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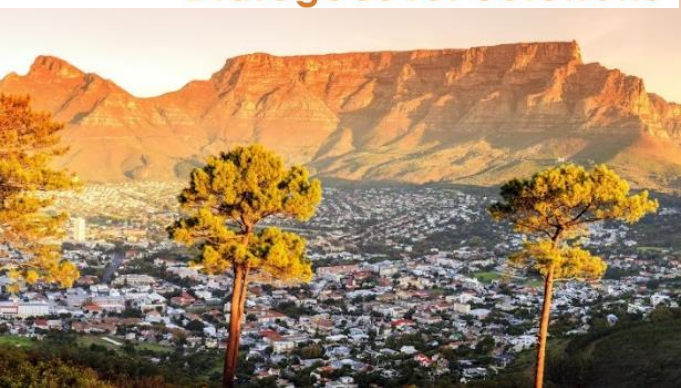
Dialogues for Solutions



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Foreword

The Conference Proceedings are the product of the 2018 Adaptation Futures conference that was held in Cape Town from 18 – 21 June, co-hosted by UCT's African Climate and Development Initiative (ACDI), the South African National Biodiversity Institute (SANBI) and UN Environment's World Adaptation Science Programme (PROVIA). Adaptation Futures is the world's premier international adaptation conference series and is held every two years. 2018 was the first time that this conference was held in Africa, and consequently, it aimed to focus on African and developing world linkages with adaptation.

The extended abstracts were submitted after the conference to allow the authors to absorb the conference insights into their work.

Contents

The Papers

Climate change adaptation law and policy in the African Union: Creating legal pathways for adaptation

Michael Addaney[1]

Abstract

Living in a region prone to the impacts and threats of climate change, African countries are already experiencing the drastic effects of climate change. Thus, support for climate change adaptation and its mainstreaming into relevant laws and policies is essential. The main aim of the paper is to discuss the enhancement of the adaptive capacity of African Union (AU) states through adaptation mainstreaming into relevant regional climate change adaptation laws and policies. It argues that Africa may increase its adaptive capacity through the adoption and/or revision and implementation of suitable legislation and policies relating to adaptation.

Keywords: *Adaptation mainstreaming, African Union, Law, Legal pathways, Policy*

Introduction

The last decades have seen an upsurge in climate-induced hazards globally, which threaten human life and property (Malcolm, et al., 2016). The Intergovernmental Panel on Climate Change (IPCC) reported that '*the warming of the earth is unequivocal*', and '*human influence on the climate system is clear*' (2014). More frequent and intense weather events can rupture the infrastructure supporting vital services including energy, transport and health in both urban and rural areas (Ruhl, 2011). Living in a region prone to the impacts and threats of climate change and natural disasters, the people in sub-Saharan Africa are therefore already experiencing the drastic effects of climate change (Jegede, 2016). Adapting to the adverse impacts of climate change will continue to raise legal issues and intensify existing environmental protection regulatory challenges, as human migration and infrastructural development could trigger disputes over environmental, land-use, and legal responses (Bodansky, 2010). In anticipation of the inevitable shift from adaptation planning and policy to adaptation action and the critical role of law in this shift, this paper discusses the role of law in strengthening Africa's adaptive capacity.

Method and analytical framework

The paper utilises the doctrinal method and the functional approach to law as analytical framework to examine how climate change adaptation is being mainstreamed into Africa Union (AU) law and policy. A systematic approach involving basic key terms search was adopted to locate relevant texts and materials for the paper including the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Paris Agreement and Conference of the Parties decisions. AU instruments including the Declaration on Climate Change and Development in Africa, Decision on the High Level Work Programme on Climate Change Action in Africa and the draft African Strategy on Climate Change are also discussed. It identifies and discusses

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climate change adaptation responses likely to put some demand on institutions and legal principles.

Findings

Legal pathways for mainstreaming climate change adaptation in the African Union

The UNFCCC provides the key legal framework that articulates the general principles and objectives governing adaptation (Ruhl, 2010). The pivotal nature of adaptation responses in tackling the adverse effects of climate change are underscored in a number of key articles in the UNFCCC text (Freestone, 2012). For instance, article 4.1(f) provides that '*where feasible, parties are to take climate change considerations into account in their relevant social, economic and environmental policies and actions*'. Parties are further to employ suitable techniques, including impact assessments, to curtail the adverse effects of adaptation projects or measures on the economy, public health and the quality of the environment (UNFCCC article 4.1[f]). The rationale of this provision is to caution societies concerning the prospect of the social, economic and environmental policies and actions that fail to consider how climate change considerations degenerate into maladaptation (Farhana and Depledge 2004). In addition, using terms such as "*to the extent feasible*" and "*as formulated and determined nationally*" imply that the issue of mainstreaming and the scale and application of impact assessment as issues best to be determined by respective state parties.

In African policy circles, climate change is often regarded as a technical problem which requires technical solutions. Africans have been adjusting to occurrences such as heat waves, drought, flood, and fire for years (Addaney, et al., 2017). Therefore, it can be argued that, to some extent, adapting to climatic changes in their extremes, frequency, and distribution may require simply transforming and strengthening existing adaptation policies and strategies in Africa. In this regard, the AU Assembly has made significant decisions that ignited the advancement of Africa's common position on climate change. The 8th ordinary session encouraged member states and the Regional Economic Communities (RECs) to incorporate climate change concerns in their respective development policies and programmes (AU Assembly, 2004). This includes Africa's preparations for the development of a common position on climate change and an inclusive agenda on African climate change programmes. However, some of the adverse effects of climate change introduce completely new forms of challenges that most African countries lack the needed technological and knowledge systems for in order to adapt. For instance, most of the populations in Africa have not dealt with sea level rise on any significant scale (Addaney, et al., 2017). Another example is the mass migration of species in response to changing temperature, hydrology, and other environmental patterns (Abebe, 2014). Although these are not inconceivable climatic events, most African countries lack the requisite models on how to manage them. As a result, designing adaptation strategies for this form of change will involve some level of borrowing from and hybridization of existing policy mechanism and technological methods (Ruhl, 2011). For instance, coastal defence strategies already being used for storm surge protection could be employed as part of the response to sea-level rise and some level of developing new adaptation approach.

The third special session of the African Ministerial Conference on the Environment (AMCEN) in Nairobi in May 2009 presented a decisive occasion in the response of Africa to the threats of

climate change. The Nairobi Declaration on the African Process for Combating Climate Change was adopted by the Ministers[2] to serve as a unified manifestation of the continent's determination to play a pivotal role in addressing the challenge of climate change. The Declaration emphasises the determination of the AMCEN to assimilate adaptation measures into national and regional development plans, policies and strategies, where appropriate, in order to guarantee adaptation to climate change in key areas, such as the environment and energy security (AMCEN, 2009). Nevertheless, many African countries apart from Kenya are yet to adopt substantive climate change law. The Kenyan Climate Change Act of 2016 contains some relevant provisions on adaptation mainstreaming. For instance, under article 3(2) of the Climate Change Act (2016), on the objects and purposes, it provides that:

'without prejudice to subsection (1), this Act shall be applied in all sectors of the economy by the national and county governments to (a) mainstream climate change responses into development planning, decision making and implementation; (b) build resilience and enhance adaptive capacity to the impacts of climate change; (c) formulate programmes and plans to enhance the resilience and adaptive capacity of human and ecological systems to the impacts of climate change; (d) mainstream and reinforce climate change disaster risk reduction into strategies and actions of public and private entities; (e) mainstream intergenerational and gender equity in all aspects of climate change responses'.

These provisions are very progressive and comply with the normative standards of relevant international and regional climate change adaptation policies, including the Cancun Adaptation Framework and the draft AU Climate Change Strategy. Regarding its implementation, it is too early to have a fair assessment on how it has translated into practice.

The Draft AU Strategy on Climate Change is still under development (AU Draft Strategy 2014). It, however, contains vital guidelines on adaptation. The overall objective of this strategy is to enable the continent achieve "*climate-smart*" socio-economic development. Regarding Africa's position on adaptation, it underscores that the importance of recognising the fact that adaptation is an overriding priority for the African continent. It places an urgent call for the implementation of adaptation measures and actions, including through the provision of substantial new and additional public financial resources, environmentally sound technologies and capacity building in a predictable and prompt manner (AU Draft Strategy 2014). The AU draft strategy (2015) outlines some major considerations on adaptation to guide member states including:

'The focus of adaptation must shift from vulnerability assessment to the implementation of adaptation programmes… Funding by developed countries for adaptation must reflect responsibility for economic and social damages resulting from climate change in the context of their historical contributions to greenhouse gases and current climate change…Funding for implementation of adaptation must be massively scaled up, in accordance with the need, and must go beyond the mainstreaming of adaptation into the development process, and include stand-alone adaptation projects'.

[2] See 15th ordinary session of the Executive Council 24-30 June 2009, Sirte, Libya EX CL/Dec 502(XV) Decision on the Report of the African Ministerial Conference on the Environment (AMCEN) Special Session on Climate Change Doc EX CL/519(XV).

Another tricky situation is that, it is not all the effects of climate change that are necessarily harmful at all locations and times (Ruhl 2012). Due to the fact that countries and different regions on the continent are likely to have different contours of the favourable and harmful effects, opting for adaptation strategies at any scale could be a highly contested legal and policy decision. In addition to the direct beneficial and harmful effects of climate change in Africa, adaptation measures such as human migration, water resources management, and new infrastructure development will lead to secondary impacts that require management responses. In its present form, the AU draft climate change strategy does not adequately address the novel policy concerns presented by scale of adaptation which require new forms of decision-making processes. For example, although coastal storm surge barriers are already subject to regulatory mechanisms, they have not been fully applied on the scale that might be necessary if most African countries were to build comprehensive sea wall infrastructure along their coasts.

