviews partially aligned with the results from the regional survey, particularly with regards to changes in rainy season patterns. Changes in the rainy season were noted by almost half of the interview participants (n = 16), particularly in terms of the impact this change was having on rain-fed agriculture (n = 14). Floods (n = 14) and high temperature events (n = 11) were also frequently mentioned. However, while droughts were not frequently mentioned in the regional survey, they emerged as the most frequently mentioned event across the interview participants (n = 19), contrasting with the survey results.

This mismatch may be due to the way in which the survey question had been phrased. As droughts can be multi-year events (Dai, 2011), if asked about the frequency of drought experiences in the last five years, one multi-year drought would classify as one event, falling into the 'rare' category given the criteria specified in the survey question. In contrast, the other extreme events specified in the survey occur on much shorter time scales, lasting from days to a season. Therefore, there is greater scope for respondents to have experienced these events multiple times in the preceding five-year period when compared to droughts, at least if respondents were thinking of yearly or multi-year droughts. This mismatch in timescales of events might be one reason why the survey responses

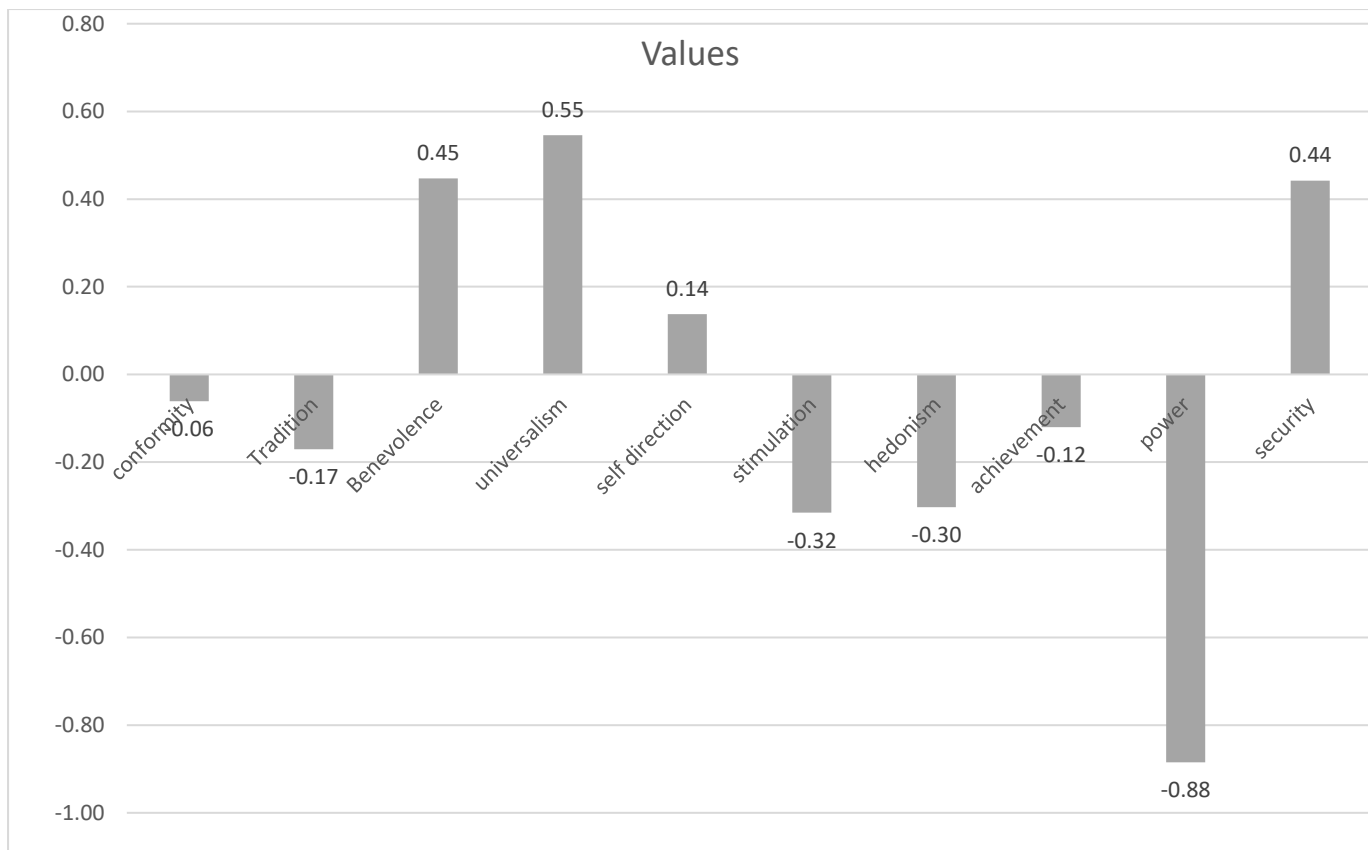
seemed to contrast with the interview responses. The prevalence with which droughts were mentioned in the interviews suggests their importance in the region, even if the survey results might suggest that they were experienced less frequently than other events.

The frequency with which both rainy season changes (onset and cessation of the rains) and droughts were mentioned in the interviews is likely to be linked, again, to the prominent role played by agriculture to economies and livelihoods in the region (Nkiaka et al., 2019; Carr et al., 2020). The onset of the long rains (March to May in most of the region) signals the beginning of the planting season. Any delay in this rainy season onset, or lengthy dry spells within the season, has significant knock-on effects on the viability of that year's crop (Agaba, 2019).

Survey participants were further asked whether they believed that the events they had experienced were made worse, or happened as many times as they did, because of climate change. An overwhelming majority (96%) of participants felt that either some or all of the events had been made worse by climate change, demonstrating a high belief that they are, indeed, experiencing climate change rather than simply climate variability. The interviews revealed a similarly high number of respondents attributing their experience of extreme events to climate change, with 33 of the respondents explicitly noting that they were feeling the effects of climate change. The remaining three respondents (all researchers) noted that they had experienced a change in weather over time but were not sure whether they could attribute that directly to climate change or not. This answer shows a technical nuance around climate change attribution that is primarily understood within the academic community (James et al., 2019).

#### 4.4 Values

The survey results suggested that, while respondents predominantly endorsed values falling within the higher-order value of self-transcendence (benevolence and universalism), they also frequently endorsed the basic value of security, which falls within the higher-order value of conservation (Figure 5.4). This finding is not unexpected, as value systems are complex, and no one individual holds just one value system (Schwartz et al., 2012).



*Figure 5.4: Centred scores for individual values averaged across the sample of 474 respondents*

Given the personal, complex and often implicitly-held nature of values systems, it was not deemed appropriate to ask direct questions about values in the interviews. However, the interview transcripts were analysed to hypothesise why these three values may have emerged as predominant amongst this audience.

The value of security in this audience is hypothesized to be linked to the high observance of social norms amongst this group (discussed in section 4.1). Bardi and Schwartz (2003) found that the value of security significantly correlates with conformity behaviour. Therefore, with security as a central value, an individual may be more likely to conform to what is expected from them in order to maintain the stable status quo. For instance, interview respondents may have expressed a desire to act on climate change because they value the security of their professional role and see conforming to the predominant norms as a way of maintaining this role (Steynor et al, 2021). In addition, the value of security encompasses a desire for personal safety and stability (Schwartz et al., 2012), so it is possible that the frequency with which respondents observed extreme weather events occurring (see above) could also have primed/activated this particular value.

The other values endorsed by the survey respondents were the self-transcending values of benevolence (preserving and enhancing the wellbeing of those one has contact with) and universalism

(a broad understanding and desire to preserve the wellbeing of wider society and natural environments). As policy decision influencers (as defined in this study) generally work in a public-facing role, making or informing policy decisions that will affect a range of people as well as the environment, it is reasonable to speculate that the role would attract those who endorse a self-transcending value system. This hypothesis is supported by Nilsson, von Borgstede and Biel (2004), who found that people who work in the public sector in Sweden have higher self-transcending values than those who work in the private sector.

A few respondents (n = 5) explicitly noted a concern for the well-being of others in their interviews, which may have been an expression of their endorsement of self-transcending values. For example, when asked why they were interested in climate change issues, one government official in Ethiopia responded that they wanted to help their community so that the community did not suffer from the consequences.

“I am very interested, especially to help the people, to help the community. Because I am very interested if the community is not suffered [sic] by flood; if not suffered [sic] by drought, I am very happy.” Respondent E17, national government, Ethiopia

Such responses lend additional support to the hypothesis that the policy decision influencer role might particularly attract individuals endorsing self-transcending values, and points towards interesting avenues for further research.

#### 4.5. Climate change risk perceptions

Climate change risk perceptions were heightened amongst the survey respondents, with an average of 92.7% of respondents noting that they were either worried or very worried about climate change and its effects (Figure 5.5).

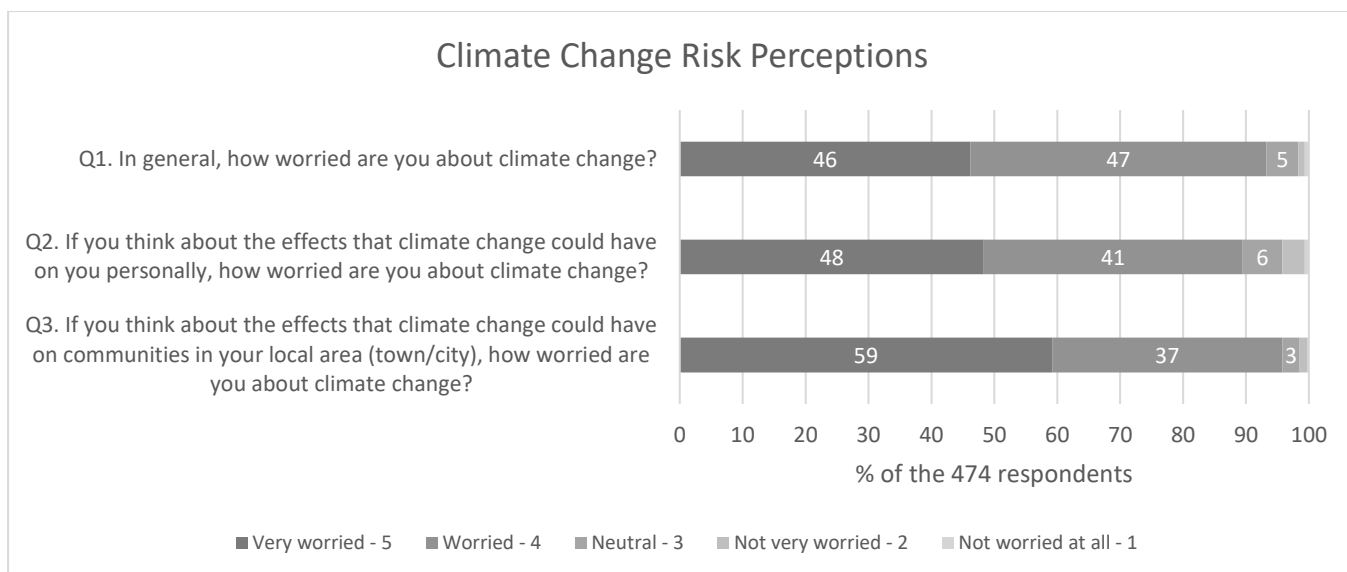


Figure 5.5: Questions assessing climate change risk perceptions

Current literature draws links between all the climate change risk perception determinants, discussed in previous sections, and climate change risk perceptions (van der Linden, 2015; Frondel et al., 2017; Steynor et al., 2021). Indeed, with specific relevance to the East African region, the model developed by Steynor et al. (2021) shows positive relationships between heightened climate change risk perceptions and the assessed determinants of: observance of social norms for climate action, psychological proximity to climate change, frequent experience of extreme weather events and endorsement of self-transcending values. These links are expected to be especially strong when the experienced extreme weather events are deemed to be due to climate change (Steynor et al., 2021), as was the case amongst this respondent group (section 4.3). Therefore, heightened climate change risk perceptions were unsurprising, given their documented relationship with the determinants discussed in sections 4.1 – 4.4.

This understanding of the heightened climate change risk perceptions context provides valuable information for informing the development of context-relevant climate services for East Africa. The ways in which this understanding can inform the development of climate services is discussed in the following section.

## 5. Aligning climate services to the East African policy decision context

An understanding of the decision context through the lens of climate change risk perceptions determinants, as presented in this paper, allows for the design of climate services that are better aligned to the context for action. On this basis, the next section suggests ways that the climate services community can better leverage the understanding of climate change risk perception determinants from this study to provide climate services that may be more readily used in decision making.



### 5.1 Aligning climate services to an understanding of the decision context through the lens of social norms

Given the general tendency among the study's sample to observe the social norm for climate action, combined with the strong enabling environment (section 4.1), leveraging social norms may become a powerful tool for influencing the uptake of climate services in the region. We outline here a series of interventions that could be used by the climate services community in designing and delivering climate services that maximise the positive effect of social norms on the uptake of climate services.

Firstly, engagement processes through workshops, discussion groups or forums (many of which are already common climate services activities (Vincent, Daly, et al., 2018)) are a powerful mechanism for building capacity and providing mutual support in the use of climate services while simultaneously highlighting the norm of climate services use amongst the group (Yamin et al., 2019). These activities are often successful in creating a community of practice for the use of climate services in decision-making (Vincent, Steynor, et al., 2018) and could also be useful in further strengthening the current enabling environment (e.g. policies and funding) that underpin the use of climate services when acting on climate change. For instance, engagement events could facilitate the creation of a cohort of individuals who use similar climate services, access funding together, or who endorse and/or create policies around the use of climate services in decision making.

Secondly, studies have shown that it is possible to influence large groups of people simply by conveying a message through an influential source (Paluck and Shepherd, 2012). These influential sources may include certain people/figures in society who exert more influence than others such as traditional community leaders, celebrities or politicians. Using this principle, the climate services community could leverage the power of social norms by having respected/influential individuals endorse particular climate services products or endorse the value of using climate services in decision-making. This recommendation relies on there being commonly-respected figures in the policy decision influencer community so that employing this technique does not sow division in the use of climate services.

Finally, providing a target audience with information on the high rates or prevalence of climate services uptake in a similar audience would highlight the social norm for using climate services in decision-making among similar groups (Yamin et al., 2019). For instance, as agriculture seems to be a sector of economic importance amongst this group, a message that indicates that 80% of agricultural professionals/planners in Kenya are using climate services in their planning, highlights the actions of similar professional people and communicates the social norm of using climate services.

## 5.2 Aligning climate services to an understanding of the decision context through the lens of psychological distance

Construal Level Theory provides a useful lens through which to understand the relationship between the psychological distance of a risk and the way people interpret or understand (construe) it (Trope and Liberman, 2011). This mental construal also influences the types of information they use to act on the risk (Trope and Liberman, 2011; Brügger et al., 2016).

Construal level theory divides thinking into the categories of high-level construal and low-level construal. High-level construal is composed of abstract and general features (big picture thinking) and is typically associated with psychologically distant risks. Conversely, low-level construal is typically associated with psychologically close risks and is characterised by concrete and specific thinking where the safety, feasibility and attainability of a good outcome is the immediate priority (Sagrignano et al., 2002; Trautmann and Van De Kuilen, 2012). For instance, the imminent threat of a storm may promote specific thinking around risks such as tiles being blown off one's roof or electricity outages due to damaged power lines, and therefore specific thinking around the actions needed to ameliorate/address these risks.

The results of this study reveal that climate change is psychologically close amongst East African policy decision influencers. This psychological proximity is thus expected to place them in a state of low-level construal about climate change. The climate services community could usefully leverage this knowledge by providing information that matches this processing mode, thereby rendering it more salient and useful for the intended audience (Brügger et al., 2016; Chu and Yang, 2020). This matching approach is different from attempting to manipulate (or proximize) the psychological distance of climate, which has drawn criticism in the global North (Brügger et al., 2016; Brügger, 2020).

The first way in which climate services can leverage this knowledge is by providing concrete, specific and solutions-based climate information (Chu and Yang, 2020). Providing uncertain, coarse resolution information is likely a hindrance to decision making in a state of low-level construal, yet it is not scientifically feasible to reduce the uncertainty inherent in current climate change projections (and thus make them more specific). Therefore, the majority of current climate service offerings for East Africa continue to provide non-specific climate information that are disconnected from any information on impacts (Nissan et al., 2019). If climate services brought together climate scientists and impacts modellers, it may be possible to understand what the projections may mean for future impacts. In turn, if decision makers were drawn into the discussion through a process of co-production, solutions that could address those impacts could be proposed. Providing a product that blends projections, impacts and solutions might assist in providing the kind of concrete and solution-based information which we expect is required for decision making in East Africa.

Secondly, low-level construal has also been linked to visual processing (Yan et al., 2016). Therefore, people in a state of low-level construal (such as those in this study) are likely to react best to climate information that is presented visually. For instance, infographics or maps may be better received than raw data or reports. Additionally, for people in a state of low-level construal, loss-framed (negatively framed) messages have been shown to lead to greater intentions to act than gain-framed (positively framed) messages (Chang et al., 2015). For instance, an example of a loss-framed message would be “food shortages requiring food relief efforts may be an annual occurrence by 2040 unless climate-smart agriculture is adopted”, whereas the same message in a gain frame may be “food shortages requiring food relief efforts on an annual basis could be prevented by adopting climate-smart agriculture”. A subtle reframing of climate services messages has the potential to influence how the message is received and whether it is acted upon (Morton et al., 2011).

### 5.3 Aligning climate services to an understanding of the decision context through the lens of the experience extreme weather events

At a basic level, knowledge of currently-experienced events provides information to climate services providers about what climatic variables may be of most interest to decision makers in the region. For instance, the frequency with which seasonal changes in rainfall was noted amongst this study’s sample indicates that climate information regarding onset, cessation, shifting rainfall seasonality and length of dry spells is likely to be of particular interest to the decision-makers in this region when planning for climate change.

Appealing to pertinent personal experiences has been shown to increase the salience and relevance of a message (Broomell et al., 2015a; Demski et al., 2017). Therefore, including these kinds of personally-experienced events in scenarios or analogies of the future could help the audience to engage with the information on a more personal level and envisage a future where climate change impacts are being played out. For instance, for this study’s audience, projected changes in rainfall seasonality could be included in future narratives of climate risk (Jack et al., 2020) to highlight the potentially increasing impact that changing rainfall seasonality may have in the future.

Lastly, knowledge of personally-experienced extreme weather events and their impacts, such as the impact of the changes in rainfall seasonality on agriculture, could provide a valuable entry point topic for engagement on additional climate change impacts. In this way, currently-experienced extreme weather events could be used as conversation starters, and offer a springboard for further engagement on future climate change impacts that may not yet have been experienced or are not yet at the forefront of the decision-maker’s mind. This approach is especially important because adapting to current climate variability will not necessarily be sufficient for adapting to future climate change (Dilling et al., 2015).