Conclusion

The impacts of climate change in Africa are likely to prompt adaptation responses that touch on many aspects of law and policy decision-making. While it is too early to predict which path is more apt, there just has not been enough climate change legislation at the domestic level on the continent. To engender a great deal of legal development regarding adaptation and its incorporation in relevant sectors will therefore require envisioning scenarios in which current legal frameworks and institutions at the continental and national levels in Africa will be tested. Therefore, the AU and other policy makers have to do more than just waiting for those scenarios to fully develop. The time is ripe for an active conversation on how climate change adaptation will transform law and policy on the African continent. As the AU has not yet adopted any substantive regional treaty on climate change adaptation (and mitigation), it should endeavour to adopt a substantive regional framework convention to govern adaptation and to provide guidelines on how adaptation can be mainstreamed into national adaptation policies and strategies.

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Crowdsourcing data and implementing on the ground projects that help people and nature in a changing climate

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Abstract

Climate change is one of the greatest threats facing society and is already having a significant impact on people and biodiversity around the globe. Rural communities in developing countries are experiencing some of the worst impacts of climate change, but removed from decision-making bodies and financial resources, they are often left to their own devices to cope with and adapt to these changes. Through WWF's Climate Crowd initiative, large amounts of data on how vulnerable communities are affected by changes in weather and climate, how they are coping with these changes, and how their responses might negatively impact biodiversity are being crowd-sourced. WWF then curates data sourced from partner organisations, analyses it, and disseminates it on wwfclimatecrowd.org for use by researchers, educators, and conservation and development practitioners. This data is also used to develop and implement site-specific solutions that reduce the vulnerability of people and wildlife to changes in climate.

Keywords: *Crowd-sourcing, Communities, Climate crowd, Data, Conservation*

Introduction

Under the Paris climate change agreement, all countries committed to create better adaptation strategies by 2020. But, few governments or institutions are incorporating data on climate impacts into their planning. If we fail to better understand how climate change is impacting people and nature, we will be unable to develop solutions that keep pace with the changes in climate we are already observing. As the human population grows and the impacts of climate change become more severe, it is therefore imperative that we better understand how climate change is impacting communities and ecosystems, and that we develop and test adaptation strategies that reduce the climate vulnerability of people and nature. To date most research on climate impacts to biodiversity has focused on the direct impacts of climate change, including species range shifts (Pecl et al., 2017) and changes in phenology (Post et al., 2018).

As the world comes to better understand and document these risks, a potentially greater and much-less studied threat is how people are unintentionally harming nature as they struggle to cope with the sometimes devastating impacts of climate change on their daily lives (Pacifici et al., 2015). Unless we understand the needs of people and empower them to find better ways to manage changes in weather and climate, conservation efforts will ultimately not succeed. For example, as global freshwater availability patterns change (Rodell et al., 2018), incidents of human-wildlife conflict over access to water may increase (Mariki et al., 2015).

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Data collection

Conservation currently lacks comprehensive, current, and reliable datasets, particularly from climate-vulnerable communities in sectors that rely on ecosystem services, such as small-scale agriculture and fishing. WWF Climate Crowd (wwfclimatecrowd.org) is a new initiative used to rapidly crowd-source large amounts of data on how vulnerable communities are affected by changes in weather and climate, how they are coping with these changes, and how their coping strategies impact biodiversity. This represents a novel way to gather data in the field of conservation and climate change, and allows us to gather data from very hard to reach places, which are often hotspots for biodiversity. In other fields, remote-sensing products have been fused with crowd-sourced data to improve the accuracy of global cropland maps (Fritz et al., 2015), for example.

Researchers should therefore look to open-source platforms such as crowdsourcing to harness the potential of big data (Ford et al., 2016). Much of the data gathered through Climate Crowd is based on indigenous, local and traditional knowledge systems. These can be a major resource for adapting to climate change, but we need to better integrate this knowledge with existing practices to increase their effectiveness (IPCC, 2014).

WWF works with a number of partners to collect this data, largely through key-informant interviews, conducted in the region where the partner organisation is based. The survey protocol WWF uses was refined and field tested over a 2 year period. Partners are also trained in data collection. As data is gathered, it is curated, analysed, and reports are submitted at wwfclimatecrowd.org/form. WWF then approves reports and posts them on the website, wwfclimatecrowd.org, for use by researchers, educators, and conservation and development practitioners. All the reports are freely available to the public. The homepage has a number of methods for accessing the reports, including summary statistics, reading each report individually, and doing a bulk download of reports as a .csv file. WWF also analyses all the reports and regularly publishes summary reports for each country. These can be found at wwfclimatecrowd.org/publications.

To date, the methods employed by the Climate Crowd project have proven to be very successful. WWF has provided resources for partners to work with communities to collect much needed data, including interview tools and guidance, and an open access platform for the data to be housed.

Findings

WWF then works with partners and community members to develop and implement solutions that help them adapt to a changing climate. The Climate Crowd model therefore provides a rapid way to gather data and mobilise financial resources for the most vulnerable communities, through a participatory method, working with the communities to understand their needs and develop solutions.

As the collected data is analyzed, WWF works with partners and communities to develop on-the-ground solutions. Over the past 2 years, WWF has implemented a number of projects, focused on improved water access, climate-smart agriculture, natural resource management, and more. To date, over 1200 reports have been submitted from over 28 countries. Key findings from all these reports are summarised in **Figure 1**.

Figure 1: Summary of key findings from Climate Crowd data collected from 2014-2018 (Source: Authors own)

Communities are increasingly dealing with increased water scarcity and changing seasonality of rainfall (**Figure 1**). This is particularly true for East Africa. A number of projects have been implemented to help communities adapt to these changes. These include converting open water springs into protected wells (Uganda), construction of a solar-powered irrigation system for farming (Uganda), recycling plastic water bottles to build a rainwater harvesting system (Uganda), construction of a rainwater harvesting and hand-washing station (Tanzania), and contour trenches and tree planting for soil and water conservation (Tanzania).

Encroaching on protected areas and use of natural resources have been identified as frequent coping strategies employed by communities (**Figure 1**). In Mexico for example, communities are shifting their activities closer to forested areas as the land is perceived to be more suitable for crops. To mitigate this, WWF supported a project using fog catchers to collect water during dry periods, and small water channels to mitigate against the effects of frost.

Image 1: Fog catcher and water channel in Mexico (Source: Authors own)

On-going monitoring of these projects suggest they have been successful in reducing climate vulnerability of both people, and in some cases biodiversity. For more about these and other projects, see wwfclimatecrowd.org/projects.

Conclusion

In the field of conservation in particular, communities are often not consulted to the extent they should be when research is being undertaken on climate change impacts. Instead the focus is often on modelling studies, taking a much longer-term view of how climate change might impact a particular system of interest. This neglects a very real and present threat to biodiversity, that of human coping strategies to changes in weather and climate. Additionally, where vulnerability assessments have been conducted, translation of this knowledge into tangible adaptation initiatives is still limited.

Conservation practitioners need to be a bit more daring in our approach. Conservation has historically been a very backward looking discipline, often looking to restore ecosystems to past states, rather than embrace the inevitable changes in climate we are already seeing, and the increasing pressure of human population growth. Through this Climate Crowd initiative, WWF works with communities to understand the challenges they face, and develop and implement solutions that help both people and nature. Findings from the project are then used to create evidence-based recommendations for better adaptation strategies by governments, financial institutions, and others.

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A changing Arctic – dialogues from the North

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Abstract

This paper discusses how climate services can support adaption decisions in the Arctic, a region that has been changing at an accelerating rate. The research is done within the framework of the APPLICATE project that aims at enhancing weather and climate predictions in the Arctic, through improving modelling, observing system design, and understanding of a changing Arctic climate. For this new climate data to become an asset for decision-making, we need to assure its usefulness and usability. The climate services paradigm proposes collaboration and knowledge co-production with various stakeholders, to transform climate data into useful knowledge. By regularly meeting with the project user group, the research managed to identify pertinent challenges that demand better climate information, while feedback from this group assures timely response to the project outputs and helps shape the products developed, maximising their usability.

Key words: *Climate services, Knowledge co-production, Local communities*

Introduction

Climate change has widespread effects on the Arctic – a region that is warming at almost twice the global average rate. The rapidly transforming Arctic represents new challenges for its sensitive socio-ecological systems. Hence, local populations need to adapt their practices to the emerging circumstances that span from new opportunities related to opening of the local markets, to the negative effects of increased ocean temperature and decreased salinity on native fish species (WMO, 2017). New and more reliable predictions of weather and climate in the Arctic – for the coming days, up to a year in advance – could help coping with the potential risks and support adaptation practices. However, only by assuring that this new climate data provides useful and usable knowledge – such as weather and climate model outputs - can it become an asset for the Arctic stakeholders. The climate services paradigm assumes the transformation of climate data into information that can support decision-making and improve knowledge about the environmental and climate change (Hewitt, 2012; Terrado et al., 2018). For this transformation to happen, scientists need to understand the broader context of changes that occur both at local and global scales. This includes considering the existing autonomous adaptation practices, societal changes that affect adaptation processes and barriers to adaptation (Nilsson et al., 2017).

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The European project APPLICATE[5] has established a dialogue between climate data providers and users to fulfil its aim to advance weather and climate predictions in the Arctic. In this paper, preliminary results about the role of climate services in supporting adaptation in the Far North are presented.

Methodology

APPLICATE employs diverse engagement techniques, such as a blog, online meetings and focus groups, to actively exchange knowledge with stakeholders from all over the vast Arctic region. The dialogue is taking place at three principal levels, from a focused engagement with the project User Group (UG), over an open discussion forum, to a wider EU coordinated dialogue with different stakeholders from the Arctic and beyond.

(i) The UG is composed of the representatives from various stakeholder groups, such as local communities, businesses, and international organisations. By regularly meeting online and in person, local knowledge is combined with scientific findings to understand the potential role of climate data in informing adaptation measures. In focus groups, the UG members discuss pertinent issues in the Arctic and the main challenges stakeholders are facing. This setting allows for finding common solutions for potentially conflicting interests, while findings inform the project and help to focus its efforts on providing relevant and useful climate data (Bojovic and Terrado, 2018). In addition, feedback from this group assures timely response to the project outputs and helps shape the products developed - maximising their usability.

(ii) The blog "Polar Prediction Matters"[6] is a discussion forum for polar environmental forecast users, providers and all those interested to learn about first-hand experiences from the Arctic. The blog features individual views on how forecasts are actually used and we expect it to foster discussion about how to improve polar prediction capabilities. Dialogue developed at this blog helps identifying priority sectors for which project outcomes could be relevant while engaging with a wider stakeholder community.

(iii) The EU Arctic cluster is a coordinated initiative between different European projects that aims to enhance international cooperation on the most up-to-date findings about Arctic change and its global implications. The cluster collaborates with policy makers, Arctic communities, business representatives and the European civil society. Dialogue within the EU Arctic cluster helps combining efforts in order to avoid overlapping and better exploit synergies among different projects.

Results

The preliminary results from the interactions with Arctic stakeholders reveal a few priority topics for which appropriate weather and climate information would be useful - these include:

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[5] Advanced Prediction in Polar regions and beyond: modelling, observing system design and LInkages associated with a Changing Arctic climaTE (https://applicate.eu)

[6] (https://blogs.helmholtz.de/polarpredictionmatters/)

- **Food security** is an important challenge for the Arctic. Local communities are concerned about the melting permafrost and the freezing and melting of lakes and rivers that is becoming ever more irregular. Fishers and hunters often cross frozen lakes and rivers while looking for preys, and need to do so safely. Having access to seasonal climate data, from two weeks up to a year in advance, particularly about precipitation, temperature and snow cover, can help for fishing and hunting planning, allowing local communities to make more reliable estimations for winter food supply.
- **Reindeer herding** reflects well the complexity of the Arctic region being composed of a wide variety of settings and contexts that require different climate change adaptation measures. One of the common challenges for reindeer herders is the difficulty to secure feed for their animals. Shifting seasons, including changes in precipitation and temperature patterns, continuous ground freezing and thawing, as well as rain-on-snow conditions that develop an ice crust, limit reindeer's foraging success (Forbes et al., 2016). Having information on autumn/winter rain-on-snow events days, months or even years in advance could help to buffer against reindeer starvation. In line with this, the project also explores the added value of high resolution weather and climate models. High-resolution data would be an asset for traditional activities like reindeer herding, but also for day-to-day activities, such as commuting.
- **Transport and resupply** is another important issue in the Arctic. In some regions, items like construction materials and fuel are only supplied once per year. Fish catch and other local goods are taken out with the same frequency. One of the questions raised in the UG meeting was about the combination of changes in climate, technology and habits that would reduce the cost of living for Arctic communities. In fact, the economy is already changing with the changing ice conditions and advancing maritime transport. A possibility of shipping out products during the whole year could increase the market value of local products (Nilsson et al., 2017). More reliable sea ice data was pointed out as crucially important for the expanding shipping industry.

In collaboration with Arctic stakeholders, APPLICATE is co-developing user-relevant metrics for some of the identified priority topics, such as:

i) enhanced and tailored sea ice prediction that can benefit maritime transport and fishing;
ii) improved understanding and prediction of freezing, thawing and rain-on-snow events, which can support reindeer herding, hunting and commuting of local communities; and
iii) better information on climate-related ocean parameters that can support nature conservation, fisheries and blue growth.

In these dialogues from and about the North, knowledge communication and integration was a recurrent topic, emphasising the need for traditional knowledge to be considered in the conventional knowledge system.

Conclusions

Establishing and maintaining a dialogue with stakeholders throughout the duration of the APPLICATE project facilitates the exchange of perspectives and ideas, and helps shaping climate data into services for various users. As depicted in this paper, some of the services already

developed in the project include improved prediction of sea ice and freezing and thawing events. Among the expected users of these services are local communities and the transport and maritime sector. Within the APPLICATE project, the dialogue is taking place between climate scientists - able to provide enhanced knowledge on weather and climate, and stakeholders from the Arctic's complex socio-ecological systems who, by witnessing changes every day, are ultimately the ones knowing what is actually needed. The dialogue results in better understanding of the new Arctic challenges and opportunities, and supports production of trustworthy predictive information. Not only is this new climate information expected to support bottom up, autonomous adaptations, but also top down measures, by informing climate change policy. Discussion forums and a coordinated activity between Arctic initiatives further enhance the exchange of knowledge and could ensure that the dialogue continues after the project ends.

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Urban climate resilience: European-African knowledge exchange toolbox

Floris Boogaard[1], Marieke de Groen[2], Rick Heikoop[3]

Abstract

There is a clear demand for collaborative, knowledge sharing tools for urban resilience projects. Climate-scan is an interactive, web-based map application for international knowledge exchange on 'blue-green' projects around the globe. The tool was applied during the Adaptation Futures & The Water Institute of Southern Africa (WISA) conferences, June 2018, in Cape Town. The use of climatescan by different stakeholders during the event led to recommendations for a better application of the web-based map in Africa and around the world.

***Keywords**: Urban resilience, Open source, Toolbox, Knowledge Exchange*

Introduction

There is a wide diversity of projects undertaken to address urban resilience and climate proofing in the world. International interactive open source tools are used as communication aids to promote engagement with stakeholders in the field of climate change and related environmental issues (Hall 2001, Hamill, et al., 2013, Tipping et al., 2015).

Climate-scan is an optimised interactive online map application that provides an easy-to-access database of international project information in the field of urban resilience and climate adaptation – or 'blue-green' projects - around the globe. The tool is able to support the tasks of prioritising risks, evaluating flood models, designing appropriate remedial measures and map several sustainable urban drainage systems. During an international knowledge exchange mission[4] from The Netherlands to Cape Town and Durban in November 2017, the need for international knowledge exchanges of Best Management Practices (BMPs) was highly recommended. Climate-scan has proven to be a successful tool with over 10,000 users and more than 3,000 international projects (mostly European). The tool is used in city climate scans around the world (Heikoop et al., 2018) and several international projects and workshops, such as Innovations for eXtreme Climatic EventS (INXCES)and Water Co-Governance (WaterCoG[5]), and serves the needs of different stakeholders (Boogaard, et al., 2017).

The open source webtool (www.climatescan.nl) was applied during the Adaptation Futures & The Water Institute of Southern Africa (WISA) conferences, both held in June 2018 in Cape Town.

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[5] https://inxces.eu and http://www.northsearegion.eu/watercog/, consulted 8 September 2018

Methodology

Engagement with stakeholders through workshops and semi-structured interviews within EU projects, such as INXCES and WaterCoG, resulted in evaluating Climate-scan in order to judge the need and potential for implementation of tools such as Climate-scan in Africa. The objective of this study is to implement and evaluate www.climatescan.nl, which is currently primarily used in Europe and Asia, in a South African context. The evaluation was undertaken via semi-structured interviews during workshops with experts (lecturers, academics) and young professionals that took place during a 'toolshed' workshop at the Adaptation Futures conference, and as a case study in the Wetskills Water Challenge during the WISA conference. The Wetskills Water Challenge is a pressure-cooker programme for young students and young professionals with a passion for water from all over the world. Climate-scan and Wetskills is a new way of authentic learning for young professionals with a passion for water. The Challenges take place worldwide during international water-related events. In mixed teams, the internationals participants work on transdisciplinary issues with both non-government and governmental organisations. They met before and during WISA, and worked on water-related topics such as the Climate-scan case.

Implementation in Africa

Previous studies indicated that stakeholders are in need of tools that are interactive, open source and provide more detailed information on climate adaptation projects (location, free photo and film material) (Boogaard et al., 2017). The first African projects were uploaded on Climate-scan during the conferences in June 2018. For example, several participants at WISA downloaded the app and uploaded stormwater Best Management Practices (BMPs) - techniques, measures or structural controls used to manage and reduce the rate and quantity of surface water runoff from developed areas and to improve runoff water quality. Good examples of sustainable urban drainage systems in South Africa are, in most cases, implemented either in gated communities or office parks, or in areas that are (for safety reasons) not easily accessible. The google view and the GPS function of Climate-scan project listings is thus a great advantage of the app. **Figure 1** shows an example of an project uploaded by Aqualinks in Johannesburg, South Africa.

Figure 1. An example of an uploaded project during the respective Adaptation Futures and WISA Wetskills conferences. Here a stormwater retention area functions as a bioswale, and contributes to the Green Infrastructure Strategy of the City of Johannesburg (Source: https://www.climatescan.nl/projects)

Users of Climate-scan can create their own climate adaptation categories and upload projects. The most uploaded projects within categories of different types of measures are listed in **Table 1**.

Table 1. Top 10 project-type uploads by category (Source: Susdrain[6] and Climate-scan)

Category		
1. Swale	A shallow vegetated channel designed to conduct and retain water, but may also permit infiltration. The vegetation filters particulate matter.	
2. Constructed wetland	Wetland: flooded area in which the water is shallow enough to enable the growth of bottom-rooted plants. Wetlands are constructed in urban area to store water after stormwater events and improve water quality.	
3. Waterharmonica	Ecological engineering (constructed wetland) treating waste water into usable surface water. The Waterharmonica focuses on integrated ecological engineering processes, by optimising multi-functional constructed wetland processes.	
4. Green roofs (and walls)	A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater, and promotes evapotranspiration. Sometimes referred to as an alternative roof.	