#### 5.4. Aligning climate services to an understanding of the decision context through the lens of values

Those with higher self-transcending and security values, such as the participants of this study, may respond better to climate services messaging rooted in self-transcendent and security values and frames (Crompton, 2010). For instance, this approach may include messaging that highlights the wider societal benefit of using climate services products when planning for climate change, while also highlighting the benefits to personal security.

However, value systems are recognised as complex, with individuals and groups rarely holding one dominant value system (Schwartz et al., 2012). Therefore, targeted value framing has been shown to have limited effectiveness for larger audiences if the values being targeted are not universally held (Corner and Randall, 2011; Corner et al., 2014). If messaging is focused upon a narrow target audience and on values that are specific only to that target audience, then targeted approach may be appropriate; however, if the audience to whom a message is directed is a broad audience, such as the general public for example, then a more effective approach might be to blend elements of different value systems into climate services messages (Crompton, 2010), or to target values that tend to be universally held, such as might be the case for health (e.g. Myers et al., 2012).

#### 6. Conclusion

If climate services are to gain traction in decision making in Africa, they need to be designed and delivered in a manner that aligns with local needs and priorities (Clifford et al., 2020). These local considerations include how people mentally process climate change, what norms surround climate services use, the kinds of extreme weather events that are frequently experienced and what people value at a personal level.

This paper has outlined several ways that climate services could be designed and delivered more effectively by taking into account the contextual nuances of the East African policy decision influencer community. Given the tendency of this group to observe the social norm for climate change action, leveraging the influence of social norms through messages or events that convey normative information is one prominent way to increase the use of climate services. The proximal nature of climate change as demonstrated through this study means that this audience would likely respond best to concrete, solutions-based climate information delivered in a loss-framed, visual manner. This climate information would most usefully focus on climate variables that inform commonly experienced extreme events, which, for this audience, might include variables such as onset and cessation of rainfall seasons and dry spell length (amongst others). Finally, the complexity of value systems, and the fact that one person rarely holds just one value system, means that, while a better

response may be elicited through messages rooted in a self-transcendent frame (the predominant value system held by this grouping), this approach should be used with caution.

This study has provided insight into the East African decision context through the lens of climate change risk perceptions. While a discrete suite of climate change risk perception determinants was chosen for exploration in this study, there is scope to expand on this research by including further determinants of risk perceptions, such as political affiliation (Akerlof et al., 2013) or religion (Milfont, 2012). Meanwhile, the findings of this study serve to fill a gap in the literature with regards to better understanding climate change risk perceptions and their determinants in the African context, as well as how this understanding relates to the development and delivery of climate services.

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## Chapter 6: Using a climate change risk perceptions framing to identify gaps in climate services

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This chapter consisted of the following published paper (further revised based on examiner comments):

**Steynor, A.** and Pasquini, L. 2022. *Using a climate change risk perceptions framing to identify gaps in climate services*. Frontiers: Climate Risk Management. [DOI: 10.3389/fclim.2022.782012](https://doi.org/10.3389/fclim.2022.782012)

**Lead author (student)** Anna Steynor      **Role:** Conceptualised the paper, obtained the underlying data, undertook the data analysis, interpreted the results and drafted the paper.

**Co-Author:** Lorena Pasquini.      **Role:** Thesis supervisor, guidance, review of draft paper

This paper uses the framework developed in chapter four as a basis for assessing and exploring the relationship between climate change risk perceptions and the use of climate services information in East Africa. Understanding this relationship allows for an assessment of what might be currently missing from the East African climate services landscape (gaps in the landscape). Using this understanding, the paper goes on to make recommendations for filling the current gaps in climate services for the region. These recommendations form an integral part of the final consolidated framework for the enhancement of climate services, proposed in the final discussion chapter (chapter seven) of this study.

### **Abstract:**

*Given the rise in climate services for decision-making, it is important to understand whether these services are meeting the context-specific needs of decision-makers, including identifying any gaps in current climate services. This study sets out to investigate the efficacy of current climate services provision in East Africa through the lens of climate change risk perceptions. Risk perceptions have established relationships with important aspects of the decision context and have been shown to*

*influence the kinds of information people use in making decisions, therefore, an understanding of how elements of risk perceptions relate to climate services use can provide valuable insights for enhancing climate services. Using this premise, the relationships between determinants of climate change risk perceptions and the use of climate services information are explored through a combination of statistical survey analysis and qualitative interview analysis. The analysis revealed three main gaps in climate services in East Africa. These gaps include the lack of long-term climate change projections disseminated through National Meteorological Services (NMS), limited locally ground-truthed delivery of impact-based forecasts and the requirement for specialist capacity to use some complex climate services. Filling these gaps will require enhanced collaboration between the NMS, other providers of climate-related information (such as research institutes) and the practitioner and user communities in order to facilitate the coordinated delivery of locally ground-truthed impact-based forecasts, facilitate capacity development across the user-producer spectrum and augment the role of the NMS as conduits of climate change information.*

## 1. Introduction

Climate variability and change represent a significant threat to developing countries, disproportionately more so than to developed countries (IPCC, 2014). Given this threat, there is a growing need to plan for climate change. This need has resulted in the rapidly growing field of climate services (Hewitson et al., 2017; Vogel et al., 2019) that, at the fundamental level, seek to provide weather and climate information that is useful for informed planning.

Alongside this escalation in climate services is a burgeoning literature base that attempts to evaluate the quality and effectiveness of currently-available climate services for Africa (e.g. Vaughan and Dessai, 2014; Vaughan et al., 2016; Carr and Onzere, 2018; Tall et al., 2018; Vaughan et al., 2018). Evaluating current climate services has two main purposes. First, it allows for the design and delivery of currently-available climate services to be improved so that they are better aligned to the individual user decision context (Steynor and Pasquini, 2019). Second, evaluations allow for the identification of pitfalls or gaps in the currently available climate services in relation to the specific user needs (the focus of this present study).

Evaluations of climate services have been useful in informing recommended changes to climate services in the past. For instance, at the continental scale, a comprehensive evaluation of the offerings from selected National Meteorological Services (NMSs) in Africa informed a set of recommended interventions for strengthened climate services provision (Winrock International, 2018). The evaluation framework developed as a result of this work forms the basis for regular World Meteorological Organisation evaluations for international reporting purposes (Dinku, Madajewicz, et al., 2018; Cullmann et al., 2019). At the country level, an evaluation of climate services in Malawi revealed that major barriers to the use of climate information (particularly the use of climate change projections) was the incomprehensibility of the climate information and the lack of consensus amongst different climate information sources (Vincent et al., 2017). The evaluation recommended the development of a national set of climate change scenarios to make long-term information more accessible to policy users. This recommendation led to the development of a national climate brief which outlined historical climate trends and future climate projections (Mittal et al., 2017).

While these examples provide a snap-shot of the utility of evaluations in informing climate services, the evaluations literature, to date, has been largely focused on evaluating individual project offerings through user consultations, surveys, independent audits or website statistics of use (Vaughan et al., 2018). In augmenting these traditional techniques, new methods for evaluating climate services are needed, especially if they have the potential to identify gaps in climate services that may not be uncovered by these traditional evaluations.



On this basis, this study i) demonstrates the efficacy of an evaluation approach based on statistical (quantitative) analysis, supported through qualitative interpretation, as a methodology for evaluating current East African climate services and ii) identifies gaps in the current East African climate services landscape. While mixed qualitative/quantitative methods are already recommended in the evaluations literature (Tall et al., 2018), the approach presented here is novel because it utilises individual climate change risks perceptions as a conceptual framing.

Climate change presents a significant risk at both an individual and societal level. There is preliminary evidence to suggest that the perceptions of climate change risk are heightened in the African context, where climate change is considered to be impacting society already (Selormey et al., 2019; Steynor and Pasquini, 2019; Steynor, Leighton, et al., 2020; Simpson et al., 2021; Steynor et al., 2021). Climate change risk perceptions have established relationships with important aspects of the decision context that influence the use of climate services. For instance, climate change risk perceptions have been shown to influence both willingness to act on climate change (Spence et al., 2012; Lo and Chan, 2017; Smith and Mayer, 2018; Xie et al., 2019) and actual action on climate change (Blennow et al., 2012; Fahad and Wang, 2018; van Valkengoed and Steg, 2019). Heightened risk perceptions have been shown to increase an individual's information seeking behaviour (Kahlor, 2007) and the desire for climate information amongst natural resource planners when acting on climate change risk in the workplace (Peters et al., 2018).<sup>9</sup> The perceived proximity of a risk has also been shown to influence the kinds of information people use in making decisions (Brügger et al., 2016). For instance, if climate change is perceived to be happening already then decision-makers may focus less on long-term climate information. Instead they may focus on trying to address climate change with short-term climate information that offers them concrete information such as potential short-term impacts (Steynor and Pasquini, 2019). Therefore, climate change risk perceptions are a useful conceptual framing with which to evaluate the fit of currently available climate services, because the types and timescales of information used within the decision context vary depending on perceptions of climate change risk.

Climate change risk perceptions are influenced by several underlying determinants (van der Linden, 2015; Steynor et al., 2021), for example social norms and experience of extreme weather events (amongst others). Given the role that climate change risk perceptions play in influencing the use of climate information in decision making, each of these risk perception determinants should also be considered when utilising a risk perceptions framing because they may also be reasonably expected to have an influence on the types of climate information used in addressing climate change-related

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<sup>9</sup> See paper reviewer comment number 6 (annex 3) with regards to the conceptual framing of the paper

risks. Therefore, exploring how each of the determinants of climate change risk perceptions relate to climate information use is proposed as a way of gaining insight into the climate services information use landscape and, in turn, what is currently missing from the landscape.

To this end, this paper begins with an introduction to the existing landscape of climate services in East Africa, as the region of study (section 2). This presentation of the existing landscape is followed by the methodological approach for exploring the relationship between determinants of climate change risk perceptions and the current landscape of climate services information use (section 3). Section 4 presents the statistical results and qualitative analysis. Finally, section 5 utilises the insight gained to identify current gaps in East African climate services and offer potential solutions for filling these gaps.

## 2. The existing landscape of climate services provision in East Africa

Climate services encompass a wide range of activities associated with the production, tailored delivery and uptake of weather and climate information into decision-making (Vaughan and Dessai, 2014) as well as the associated user engagement and capacity development (Vincent, Daly, et al., 2018). In the present study we focus principally on the information provision component of climate services<sup>10</sup>.

While it is important to draw a distinction between weather and climate information, the line between the two is somewhat blurred in the climate services space, primarily because, in order to provide a seamless information product for decision-making, it is important that information on both weather and climate timescales operate together (Tall, 2013). Further, products such as historical observations and trends of weather are essential for informing the production of numerical weather prediction models as well as climate models. This interconnectivity has led the World Meteorological Organisation to adopt a framing of climate services that includes consideration of all timescales of information from historical observations through to climate projections data (e.g. Cullmann et al., 2019, 2020). For the purposes of this study, therefore, we have adopted this comprehensive framing of climate services.

We focus this section on the current actors in the climate services provision space, and the types and timescales of available information, for the Greater Horn of Africa (hereafter referred to as East Africa) with particular focus on the countries of Ethiopia, Kenya, Rwanda, Tanzania and Uganda (as our study's focus countries). This section draws on review of the literature and on review of each country's online offerings through their NMS (Table 6.1).

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<sup>10</sup> See paper reviewer comment number 7 (annex 3) with regards to the focus on the information provision component of climate services

## 2.1 Climate services in East Africa

The provision of climate services in East Africa are supported by several internationally-funded research and implementation programmes. These programmes range from short-term research and practice-based interventions (such as the Weather and Climate Information Services for Africa programme) to sustained development solutions (such as the Famine Early Warning Systems Network). In addition, the World Meteorological Organisation-affiliated regional centres, namely the African Centre of Meteorological Applications for Development and the Intergovernmental Authority on Development Climate Predictions and Application Centre (ICPAC) provide focused regional support (Ngari et al., 2016). The latter (ICPAC) has a specific mandate to focus on addressing the East African regional challenges associated with climate risks (Percy et al., 2021). To this end, ICPAC disseminates weekly, monthly and seasonal forecasts at the regional scale as well as rainfall and crop monitoring products<sup>11</sup>. ICPAC also has regional climate modelling capacity allowing for modelling of longer-term climate change projections (Percy et al., 2021). ICPAC is instrumental in convening the Greater Horn of Africa Climate Outlook Forums (GHACOFs) which allows for collaboration between regional, national and international climate experts in developing national seasonal forecasts (Cullmann et al., 2019; Percy et al., 2021). The GHACOFs are attended by representatives from each of the NMSs in the region as well as sectoral representatives and users.

## 2.2 Climate services at the national level

The primary mechanism for delivery of climate services at a national level is through each country's respective NMS (Singh et al., 2018), who are the mandated national authorities for provision of climate services (Hansen et al., 2019). While we recognise that each NMS is complemented by various public and private (both non-profit and profit) sources of climate services, these sources are too numerous to document here. Examples of these additional sources include private sources such as aWhere (Ngari et al., 2016) or tailored climate services provided through ministerial bodies, such as the Ministry of Health or Agriculture (Kadi et al., 2011). Given the complexity of the national landscape, our country-level review is focused on the online climate service offerings provided by each of the five country's NMSs (Table 6.1). This focus is justified given the prominent position occupied by the NMSs as the authoritative climate services provider in each country.

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<sup>11</sup> <https://www.icpac.net/>

Table 6.1: Climate services offered to the public by each country's National Meteorological Service (NMS) (collated through an online review of each NMS's website, undertaken in May 2021). The final column presents a synthesis interpretation of the similarities across each of the NMS offerings

	Ethiopia National Meteorological Agency	Kenya Meteorological Department	Rwanda Meteorological Agency	Tanzania Meteorological Authority	Uganda National Meteorological Agency	Synthesis commentary
Observed data	<p>✓ Daily data available for purchase.</p> <p>Map room containing historical climate analyses</p>	<p>✓ Daily data available for purchase.</p> <p>Map room not operational</p>	<p>✓ Daily data available for purchase (with exceptions for research and government contractors).</p> <p>Map room containing gridded reanalysis / satellite datasets as well as climatological averages</p>	<p>✓ Daily data available for purchase.</p> <p>Map room containing gridded reanalysis / satellite datasets as well as climatological averages</p>	<p>✓ Daily data available for purchase.</p> <p>Map room not operational</p>	<p>All NMSs facilitate the purchase of daily observational (station) data. This data is not freely available, with the exception of Rwanda where free access to observational daily data can be obtained for use in research or for civil infrastructure.</p> <p>All NMSs host “map rooms”, however, at the time of the review, two of these map rooms were not operational. The map rooms provide access to gridded reanalysis data and satellite data in Rwanda and Tanzania. The map rooms also offer access to additional historical climate analyses, such as Malaria risk in Ethiopia, Rwanda and Tanzania.</p>
Daily to weekly forecasts	✓	✓	✓	✓	✓	The focus of the NMSs is on short-term forecasts from days to seasons. Most of the seasonal forecast bulletins also provide high-level advisories for chosen sectors within each country
Monthly forecasts	✓	✓	✓	✓	✓	
Seasonal forecasts	<p>✓ Includes sectoral impact advisories for health, agriculture and water</p>	<p>✓ Includes sectoral impact advisories for: Agriculture, food security and livestock;</p>	<p>✓ Includes broad-scale impact advisory (Not sector specific)</p>	<p>✓ Includes sectoral impact advisories for: agriculture and food security; livestock and</p>	<p>✓ Includes sectoral impact advisories for a selection of: agriculture; livestock;</p>	

		environment and natural resources; disaster management; health; transport; water and energy		fishery; tourism and wildlife, transport; energy, water and mineral; local authorities; health; disaster management; media	fisheries; forestry; health, water and energy; works and infrastructure	
Separate sectoral advisories (including impacts information)	<p>✓ Health, agrometeorological and hydrometeorological bulletins.</p> <p><u>Map room:</u> Historical Malaria risk, historical and future water conditions and historical analysis of climate variables relevant to agriculture</p>	<p>✓ Bio and agrometeorological bulletins.</p> <p>Map room not operational</p>	<p>✓ Agrometeorological bulletin.</p> <p>Other sectoral services for purchase</p> <p><u>Map room:</u> Historical Malaria risk, historical analysis of climate variables relevant to agriculture, climate summaries for local governments</p>	<p>✓ Agro - and Hydrometeorological bulletin.</p> <p>Restricted access aviation forecasts.</p> <p>Other sectoral services for purchase</p> <p><u>Map room:</u> Historical Malaria risk.</p>	<p>✓ Restricted access aviation forecasts</p> <p>Map room not operational</p>	All NMSs provide some broad sectoral advisories as stand-alone bulletins, with the level of detail dependent on the individual NMS.
1-5 year projections	X Not available	X Not available	X Not available	X Not available	X Not available	None of the NMSs provide climate information beyond the seasonal timescale
Climate change projections (5 years or further into the future)	X Not available	X Not available	X Not available	X Not available	X Not available	

The sale of observational data (Table 6.1) is a common financial model replicated by NMSs across Africa (Hansen et al., 2019). It is a vital mechanism for supplementing the income of the NMSs and, in turn, supporting their sustainability as a national service (Hansen et al., 2019). A recent initiative that sought to improve the availability and equitable access to historical information was the Enhancing National Climate Services initiative (Dinku, Thomson, et al., 2018). Through a collaborative approach between the International Research Institute for Climate and Society at Columbia University with each NMS, the project enabled access to satellite-derived reanalysis products through map rooms hosted by each NMS (Dinku, Thomson, et al., 2018). This satellite-derived data can act as proxies for observational data for some applications (Dinku, Thomson, et al., 2018) providing a potential alternative to station observation data. The map rooms hosted at each NMS (Table 6.1) and at the ICPAC regional centre are a legacy of this initiative and provide a foundation for the addition of further services based on the emerging user need (Dinku, Thomson, et al., 2018). To this end, training was provided to NMS staff on how to create and maintain the map rooms (Dinku, Thomson, et al., 2018).

Beyond observational data, the main focus of East African NMSs is on short-term forecasts (daily to seasonal forecasts) (Table 6.1). African NMSs work closely with each country's respective disaster management authorities in leveraging these short-term forecasts to provide early warning advisories of extreme weather events, where possible (Cullmann et al., 2020). In addition, when compared to other regions in Africa, East Africa has a reasonably strong base of impact-based forecast information on the daily to seasonal timescales (Nkiaka et al., 2020). It should be noted, though, that impact-based forecasts currently focus, primarily, on the national or regional level and at daily, weekly to seasonal timescales (Table 6.1).

While the literature documents ready access to longer term information in the region (including climate change projections) (Singh et al., 2018) these are not provided by any of the five country's NMSs and are, almost exclusively, provided by international sources such as the Intergovernmental Panel on Climate Change (IPCC) and the Coordinated Regional Downscaling Experiment (CORDEX), amongst others (Hansen et al., 2019). Ethiopia is an exception in this regard, with an in-country dedicated Ethiopian Panel on Climate Change established by the Ethiopian Academy of Science to provide a country level interpretation of the IPCC fifth assessment report (Ethiopian Panel on Climate Change, 2015).

It is within the context described above that we position our current study. We seek to understand how well this landscape of climate services actors and provision of information matches the current needs of climate services users at the policy level.

### 3. Method

The study employed an explanatory sequential mixed-methods approach (Creswell and Creswell, 2017). This approach starts with quantitative analysis and then builds on the results of the quantitative analysis to explore and explain them through qualitative research. This mixture of quantitative and qualitative approaches recognises their complementarity but also their differential explanatory power for answering specific research questions.

As a framing, our study uses the model introduced by Steynor et al. (2021), which offers an East African framework for identifying and prioritising the various determinants of climate change risk perceptions that motivate action on climate change in the workplace of policy decision influencers. The Steynor et al. (2021) model includes the following climate change risk perceptions determinants: observance of social norms, the psychological distance of climate change, experience of extreme weather events, personal values (both self-enhancing and self-transcending values) and the socio-demographic variables of age, gender and education. Each of these risk perception determinants are further explained in section 3.1.1.

#### 3.1 Design and participants in the survey

Following the target community defined by Steynor et al. (2021), we focused our research on policy decision influencers in East Africa, as the frequently targeted recipients and users of climate services. Policy decision influencers, in this context, were defined as individuals who are able to influence natural resource policy and would be expected to use climate services in this regard. For instance, policy decision influencers included national and local government officials (38% of the sample), private enterprise (18%), academic researchers (16%), non-governmental organisations (NGOs) (11%), parastatals (8%) (organisations owned by the government), Unions/federations (5%) and international development agencies (4%). An evaluation of climate services amongst this group is important because it is comprised of individuals who have the authority to influence local and national planning around climate variability and change.

Data to inform the study were collected through 474 surveys (a participant response rate of 77%) with policy decision influencers in the five East African countries of Ethiopia, Kenya, Rwanda, Tanzania and Uganda (hereafter referred to together as “East Africa”) between September 2018 and January 2019. The minimum number of country surveys collected was 49 (Uganda) and the maximum number was 138 (Kenya). Relevant policy decision influencer organisations in the region were identified through a consultative exercise with stakeholders at an earlier project workshop and specific respondents at each organisation were identified based on the criterion that they would be expected to use or benefit from the use of climate services in their role.

The surveys were administered in English by trained enumerators in each country. Each survey was conducted in-person, with the exception of the section on individual values, because of its potential to be subject to social desirability bias. The values section was completed by the respondent themselves, independent of the enumerator, in order to minimise this potential bias. Participants took part in the survey on a voluntary basis and were granted anonymity through a consent form. The final sample consisted of 29,7% females and 70,3% males with an average educational attainment of an undergraduate university degree and an average age of 30-39 years.

### *3.1.1 Survey measures*

Brief descriptions of each of the survey measures are included here. More detailed descriptions of each of the risk perception determinant survey measures are included in Steynor et al. (2021).

#### *3.1.1.1. Observance of social norms*

Social norms refer to the external expectations on an individual to behave in a certain way and are generally understood to be unwritten rules or standards set by a social group (Popenoe, 1983). Social norms have been shown to have a strong influence on human behaviour at home and in the workplace (Inoue and Alfaro-Barrantes, 2015), including influencing pro-environmental behaviour (Doherty and Webler, 2016).

Six survey items were included to measure the observance of social norms for action on climate change and use of weather and climate information at work amongst this group. Three questions measured descriptive norms (what most people around them do) and three measured prescriptive norms (what most people around them approve of). The responses to the survey were measured on a five-point Likert scale from “strongly agree” to “strongly disagree”.

#### *3.1.1.2. Psychological distance of climate change*

Psychological distance is a measure of the perception of a threat as either far away or near (Pahl et al., 2014). It is measured on four dimensions, namely how close a threat is socially (the threat to oneself or ones social group), spatially (the geographical proximity of the threat), temporally (whether the threat is happening now or in the future) and hypothetically (the certainty of the threat) (Trobe and Liberman, 2011). Previous studies have demonstrated a relationship between the psychological distance (closeness) of climate change and perceptions of climate change risk, i.e. the more psychologically close climate change is, the more it is perceived as a risk of concern (Spence et al., 2012).

The psychological distance of climate change was measured using seven survey items covering each of the four dimensions of psychological distance. These survey items were based largely on those proposed by Spence et al. (2012) and included two questions on social distance, two questions on



spatial distance, two questions on hypothetical distance and one question on temporal distance. Responses were recorded on a five-point Likert scale from “strongly agree” to “strongly disagree”, apart from the question related to temporal distance which was measured on a five-point Likert scale of “never” to “the effects are already being felt”.

#### 3.1.1.3. Experience of extreme weather events

Previous experience of extreme weather events have been shown to increase climate change risk perceptions because experience renders the potential impacts of climate change more real or tangible (Akerlof et al., 2013; Demski et al., 2017). Experience of extreme weather events were measured through four items in the survey, namely how often, in the past five years, participants had experienced i) floods, ii) droughts, iii) high temperatures/heat events and iv) changes to the rainy season pattern. Responses were captured on a five-point Likert scale from “very often” (more than ten times) to “never”.

#### 3.1.1.4. Values

Values are defined as core beliefs or standards that guide ones attitude, priorities and behaviour (Rokeach, 2008). Broadly, values can be grouped into four higher-order categories including self-transcending values (a focus outside of oneself for the greater humanitarian good), self-enhancing values (a focus on the prosperity and achievement of oneself), conservation (a focus on maintaining the current situation and traditions) and openness to change. In this study, we focussed on self-transcending and self-enhancing values, which have both been shown to have a relationship with perceptions of climate change risk. Self-transcending values have been linked to higher climate change risk perceptions (Poortinga et al., 2011b, 2019), whereas self-enhancing values have been linked to lower climate change risk perceptions (Smith and Leiserowitz, 2012).

Values were assessed in the survey by using the Schwartz (2003) 21-item Portrait Values Questionnaire and responses were recorded on a seven-point Likert scale from “very much like me” to “not like me at all”. Using guidance from Schwartz (2003b), the responses were converted to centred scores and the two higher-order values of self-transcending values and self-enhancing values were extracted for use in the analysis.

#### 3.1.1.5. Demographics

Demographics such as age, gender and education have all been shown to have a relationship with climate change risk perceptions (van der Linden, 2015). Therefore, demographic data including age range (in 10-year bands from 20 – 29 onwards), educational attainment (highest qualification) and gender were collected in the survey.

#### 3.1.1.6. Types of climate services information used

One survey item was included with respect to what climate services information types are currently being used for decision-making. Survey participants were asked to select all weather and/or climate and/or impact information they currently use for their job. Choices included observed weather data (i.e. historical records), daily to weekly weather forecasts, seasonal forecasts (3 months), 1-5 year projections of climate, projections of climate 5 years or further into the future and impact-based forecasts. Impact-based forecasts were described as including, for example, forecasts of dam levels, of crop yields, of river levels, of climate-related disease outbreaks etc. Responses were coded as a binary variable of use versus non-use for each information type.

#### 3.1.2.7. Trust in sources of information

In order to assess the participant's most trusted source of climate services, participants were asked to rank their top three most trusted sources for receiving climate services information. Choices included: university scientists / other research scientists, government scientists, representatives of national government, representatives of local/regional government, politicians, the country's NMSs, independent companies that provide weather and climate information (for example AccuWeather), friends and family, environmental consultants, non-governmental organizations (NGOs), community leaders, television, radio, newspapers or other. Responses were recorded on a ranking schedule from first to third trusted source.

### 3.2 Interview design and participants

In order to further explore the findings from the survey, a set of in-depth semi-structured interviews were conducted in two countries. While interviews are an effective way of gaining a deeper understanding of quantitative findings (Baxter and Jack, 2008), it was only possible to conduct interviews in two countries due to resource and time constraints. Therefore, although there are many socio-cultural and political similarities across the region, it should be acknowledged that the interviews would not have captured subtle nuances from the other three countries. The interviews took place in the countries of Kenya and Ethiopia during August and September 2019 respectively. Interviews were conducted with 20 participants in Kenya and 16 participants in Ethiopia (a total of 36) with eight participants from national government, three from local government, three from the private sector, seven from NGOs, two from international development agencies, five from parastatals and eight academics/researchers. No incentive was offered for participation and each interview lasted approximately one hour. The interview cohort consisted of a range of respondents that spanned the same sectors and similar organisational affiliations as the survey respondents and were identified through introductions or by approaching relevant organisations. Care was taken to ensure an

equitable gender balance in interview respondents and all interviewees were assured of confidentiality.

The interviews covered a range of topics of relevance for further understanding the survey findings. Of importance to the present study, the interviews sought to gain an understanding of what climate services information types were being used, what facilitated or hindered their use, from where that information was obtained and what it was used for. All interviews were recorded and transcribed.

### *3.3 Analyses*

For the purposes of analysing and presenting the quantitative regional survey results, the data from each of the five countries were aggregated together to represent the “East African region”<sup>12</sup>. This decision was justified due to the homogeneity in climate change risk perceptions (Steynor et al., 2021) and in the types of climate services information used across all the countries. These similarities were likely a result of the region experiencing similar climate risks, having similar products available from their respective NMSs (Table 6.1) and receiving joint regional support from mechanisms such as ICPAC and the GHACOFs.

The quantitative data from the survey was statistically analysed in SPSS Statistics 26 to ascertain the relationship between each climate change risk perception determinant and the current use of each climate services information type in decision-making (described in 3.1.1 above). Robust statistical analysis requires 10 participants for each included parameter (Schreiber et al., 2006), therefore the sample size of 474 more than adequately met the minimum criteria of 140 participants.

The non-parametric Mann Whitney U test was chosen for the analysis because of the Likert scale nature and non-normal distributions present in the risk perceptions data. As the only categorical variable, the relationship between gender and climate services information use was analysed with Chi-Square analysis.

The qualitative data from the interviews were coded through a multi-step process in NVivo. First, the data were deductively coded into broad pre-defined categories of interest related to climate services information access and use, such as the use of the different types and timescales of climate information, barriers to the access and use of climate information, source of climate information, etc. Through repeated subsequent coding processes, these categories were then further sub-divided into sub-categories representing repeated ideas or patterns in the responses arising from the data. These sub-categories were used to detect consistent overarching themes in the data, providing further understanding and explanation of the statistical findings.

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<sup>12</sup> See paper reviewer comment number 8 (annex 3) with regards to the regional aggregation

## 4. Results and discussion

### 4.1 Results of the statistical analyses

For the purposes of this study, only statistically significant results ( $p$  value < 0.05) were taken as relevant for identifying the relationship between risk perception determinants and the current use of climate services information types. Therefore, while tests were performed for all combinations of risk perception determinants and information types (Table 6.2), only statistically significant results (presented in bold) are further interpreted in the final column of the table. The Chi-Square analysis revealed no statistically significant differences in types of climate services information used between the two genders.

Table 6.2: *r* -values (bold where *p* value < 0.05) of the Mann Whitney U tests between risk perception determinants and current use of climate services information types. The final column provides an interpretation of the statistically significant relationships in that row. Both the medians (Mdn) and mean ranks from the Mann Whitney U tests have been included in the interpretation.

<b>N = 474</b>	<b>Observed data</b>	<b>Daily to weekly forecasts</b>	<b>Seasonal forecast</b>	<b>1-5 years projections</b>	<b>&gt;5 years projections</b>	<b>Impact-based forecasts</b>	<b>Interpretation of statistically significant relationships</b>
<b>Observance of social norms for action on climate change and using weather and climate information at work</b>	.08	.08	<b>.14**</b>	.07	.08	.04	Observance of social norms was greater for those who used seasonal forecasts (Mdn = 23; Mean rank = 251) than for those who did not (Mdn = 22; Mean rank = 211), $\rho = .003$
<b>Psychological distance</b>	.02	.01	0	0	.05	0	
<b>Experience of extreme weather events</b>	.04	.05	.01	.02	.01	<b>.11*</b>	Reported experience of extreme events was higher amongst those who used impact-based forecasts (Mdn = 13; Mean rank = 257) than those who did not (Mdn = 12; Mean rank = 227), $\rho = .022$
<b>Self-enhancing values</b>	.07	.05	.01	.05	<b>.11*</b>	<b>.22**</b>	Self-enhancing values were lower amongst those who used projections further than five years into the future (Mdn = -.58; Mean rank = 209) than those who did not (Mdn = -.38; Mean rank = 246), $\rho = .013$ and lower for those who used impact-based forecasts (Mdn = -.62; Mean rank = 197) than those who did not (Mdn = -.31; Mean rank = 260), $\rho = .000$
<b>Self-transcending values</b>	.09	.06	.01	.02	.07	<b>.13**</b>	Self-transcending values were higher amongst those who used impact-based forecasts (Mdn = .58; Mean rank = 261) than those who did not (Mdn = .43, Mean rank = 224), $\rho = .005$
<b>Education</b>	<b>.11*</b>	.06	.06	<b>.14**</b>	<b>.19**</b>	<b>.14**</b>	Level of educational attainment was higher amongst those who used observational data (Mdn = 3, Mean rank = 250) than those who

							did not (Mdn = 3, Mean rank = 222), $\rho = .018$ , amongst those who used 1-5 year projections (Mdn = 4; Mean rank = 264) than for those who did not (Mdn = 3; Mean rank = 226), $\rho = .002$ , amongst those who used projections of further than five years into the future (Mdn = 4; Mean rank = 283 ) than those who did not (Mdn = 3; Mean rank = 224), $\rho = .000$ , and amongst those who used impact-based forecasts (Mdn = 4; Mean rank = 262) than those who did not (Mdn = 3; Mean rank = 224), $\rho = .002$ .
<b>Age</b>	.06	.09	.02	.01	<b>.11*</b>	<b>.10*</b>	Those who used projections of further than five years into the future (Mdn = 2; Mean rank = 265) were older than those who did not (Mdn = 2; Mean rank = 229), $\rho = .013$ , and those who used impact-based forecasts were older (Mdn = 2; Mean rank = 254) than those who did not (Mdn = 2; Mean rank = 228), $\rho = .035$ .

## 4.2 Qualitative results and discussion

The semi-structured interviews allowed for further exploration, in two countries, of the statistically significant relationships between individual drivers of climate change risk perceptions and the use of climate services information types in the regional survey. The qualitative results and discussion are presented per climate change risk perception determinant.

### 4.2.1 *The relationship between observance of social norms and the use of climate services*

The statistical analysis of the regional survey revealed that observance of social norms for climate change action and use of climate services information at work was higher amongst those who used seasonal forecast information than those who did not (Table 6.2). The interviews provided insight into the reasons why this relationship between observance of social norms for climate change action and the use of seasonal forecast information may have existed. The interviews revealed that planning along seasonal timescales was considered to be part of taking action on climate change, thereby encouraging the use of seasonal forecast information in acting on climate change. This understanding was revealed when respondents were asked to provide examples of how they were planning for climate change: 13 respondents provided examples of addressing climate change through interventions aimed at coping with climate risk on a seasonal basis, a proportion greater than the number providing examples of taking action on climate change on any other timescale. For instance, when asked about expectations to prepare for climate change in job activities, one national government respondent provided an example of climate change action by saying they needed to provide advice to farmers on how to deal with inadequate rainy seasons.

*“Yes [there is a strong expectation on us to prepare for the impacts of climate change] because most of our farmers out there are relying on rain-fed agriculture. So, they need directions from the specialists, that is like our ministry here, to give them the best way forward, in the event that the rain is short, it’s not adequate to see the crops through the season”* Respondent K9, national government, Kenya

If taking action on climate change is conflated with taking action on the seasonal timescale then it would make sense that those who have a higher observance of social norms for action on climate change would also report the use of seasonal forecasts in taking action.

Despite this focus on the seasonal timescale, a few respondents (n = 5) acknowledged that this type of seasonal response mode was not a holistic approach to adaptation planning, and it meant that there was limited consideration of longer-term climate change information in climate change planning/action. This was demonstrated by a respondent from local government who stated that they

had not used longer-term climate information, but he believed that it would be good to use it for resilience planning,

*“The nature of our activity has not taken us there. But I want to believe that it will be good if we can see what the weather is going to be in the future, so that we, as a county, are able to do long-term planning . . . so that you can be able to prepare for the city to be resilient”*

Respondent K14, local government, Kenya<sup>13</sup>

One respondent explained the focus on the seasonal timescale by saying it resulted from agriculture being a sector of priority economic importance.

*“Of course we know the government should be planning with the long-term climate information, but if you look at the priority areas like agriculture, then they tend to look for seasonal forecasts”* Respondent K1, NGO, Kenya

Agriculture is of high economic importance in many African countries (Nkiaka et al., 2019; Carr et al., 2020) and, as such, is a primary focus for policy decision influencers. This importance was demonstrated through the interviews in which 26 respondents cited impacts on agriculture or farming when providing examples of climate change impacts. Agriculture is particularly sensitive to seasonal climatic patterns such as variations in the onset and cessation of rainfall, droughts and prolonged heat events (Adhikari et al., 2015). For instance, heat stress during development and flowering of a crop can cause poor crop quality and yield (ibid) and planting during a false onset of the rainy season can result in lower yields or the need to replant the entire crop (Lala et al., 2021).

With agriculture as a primary economic focus, it is likely that the seasonal planning timescale became the predominant planning timescale because, as explained below by the same NGO respondent as above, planning on the seasonal timescale enables interventions in the agricultural sector, providing tangible economic outcomes and benefits to policy decision-makers within their typically short-term policy planning cycles.