[6] https://www.susdrain.org/resources/glossary.html, consulted 8 September 2018

5.	Floating urbanisation	Floating or amphibious constructions as floating homes will adapt to variation of waterlevels (flooding, drought). Floating homes are constructed around the world to adapt to climate adaptation.	
6.	Permeable pavement	A permeable surface that is paved and drains through voids between solid parts of the pavement. A permeable is a surface that is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration of water to the sub-base through the pattern of voids, for example concrete block paving.	
7.	Opportunities for adaptation	This category shows locations that provide opportunities for climate adaptation. Uploaded projects are implementation of nature based solutions or locations that are suited for urban resilience	
8.	Hollow gully free roads	Roads that are constructed as drainge. An example is a surface flood pathway: routes in which exceedance waterflows are conveyed on the ground.	
9.	Sub-surface infiltration	A sub-surface structure into which surface water is conveyed, designed to promote infiltration.	

10. Heat stress measures	An upcoming category linked to implementation of green and blue measures in previous categories (swales, green roofs and walls, permeable pavement, raingardens etc.)	

The participants of the workshop at Adaptation Futures gave positive feedback on the free and open access usage of Climate-scan and the number of projects uploaded (over 2000 projects in 2 years). However, this 'learning-by-doing' concept also raised legitimate questions of ownership, quality control, maintenance, business model design and sustainability. Most users wanted to incorporate and engage with such development issues within a more interactive platform that includes stakeholders. Climate-scan was also used during the Wetskills case study at the WISA conference (**Image 1**).

Image 1. Minister Gugile Nkwinti of Water and Sanitation of South Africa and Wetskills participants that used Climate-scan during the Wetskills challenge (Source: Dutch water sector, 2018).

Conclusion

The website www.climatescan.nl was particularly appreciated by postgraduate students, lecturers and researchers. The webtool has been used during workshops in South Africa and the outcomes of this project have shown there is a clear demand for a collaborative, knowledge sharing tool where first impressions of different urban resilience projects can be quickly gained. The semi-structured interviews during (and outside of) the South Africa workshops yielded positive feedback on the free and open access usage. The challenge for Climate-scan will be changing the free

'learning-by-doing' concept to a platform with more interaction with stakeholders and clear strategy on ownership, quality control, maintenance, business-model design and sustainability. It is hoped that the new Climate-scan uploads will stimulate international knowledge exchange on wicked problems such as drought, heatstress and floodings, while clear recommendations for a better application of the web-based map in South Africa, and beyond, provide guidance on how the tool can best be used in the field of adaptation policy and practice.

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Innovative approaches in monitoring rapidly changing environments in different socio-economic contexts around the globe

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Abstract

Water resources are very important for livelihoods, as well as natural ecosystem settings. There is urgent need for developing methods that are capable of monitoring fast-changing water systems (for indicators such as pollution) affected by climate change and the increase of anthropogenic pressures. Updated and real-time detailed data is necessary to support water and soil management strategies. This study evaluates the implementations of novel techniques in different socio-economic settings. Sensors and cameras were installed in mobile platforms (including boats and underwater drones), and deployed to assess spatial data variability. Environmental scans were performed at multiple locations with different water systems in The Netherlands, Indonesia and Denmark. Results from the multiple methods provided new insights into spatial variation of water quality, contrasting with traditional point sampling. Feedback from water authorities and other stakeholders indicate that collected data can be used to support management actions, and that such increasingly accessible technologies contribute to creating awareness of water-related issues.

Keywords: *Water quality, 3D Data visualisation, Mobile sensors, Underwater drones, Unmanned ROV*

Introduction

With climate change and increasing anthropogenic pressure, alarmingly accelerated changes to water bodies and catchments are being observed all around the globe. There is an urgent need for monitoring methods that are capable of accompanying these trends, which can provide updated and detailed data that supports water and soil management actions. The usability and effectiveness of different methods is investigated with regard to different socio-economic contexts in Europe, Asia and (South) Africa. This article describes the method and results in a recent pilot in Surabaya, Indonesia. Special attention is given to methods that raise awareness, capacity building, or serve educational purposes for training of stakeholders, water managers or populations.

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Objectives

The objective of this work is to describe novel and versatile *in-situ* data collection possibilities in catchment-scale surface water bodies that enhance data spatial resolution with reduced costs. This work focuses on the case of Indonesia and Mali, and relates findings to results from previous field implementations in Europe (de Lima et al, 2015a; de Lima et al. 2015b, de Lima et al., 2017; Boogaard et al., 2017). There, different *in-situ* methods were used to monitor and perform quick scans to the current status of surface water bodies.

Methodology

Sensors and cameras were combined with boats and unmanned underwater vehicles (ROVs) in order to enable the continuous collection of data along surface water bodies and to get insight into underwater life from underwater footage. Vertical profiling from boats/bridges, use of test strips combined with apps and strategic placement of static sensors in outlets were also applied. These methods enabled spatial visualisation/mapping of water quality concentrations, and assess stratification/variation with depth.

The different measuring locations were selected to cover most sections within the investigated water systems and basins (e.g. spring/source, big reservoirs/dams, upstream/downstream of industry and urban areas, some tributaries and at the mouth/estuary). Measurements took place in the Brantas Basin near Surabaya, Java Islands, in February 2017 (Dutch Water Sector, 2017) and Mali (Dutch Water Sector, 2018). Measured parameters include turbidity, electrical conductivity, dissolved oxygen or nutrients (ammonium/nitrate).

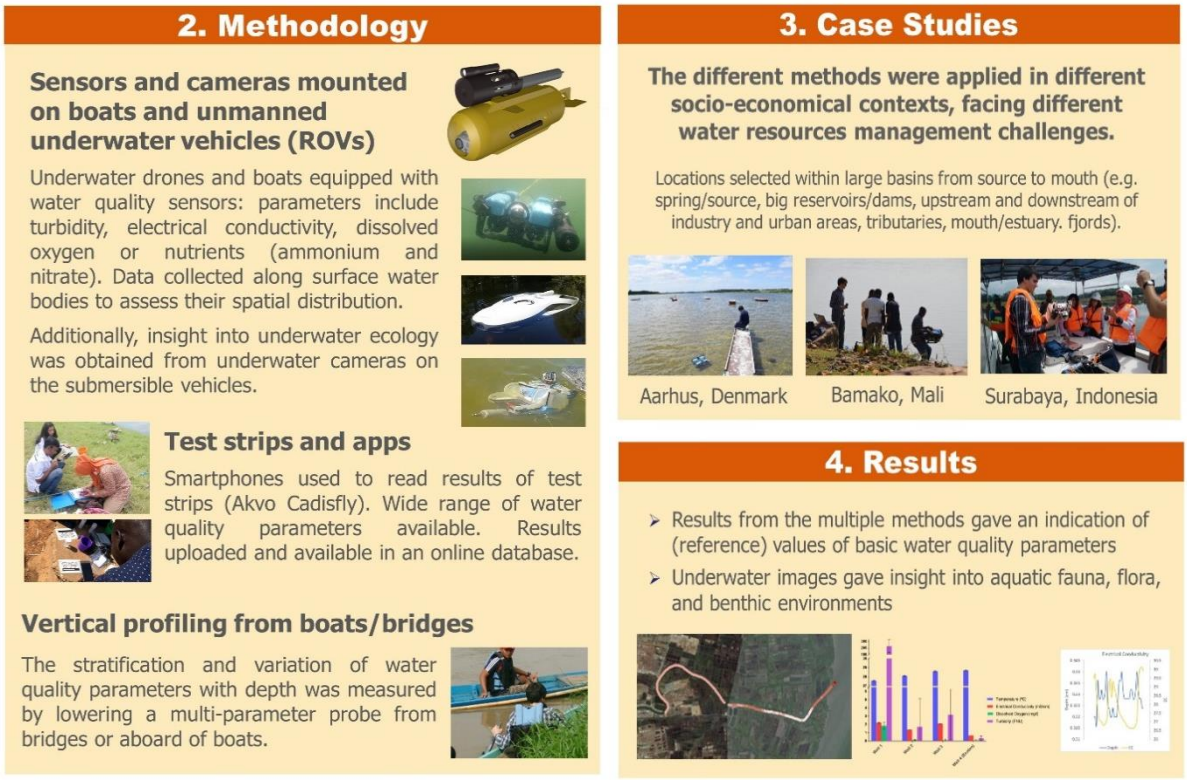

Figure 1. Methodology, case studies and results (Source: Authors own)

Findings

Results from the multiple methods gave an indication of (reference) values of basic water quality parameters. Areas with higher concentrations of parameters could be identified, and potential pollution sources tracked. When in low turbidity conditions (rare in polluted rivers of Indonesia), underwater images allowed to get insight into aquatic fauna, flora, and benthic environments. The collected data allowed researchers to further understand the behavior of the water systems, and to utilise as a base for intervention recommendations. Additionally, the work conducted showed how local water managers and stakeholders can use new technologies in favor of data quality and quantity.

The data generated by the underwater drone contrasted with the lack of updates in the region (only a few points along the river were available). The local actors in Indonesia and Mali see high value in the water quality maps and results produced, which emphasised spatial variation (even in very small distances – for example, as shown in **Figure 2**).

Image 1. Local stakeholders received training on how to operate and interact with new technologies in the Niger river near Bamako, Mali. The aim of the monitoring is to enable river basin commission, Agence du Bassin Fleuve Niger, to provide reliable and continuous data to policy-makers (Source: Dutch Water Sector, 2018)

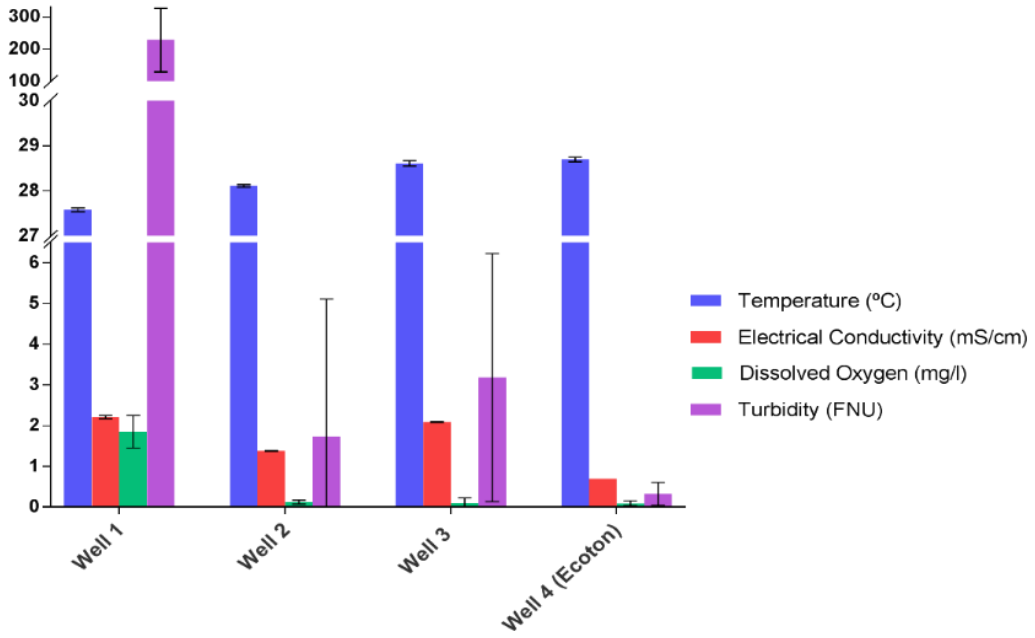

Figure 2. Scanning of water quality in multiple wells within a village dealing with industry waste contamination (Source: Authors own)

Industry/domestic outlets could be located, based on the fact that the water has different characteristics (e.g. different temperature and nutrient and dissolved oxygen content). Autonomous collection of data, real-time access to datasets and quick response triggered by events, were highlighted as top needs for monitoring improvement. In small catchments, this technology can have high impact by supporting better informed resources management decisions.

Conclusion

Fast changing water quality due to climate change needs to be tracked as fast as it changes, and records made of what is influencing the changes. This can be done efficiently by using smart technology such as 3D data visualisation, mobile sensors, underwater drones, and unmanned ROVs. The significance of this work is to introduce novel and versatile *in-situ* data collection possibilities catchment-scale surface water bodies that enhance data spatial resolution with reduced costs. Innovative/dynamic monitoring methods (e.g. underwater drones, sensors on boats) contribute to better understanding of the quality of the living environment (water, ecology, sediment) and factors that affect it. Although further research is still needed to fully characterise these processes and to optimise the measuring tool, the method provides valuable information about the behaviour of water systems and spatial/temporal variability, and shows potential as an efficient monitoring system. In the Netherlands and Denmark, where water bodies are already monitored regularly, this type of monitoring is requested to investigate in detail certain specific issues (e.g. presence of mussels at the bottom of lakes, blue-green algae monitoring) that require comprehensive data to complement existing information. In developing countries such as Indonesia or Mali, due to the inexistence/scarcity of reliable and updated data, the main use of the unmanned vehicles is to survey large areas in order to characterise the water system, and identify pollution sources. The cooperation of local managing organisations, and their willingness to work together is important to ensure participatory actions and social awareness regarding the process of adaptation and strengthening of regulations, or for the implementations of water management actions.

Acknowledgements

This study would not have been possible without many project partners[6], and without the funding and collaboration within the 3 projects: '*WaterCoG*', '*Fostering inclusive growth, health and equity by mainstreaming water quality in River Basin Management in the Brantas River Basin, Indonesia*', and '*Capture and share continuous Water Quality data of the Niger River around Bamako*'.

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High resolution thermal stress mapping in Africa: decision maps for urban planning in Johannesburg

Floris Boogaard[1], Jeroen Kluck[2], Marieke de Groen[3]

Abstract

Urban planning will benefit from tools that can assess the vulnerability to thermal stress in urban dense cities. Detailed quick-scan heat stress maps, as developed in this study for Johannesburg, South Africa, have proven valuable in the decision-making process on this topic. It raised awareness on the urgent need to implement measures to tackle the effects of climate change and urbanisation. Awareness on heat stress has led to the implementation of measures to mitigate the effects of climate change. As in other countries, nature-based solutions (e.g. green roofs and walls, swales, rain gardens, planting trees etc.) are considered in urban areas in South Africa for various reasons. The awareness of the effect of nature-based solutions on heat stress is still low, which can be improved by the use, understanding and importance of heat stress maps. Some of these measures are already mapped on the open source web tool, Climate-scan (www.climatescan.nl) for international knowledge exchange around the globe.

Keywords: *Heat stress, Modelling, Urban Planning, Thermal stress*

Introduction

Thermal stress has become a key issue for many cities around the world. Densely-populated urban landscapes with concomitant infrastructure (asphalt, concrete, brick, metal) soak up heat from sunlight. This energy absorption leads to "*urban heat islands*", where cities experience higher-than-normal heat temperatures, as compared to surrounding areas. Urban areas throughout the world are exposed to heat stress and the resultant effects on infrastructure, livelihood, health etc. With the continuing impacts of climate change, thermal stress - already experienced in dense urban areas - will become more acute and will lead to serious problems such as indicated in the mindmap (**Figure 1**), which is used in the Netherlands to discuss and explain urban heat issues. Therefore, urban planning departments are in need of tools that can assess the vulnerability to thermal stress so that they can plan the implementation of measures to reduce heat stress, such as nature based-solutions (green roofs and walls, planting trees, swales, rain gardens etc.). In Johannesburg and other urban areas in South Africa, tree planting programmes by municipalities, sponsored by corporates or implemented by the communities themselves helps alleviate related heat stress issues, and improves air quality and liveability. This is also necessary to compensate for poor spatial and town planning in the apartheid-area (Kings, 2016).

In addition, the maps will assist in making stakeholders and role players, such as property developers and urban planners, aware of heat stress effects. Quick scan climate models can

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visualise priority areas to address several challenges in urban dense areas, such as flooding, drought etc. (Boogaard et al., 2017). Quick scan detailed heat stress models are relatively new and are under development to provide urban planners with detailed insights into the heat stress effect in cities at a street, or even object level.

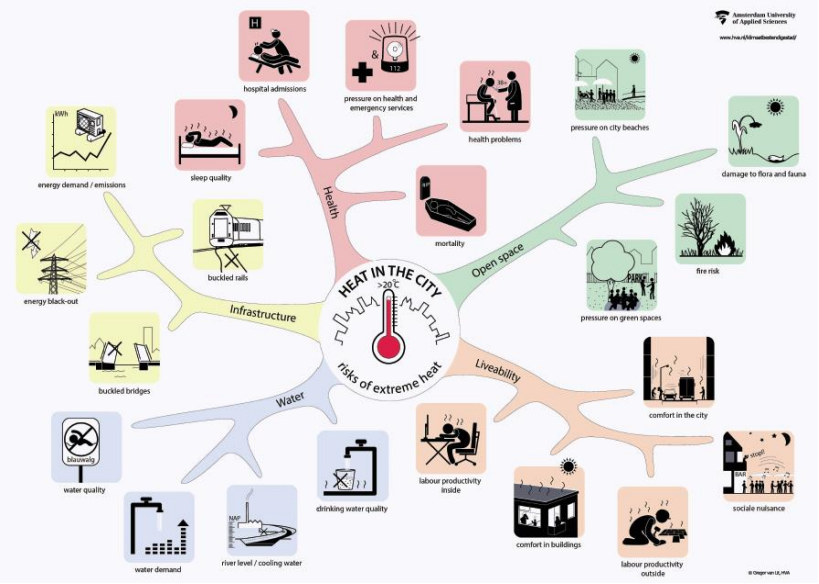

Figure 1. Map of City level heat stress effects (Source: Klok and Kluck, 2016)

Objectives

Heat stress maps are currently not applied in South Africa. The objective of this research is the development of a detailed geographic information system (GIS)-based thermal stress map for cities like Johannesburg. While maps on flooding, drought, land subsidence (resulting in damage to infrastructure) are widely used, maps indicating heat stress in cities are relatively new for target user groups, such as urban planners, to assess the resilience and well-being of cities with these high resolution decision maps for urban planning.

Method

The quick-scan GIS-based thermal stress map of Johannesburg was developed in order to give quick insight into the possible thermal stress locations in a part of the city. It is based on an accurate Digital Elevation Model in which physical processes are modelled in detail for a limited area. For a quick insight into thermal stress on a larger scale, to limit computation times, some rough simplifications of the actual physical processes can be made (Boogaard et al., 2016). Those simplifications imply that the (relative) increase in air temperature is a summation of local effects, like presence of buildings, trees, greenery and water (Kluck et al., 2015). The maps present the Physiological Equivalent Temperature (PET) at the hottest hour of an almost windless day and are presented relative to the rural temperature of a meadow. The PET is calculated from the local estimation for air temperature, wind, and humidity. The choice for the hottest time of a windless day means that the direct radiation has a major influence on the PET (much more than air temperature, wind and humidity).