*“A season is very small and if I am told rains will come then you take action, and you will reduce certain losses or increase the yields then it is short term and the outcome is likely to be realised in the foreseeable future. But when you start talking of long term, then some people will not be keen, especially from the political level . . . they are interested in the next five years, when they are sure of being in the office, so they want to do things within that time frame”*

Respondent K1, NGO, Kenya

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<sup>13</sup> See paper reviewer comment number 9 (annex 3) with regards to the desire for longer-term information



This focus on short-term policy planning cycles was a factor noted by 9 interview respondents, therefore it is likely that the focus on agriculture, together with the need to demonstrate tangible impacts within policy planning cycles, is an influential factor behind the focus on seasonal planning as the predominant planning horizon. However, as the policy planning cycles can be anything up to five years, the policy cycles do not fully explain why projections longer than seasonal are not used more in planning. The interview results suggest that there may be a further reason for the predominant use of seasonal information in climate change planning.

When asked about their main sources of climate services information, 28 respondents said they obtained this information primarily from the NMS, with 13 stating that the NMS was the mandated or authoritative source of climate services information for the country. This finding aligned with the results from the regional survey which found that the NMS was the most trusted (first rank) source of climate services information by 59.5% of participants (Figure 6.2, supplementary material). However, the longest timescale of forecasts currently provided by the NMSs in the region are seasonal forecasts (Table 6.1), meaning that those receiving their information from the NMS would not have access to projections longer than the seasonal timescale.

Lack of accessibility to longer-term climate projections was cited as a barrier to use of this information by 8 respondents, suggesting that despite the scientific literature documenting ready access to longer-term climate information outside of the NMS (Singh et al., 2018), its use is limited because of the prevalent role that the NMS plays in information dissemination at the national level. For instance, one respondent stated that he did not use longer-term projections because he didn't know where to get them, despite demonstrating that he believed he ought to know where to get them as a specialist in his field.

*“We are not using that [long term projections]. We don't have the access, even I don't know where to get that kind of information”* Respondent E13, NGO, Ethiopia

Additional barriers to the use of longer-term climate information also emerged from the interviews. These included difficulty in understanding the longer-term projections and/or how to use them (n = 9) and a distrust of longer-term climate information because of its inherent uncertainty or the evolving nature of the science (n = 7).

This section's analysis of the relationship between social norms and the use of climate services suggests that the lack of longer-term climate projections provided by the NMSs, together with limited trust and capacity to use longer-term information, are potentially posing structural barriers to the

uptake of longer-term climate information into planning, thus potentially further reinforcing the seasonal timescale as the predominant planning time horizon. This highlights a potential gap in the provision of accessible climate services, particularly if the climate services community wish to promote the use of longer-term climate information in planning.

#### *4.2.2 The relationship between experience of extreme weather events, values and the use of climate services*

The statistical analysis of the regional survey found reported experience of extreme weather events to be higher amongst those who used impact-based forecasts when compared to those who did not use impact-based forecasts (Table 6.2). Experience of extreme events can evoke strong emotions, making the events memorable and concrete, often associated with vivid negative consequences (Loewenstein et al., 2001; Weber, 2006). Furthermore, experiences of extreme weather events have been shown to play a role in bringing climate change psychologically closer (Steynor et al., 2021) thereby influencing how individuals mentally construe climate risk (Reser et al., 2014b) and, in turn, the types of information they use to act on the risk (Trope and Liberman, 2011; Brügger et al., 2016). When in a mental processing mode associated with a risk that is construed as psychologically close, individuals seek out concrete, actionable information (Brügger et al., 2016).

Considering all interview respondents (n = 36) recalled at least one recent extreme weather event that impacted negatively on the region, it makes sense that greater experience of extreme weather events might lead them to use impact-based forecasts, which are likely to provide the kind of concrete, actionable information required in this mental processing mode. A local government official explicitly linked his experience of specific past extreme weather events to the desire for future impacts information to support planning, particularly around similar events, by saying:

*“[W]e usually look at what kind of impacts we anticipate; what kind of losses will occur. And when we are seeking information, we also start thinking what kind of information is necessary so that we are able to avert such events, that is in terms of preparedness. Some of these areas where we have previous experiences, for example, flood-prone zones, we also start thinking this has been a problem for us, but moving in the future, what we want to do so that it doesn’t happen [again].”* Respondent K14, local government, Kenya

The regional survey results also revealed self-transcending values to be higher, and self-enhancing values to be lower, amongst those who used impact-based forecasts. As these values lie in opposition to each other, their relationship with the use of impact-based forecasts is not surprising and can also be explained through the different ways these groups may construe climate risks. Those with predominantly self-transcending values (the majority of this cohort), who, by definition, have a more

outward-facing awareness of the world around them, being motivated to help others and the environment, might therefore be more aware of climate risks and the associated impacts experienced by communities and ecological systems. This awareness might translate to a state of construal that leads them to seek concrete, impact-based information to mitigate the potential for future impacts. The hypothesized link between the use of impact-based forecasts and this cohort's outward-facing desire to help wider society was found in 10 of the interviews. For instance, a national government official linked the use of impact-based forecasts to the need to provide government assistance during periods of drought.

*“If it was a drought, and we need to get maybe livestock feed or we need to know how to take care of people in those areas . . . part of the information that we prepare is possible impacts of that weather forecast”* Respondent K9, national government, Kenya

While the survey revealed that impact-based forecasts were used by 36% of policy decision influencers (Figure 6.1, supplementary material), the interviews revealed a mismatch between the readily available impact-based forecasts and those suitable for local application by the user community, with 15 respondents reporting that they generated their own impact-based forecasts based on the information received from the NMS. For instance, a national government official in Ethiopia noted that, while the NMS did provide impact-based forecasts, this information required further strengthening through ground-truthing (comparing to direct observations or measurements) with local information in order to be applicable to the local decision context. This ground-truthed information was produced in-house.

*“The met[eorological] people are trying to give that [impacts] forecast. But the detailed one is prepared here, with ground information. So, we are using that ground information, so we can strengthen the information that we get from the met[eorological] office”* Respondent E14, national government, Ethiopia

Given the prominence of the NMS as a source of climate services information (section 4.2.1), this mismatch between the readily available impact-based forecasts from the NMS and what is required for on-the-ground decision-making revealed a potential shortcoming in the current delivery of impact-based forecasts.

Finally, the regional survey analysis found that self-enhancing values were lower amongst those respondents who used long-term projections (projections of climate further than five years into the future) than among those who did not. This relationship was more difficult to explain through the

interviews, especially as respondents did not openly report self-enhancing tendencies (which may be perceived as undesirable). However, speculative reasons for this relationship can be drawn from the literature. Those with higher self-enhancing tendencies tend to have a lower engagement with climate change and are less concerned about it (Corner et al., 2014). On this basis, it can be hypothesized that those with high self-enhancing values would be less likely to engage with long-term projections of changing climate, primarily because of their lower engagement with climate change. Therefore, this may then explain why the respondents using long-term projections of climate change have lower self-enhancing values.

This section's analysis of the relationship between experience of extreme weather events and the use of climate services revealed a gap in the provision of climate services with regards to the delivery of decision-relevant, locally ground-truthed impact-based forecasts. As decision makers are likely to continue to seek concrete, actionable information to address the impacts of climate change going forward, the enhanced provision of impact-based forecasts is likely an important area of focus for climate services improvement.

#### *4.2.3 The relationship between education, age and the use of climate services*

The statistical analysis of the regional survey revealed that the level of educational attainment was higher amongst those who used observational data, 1-5 year projections, projections of further than five years into the future and impact-based forecasts (Table 6.2). All of these information types were used less than daily/weekly forecasts or seasonal forecasts by the regional survey respondents (Figure 6.1, supplementary material). An understanding of the reasons behind their lower use provides insight into their relationship with educational attainment.

Starting with the use of longer-term information (1-5 year projections and projections five years or further into the future), the interviews revealed that reasons for not using longer-term information included: difficulty in understanding the longer-term projections and/or how to use them (n = 9), lack of accessibility (n = 8), and a lack of trust in the longer-term climate information (n = 7) (section 4.2.1). Of these reasons, the difficulty in understanding longer-term projections and their use would seem to be the reason that best explains why respondents who use these types of information are the most educated respondents. It seems reasonable to suppose that the relationship between the use of longer-term information and higher educational attainment would be explained by the potential for education to provide the required capacity to access, understand and interpret this information.

With regards to observational data, the interviews highlighted a requirement for specialist capacity for pre-processing or filling incomplete datasets before they could be useful. The skills required to pre-process incomplete data are often acquired through higher educational attainment. For instance,

a senior hydrologist with a Masters degree noted that he had to pre-process observational data from the NMS before he was able to use it:

*“This climate information we got from the National Meteorological Agency, there is a lot of data gaps . . . so, we have to prepare it, we have to fill it. It is difficult to fill the data gaps”*

Respondent E4, private sector, Ethiopia

The same requirement for specialist capacity can be applied to explain the relationship between the use of impact-based forecasts and educational attainment. As evidenced in section 4.2.2, many of the impact-based forecasts were produced in-house in response to specific user needs. As noted by a respondent from Kenya, the ability to generate these in-house forecasts or advisories requires specialist knowledge.

*“When you look at the seasonal forecast, they [the NMS] will give you some [impact] advisories, but I find that these advisories could apply in any season, anytime, anywhere . . . So, a lot of people have to interpret the forecast for themselves. The extent that is possible also depends upon capacity, knowledge”* Respondent K5, NGO, Kenya

The statistical analysis also revealed that those who used climate projections of further than five years into the future and those who used impact-based forecasts were older than those who did not. Unfortunately, the age of the interview respondents was not recorded, so it is not possible to explain the relationship between age and the use long-term climate information and impact-based forecasts through the interviews. However, a speculative reason for the existence of these relationships may be that older policy decision influencers have, through experience, come to appreciate the limitations of planning based on short-term information alone and have also come to understand the added value that impact-based forecasts might provide them for planning.

This section’s analysis of the relationship between education and the use of climate services revealed that the specialist knowledge required to use some climate services is potential posing a barrier to their uptake.

## 5. Filling the gaps in climate services for East African

The analysis of the intersection between climate change risk perception determinants and the use of climate services provided useful information in understanding and explaining current climate services use. The analysis also allowed for the identification of potential gaps in the services supply landscape,

through the lens of climate change risk perceptions. These gaps are noted below, alongside recommendations for responding to them.

5.1. The need for provision of longer-term climate projections alongside short-term forecasts  
The extent to which short-term information is used by policy decision influencers emphasizes the need to continue providing short-term information for decision-making. However, it was revealed that there was limited use of longer-term information among policy decision influencers, despite some recognition that they should be using it. One reason for this limited use seems likely to be due to the gap in provision of longer-term climate information from the NMSs, who are the mandated and trusted information source in each country.

To support the uptake of longer-term, particularly climate change information, into planning, the NMSs could be encouraged to act as conduits for climate change projections while continuing to provide shorter-term information. This provision of longer-term climate information may begin with simple messages around the direction of change of future climate (for example from the United Nations Framework Convention on Climate Change national communication documents) and move towards developing an approach that integrates both short-term weather forecasting and longer-term climate change projections into a continuous forecast of the future (Singh et al., 2018), also known as seamless forecasting.

While integrating longer-term information into the NMS offerings seems a straightforward recommendation, it is acknowledged that anything beyond very simple messages, such as the direction of change of future climate, requires additional staffing resources and capacity (Winrock International, 2018). NMSs in the region are already notoriously underfunded and understaffed and lack the institutional legacy of capacity that some of the NMSs in developed countries have (Winrock international, 2018). Therefore, to achieve this seamless forecasting approach, opportunities lie in strengthening the international and in-country collaborations between, for instance, universities, the private sector and the NMSs, in order to draw on a range of national and international expertise in tailoring longer-term information for specific users, as well as providing guidance to ensure their robust use. However, while this kind of collaborative approach has been widely supported in the literature (e.g. Winrock International, 2018; Cullmann et al., 2019), the siloed culture of national institutions at present (Winrock International, 2018) is a hindrance to this type of collaboration, presenting a barrier that would need careful consideration in overcoming. An initial step towards overcoming this barrier may be to embark on developing memorandums of understanding between institutions for data sharing and collaborative working or to leverage the burgeoning development of the National Climate Services Frameworks (under the Global Framework for Climate Services) to establish sustained collaborative engagement platforms.

## 5.2 The need for enhanced delivery of impact-based forecasts

While it is evident that East Africa is more advanced in the delivery of impact-based forecasts than some other parts of Africa (Nkiaka et al., 2020), there is still scope to improve the delivery of impact-based forecasts so that they incorporate more locally-specific detail. Through enhanced collaboration and coordination between, for instance, the NMS, other suppliers of climate-related information (such as research institutes and regional bodies), sectoral experts and indigenous knowledge holders there is scope to enhance the delivery of these impact-based forecasts so that they are locally ground-truthed, providing information that is more relevant for local decision-making.

Building on the mandate and authority of the NMS, as the central source of climate services information, the NMS and ICPAC map rooms provide potential for hosting these impact-based forecasts, as is currently the case for historical Malaria risk in Rwanda and Tanzania (Table 6.1). However, at the time of this review, the map rooms of the Ethiopian National Meteorological Agency and the Kenyan Meteorological Department were not functioning, which confirms the need to carefully consider the sustainability of any suggested intervention at each NMS. The establishment of a strategic oversight group within each NMS to both coordinate donor funding and lobby government for sustainability funding would likely assist in this process.

## 5.3 The need for building capacity, trust and user-focused climate services

The analysis revealed that specialist knowledge is required to use some climate services such as observational data, impact-based forecasts and longer-term information. With particular respect to longer-term information, limited trust in the information was also cited as a barrier.

Previous literature has commonly offered user capacity development as a solution to increase the use of complex climate information (e.g. Hansen et al., 2019; Jones et al., 2015; Nkiaka et al., 2019; Singh et al., 2018; Vincent et al., 2017), because, as highlighted in this research, higher educational attainment has a relationship with the use of some of the more specialist climate services information types. The push towards capacity development has led to a growing number of tailored and targeted short courses to enhance the use of climate services in Africa. As an additional form of capacity development, the current research suggests that mentorship between senior (older), more qualified, and junior (younger), less qualified members of staff may encourage the use of climate change projections, as it was found that older respondents were also more likely to use longer-term information.

However, while user capacity development is undoubtedly one part of the solution, the onus should not be placed solely on the users of climate services to increase their ability to use complex information. There is a reciprocal need for capacity building amongst the providers of climate services

to enable them to produce usable information. This requires that the climate services producers gain a better understanding of the complexities of the user decision context (L. Jones et al., 2017; Müller et al., 2020), understanding what constitutes usable as opposed to useful information (Lemos et al., 2012) and how to effectively communicate climate services information in a way that maximises uptake and use (Daron et al., 2021).

Similar to the recommendations for further collaboration made in section 5.2, enhanced collaboration and knowledge exchange between climate services providers, intermediaries and the users of climate services are an increasingly recognised way of enhancing the utility and use of climate services information (Steynor et al., 2016; L. Jones et al., 2017; Steynor, Lee, et al., 2020; Done et al., 2021; Vincent et al., 2021). These transdisciplinary collaborations (often described as processes of co-production in the literature) have also proved to be effective ways of building trust relationships which, in turn, create trust in the resulting climate information (Vincent, Daly, et al., 2018).

## 6. Conclusion

This study introduced a climate change risk perceptions approach for identifying the current gaps in climate services information available in East Africa. Three main gaps have been elucidated, namely the lack of longer-term climate information disseminated through NMSs, the limited delivery of ground-truthed impact-based forecasts and the limited capacity to understand, trust and use complex longer-term climate projections. While none of these gaps are surprising, the seemingly central role played by the NMSs in driving information use is important to note and could provide a valuable leverage point for increasing the use of climate services.

In addressing these gaps, a future vision for climate services in East Africa may include an approach that is premised on the enhanced collaboration between the NMS, research institutes and the practitioner communities in developing a community of practice that would facilitate the ready access to longer-term climate projections and locally-relevant impacts information. This enhanced collaboration would also provide the framework required to build capacity across the climate services community (between producers, practitioners and users) in the robust supply and uptake of climate services into decision-making. Under the auspices of each country's National Framework for Climate Services, the NMS could act as a central point or champion for this community, thereby providing a critical role in connecting the community and acting as a conduit for the dissemination of decision-relevant information, including longer-term climate change information.

While this vision appears a simple suggestion, a collaboration such as the one described above would require significant changes in the current operating culture in the region. While some partnerships do exist, enhanced collaboration on the scale recommended here would likely be constrained due to lack



of financial or personnel resources (Winrock International, 2018). Therefore, there is a need for further research to understand the cost-benefit trade-offs between focusing limited funding resources primarily on the advancement of decision-relevant products or focusing resources on the enhancement of networks and collaborative arrangements that underpin the development of these products. Given the growing need to adapt to a changing climate, this is a question that needs careful consideration within the current funding landscape.

## Supplementary Material

The descriptive statistics for each of the climate change risk perception determinants are presented in Steynor et al., (2021) and are, therefore, not presented again here. The survey results with respect to the use of various climate services information types and trusted sources of climate services are presented in Figure 6.1 and 6.2 below.

As is evident from the figure 6.1, the leading information types used are, in order of percentage of participants reporting their use: daily to weekly forecasts, seasonal forecasts, and observed/historical records. With respect to trust in service providers, the survey results are presented in Figure 6.2. The National Meteorological Service was the most trusted information source by a considerable margin, and the category “University and other research scientists” the second most trusted information source.

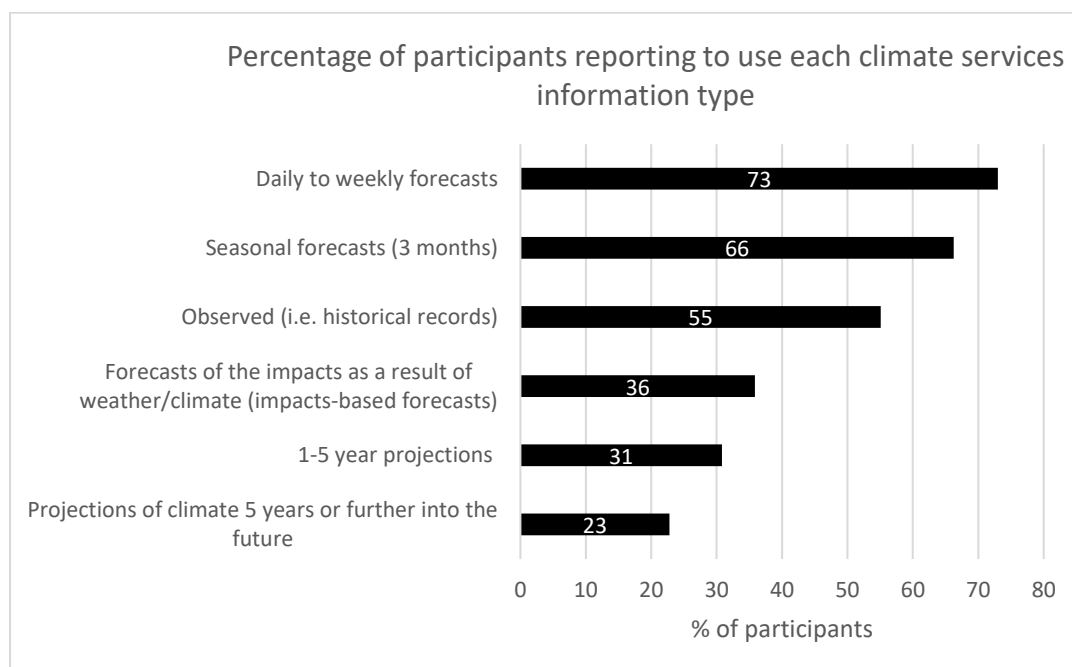


Figure 6.1: The percentage of participants who specified that they used each climate services information type in their jobs. Participants chose all options that applied to them.

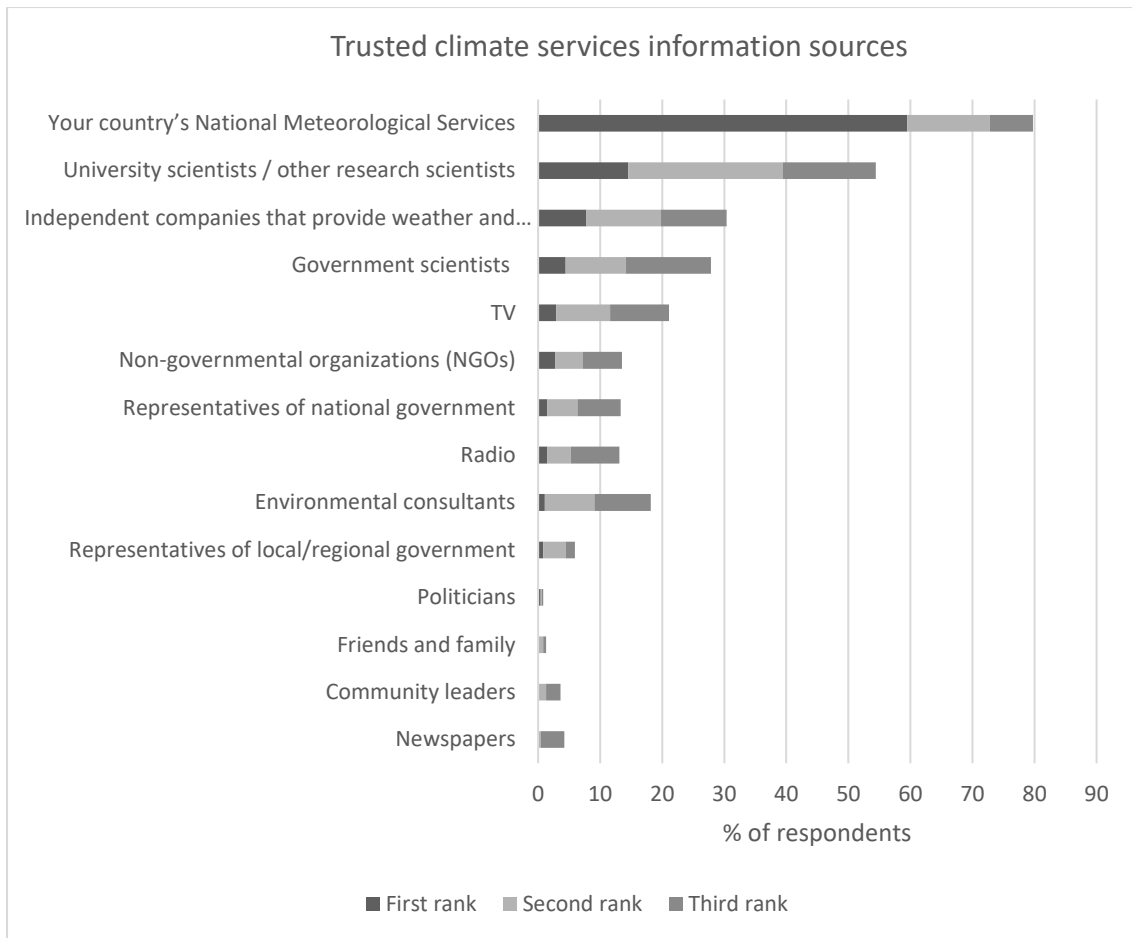


Figure 6.2: Most trusted climate services information sources by rank, where respondents were asked to rank their top three most trusted sources.

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## Chapter 7: Discussion and conclusion

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## 1. Introduction

The central aim of this study was to explore and better understand East African climate change risk perceptions in order to contribute to emerging discourses and developments in (i) climate change risk perceptions theory and (ii) the climate services field. In working towards this aim, the study has employed a sequential approach to addressing each of the study objectives to advance theoretical knowledge of climate change risk perceptions in Africa. This knowledge was additionally used to inform the future development of climate services and to contribute to the growing climate services literature.

This chapter first summarises the research steps while drawing together the study findings in proposing a practical framework for the enhancement of climate services for East Africa. This proposed framework is then discussed with respect to its generalisability beyond the East African region to demonstrate the potential contribution of the framework towards the practice of climate services more broadly. The chapter goes on to discuss the unique theoretical advances and contributions made by the study in the fields of climate change risk perceptions and climate services, and how risk perceptions are a critical component of the decision process. Finally, potential limitations of the study, as well as avenues for future research, are outlined.

## 2. A proposed framework for the enhancement of East African climate services

A primary objective of climate services is to provide climate information in a way that can be used in practical decision-making (Hewitt et al., 2012). This objective requires understanding the decision context within which climate services are used (Hewitson et al., 2017). This study set out to better understand this decision context in order to develop a framework that could be used by climate services providers to design, develop and deliver climate services that better meet the decision context specificities of East African policy decision influencers.

The research undertaken in this study enabled the development of this framework. First, climate change risk perceptions were established as a valuable theoretical framework for understanding the decision context and, in turn, informing climate services (chapter three). Second, by selecting a set of climate change risk perception determinants of relevance to Africa, exploratory research was undertaken to understand how the various determinants of climate change risk perceptions interact with each other to potentially influence climate change risk perceptions and, in turn, action on climate change in East Africa (chapter four). Through structural equation modelling, a model was developed to elucidate the effects of climate change risk perception determinants on climate change risk perceptions and action. This model offered a structure for prioritizing the various climate change risk perception determinants by their degree of influence, which, in turn, provided the structural basis for a framework to inform the enhancement of climate services.

Third, with the developed model as a basis, the identified climate change risk perception determinants were investigated amongst policy decision influencers in East Africa to gain further insight into their decision context (chapter five). Based on this understanding, known principles from environmental psychology were used to propose a set of suggestions for the enhancement framework, outlining how currently available climate services could be better aligned to the East African decision context.

Finally, the relationships between identified determinants of climate change risk perceptions and the use of climate services information types were explored through a combination of quantitative and qualitative analysis (chapter six). This analysis enabled the identification of potential gaps in currently available climate services for East Africa. Options for filling these gaps, so that climate services better serve East African knowledge needs, were used to inform the enhancement framework.

This chapter now integrates the results from each of the preceding chapters to propose the framework for the enhancement of climate services for East Africa. The framework is presented visually (figure 7.1) by utilising a simplified and inverted version of the model structure developed in chapter four. The model structure has been inverted so that it is visually simple to grasp which recommendations (linked to each category of risk perception determinant) are likely to offer the most relative benefit for climate services enhancement (i.e. those that are situated closest to climate change risk perceptions (and, in turn, action)).

The refined version of the model structure reflects the results from chapter four, in that the pathways to heightened climate change risk perceptions differ depending on individual value systems. Heightened climate change risk perceptions of those with primarily self-enhancing (i.e. inward-looking) values are more influenced by social norms, whereas heightened climate change risk perceptions of those with primarily self-transcending (i.e. outward-facing) values are more influenced by their experience of extreme events and, in turn, of their psychological proximity to climate change. However, as people very rarely encompass just one value system, these influences are not mutually exclusive.

Recommendations for the enhancement of climate services targeted at East African policy decision influencers are grouped/listed under their related climate change risk perception determinant in the model (as determined in chapters five and six). For instance, under psychological distance (closeness), it is recommended that climate services be delivered as concrete, impacts and solutions-based information to better align climate services to the construal level associated with climate change as psychologically close (chapter five) and, under experience of extreme weather events it is recommended that locally ground-truthed impact-based forecasts are provided (chapter 6).

While the framework offers a concise way of presenting the various enhancement recommendations together, it is important to recognise that the recommendations are divided into two groups. One group is a set of recommendations for better aligning climate services to the decision context that result from chapter five (blue boxes) and another group is recommendations for filling gaps in climate services that result from chapter six (orange boxes).

Each of these groups of recommendations require enactment at different implementation levels. The recommendations with regards to filling gaps in currently available climate services (orange boxes) apply, primarily, at the broader systemic level. For instance, widespread delivery of longer-term climate projections through the National Meteorological Services (NMSs) will require a fundamental step-change in the way climate services are delivered, which is unlikely to be achieved through a single climate services project or initiative. Conversely, the recommendations for aligning climate services to the decision context could be applied more readily to individual climate services projects or initiatives. For instance, providing concrete impacts and solutions-based information is a recommendation that could be applied within an individual climate services initiative. Hence, different components of the framework have varied levels of applicability.

No framework can consider all dimensions of a complex social context. Nonetheless, the approach proposed here presents an evidence-based toolbox that offers a suite of recommendations for developing and delivering more context-relevant climate services to enhance their beneficial value and increase the uptake of climate services by policy decision influencers when they undertake action on climate change. It should be noted that the implementation of the proposed recommendations in the framework rests on the premise that there is capacity to implement these suggested recommendations, which isn't necessarily the case. Where capacity is a limitation, the framework offers a basis for assessing current climate service practices and, where shortcomings are identified, provides a basis for motivating for specific remedial actions/solutions.

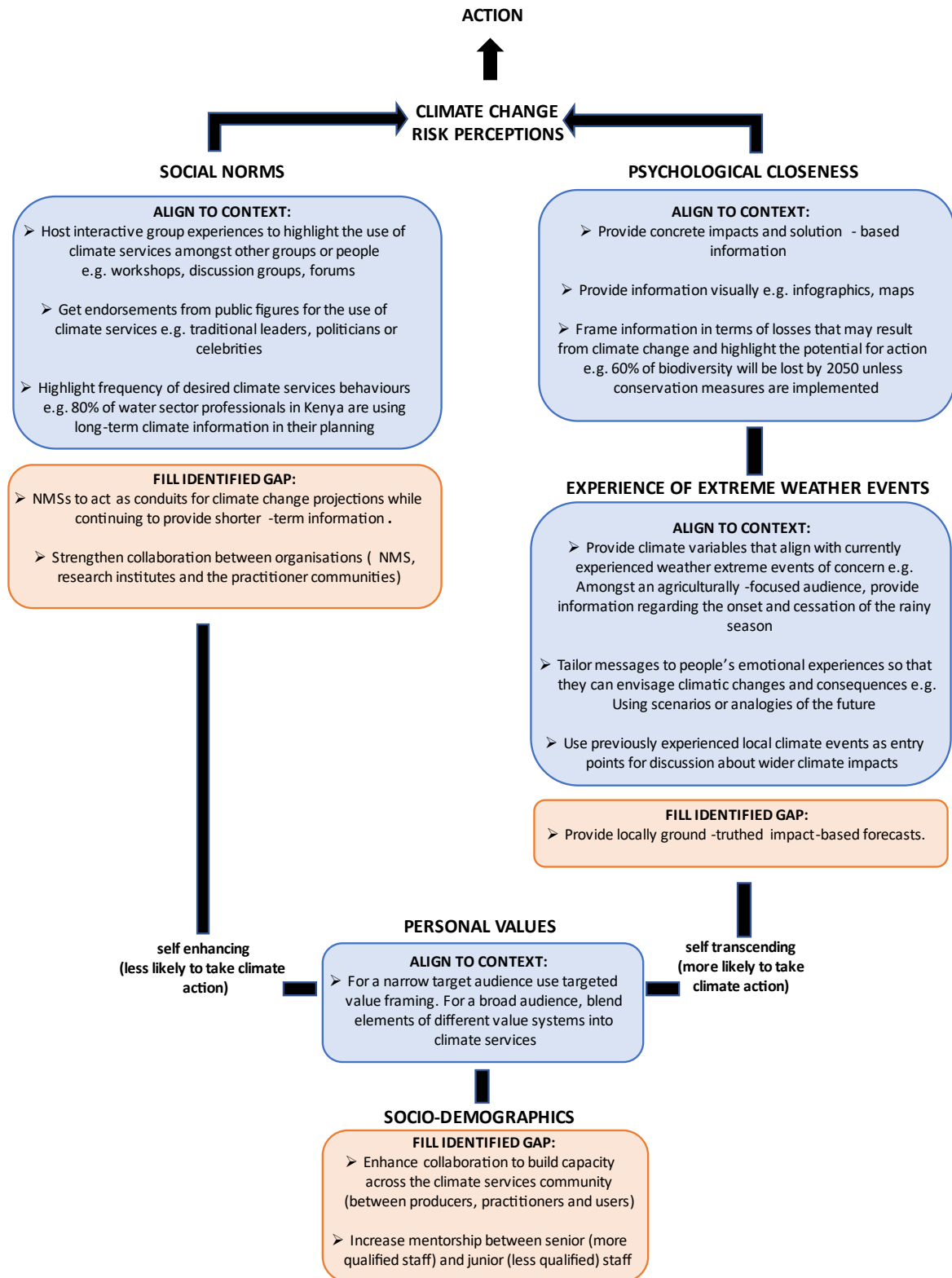


Figure 7.1: Framework showing priority recommendations related to climate change risk perceptions to enhance the development of more context-aware climate services for policy decision influencers in East Africa. Common gaps seen in existent climate services are represented in the orange boxes and approaches for better aligning climate services to the decision context are represented in the blue boxes

## 2.1 Generalisability of the recommendations within the framework

While this study was focused on the East African region, there may be wider applicability of the recommendations within the framework beyond East Africa to other regions in Africa or internationally. An exploration of the generalisability of recommendations in the framework provides the basis from which to discuss its contribution to the field of climate services more broadly.

### *2.1.1 Generalisability of the recommendations for aligning climate services to the context*

The framework's recommendations for aligning climate services to the decision context result from an understanding of the determinants of climate change risk perceptions amongst East African policy decision influencers. Many of the alignment recommendation categories such as aligning climate services to the value systems of a group, leveraging social norms and tailoring messages to people's emotional experiences are recommendations that might broadly apply in any context and have been offered as recommendations in the international literature, outside of the climate services field (Crompton, 2010; Broomell et al., 2015b; Demski et al., 2017; Yamin et al., 2019).

However, some of these alignment recommendations include elements that apply specifically to aspects of climate change risk perceptions of this audience. In particular, this specificity applies where examples of how to implement a recommendation are provided. For instance, elements of the framework recommendations that are audience-specific include providing information on onset and cessation of rainfall due to the importance of agriculture amongst this community, and providing concrete, visual and loss-framed information because climate change is psychologically close amongst this audience.

Therefore, a key generalisability consideration is how much these audience-specific alignment recommendations might resonate with other audiences outside of East Africa. To inform this discussion, the following section explores potential similarities in climate change risk perceptions in other parts of Africa and (where relevant) internationally.

The African climate change risk perceptions literature is abundant with experiences of extreme weather events, with the vast majority of African studies focused on personal experience of extreme weather events as the primary determinant of climate change risk perceptions (e.g. Chichongue et al., 2015; Mubiru et al., 2018). Table 2.2 (chapter 2) provides a summary of reviewed studies that highlight this heightened experience of extreme weather events in all regions of Africa. The heightened experience of extreme weather events illustrated in Table 2.2 is also aligned with the most recent widespread Afrobarometer study documenting perceptions of climate change across Africa. The study found that 46% of Africans perceived experiencing more severe droughts in the last 10 years and 31% of Africans perceived experiencing more severe flooding in the last 10 years (Selormey et al., 2019).



While it is evident that experience of extreme weather events is a widespread phenomenon across all African regions, the Selormey (2019) study suggests that perceived experience of each type of extreme weather event (e.g. rainy season changes, extreme heat) likely differs depending on the predominant economic activity of the region. Therefore, recommendations in the framework such as providing information on the onset and cessation of rainy seasons may only be relevant to those Africans who rely on distinct rainy seasons, such as for agricultural activities (most of Africa apart from Northern Africa).

There is also evidence to indicate that climate change is likely psychologically close in other regions of Africa beyond the East African region. These similarities are outlined in detail in chapter three but were also subsequently discussed by Steynor et al. (2020) who noted the psychologically proximal nature of climate change amongst policy-makers in three southern African cities. The psychological closeness of climate change in other African regions suggests that recommendations such as providing concrete, visual and loss-framed information would be broadly applicable in the rest of Africa.

With respect to areas outside of Africa, some literature from the developed world has documented climate change as psychologically distant (Leiserowitz, 2005; Spence et al., 2012; C. Jones et al., 2017; Loy and Spence, 2020), albeit mostly amongst general public groupings. This suggests that framework recommendations related to the psychological closeness of climate change may not be currently transferrable to a developed country audience, however, more research is required to determine the psychological proximity of climate change amongst developed country policy decision influencers. It is also worth noting that recent polls suggest that the perceptions of developed country individuals are rapidly changing (Pew Research Center, 2021).

#### *2.1.2 Generalisability of the recommendations for filling gaps in currently available climate services*

It can be argued that most of the recommendations for filling gaps in currently available climate services (orange boxes) would constitute good practice anywhere in the world. For instance, capacity-building and enhanced collaboration are commonly recommended actions in much of the international climate services literature (Dinku et al., 2014; Mataya et al., 2019; Sultan et al., 2020; Vincent, Conway, et al., 2020). A call for locally ground-truthed impact-based forecasts is also present across the literature (Harrowsmith et al., 2020) but is particularly emphasised within the African literature (Mataya et al., 2019; Nkiaka et al., 2019, 2020; Vincent, Conway, et al., 2020). For instance, Nkiaka et al.'s (2020) study in three west African countries (Ghana, Nigeria and Senegal) concluded that, in order to increase the uptake of climate services in west Africa, NMSs should produce user-tailored impact-based forecasts as a routine forecasting activity. This emphasis on locally ground-truthed impacts-based forecasts in Africa is likely driven by the high experience of extreme weather

events in Africa (as noted in section 7.1.1.1 above) resulting in users of climate services seeking concrete, solutions-based information (in a state of low-level construal).