To make a detailed heat stress map, topographical data with detailed information on materials, roads, waterways and dataset inclusive of the height of all infrastructure and trees (to model

shadow effect) is needed. Combining the elevation model, the dataset with buildings and aerial photographs, a model of the city is constructed to get a better overview of the outcomes of the model. The maps give a detailed estimate of the maximum PET during a heat wave, as a measure of thermal comfort.

Findings

The heat stress map and topographic map of Johannesburg (**Figure 2**) developed for this study indicates hot areas in red ('much warmer') to purple ('very much warmer'), where high PET (thermal comfort) values can be expected, as in other pilot cases around the world. Purple areas are generally open spaces with hardly any shadow and greenery. The thermal maps for the African, Dutch and Asian cases are used to compare the differences in simulation results between different climates zones.

Figure 2. Heat stress map for Johannesburg (Source: Authors own)

Corresponding to the legend, the darker areas in **Figure 2** indicate areas where heat stress or thermal discomfort will be most experienced, and measures to mitigate these high temperatures will be advised. Measures that provide shading (trees or fabric) or minimise paving (replacing stones or tarred areas by greenery, lawns etc.) are mostly implemented to lower temperatures in the urban dense area.

Conclusion

The heat stress maps are intended for use by urban planners and other stakeholders and decision makers to assess the resilience and well-being of cities. With previous climate modelling around the globe, the end result is an international comparison of the potential use of heat stress maps under different climates in Europe, Asia and Africa. These maps are ideal quick-scan tools for urban planners who, in combination with other tools, can use it to improve planning. The heat stress maps are clearly related to land and water cover, which gives an argument for urban

planners for implementing green and blue measures from the perspective of mitigation of heat stress – and adaptation to health impacts due to climate change. As in other cities, in the city selected for this study, Johannesburg, such mapping tools have proven valuable in the decision-making process and it is envisaged that they will have similar successes in other cities the world over. In Europe and Asia, these maps have been an important input for master classes on climate adaptation in The Netherlands and Taiwan. It raised awareness on the need to implement measures to tackle heat stress and has led to consideration of implementation of various sustainable urban drainage systems in The Netherlands (Kluck et al., 2018).

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Examining barriers and opportunities for sustainable adaptation to climate change for smallholder farmers in semi-arid Buhera District, Zimbabwe

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Abstract

Climate change adaptation is increasingly becoming a more visible and pressing issue in smallholder agriculture of semi-arid environments. In some cases, what seems to be a successful adaptation strategy to climate change may in fact undermine the social, economic and environmental objectives associated with sustainable development of a nation as a whole. This paper examines opportunities and threats to sustainable adaptation to climate change in the case of semi-arid Buhera District in Zimbabwe.

Key words: *Sustainable adaptation, Livelihoods, Semi-arid, Agriculture, Zimbabwe*

Introduction

Adaptation to climate change is comprised of adjustments in response to (or in anticipation of) climatic impacts to reduce disruption to key resource flows and the adverse effects on people's general well-being and quality of life. Although adaptation can potentially reduce the negative impacts of climate change, little attention has been paid to the consequences of adaptation policies and practices in terms of sustainability (Bhatasara and Nyamwaza, 2018). Strategies or policies that make sense from one perspective, or for one group, may at the same time reduce the livelihood viability or resource access of other groups. Reduction of climate risk through specific technologies or infrastructural changes may sometimes lead to the neglect of other environmental concerns, such as biodiversity (Eriksen, 2011). Hence, adaptation can have unintended negative effects both on people and on the environment – so-called maladaptation. A recognition that not every adaptation to climate change is good has drawn attention to the need for sustainable adaptation strategies and measures for enhanced livelihoods, and for qualifying what types of adaptation are desirable or not. The increase in attention to mobilise resources for adaptation suggests that it is critical to get adaptation right in order to solve, rather than exacerbate, problems resulting from climate risks (Chanza, 2017).

Consequently, it is crucial to understand what it means to sustainably adapt to climate change. A working definition of sustainable adaptation would be adaptation that contributes to socially and environmentally sustainable development pathways, including both social justice and environmental integrity. This paper presents and discusses the concept of sustainable adaptation to climate change, and illustrates the principles of sustainable adaptation as outlined by Eriksen (2011) and their significance by examining the case of smallholder farmers in the semi-arid region Buhera District, Zimbabwe. Buhera District is characterised by relatively low rainfall of <650mm p.a.

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There is evidence of warming of 1^0C over the last several decades in Zimbabwe and the country has begun to experience more hot days and fewer cold days. A rainfall simulation of the country has estimated that rainfall will be 15 to 19% lower by 2075 and that evapotranspiration rates could increase by between 7.5 to 13%, creating a great moisture deficit scenario (GoZ 2016). The length of the growing season has become short and is now characterised by late onset of rainfall, prolonged intra-season dry spells and early cessation of rainfall. Such a pattern has negatively affected both crop and livestock farming. The area has also experienced increased incidences of weather extremes in the past 10 years (droughts, heat waves, windstorms, hailstorms). There is a general decrease in river flows and drying up of boreholes shortly after the rain season. The district has a poor road network and general low development infrastructure. Education levels are relatively low for the people living in that community as the young and educated population continue to migrate to urban areas in search for a better living. The area is characterised by general low food production and low incomes (ZIMVAC, 2016). This research thus examined the social-ecological system responses of the communities to climate change effects.

Methodology

The study used a qualitative approach comprising of three focus group discussions and 15 key informant interviews. Participants for focus group discussions were conveniently selected due to their availability, and effort was made to include various age groups (young adults, roughly 18-30; middle aged 31-45; and the elderly 46+ years), and to balance the number of female and male participants. Focus group 1 comprised of 13 participants (8 females and 5 males) group 2 had 11 participants (5 females and 6 males) and group 3 had 12 participants (7 males and 6 females). The interviewees were purposively identified due to their positions of influence and involvement in livelihood systems in the district. These were community leaders, agricultural extension officers, livestock production officers, gender and community development officers and district livelihoods and welfare officers.

Findings

Major livelihood options in the area are climate sensitive i.e. rain-fed agriculture (97%), gardening (87%) and livestock rearing (78%). The research established that the communities are resorting to soil-water conservation, planting of climate tolerant crop cultivars (small grains like sorghum and millet), strategic cropping, animal husbandry and embarking on alternative livelihood options to support income levels of their households. Red sorghum contract farming, improved livestock breeding (cross-breeding) and Small Ruminants 'Pass On' projects (where a female goat or a heifer is passed on to the next household when it gives an offspring in order to increase livestock ownership) were found to be major intervention activities, though their implementation are marred with challenges. The following are the principles of sustainable development examined in this research:

i) Recognition of context in which vulnerability to climate change occurs.
Farmers are increasingly concerned about unfamiliar climate dynamics, which results in uncertainty around planting, loss of crops and livestock, and damage to infrastructure because of hydrological extremes. The community is living in an area of perpetual aridity, and experiencing the occurrence of climate-related extreme events such as heavy storms, windstorms, hailstorms and other unpredicted weather regimes. These have led to extensive damage to property. The livelihood dynamics form part of the vulnerability

context, with support networks from family and friends being fundamental. It was also evident that several organisations dealing with livelihoods enhancement programmes through income generation are in operation. Some of the non-governmental organisations only operate for a short period of time with a relatively weak exit strategy, thus leaving the community still at risk. It is against this recognition that there is need to broaden adaptation responses by a livelihood diversification enabling environment.

ii) Acknowledgement of different values and interests that differently affect adaptation outcomes.
Strong vested interests within particular adaptation strategies may act as a barrier to sustainable adaptation. There was evidence that most programmes were gender specific or targeted a certain group of the population. For example, men were mostly in higher capital projects, while women in relatively low income projects. This generates some divisions within households and may challenge project viability and longevity. Some projects beneficiaries are divided on political affiliations and this challenges the sustainability of adaptation initiatives. This is because development projects, in as much as they are part of policy implementation, change with a change of political regime. Infrastructure provision ends up being dependent on individuals and some government structures instead of being an institutionalised adaptation policy process.

iii) Consideration of potential feedbacks between the local and global processes.
Some adaptation strategies affect other socio-ecological systems. For example, the promotion of livestock production in the area may result in increased production of methane; the establishment of woodlots of exotic trees in riverine systems has resulted in depleted wetlands; and out migration to urban areas has reduced labour force in the source area and created relative pressure on resources in the receiving area. Households benefit from remittances from members who would have moved to the city and this creates an attraction for continued migration.

iv) Integration of indigenous knowledge systems into climate change adaptation.
Over time, vulnerable people have developed responses to climate risks based on their knowledge and understanding of the conditions and environment where they live (Brown, et al., 2012). In-depth interviews revealed that a crucial aspect that helped the community to survive after a weather extreme is the knowledge people had of their environment. It is imperative, therefore, to generate local knowledge and integrate it with other sources of knowledge in order to develop successful responses to climate change and empower local decision-making. Integration of local knowledge into adaptation planning and decision making is also important in determining which interests or development paths can be prioritised. Development initiatives (prioritized according to potential harm to livelihoods), should be matched with adaptation needs and cultural acceptance to enhance local level participation.

Conclusions

There is need to capacitate communities with skills that create an adaptive society through participation and alignment of community adaptation interests with the national economic development plans. Human and social capital development would therefore enable communities to balance between losses and gains and also to take advantage of opportunities that arise with climate change and deal with probable climate risks. There is a need for increased

political commitment to an integrated approach to sectoral development to enhance livelihoods and creation of an enabling adaptation environment. Major opportunities can be necessitated by the existence of a new policy arena, i.e. the launch of the national climate policy to guide the implementation of adaptation in the country. This would increase confidence in investors and development partners. Communities have experienced livelihood losses and generally want change. However, if there is no political commitment to policy implementation, financing and capacity building, sustainable adaptation will remain a dream.