There is one exception to this wider applicability. The gap in provision of climate change projections from NMSs is not a commonly experienced gap worldwide. Many NMSs in the global North already fulfil this role (for instance the UK Met Office<sup>14</sup>). However, the lack of provision of climate change projections from NMSs does appear to be a common gap in the rest of Africa. As evidence for this assertion, it is possible to draw on work undertaken by the World Meteorological Organisation in assessing and categorising climate services in African countries. Each country’s NMS was classified as a basic, essential, full or advanced service (figure 7.2) (Dinku, Madajewicz, et al., 2018). In an initial assessment of the climate services offered by seven African NMSs (Senegal, Cote d’Ivoire, Niger and Mali in west Africa, Ethiopia and Rwanda in East Africa and Malawi in southern Africa) none achieved either a full or an advanced climate services categorisation (figure 7.2), with all classified as either basic or essential (Winrock International, 2018) – and therefore lacking in the delivery of climate change projections (Figure 7.2).

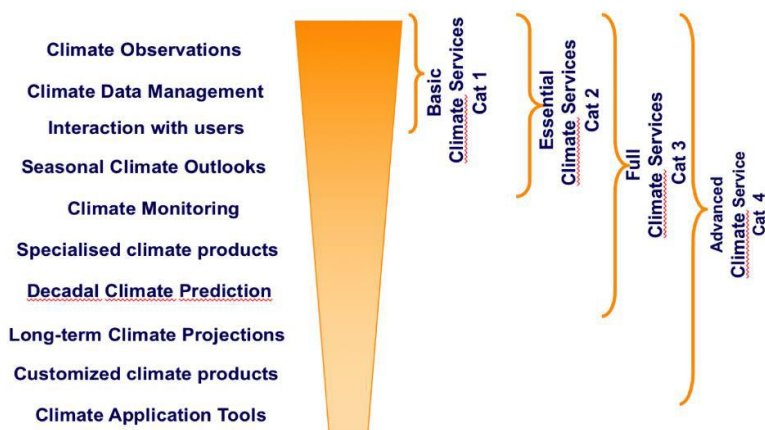


Figure 7.2: World Meteorological Organisation NMS categories (Dinku, Madajewicz, et al., 2018)

While only seven NMSs were included in this initial categorisation study, given that all African NMSs are supported by similar regional climate centres, have similar funding resource constraints (Georgeson et al., 2017) and fall within similar developing country contexts, it would seem likely that very few (if any) African NMSs offer an advanced climate service (category 4). These similarities mean that seasonal to decadal climate projections are likely the longest time-period of climate information offered from the majority (if not all) African NMSs because, as is apparent from figure 7.2, long-term climate projections are only provided by category 4 climate services. Therefore, it is likely that the framework’s recommendation for NMSs to strengthen their national and international collaborations

<sup>14</sup> <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp>

and to act as conduits for the provision of longer-term climate projections would be a widely applicable recommendation within many African countries.

Overall, apart from some regional nuances in the specificities of the recommendations, many of the recommendations in the framework are expected to have reasonable applicability to other regions of the world and would have particular relevance in places with a comparable state of development and climate services structures, such as other parts of Africa.

## 2.2 Contribution of the framework to the field of climate services

There are still few tools that allow climate services to be designed, delivered and communicated in a way that accounts for context-specific needs. In addressing this gap, this framework makes a practical contribution to the climate services field by providing a set of recommendations for enhancing climate services for East Africa, in the first instance. However, the potential wider applicability of the tool (as discussed above) likely expands the contribution of the framework beyond the bounds of East Africa. In instances where there is limited capacity to implement the framework's recommendations, the framework offers a further contribution as an evaluative tool against which climate services could be assessed for good practice. This assessment process could be used as evidence to motivate for further resources or capacity to address potential shortcomings of currently available climate services.

The proposed framework also demonstrates a practical middle ground between the user-first and data-first approaches to climate services (a polarisation within the climate services community that is outlined in chapter 2, section 2.11). The framework achieves this middle ground by taking into account aspects of the user-first approach, specifically an understanding of the decision context, together with aspects of the data-first approach, specifically the tailoring (or aligning to climate change risk perceptions) of current climate data/information products. While not intended to replace either approach, the demonstration of a complementary approach is useful in providing an intermediate solution in the currently polarised debate about approaches to climate services.

## 3. Theoretical advances and contributions to the literature

The study aimed to explore and better understand East African climate change risk perceptions to contribute to academic discourses and developments in both climate change risk perceptions theory and the climate services field. The study was successful in meeting this aim by making several theoretical advances and contributions to the literature, discussed in this section.

The initial major theoretical contribution of this study is in drawing together climate change risk perceptions theory and the climate services field (initially proposed in chapter three) by elucidating the links between risk perceptions and the decision-making process. The development of this relationship responds to the growing call for climate services to be informed by the decision context

(Hewitson et al., 2017; Vogel et al., 2019) and by interdisciplinary knowledge (Carlton and Jacobson, 2013; Alexander and Dessai, 2019).

While there is an established knowledge base on informing risk communication using risk perceptions (Fischhoff, 2009; Moser, 2010; Stoknes, 2014; Corner et al., 2018), climate services are much broader than simply a risk communication activity. The climate services community recognise that the one-way communication of information (such as risk communication) is necessary but insufficient in bridging the science-society divide (Lemos et al., 2012). Instead climate services take a broader approach by aiming (in many cases) to understand the context in which decisions are made to build mutual understanding between science and society and act to build relationships that are necessary for the relevant production and uptake of climate research (Bednarek et al., 2018).

Some aspects of this research demonstrate the risk communication attributes of climate services, such as the proposed alignment between currently available climate services and known environmental psychology principles (chapter five). However, the primary focus of the research is on better understanding the policy decision influencer decision context to inform climate services (chapters four, five and six). This focus of the research is demonstrated, for instance, when drawing together climate change risk perceptions and the use of climate services to develop a new evaluation methodology for identifying gaps in currently available climate services (chapter six). This evaluation methodology intentionally seeks to challenge the one-way notion of climate services communication and rather promote the notion that climate services providers have a responsibility to better understand the decision context to design and develop climate services, from first principles, that respond to contextual requirements. This newly developed evaluation methodology is not constrained to the African context and offers the potential for future studies to identify gaps in climate services that may not be uncovered by current traditional evaluation methodologies, thereby offering a novel methodological contribution to the climate services evaluation literature.

A further contribution of the research lies in the better understanding of East African climate change risk perceptions, in particular amongst policy decision influencers who are an important focus community for climate services. To date, African climate change risk perceptions are not well understood. Most of the literature focuses on personal experience of extreme weather events as a proxy for understanding climate change risk perceptions (chapter 2, section 2.2.3) with less attention focused on understanding the multiple determinants of risk perceptions in the African context.

Multiple determinants of risk perceptions have been investigated in the global north through multivariate models of climate change risk perceptions (e.g. Akerlof et al. 2013; Milfont 2012; van der Linden 2015). Each of these models has purported to account for varying levels of explained variance

in climate change risk perceptions and have been primarily applied within studies focused on the general public. However, it is likely that the explanatory power of climate change risk perception models will vary depending on developmental context and study audience (Poortinga et al., 2019). Therefore, there is potential for research on the multiple determinants of climate change risk perceptions in the African context and for new and unexplored climate change risk perception determinants to be incorporated into climate change risk perception models, particularly if they are deemed potentially important to the context or audience for which the model is being developed.

It is against this backdrop that this research contributes to climate change risk perceptions theory by developing the first multi-variate climate change risk perceptions model designed specifically to understand how climate change risk perceptions interact in East Africa amongst policy decision influencers (chapter four). The model elucidates the proportional contribution of determined climate change risk perception determinants in influencing climate change risk perceptions and climate change action in East Africa. The fact that the climate change risk perceptions model is not able to account for a larger proportion of explained variance (explaining 18.4% of explained variance) is unexpected, especially given many prominent climate change risk perception determinants from global North models were included in the model construction. This points to potentially strong inadequacies of models developed in the global north when applied to the social heterogeneity of the global south.

The lower explained variance of the model highlights the complexity of African climate change risk perceptions and the priority need for focused research on the multi-faceted determinants of climate change risk perceptions in Africa. Chapters five and six made initial strides towards this better understanding by qualitatively investigating, in greater detail, climate change risk perception determinants and their context amongst East African policy decision influencers. This further investigation highlights the potential additional roles of aspects such as trust in information, however a full investigation of further aspects that could be included in a multi-variate risk perceptions model for Africa is beyond the scope of this research.

An important additional contribution of the new multi-variate climate change risk perceptions model is the inclusion of the psychological distance of climate change, representing the first time that psychological distance has been included in a multi-variate risk perceptions model. The risk perceptions literature has, until recently, largely separated Liberman and Trope (1998)'s construal level theory (under which psychological distance falls) from Loewenstein *et al.* (2001)'s 'risk as feelings' (affect) theory, even though they both fall under the broad banner of experiential approaches to understanding risk perceptions. Yet Liberman, Trope, and Stephan (2007) proposed that

psychological distance provides the unifying framework that explains variations in affect. This proposal has been further investigated recently by Chu and Zang (2019) who confirmed that emotions (affect) varied according to psychological distance. Therefore, it was regarded as appropriate to incorporate the psychological distance of climate change in the multi-variate model (in the place of affect) in order to investigate the unique value that psychological distance may add.

The addition of the psychological distance of climate change to the multi-variate climate change risk perceptions model is shown to add value to the model and, in particular, psychological distance of climate change is shown to have the biggest direct effect on climate change risk perceptions (chapter four). These findings are a significant contribution to theory as they serve to highlight the value of including psychological distance in climate change risk perceptions models and thus set the stage for further research in this regard to assess the value that the inclusion of psychological distance may have amongst different audiences or geographical contexts.

The study's findings on the psychological distance of climate change in Africa, and on its interactions with other climate change risk perception determinants, contribute to broader academic discourses on psychological distance. Firstly, climate change is found to be psychologically proximal amongst East African policy decision influencers. This psychological proximity was first proposed in chapter three (drawing on studies from various African countries) and later confirmed in chapters four and five. This finding is an important contribution to the academic discourse because, to date, research on the psychological distance of climate change has primarily hailed from the global North where climate change has been found to be psychologically distant (Leiserowitz, 2005; Spence et al., 2012; C. Jones et al., 2017; Loy and Spence, 2020). Although the research in this study took place amongst a policy decision influencer audience (which is a different audience to much of the international literature on psychological distance to date), it serves to reinforce the understanding that the psychological distance of climate change is not the same world over. Geographical and/or developmental context have a profound influence on the psychological distance (closeness) of climate change, a distinction that is rarely acknowledged in the current literature.

In addition, previous literature assumes a strong relationship between the psychological distance of climate change and experience of extreme weather events (McDonald et al., 2015; McDonald, 2016; Weber, 2016; Fownes and Allred, 2019). The precedent set by this literature therefore suggests that the heightened psychological proximity of climate change in Africa would likely be strongly influenced by the heightened experience of extreme weather events in Africa (this heightened experience is highlighted in chapter 2, table 2.2). However, this study allowed for an exploration of the strength of the relationship between the two variables by separating the psychological distance of climate change

from experience of extreme weather events in the model. The relationship between the two variables is found to be weaker than expected, demonstrating that the experience of extreme weather events is not as strong an indicator of the psychological distance of climate change as originally thought. The finding with regards to the weak relationship between extreme of extreme weather events and the psychological distance of climate change represents a contribution to theory and provides a basis from which to justify further research on the additional factors that may contribute to the psychological distance of climate change.

Finally, the study, as a whole, makes an important contribution to literature by contributing towards a greater understanding of climate change risk perceptions amongst African policy decision influencers. Policy decision influencers are an understudied community but are an important community to understand because they are in a position of authority to take action on climate change using climate services. Therefore, the knowledge gained through this study allows for the design and delivery of context-specific and decision-relevant climate services for this community.

#### 4. Limitations of the study and future research directions

While this study made many constructive practical and original theoretical additions to the literature, it is necessary to reflect on the bounds or limitations of the study. Undertaking this reflective process is an important part of stepping back from the research to set goals for future research directions.

One constraint to the wider applicability of the study is that it took place amongst a very targeted audience. This both aids the study by constraining its complexity, and hinders it by limiting its direct extrapolation to other contexts. Therefore, one future area of possible research would be to test the explanatory power of the study's climate change risk perceptions model (developed in chapter four) with different sample populations in Africa, beyond policy decision influencers. This process could also be used to test the inclusion of further climate change risk perception determinants to assess the limits to the explanatory power of the model. For instance, the study showed that policy decision influencers have a consistently high awareness of climate change and its anthropogenic cause. This climate change awareness and understanding is likely higher than that of the general public because policy decision influencers are a highly educated grouping. As knowledge and awareness of climate change was consistently high amongst this study's focus audience, it did not offer significant value in understanding variations in climate change risk perceptions in this study. However, climate change awareness and understanding varies significantly across other population groups in Africa (Simpson et al., 2021) so may make a valuable addition when applying the model to other population groups.

A second area for possible further research would be to gain an understanding of how stable climate change risk perceptions (and the determinants) of East African policy decision influencers are over

time and test the emerging evidence from the literature base that climate change risk perceptions fluctuate over time (Brügger, 2020). It is possible that the timing of the research, and whether the participants had recently experience extreme weather events, may have had an influence on the findings. Previous research, amongst climate change literate audiences, has shown that perceptions of climate change risk increase after recent experience of an extreme weather event (Reser et al., 2014b; Konisky et al., 2016). This effect is described through the heuristics of recency bias and of availability bias. Recency bias is a cognitive memory bias whereby more recent events are more easily recalled and ascribed greater importance over more distant events (Marx et al., 2007). Availability bias influences people's judgment of the likelihood of an event based on how readily a previous example comes to mind (Tversky and Kahneman, 1974). This is a function of frequency as well as severity of experienced events. For instance, if farmers have recently experienced a drought, they may be more likely to ascribe a higher likelihood to a repeat drought occurring in the future (Diggs, 1991; Menapace et al., 2012) and weather-related disaster victims have been shown to be more concerned about climate change than non-victims because of their lived experiences which influence their perceptions (Whitmarsh, 2008; Myers, Maibach, et al., 2012). Given that the policy decision influencers in this study reported frequent ongoing experience of extreme weather events, it is likely that there will continue to be a constant supply of extreme events that they can mentally draw on in the future to maintain their heightened climate change risk perceptions. However, this assertion could be tested by repeating this, or a similar study, at a later date. Understanding the temporal stability of climate change risk perceptions and its determinants amongst this community would provide an indication as to whether some recommendations within the proposed climate services enhancement framework need to be continually revisited to assure their continued suitability. For instance, should the psychological closeness of climate change move from its current proximal state, then recommendations such as aligning climate services to low-level construal (providing concrete, solutions based, visual and loss-framed information) may no longer be appropriate.

An additional suggestion for further research is an assessment of how homogeneous climate change risk perceptions are within the sub-groups of the policy decision influencer community (for example, national government, private sector, non-governmental organisations etc). The data collected for this study did not provide large enough samples of each of the sub-groups to enable robust analysis of the differences between the sub-groups. However, as the policy decision influencer community includes a diverse set of actors, it is likely that there may be differences within the community, both in climate change risk perceptions and the determinants of climate change risk perceptions. For instance, in Sweden, Nilsson, von Borgstede and Biel (2004) found that people who work in the public sector in Sweden have higher self-transcending values than those who work in the private sector.



Understanding these differences within the community may assist in further audience segmentation to inform the design and delivery of climate services that are tailored to each of the sub-groups, where appropriate.

Finally, due to the different developmental contexts between African countries and the global North (developed world), it is assumed that the model (developed in chapter four) might not translate well into a developed world context. However, this is an untested assumption that may prove to be false should further research test the model in a developed country context. In particular, the addition of psychological distance of climate change may prove a valuable addition to developed world climate change risk perceptions models because this study has shown it to add a valuable contribution in the African context.

## 5. Concluding thoughts

This study highlighted the unique African context and why it is important to better understand the African decision context when designing and developing climate services for Africa. To this end, the study introduced a novel climate change risk perceptions framing to better understand the climate change decision context in East Africa. The study culminated in a proposed framework for the enhancement (and/or assessment) of East African climate services. This framework offers a set of suggested enhancements to climate services through the lens of climate change risk perceptions. Given this focused lens, the framework is not offered as the authoritative guide to designing and delivering effective climate services. Rather, this framework is offered to provide insights into one piece of the very complex climate services puzzle. There is tremendous scope for this topic to be further investigated, particularly with regards to more place-based, structural factors that fell outside of the remit of the current study. Understanding what constitutes effective climate services for Africa goes beyond single method studies and requires bringing together multiple disciplines and approaches, including, critically, strengthening collaborations between scientists and decision-makers to better integrate science into societal decision making (Lemos et al., 2012).

Overall, uptake of climate services in Africa is still relatively limited (Singh et al., 2018; Trisos et al., 2022). While this study attempts to address one of the barriers to uptake of climate services, namely the mismatch between the way climate services are supplied and what is required for decision-making (Jones et al., 2015; Singh et al., 2018; Vincent, Daly, et al., 2018; Vogel et al., 2019), additional barriers to the uptake and use of climate services are plentiful. These barriers include, for example financial and personnel resource constraints for using climate services (Winrock International, 2018) as well as limited institutional mandates to use climate services (Vincent, Conway, et al., 2020), amongst others. Therefore, enhancing the uptake of climate services will require a concerted effort in the future to

identify, understand and address each of these barriers through a combined focus on research and practical application.

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## Annex 1: Survey

**Section 1.** You may have heard of the term ‘climate change’ (also referred to as ‘global warming’ in the media). Climate change refers to the idea that the world’s climate is changing (because of increasing temperatures) and will continue to change into the future. This section of the survey asks you about your opinions about climate change and your experiences with it.