Acknowledgements

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Operationalising stakeholder insights for adaptation – best practices to engage stakeholders and bridge academic, government and local knowledge for action

Darrell R. Corkal[1] and David Sauchyn[2]

Abstract

This research addressed adaptation to climate change, focusing on institutional adaptation, water scarcity and extreme events in vulnerable watersheds in Canada and South America. This paper describes the collaborative research model utilised on two major initiatives, designed specifically to bridge adaptation science with stakeholders. Natural and social scientists committed to cross-disciplinary relationships and integration. Researchers worked with stakeholders, practitioners, government, and boundary organisations, who helped link research with stakeholders' needs. A relationship-centred research model is complex and difficult to manage but better positioned to directly influence policies and practices. Increased efforts at knowledge outreach are recommended to improve research-for-impact.

Keywords: *Collaborative adaptation research model, Boundary organisation, Stakeholder values, Natural and social sciences, Vulnerability*

Introduction

Vulnerability to water scarcity in semi-arid watersheds was studied under the *Institutional Adaptation to Climate Change (IACC)* research in Canada and Chile (2004-09). Vulnerability to extreme events (floods, droughts, storms) was studied under the *Vulnerability and Adaptation to Climate Extremes in the Americas (VACEA)* research in Canada, Chile, Argentina, Brazil, and Colombia (2011-16). In Canada, researchers collaborated with the *Prairie Farm Rehabilitation Administration (PFRA)*, a boundary organisation highly respected for its important historic role in helping stakeholders adapt to climate and water stress. This paper focuses on the 165,000 km^2 South Saskatchewan River Basin spanning Saskatchewan and Alberta in Western Canada, historically prone to water scarcity, floods, and severe multi-year droughts.

Methodology:

This paper describes the collaborative adaptation research model utilised in the IACC and VACEA research (i.e. the methodology, see **Figure 1**; Diaz, 2009, 2016). Natural and social scientists examined past and present climate vulnerability and adaptation strategies to cope with climate and water stressors. Historic and current climate and water risks affecting socio-economic activities were investigated to understand impacts from water scarcity, droughts and extreme events. Quantitative and qualitative data on vulnerabilities and adaptive strategies were

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collected to understand coping mechanisms in targeted watersheds. Semi-structured stakeholder interviews and workshops with rural communities, practitioners, the agricultural sector, water agencies, government institutions and NGOs were conducted to gather ethnographic and social science data to assess community vulnerability, stakeholder values, institutional capacity and governance. Geographers, climatologists, agrologists, and engineers studied historic climate impacts on water resources to understand risk exposure. Sociologists, human geographers, economists, and political scientists investigated human systems to better understand rural vulnerability, water management and conflict, economic impacts, and regional adaptive capacity. Future climate scenarios, regionally downscaled, were modeled to determine future risks. PFRA's historic adaptation role was studied. As an IACC and VACEA collaborator, PFRA also conducted research, provided and gathered data, facilitated researcher engagement with practitioners, liaised with industry and government, and helped translate research findings to stakeholders. Opportunities and constraints for future adaptations to reduce vulnerability and strengthen resilience were explored by researchers and practitioners.

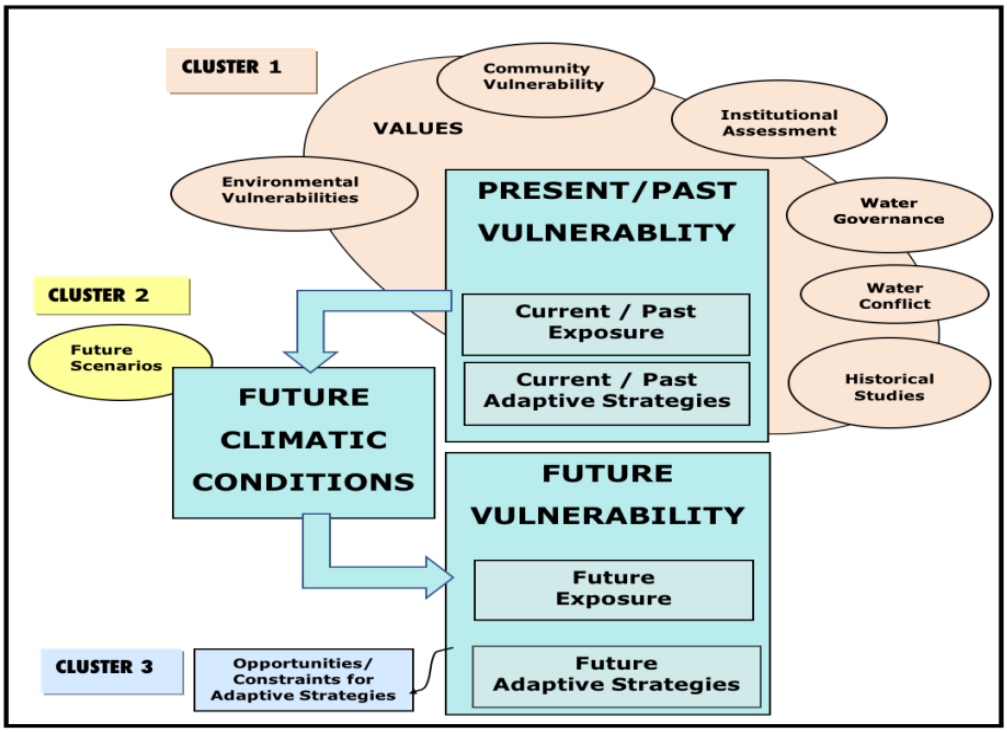

Figure 1. Collaborative Adaptation Research Model - Vulnerability Assessment Model (Source: after Diaz, 2009)

Findings

Since post-European settlement in the late 1800s, the Canadian prairie region has adapted to cope with water scarcity lasting from two- to three-years in duration, albeit with serious social and economic impacts. However, the dendrohydrology and climate modeling research clearly depicted the region as vulnerable to a wider climate variability than the instrumental record indicates. Future climate scenarios depict warmer, wetter winters and hotter, drier summers, reduced stream flows and risk of more extreme events (droughts, floods). Stakeholders understood

future climate variability better when compared to historic records and experience (Marchildon, 2009a; Sauchyn et al, 2016).

Historic analysis of PFRA (1935-2013) demonstrated its boundary organisation role. Canada created the agency to help the prairie region recover from multi-year droughts (1920s-30s). Its mandate was to aid in rehabilitating and conserving the Prairie Provinces' soil, land and water resources for improved regional economic security. As a technical organisation, PFRA worked with scientists, universities, industry, and government to test water and agronomic adaptive practices in the field. By linking science with adaptive practices, PFRA enabled the agricultural-dependent region to better understand its natural capital limitations. Best practices for soil/water conservation and agricultural production were developed to support the region's current sustainable crop and livestock production. Stakeholders and practitioners viewed PFRA as an effective organisation (Marchildon, 2009b).

Natural and social science research discovered that stakeholders are concerned about future vulnerabilities and coping capacity (Diaz, 2009; Hurlbert et al., 2009; Corkal et al., 2011). Stakeholders identified limitations in existing adaptation practices, local/regional planning, water data/management, and governance. They identified a need for:

i) better inter-agency coordination and government leadership;
ii) incorporating climate change science in water management and regional planning;
iii) strengthened resilience with anticipatory long-term climate and water plans;
iv) more integration of government and community adaptation initiatives;
v) simplified water governance;
vi) participatory planning;
vii) conflict resolution mechanisms;
viii) better water data; and,
ix) interdisciplinary approaches for adaptation.

Values analysis research revealed different stakeholders' motivations as *market (economic), autonomy (choice), society (equity),* and *place (culture)*. It was demonstrated that values drive adaptation decision-making. Differing values may lead to conflict, but values mapping helps stakeholders and decision-makers identify adaptation choices (Corkal et al., 2016).

Our results show that wicked problems like climate change adaptation require integrative solutions with diverse stakeholders. Integrative research is not appealing to all. It is complicated, time-consuming and forces discipline-defined researchers to think beyond their expertise, in areas that may not seem relevant. Researchers may be averse to engaging with stakeholders before the work is complete, especially without direct incentives. External integration with government, end-users, and diverse stakeholders is very challenging (Mussetta and Hurlbert, forthcoming). Findings from IACC and VACEA show that adaptation research and its knowledge translation are constrained without sufficient institutional capacity. Resilience can be strengthened with institutional adaptation and improved governance.

Collaborative research to better understand how climate change affects environmental and social systems is complex. It requires integration of different research disciplines, commitment,

leadership, and effective project planning/management. Active government roles strengthen research impact. Engagement between researchers and stakeholders establishes context, provides stakeholder knowledge on operations and governance, and improves outreach. Boundary organisations can enable adaptation research, cross-disciplinary integration, and incorporation of practitioner knowledge. Post-research, an ideal boundary organisation will act with government agencies to bridge adaptation science with practice change (see **Figure 2**).