**Q1.1** How long have you lived in your local area (city or town)? \_\_\_\_\_

*Choose one option for each statement below to show how much you agree or disagree with it*

	<b>Strongly agree</b>	<b>Agree</b>	<b>Neither agree nor disagree</b>	<b>Disagree</b>	<b>Strongly disagree</b>
<b>Q1.2</b> I think of myself as being ‘from’ my local area	5	4	3	2	1
<b>Q1.3</b> What happens in my local area is usually important to me	5	4	3	2	1
<b>Q1.4</b> I think that climate change is really happening	5	4	3	2	1

**Q1.5** Thinking about the causes of climate change, which, if any, best describes your opinion?

- a) Climate change is a result of human forces
- b) Climate change is a result of natural forces
- c) Climate change is caused by a mixture of human and natural forces
- d) Climate change is not happening
- e) None of the above (please say what your belief is): \_\_\_\_\_
- f) I don’t know

*Choose one option for each statement below to show how much you agree or disagree with it*

	<b>Strongly agree</b>	<b>Agree</b>	<b>Neither agree nor disagree</b>	<b>Disagree</b>	<b>Strongly disagree</b>

<b>Q1.6</b> Climate change will mostly affect areas that are far away from here	5	4	3	2	1
<b>Q1.7</b> My local area (town/city) is likely to be affected by climate change	5	4	3	2	1

**Q1.8** When do you think your local area (town/city) will start feeling the effects of climate change? *Choose one option from the below to show when you think your area will feel the effects of climate change*

<b>We are already feeling the effects</b>	<b>In the next 10 years</b>	<b>In the next 25 years</b>	<b>After the next 25 years</b>	<b>Never</b>
5	4	3	2	1

*Choose one option for each statement below to show how much you agree or disagree with it*

	<b>Strongly agree</b>	<b>Agree</b>	<b>Neither agree nor disagree</b>	<b>Disagree</b>	<b>Strongly disagree</b>
<b>Q1.9</b> I think that climate change will have a big impact on me and my family	5	4	3	2	1
<b>Q1.10</b> I think that climate change will have a big impact on my local area (town/city)	5	4	3	2	1
<b>Q1.11</b> The effects of climate change in my local area (town/city) are certain, if nothing is done to prevent them	5	4	3	2	1

*Choose one option for each statement below to show how worried or not worried you are*

	<b>Very worried</b>	<b>Worried</b>	<b>Neutral</b>	<b>Not very worried</b>	<b>Not worried at all</b>
<b>Q1.12</b> In general, how worried are you about climate change?	5	4	3	2	1

<b>Q1.13</b> If you think about the effects that climate change could have on you personally, how worried are you about climate change?	5	4	3	2	1
<b>Q1.14</b> If you think about the effects that climate change could have on communities in your local area (town/city), how worried are you about climate change?	5	4	3	2	1

**Q1.15** In the last five years, more or less how often has your local area (town/city) experienced the following events? *Choose one option for each statement below to show how often your local area has experienced each event*

	<b>Very often (More than 10 times)</b>	<b>Often (Between 6 and 10 times)</b>	<b>Sometimes (Between 2 and 5 times)</b>	<b>Rarely (Once)</b>	<b>Never (None that I can remember)</b>
<b>A) Floods</b>	5	4	3	2	1
<b>B) Droughts</b>	5	4	3	2	1
<b>C) Coastal storms/ big waves/ coastal flooding</b>	5	4	3	2	1
<b>D) High temperatures/heat</b>	5	4	3	2	1
<b>E) Changes to the rainy season's patterns</b>	5	4	3	2	1
<b>F) Other: Please specify: _____</b>	5	4	3	2	1
<b>G) Other: Please specify: _____</b>	5	4	3	2	1

**Q1.16** Do you think these events were made worse, or happened as many times as they did, because of climate change?

Yes / No / Some of them / Don't know

**Section 2.** One way of taking action on climate change is by “adapting” to the changes it brings. In other words, making yourself or others less vulnerable to the effects of climate change. Adaptation is different from “mitigation” – which means taking actions that lower greenhouse gas emissions like carbon dioxide. This section of the survey asks you to think about **adaptation** (and not mitigation) actions in your personal and work life.

Choose one option for each statement below to show how much you agree or disagree with it

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<b>Q2.1a</b> In my personal life, I do things (at least sometimes) to prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.1b</b> ( <i>Only answer if you replied 'disagree' or 'strongly disagree' to question 2.1a above</i> ) In my personal life, I would like to do things to prepare for the impacts of climate change	5	4	3	2	1

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
<b>Q2.2a</b> As part of my job activities, I do things (at least sometimes) that help to prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.2b</b> ( <i>Only answer if you replied 'disagree' or 'strongly disagree' to question 2.2a above</i> ) In my job activities, I would like to do things to prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.3</b> Most of my family/friends are doing something in their personal lives to prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.4</b> Most of the colleagues that I work with closely are doing things as part of their job activities that help to prepare for the impacts of climate change	5	4	3	2	1

<b>Q2.5</b> Most of the colleagues that I work with closely use weather or climate information in their job (at least sometimes)	5	4	3	2	1
<b>Q2.6</b> Most of my family and friends think that I should do things to personally prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.7</b> As part of my job activities, most of my colleagues expect me to do things that help to prepare for the impacts of climate change	5	4	3	2	1
<b>Q2.8</b> At work, most of my colleagues expect me to use weather or climate information in my job activities	5	4	3	2	1

**Section 3.** In this section of the survey, some people are briefly described. Please read each description and think about how much each person is or is not like you. Tick one box to the right that shows how much the person in the description is like you.

### Male Respondents

	Very much like me	Like me	Somewhat like me	A little like me	Not like me	Not like me at all
<b>M3.1</b> Thinking up new ideas and being creative is important to him. He likes to do things in his own original way.	6	5	4	3	2	1
<b>M3.2</b> It is important to him to be rich. He wants to have a lot of money and expensive things.	6	5	4	3	2	1
<b>M3.3</b> He thinks it is important that every person in the world should be treated equally. He believes everyone should have equal opportunities in life.	6	5	4	3	2	1
<b>M3.4</b> It's important to him to show his abilities. He wants people to admire what he does.	6	5	4	3	2	1

<b>M3.5</b> It is important to him to live in secure surroundings. He avoids anything that might put his safety in danger.	6	5	4	3	2	1
<b>M3.6</b> He likes surprises and is always looking for new things to do. He thinks it is important to do lots of different things in life.	6	5	4	3	2	1
	<b>Very much like me</b>	<b>Like me</b>	<b>Somewhat like me</b>	<b>A little like me</b>	<b>Not like me</b>	<b>Not like me at all</b>
<b>M3.7</b> He believes that people should do what they're told. He thinks people should follow rules at all times, even when no-one is watching.	6	5	4	3	2	1
<b>M3.8</b> It is important to him to listen to people who are different from him. Even when he disagrees with them, he still wants to understand them.	6	5	4	3	2	1
<b>M3.9</b> It is important to him to be humble and modest. He tries not to draw attention to himself.	6	5	4	3	2	1
<b>M3.10</b> He really wants to enjoy life. Having a good time is very important to him.	6	5	4	3	2	1
<b>M3.11</b> It is important to him to make his own decisions about what he does. He likes to be free and he does not like to rely on other people.	6	5	4	3	2	1
<b>M3.12</b> It's very important to him to help the people around him. He wants to care for other people	6	5	4	3	2	1
	<b>Very much like me</b>	<b>Like me</b>	<b>Somewhat like me</b>	<b>A little like me</b>	<b>Not like me</b>	<b>Not like me at all</b>
<b>M3.13</b> Being very successful is important to him. He hopes people will recognize his achievements.	6	5	4	3	2	1
<b>M3.14</b> It is important to him that the government makes sure he is safe against all threats. He wants the state to be strong so it can defend its citizens.	6	5	4	3	2	1
<b>M3.15</b> He looks for adventures and likes to take risks. He wants to have an exciting life.	6	5	4	3	2	1

<b>M3.16</b> It is important to him always to behave properly. He wants to avoid doing anything people would say is wrong.	6	5	4	3	2	1
<b>M3.17</b> It is important to him to be in charge and tell others what to do. He wants people to do what he says.	6	5	4	3	2	1
<b>M3.18</b> It is important to him to be loyal to his friends. He wants to support the people close to him.	6	5	4	3	2	1
<b>M3.19</b> He strongly believes that people should care for nature. Looking after the environment is important to him.	6	5	4	3	2	1
<b>M3.20</b> Tradition is important to him. He tries to follow the customs given to him by his religion or his family.	6	5	4	3	2	1
<b>M3.21</b> He looks for every chance he can to have fun. It is important to him to do things that give him pleasure.	6	5	4	3	2	1



**Section 3.** In this section of the survey, some people are briefly described. Please read each description and think about how much each person is or is not like you. Tick one box to the right that shows how much the person in the description is like you.

**Female Respondents**

	<b>Very much like me</b>	<b>Like me</b>	<b>Somewhat like me</b>	<b>A little like me</b>	<b>Not like me</b>	<b>Not like me at all</b>
<b>F3.1</b> Thinking up new ideas and being creative is important to her. She likes to do things in her own original way.	6	5	4	3	2	1
<b>F3.2</b> It is important to her to be rich. She wants to have a lot of money and expensive things.	6	5	4	3	2	1
<b>F3.3</b> She thinks it is important that every person in the world should be treated equally. She believes everyone should have equal opportunities in life.	6	5	4	3	2	1
<b>F3.4</b> It's important to her to show her abilities. She wants people to admire what she does.	6	5	4	3	2	1
<b>F3.5</b> It is important to her to live in secure surroundings. She avoids anything that might put her safety in danger.	6	5	4	3	2	1
<b>F3.6</b> She likes surprises and is always looking for new things to do. She thinks it is important to do lots of different things in life.	6	5	4	3	2	1
	<b>Very much like me</b>	<b>Like me</b>	<b>Somewhat like me</b>	<b>A little like me</b>	<b>Not like me</b>	<b>Not like me at all</b>
<b>F3.7</b> She believes that people should do what they're told. She thinks people should follow rules at all times, even when no-one is watching.	6	5	4	3	2	1
<b>F3.8</b> It is important to her to listen to people who are different from her. Even when she disagrees with them, she still wants to understand them.	6	5	4	3	2	1
<b>F3.9</b> It is important to her to be humble and modest. She tries not to draw attention to herself.	6	5	4	3	2	1

<b>F3.10</b> She really wants to enjoy life. Having a good time is very important to her.	6	5	4	3	2	1
<b>F3.11</b> It is important to her to make her own decisions about what she does. She likes to be free and she does not like to rely on other people.	6	5	4	3	2	1
<b>F3.12</b> It's very important to her to help the people around her. She wants to care for other people.	6	5	4	3	2	1

	<b>Very much like me</b>	<b>Like me</b>	<b>Somewhat like me</b>	<b>A little like me</b>	<b>Not like me</b>	<b>Not like me at all</b>
<b>F3.13</b> Being very successful is important to her. She hopes people will recognize her achievements.	6	5	4	3	2	1
<b>F3.14</b> It is important to her that the government makes sure she is safe against all threats. She wants the state to be strong so it can defend its citizens.	6	5	4	3	2	1
<b>F3.15</b> She looks for adventures and likes to take risks. She wants to have an exciting life.	6	5	4	3	2	1
<b>F3.16</b> It is important to her always to behave properly. She wants to avoid doing anything people would say is wrong.	6	5	4	3	2	1
<b>F3.17</b> It is important to her to be in charge and tell others what to do. She wants people to do what she says.	6	5	4	3	2	1
<b>F3.18</b> It is important to her to be loyal to her friends. She wants to support the people close to her.	6	5	4	3	2	1
<b>F3.19</b> She strongly believes that people should care for nature. Looking after the environment is important to her.	6	5	4	3	2	1
<b>F3.20</b> Tradition is important to her. She tries to follow the customs given to her by her religion or her family.	6	5	4	3	2	1
<b>F3.21</b> She looks for every chance she can to have fun. It is important to her to do things that give her pleasure.	6	5	4	3	2	1

**Section 4.** This section of the survey asks you some questions about the use of weather or climate information in your job

**Q4.1** At work, I use weather or climate information in my job (this could include information relating to the impacts of weather/climate changes on my sector). For examples of weather/climate/impact information see question 4.2 below.

Very frequently	Frequently	Neither frequently or infrequently	Infrequently	Never
5	4	3	2	1

**Q4.2** (If you replied “very frequently”, “frequently” or “neither frequently or infrequently” to question 4.1 above) What types of weather and/or climate and/or impact information do you currently use for your job? (Choose all that apply)

Observed weather data (i.e. historical records)	
Daily to weekly weather forecasts	
Seasonal forecasts (3 months)	
1-5 year projections of climate	
Projections of climate 5 years or longer into the future	
Forecasts of the impacts as a result of weather/climate e.g. forecasts of dam levels, of crop yields, of river levels, forecasts of climate-related disease outbreaks, etc.	

Other, please say what it is:

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**Q4.3** (If you replied “very frequently”, “frequently” or “neither frequently or infrequently” to question 4.1 above) Where do you get this information from (specifically)?

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**Q4.4** (If you replied “very frequently”, “frequently” or “neither frequently or infrequently” to question 4.1 above) Why do you use this information, what for?

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**Q4.5** (If you replied “never” or “infrequently” to question 4.1 above) Why do you not use weather or climate information much, or at all, in your job? (Choose all that apply)

I don't think weather/climate/impact information is necessary to be able to do my job	
I do not have the time to include it	
I do not have access to the weather/climate/impact information I need	
I don't think the weather/climate/impact information that is available is easy to understand	

Other reason, please say what it is:

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**Section 5.** This section of the survey now asks you some questions about the kind of information you would *like* to have for your job

**Q5.1** Thinking for a moment just about weather/climate information, and assuming you could have any type of this information you liked, which ones would you like to receive for your job? Please put them in order of preference

Observed (i.e. historical records)	
Daily to weekly forecasts	
Seasonal forecasts	
1-5 year projections	
Projections of climate 5 years or longer into the future	

Other, please say what it is (and please put in order of preference): \_\_\_\_\_

**Q5.2** Thinking for a moment just about information related to the impacts of weather or climate on your sector, and assuming you could have any type of this information you liked, what kind of impacts information would you like to receive for your job (e.g. crop yields etc)?

**Q5.3** What format would you like to receive information in, to be able to do your job? Please put them in order of preference

Information presented as raw data (for example, data in an excel sheet)	
Information presented visually (for example, information presented as maps or graphs)	
Information presented as a mixture of visual and text information (for example, infographics)	
Information presented as text (for example, in reports or weather bulletins)	
Information communicated verbally (for example, in discussions or workshops)	

Other, please say what it is (and please put in order of preference): \_\_\_\_\_

**Q5.4** Please choose your top 3 most trusted sources for receiving weather and climate information (or impacts information). Use 1 - 3 to show the three sources you trust the most, where 1 means the most trusted source, 2 the next most trusted source, and 3 the next.

Information source	Rank
University scientists / other research scientists	
Government scientists	
Representatives of national government	
Representatives of local/regional government	
Politicians	
Your country's National Meteorological Services	
Independent companies that provide weather and climate information, for example AccuWeather	
Friends and family	
Environmental consultants	
Non-governmental organizations (NGOs)	
Community leaders	
TV	
Radio	

Newspapers	
Other (note who this is below)	

Other, please say what it is (and please rank): \_\_\_\_\_

**Section 6.** This section of the survey asks you a few general questions about yourself

**Q6.1** What is your job title? \_\_\_\_\_

**Q6.2** What type of institution do you work for?

Government or ministry	
Private sector	
NGO	
International development agency	
Research or academic	
Parastatal (organization owned by or operating for government) e.g. electricity supply company	
Federation or union e.g. farmers federation or workers union	

Other, please say what it is: \_\_\_\_\_

**Q6.3** What is your nationality? Or, if you have more than one, what would you consider as your first nationality? \_\_\_\_\_

**Q6.4** How would you describe your gender? Male / Female / Non-binary

**Q6.5** What is your age?

20 – 29	
30 – 39	
40 – 49	
50 – 59	
60 – 69	
70 or above	

**Q6.6** What is the highest degree or level of schooling you have completed? \_\_\_\_\_

## Annex 2: Interview Protocol

Interview aims
A1. Explore in greater detail/explain the most important/interesting determinants of risk perceptions (including institutional influences)
A2. Explore in greater detail the most interesting findings relating to use/desire for climate services, including exploring currently available climate services
A3. Explore how the determinants of risk perceptions relate to 1. professional action, and 2. the use of weather and climate information
A4. Explore how the current institutional/policy/cultural frameworks act as either facilitators or barriers to 1. The uptake of climate information, and 2. To taking climate action

The below interview guide is coded based on the primary aim that the question addresses (A1/A2/A3/A4 in square brackets). However, some questions may address other aims through the participants answers.

- **[A1]** Would you say that you personally are experiencing the impacts of CC? Could you tell us more about your experiences?  
*(Alternative prompt)* Would you say that you personally experience the impacts of EWEs? Could you tell us more about your experiences?
- **[A2]** What kind of weather or climate information are you using in your work, if any, and what for? Why do you use that kind of information, specifically? (e.g. is it all that is available?)
  - Where are you getting this information from, and why?
  - Do you need, or would you like to get, any further kind of climate or weather information, and why? Do you know where you could get this kind of information from?
- **[A3]** Do you think most of your colleagues (by this I mean the people you work with closely) also use the kind of climate information that you do, and if so, why?
  - *(If no)* What kind of weather or climate information do you think your colleagues use, and why?



- Would you say the people you work with most closely are within your organization or outside of it?
- **[A2]** (*If they do not mention long-term climate change information*) Do you use long-term climate change information in your work, and if so, what kind and what for? (*if they use it*)
  - Where are you getting this information from, and why? (Did you have any specific education or training in how to use long-term climate change information, or on how to get hold of it?)
  - (*If they do not use it*)
  - Why are you not using long-term climate change information?
  - Would you know where to get long-term climate change information from, if you wanted it?
  - Do you think your colleagues use long-term climate change information? Why, or why not?
- **[A2]** (*If they do not mention impacts information*) Do you use impacts information (this is information about the impacts of weather or climate, e.g. dam levels, crop yields, river levels, forecasts of climate-related disease outbreaks) in your work? (*if they use it*)
  - What kind, what for, and why do you use that kind of impacts information, specifically?
  - Where are you getting this information from, and why? Did you have any specific education or training in how to use impacts information, or on how to get hold of it?
  - (*If they do not use it*)
  - Why are you not using impacts information? Can you tell me more about that?
  - Would you know where to get impacts information from, if you wanted it?
  - Do you think your colleagues use impacts information? Why, or why not?
- **[A1]** Do you feel that there's a strong expectation in your workplace that you should take action to prepare for any impacts of changes in the climate? (*if yes*)
  - Why do you feel this is the case?
  - What do you feel these expectations for taking action are, i.e. what you do feel you are expected to do, specifically? Why do you think this is the case?
- **[A3]** Are you taking action, in your job, to prepare for any impacts of changes in the climate? This is different to whether you are using weather or climate or impacts information to do your job, which we just spoke about. Can you tell us more about that? (*If no*) Why not? (*If yes*)
  - Why would you say that you are taking action to prepare for the impacts of climate changes?
- **[A4]** Do you feel you have everything you need – including the necessary time and authority – to prepare for the impacts of changes in the climate in your job?

- Can you tell us more about what things might be stopping you or slowing you down in taking action to prepare for the impacts of climate changes?
- Can you tell us more about the things that might be making it possible for you to take action to prepare for the impacts of climate changes?
- **[A2]** What kind of climate or weather or impacts information, if any, are you using to prepare for the impacts of climate changes? (*If they are using climate/impacts information*)
  - Where are you getting this information from, and why from there?
  - Do you need any further kind of climate or weather or impacts information, and why?
 (*If they are not using climate/impacts information*)
  - Why not? Do you think any of your colleagues do, and if so, why?
- **[A2]** (*If the above doesn't bring in the long-term*) Do you use any long-term climate change information to prepare for the impacts of climate changes? (*If they are using long-term climate information*)
  - Where are you getting this information from, and why from there?
  - Do you need any further kind of long-term climate change information, and why?
  - Do you think most of your colleagues also use the kind of long-term climate change information that you do, and if so, why?
 (*If they are not using long-term climate information*)
  - Why not?
  - Do you think any of your colleagues do, and if so, why?
- **[A2]** Thinking for a moment about all the climate-related information we've discussed - that you use in your job, or to prepare for climate change, etc. - is there one type of information that is most useful to you - or that you might want more of? So, it could be: historical records of weather data, daily or / weekly forecasts, seasonal forecasts, 1-5 year projections, 5+ projections, or impacts information. Why?
- **[A2]** What kind of format is the data you use in (numbers, visual, text, combination of visual and text, verbal) and why do you use this format? (e.g. is it easy to get hold of?)
  - Do you think most of your colleagues use the same format of information? Why do you think they use that format?
  - If you could have any of these example formats, would you choose something different from what you currently use? Why?
- **[A1]** Do you feel that among your colleagues, climate change and other environmental issues are considered very important, or do you think they feel other problems are more important, for example, poverty relief, or economic growth? (Explore the answers they give - e.g. do they think their colleagues see climate change as a development problem)
  - What about people that work outside of your sector? And for Kenyan society in general? What about at the political level?

- **[A1]** Do you think women are, at the moment, well-represented in your line of work? Why do you think this is the case?
- **[A1]** Demographic questions: Can you tell us a bit about your educational and experience background? Note gender

### Annex 3: Selected journal paper review comments and responses

This annex contains a selection of reviewer comments that pertain to each of the reviewed papers (chapter 3,4 and 6). These selected comments and responses have been included to highlight my responses to high-level queries raised by the paper reviewers, should the thesis examiners have any similar queries. These responses served to allay any reviewer reservations in order for the papers to be accepted for publication.

No.	Reviewer comment:	Author response:
Chapter 3: Steynor, A. and Pasquini, L. 2019. <i>Informing climate services in Africa through climate change risk perceptions</i> . <i>Climate Services</i> . 15, 100112: DOI: 10.1016/j.cliser.2019.100112		
1.	One major comment concerns the level of aggregation when it comes to geography. The article talks about Africa, and then in section 3 sub-Saharan Africa, but the study only includes findings from 6 African countries in table 1 (Africa has 54 countries, and 46 of them belong to the UN definition of Sub-Saharan Africa.) Considering the wide spread of cultures and languages, the large variations in wealth between and within countries within sub-Saharan Africa, it would be recommended wise to not extend these findings to the whole of Africa, without further data.	<p>I agree with the reviewer that Africa is not homogeneous and have made some additions to the paper in this regard (see below). However, lack of homogeneity is true for any region in the world – including within countries, yet, for many purposes (and research outcomes) it is often necessary to make draw generalised findings for larger regions – particularly at the continental scale. At the kind of generalised level that we address in this paper, there is precedent set (by the IPCC, WHO etc) to treat Africa as a fairly homogenous region (socio-economically etc) in the same way that Europe has some level of homogeneity. All countries within Africa are from the developing world, have a colonial past and face similar developmental, social and economic challenges. Therefore, in the climate change risk perception context, the intra-continent differences in Africa will be smaller than the inter-continent differences. So, it seems reasonable (particularly given that this is a perspective piece) to draw tentative conclusions for the region as a whole while always acknowledging the need for further research to verify these assertions. I have now explicitly noted this by adjusting the text to say “We acknowledge that the evidence focus is on sub-Saharan Africa and perceptions may not be uniform across all African countries or sectors of society.....” “Given this caveat, I note that this evidence is exploratory only, with a need for further research that extends this analysis to all African countries “</p> <p>But I acknowledge the reviewers concern about drawing conclusions from only 6 countries. In response, I would like to highlight that while this research draws on detailed data from the countries of Mozambique, Malawi, South Africa, Botswana, Zimbabwe and Tanzania, there are also linkages made to how the results align with broader research by the BBC into public understanding of climate change in 8 further countries. This increases the evidence base to 14 countries.</p>

		<p>Therefore, to strengthen the paper in response to the reviewer’s concerns, I have:</p> <ol style="list-style-type: none"> <li>1) Brought in reference to the BBC project as additional evidence in further places throughout the discussion in section 3.2.</li> <li>2) Explicitly acknowledged the limitation of drawing on results from a selection of African countries</li> </ol> <p>Finally, a lot of the paper talks more generically about how a better understanding of risk perceptions could inform the design of climate services, therefore these sections refer to Africa in the generic sense. However, I have nuanced the section that talks about “Africans” to say that “it would be reasonable to expect that <i>more</i> Africans may perceive climate change as a greater threat than do residents of developed countries.</p>
2.	<p>The use of data from different years from different countries needs some attention. Many references are quite old. With old I mean that they refer to the years earlier than 2007, when IPCC (AR 4) arrived. A lot happened in the climate discussions in news and media after that, and also after the next report which was launched in 2014 (IPCC AR5). That may be needed to take into consideration when comparing the figures of 2014 and 2017 for some countries. It then becomes important to know whether the figures from 2014 was collected before or after the release of the report maybe.</p>	<p>I have gone through again and, where possible, we have updated references – in some places to documents that were released after the paper was submitted for review. Unfortunately, the majority of the recent polling has focussed on the United States so most of the updated references are for the United States.</p> <p>The below outlines the reference dates that now support each section. All sections now include data post 2017:</p> <p><b>2.1 Hypothetical distance</b> is supported by evidence from 2016 and 2018.</p> <p><b>2.2 Temporal distance</b> is supported by evidence from 2015 and 2018</p> <p><b>2.3 Spatial distance:</b> I am specifically looking for evidence that supports beliefs of where the impacts of climate change will be (geographically) <i>in the future</i> (not now). None of the more recent polls outside of the US ask that question therefore I have had to support this section with references from 2009, 2012 and 2017 (the 2017 reference has been added during this revision).</p> <p><b>2.4 Social distance:</b> Again, I am looking for questions that address beliefs of what will happen in the future. This is supported by evidence from 2012 and 2017.</p> <p>I agree that the IPCC reports are likely to have an influence on perceptions (at least in the year they are released) and have now made reference to them in section 2.3.</p>

3.	<p>In terms of the overall structure of the report, I feel that separating Section 4.1 (personal experience) from the discussion of psychological distance in Section 3 is a little odd, as a key point about the African studies conducted is that reported experience seems to be linked to lower distancing.</p>	<p>I understand that separating psychological distance and personal experience could be viewed as redundant, however, the primary remit of this analysis is to inform the development of climate services. In this context, it is important to separate personal experience and psychological distance as they provide separate and different value in informing climate services. Their individual value in informing climate services is clarified and discussed in section 5.</p> <p>At the beginning of section 4 we state “Although these determinants of risk perceptions are documented separately here, they are inextricably linked together and influence each other. This means that, in practice, they cannot be treated as standalone determinants of risk perceptions but should always be considered in relation to the other determinants, including psychological distance.” We go on to state that “personal experience of climate change and psychological distance have been shown to correlate with each other”, however it is important to note that many of the other risk determinants discussed in section 4 also influence psychological distance (e.g. social norms, values etc). So, I feel it is acceptable to separate personal experience into a separate section, most importantly because of its individual purpose in informing climate services development.</p>
<p>Chapter 4: Steynor, A., Pasquini, L., Thatcher, A. and Hewitson, B. 2021. Understanding the links between climate change risk perceptions and the action response to inform climate services interventions. 41(10). Risk Analysis. DOI: 10.1111/risa.13683</p>		
4.	<p>Overall, further elaboration needs to be made regarding why someone’s personal differences (e.g., socio-demographics, values, etc.) would make a difference regarding the decisions that people make at work. This suggests that these individuals have a lot of agency and power to affect decisions regarding the management of natural resources. Why would this necessarily be the case? In what ways and under what circumstances would this not be so?</p>	<p>I understand the linked concerns are 1) whether personal attributes such as values, norms and education influence workplace actions and, 2) whether individuals have agency to affect decisions in the workplace.</p> <p>On the first point, previous literature has shown that individual (personal) characteristics have an influence on pro-environmental behaviour in the workplace. I have now included some of these references in the text in section 2.3 to better clarify this connection:</p> <ul style="list-style-type: none"> <li>Inoue, Y. and Alfaro-Barrantes, P., 2015. Pro-environmental behavior in the workplace: A review of empirical studies and directions for future research. <i>Business and Society Review</i>, 120(1), pp.137-160.</li> </ul>

	<p>Concept of social norms: In the measurement of social norms, the authors measure both personal (the descriptive and injunctive norms of friends/family around them) and professional (colleagues) norms of people around them. Why did the authors decide to put both professional and personal social norms together? Isn't there an argument to be made for professional norms dominating in a work environment?</p>	<ul style="list-style-type: none"> <li>• Ture, R.S. and Ganesh, M.P., 2014. Understanding pro-environmental behaviours at workplace: Proposal of a model. <i>Asia-Pacific Journal of Management Research and Innovation</i>, 10(2), pp.137-145.</li> <li>• Wehrmeyer, W. and McNeil, M., 2000. Activists, pragmatists, technophiles and tree-huggers? Gender differences in employees' environmental attitudes. <i>Journal of Business Ethics</i>, 28(3), pp.211-222.</li> <li>• Madsen, H. M., Mikkelsen, P. S. and Blok, A. 2019. Framing professional climate risk knowledge: Extreme weather events as drivers of adaptation innovation in Copenhagen, Denmark, <i>Environ. Sci. Policy</i>. Elsevier, 98, pp. 30–38. doi: 10.1016/J.ENVSCI.2019.04.004.</li> <li>• Lee, Y.-J., Young, R. De and Marans, R. W. 1995. Factors Influencing Individual Recycling Behavior in Office Settings: A Study of Office Workers in Taiwan, <i>Environ. Behav.</i> Sage PublicationsSage CA: Thousand Oaks, CA, 27(3), pp. 380–403. doi: 10.1177/0013916595273006.</li> <li>• Andersson, L., Shivarajan, S. and Blau, G. 2005. Enacting Ecological Sustainability in the MNC: A Test of an Adapted Value-Belief-Norm Framework, <i>J. Bus. Ethics</i>, 59, pp. 295–305. doi: 10.1007/s10551-005-3440-x.</li> <li>• Lo, S. H., Peters, G.-J. Y. and Kok, G. 2012. A Review of Determinants of and Interventions for Proenvironmental Behaviors in Organizations, <i>J. Appl. Soc. Psychol.</i> John Wiley &amp; Sons, Ltd, 42(12), pp. 2933–2967. doi: 10.1111/J.1559-1816.2012.00969.X.</li> <li>• Scherbaum, C. A., Popovich, P. M. and Finlinson, S. 2008. Exploring Individual-Level Factors Related to Employee Energy-Conservation Behaviors at Work1, <i>J. Appl. Soc. Psychol.</i> John Wiley &amp; Sons, Ltd, 38(3), pp. 818–835. doi: 10.1111/J.1559-1816.2007.00328.X.</li> </ul> <p>This further supports the widely documented notion that humans are not “rational” beings who, in the workplace, are purely driven by logical, rational thinking tied to their workplace. People are driven also by norms and deeply held values outside of the workplace which influence their action at work. Therefore, in order for the proposed model to be robust, I believe it is important that both professional and individual characteristics are included in the model, as has been done.</p>
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		<p>In response to the second concern, regarding agency and power, the particular audience chosen for this study (policy decision influencers) are predominantly those who do have exactly that agency and power within an organisation to influence change, hence why it is so important to understand what drives them to act on climate change. This influence is described in the paper with the following text in section 1 which hopefully helps to address this concern.</p> <p><i>“In this study, these individuals are referred to as ‘policy decision influencers’ and are defined as people who directly or indirectly influence the development of principles, plans and courses of action around natural resource management at the local or national level. Examples of such individuals include government officials, researchers, trade union representatives, NGO practitioners, and others. These individuals are an important community because they are an accessible group for introducing adaptation-oriented interventions and are in a position of leadership to drive social adaptations around climate change (Mohamed, 2016)”</i></p>
5.	<p>Climate adaptation behavior: The description of this dependent variable does not give the reader a good idea of what “adaptation” means in this context. Does it mean that the decision-maker approved a solar PV project? Does it mean that the decision maker created a memo describing the potential impacts of climate change to the region? Each type of action has differing levels of difficulty and needed resources/buy-in from colleagues and government. Without more information, it is difficult for the reader to ascertain whether this is a useful outcome measure. Further, why did the authors decide to include only one item measuring adaptation behavior?</p>	<p>This section has now been changed to make it clearer to the reader. The actual wording of the question is now included in section 3.2.1. and text has been added to this section to explain the reasoning behind choosing a single measure of action.</p> <p>The included measure is one of self-reported action, broadly defined, in preparing for the impacts of climate change. This self-report single measure was chosen because the study was focused on the “internal landscape” of respondents, and therefore on which risk perception determinants play a greater/lesser role in respondents’ perceptions of risk, and their knock-on effects to professional action. Therefore, the self-report about whether respondents perceive themselves to be taking action at work is more important for the purposes of this paper than <i>what</i> action they are taking, or the scale of such action. Structural drivers of action (such as resource availability, mandates, etc.) have been specifically excluded from the model because it is only concerned with psychological factors internal to the individual and are noted in the concluding section 6 as additional potential drivers of professional action.</p>



		<p>Following on from this reasoning, a simple indication of whether they self-report taking action to prepare for the impacts of climate change (one question) was considered sufficient for the purposes of the paper. While an interesting avenue of research, asking multiple questions related to the specificities of adaptation action fell outside of the scope of this investigation, and would have brought the risk of contributing to respondent fatigue.</p>
<p>Chapter 6: Steynor, A. and Pasquini, L. <i>Using a climate change risk perceptions framing to identify gaps in climate services</i>. Accepted. <i>Frontiers: Climate Risk Management</i></p>		
<p>6.</p>	<p>Conceptual Framing: The linkage between the climate risk perception model utilized in the study and the evaluation of climate services available in the region remains somewhat unclear. Most of the determinants of risk perception in the model focus on individual traits of respondents that may drive the use of some types of information; however, I am unsure what these determinants tell us about the quality and fit of the climate services being produced as related to specific decisions/decision contexts, rather than simply describing pre-existing attributes of climate services users that are correlated with use of some types of climate information. It would be helpful if the authors could more explicitly articulate how the risk perception model is successfully applied and translated to provide an evaluation of climate services in the region. I suggest adding some additional discussion within the introduction to explain the theoretical links between the assessment of risk perception and the evaluation of climate services, and I think that this would help to frame the rest of the paper more concretely.</p>	<p>The introduction section has been expanded to highlight the importance of understanding the decision context in order to evaluate climate services and has more fully explained the connection between climate change risk perceptions and the decision context. In particular the following text has been added:</p> <p>“Climate change risk perceptions have established relationships with important aspects of the decision context that influence the use of climate services. For instance, climate change risk perceptions have been shown to influence both willingness to act on climate change (Spence et al., 2012; Lo and Chan, 2017; Smith and Mayer, 2018; Xie et al., 2019) and actual action on climate change (Blennow et al., 2012; Fahad and Wang, 2018; van Valkengoed and Steg, 2019). Heightened risk perceptions have been shown to increase an individual’s information seeking behaviour (Kahlor, 2007) and the desire for climate information amongst natural resource planners when acting on climate change risk in the workplace (Peters et al., 2018).”</p>

7.	The authors note that this paper is only focusing on the “information provision component of climate services” but climate services are a “service” precisely because they are not simply the uni-directional delivery of climate information, and it seems overly narrow to focus on this aspect alone.	I note this concern and hope that the changes to section 5.3 (in particular) have addressed this comment to an extent by showing the need for reciprocal knowledge exchange because producers and users of climate services. The nature of the study is that it is premised on the relationship between climate services information use and climate change risk perceptions, so it is important that this focus is noted in this section.
8.	I am a bit confused by the decision to combine all survey results from the five countries together, especially given that weather forecasts are included within the study’s definition of climate services and NMS in the region provide their own weather and climate forecasts independent of regional products. Lines 315-316 states that there is “homogeneity” of the climate information delivered across these countries (perhaps this is referring to attributes such as timescale, types of impacts forecasted, etc.); however, the national climate information products themselves, including the ways in which these are produced, packaged, and delivered varies significantly across these countries, as does the perceived credibility and legitimacy among citizens regarding the NMS and the services they provide. Moreover, the individual size and capacities of NMS in the region and proximity to regional centres varies significantly, which also creates significant disparities / differences in the services provided at the national level across these countries. Can the authors please say more about the decision to combine survey results across all 5 countries? It would be helpful to also state how this decision	I think this is perhaps a misunderstanding. The text reads that “This decision was justified due to the homogeneity in the types of climate services information <b>used</b> across all the countries” not delivered. As the focus of the study was on the use of climate information and the types of climate information used were homogeneous across the region, this decision was considered justified because a country-level study would have yielded similar results.

	may affect analysis and interpretation of the results.	
9.	Could it simply be the case that the long-term information is not credible or relevant to decisions being made in these organizational contexts? In other words, could this rather be a problem related to a lack of “fit” with the decision-making contexts, including the systems and structures within which agencies and organizations make decisions, including the mission, incentives, and goals of the agencies and organizations in which they work (see Lemos et al. 2012)?	The desire for short-term information for the decision context is made clear in sections 4.2.1 and section 5.1 so I am not suggesting that longer-term information is the panacea. However, the interviews demonstrated a desire to use longer-term information in addition to the short-term (mostly seasonal) information currently used. An additional quote has been added to section 4.2.1 to demonstrate the desire to use longer-term climate information. The interviews also demonstrated barriers to the use of this longer-term information which inform the recommendations in sections 5.1 and 5.3, aimed at increasing the use of longer-term information while simultaneously recognising the ongoing need for short term information.