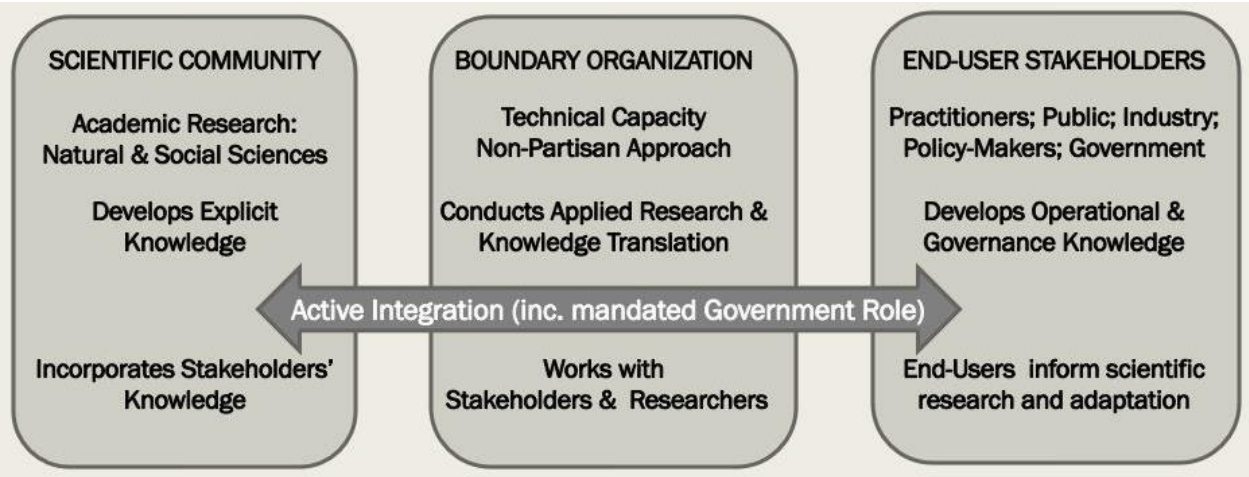

Figure 2. The Ideal Boundary Organisation bridges research with stakeholder outreach (Source: adapted from Batie, 2008; Clark and Holliday, 2006)

Conclusions

Building on IACC and VACEA findings, a strengthened collaborative approach is recommended for adaptation research. Researchers need to be more effectively engaged with policy-makers, boundary organisations, stakeholder practitioners and communities of practice throughout the project. Mandated researcher and government roles need to be included in adaptation research, to improve science translation to stakeholders, encourage adaptive change, and strengthen institutional adaption.

Adaptation research requires a science translation component to extend the science beyond "publication" to a new "adaptation practice" end-state. Outreach should also include more cross-disciplinary integration of the natural and social sciences, and cross-country initiatives to help countries learn from each other's adaptation approaches.

Boundary organisations and government leadership can help translate adaptation science and influence policy and practice. Though challenging, a properly delivered relationship-centred research model will enable researcher-practitioner collaboration, increase potential for research impact and lead towards more transformative adaptations.

Acknowledgements

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Nation-wide interdisciplinary assessments of climate change impacts on agriculture for adaptation planning

Olivier Crespo[1, 2], Mariko Fujisawa[1], and Hideki Kanamaru[1]

Abstract

Impact assessments of climate change on a large-scale, such as nation-wide, produce valuable information to partake in national adaptation planning and policy making. However, the interdisciplinary nature of this exercise, involving multiple actors and institutions, often challenges the production of an integrated assessment. FAO is presenting here an approach dedicated to conduct the nation-wide assessments through the explicit integration of multiple actors, multiple disciplines, and multiple institutions through a modeling platform as the medium for integration.

Keywords: *Nation-wide impact, Interdisciplinary assessment, Planning, Assessment*

Introduction

The Food and Agriculture Organisation of the United Nations (FAO) has been supporting developing countries to further build their capacity to conduct nation-wide impact assessments of climate change on agriculture and food security. Such assessments strengthen the evidence base of current and future impacts, and support effective adaptation planning and policies at national level. Many climate change impact studies exist, yet with a diverse range of scales (in space and time) and foci, so that it becomes challenging to extract clear nation-wide information and messages for policy making. Local experts hold local knowledge and they are best suited to produce the assessments, and later disseminate and advocate them to a wider audience. However, in many cases, local experts take part in the process of those assessments, but often remain isolated from other national participants, particularly after the conclusion of the project or program, or they do not have further access to - or adequate skill to use - the assessment tools, such as those typically needed for nation-wide large-scale integrated assessment.

By introducing robust and simple tools, and initiating the production of such assessments, we aim to develop specific and interdisciplinary capacities within the country. We believe that this step leads to producing nation-wide relevant impact assessment, by enhancing collaboration among stakeholders, and facilitating further development and engagement within the country. By involving the national experts from the beginning of the study design to its dissemination, we further aim to promote the communication between science and policy making at the national level.

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Methodology

This activity is led by the Climate and Environment Division (CBC) of FAO, which has an objective to support countries by developing the capacity within to conduct assessments in the agricultural sector. It introduces the tools for data analysis, numerical simulation, and expert interpretation of the outcomes. A wide range of national experts who hold various disciplinary expertise (e.g. climate, crop, policy), and different positions in research or government bodies, are involved in this effort. Their interaction, during and beyond the activity, contributes to produce nation-wide assessments with sub-national dis-aggregation expressly targeting national policy making.

The challenges which arise from connecting multiple actors and discussing multiple disciplines can be helped by the introduction of a common platform, which includes a complete set of tools (not necessarily all available tools) that allows for handling of existing national climate data, from GIS management to the simulation of gridded nation-wide impacts and their economic implications. FAO developed such a platform: the Modelling System for Agricultural Impacts of Climate Change (MOSAICC[3]). It facilitates a collaborative and integrated research that examines climate impacts on crops, water resources, forests, household-level food security, and national economy (**Figure 1**).

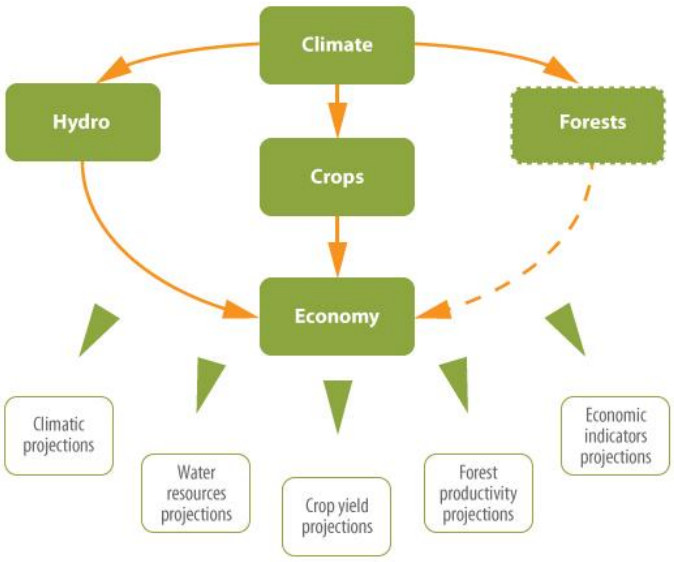

Figure 1. MOSAICC, interconnected models designed to facilitate the data flow from one to the other (Source: FAO, 2014[4])

The platform also proves to be of sufficient simplicity and scope to interest all the partners, and to be a common hands-on support to reinforce existing, and develop new, skills. The capacity development and stakeholders' participation are an integral part of the process, as the trained national scientists ultimately are the ones producing the evidence, using their country's own data

[3] www.fao.org/in-action/mosaicc/en/

[4] http://www.fao.org/climatechange/mosaicc/66705/en

and running the impact models in order to produce information responding to the nation level stakeholders' needs.

Results

The approach has been, and continues to be, implemented in various developing counties such as Morocco, Peru, Philippines, Paraguay, Indonesia, Uruguay, Malawi and Zambia. We briefly refer here to the key processes and lessons from recent Malawi and Zambia cases. Each country holds the MOSAICC platform on national servers maintained by local experts - meteorological Services in both countries. The platform is accessible through a web interface and allows the various modules to access the different data sets to build interdisciplinary simulation experiments (e.g. climate, crop). By explaining below the full process of an integrated assessment, we want to particularly highlight the robustness of this approach toward producing the information responding to independent needs of the countries.

- **Climate** – Using the available weather station records in the country and getting support from international experts, the national climate experts do the quality control of climate data and perform the statistical downscaling for at least two Representative Concentration Pathways (RCPs) and three Global Climate Models (GCMs). This data is then uploaded and consequently made available to all modules in the platform.
- **Crop** – Various crop growing characteristics can be calibrated following the simple concept of crop coefficients (Allen et al., 1998). Climate, crop coefficients and soils (FAO global soil database) are used in the WABAL model to simulate crop related water balance (Gommes, 1999). The users also set the planting date (including rain-based planting rule) and growing length. Zambia simulated seven crops and Malawi simulated six, allowing for sufficient crop representation.
- **Climate Change impact on agriculture** - With the yield projections of multiple crops, under multiple GCMs, under multiple RCPs, the teams can analyze the crop production changes in time through simple statistics (e.g. change in mean, compared to historical standard deviation). The data is spatially aggregated according to user preferred scales (e.g. provinces in Zambia, Agricultural Development Divisions in Malawi) so to be more relevant to policy makers.
- **Capacity Building** – Beyond the technical skills needed, each team member develops a dedicated understanding of, and collaborative skills with, connected disciplines. Despite external support for the initial training and follow up support, the climate change impact assessment is the exclusive product of the national expert teams, who become the understanding messengers of new and scale relevant evidences of climate change impact for agriculture, hence leading to a more efficient dissemination of actionable interdisciplinary information for adaptation planning in their country.
- **Connecting beyond** – Although different from one county to another, the result of the assessment produced by the national team is shared with national and regional stakeholders (e.g. international organisation, national government, NGOs), leveraged in background analysis of future projects, and takes a role in adaptation planning initiatives at country level (e.g. National Adaptation Plans).

Conclusion

Both Zambian[5] and Malawian[6] teams are in the process to record and disseminate their results. With various degrees of agreement due to spatial aggregation and future projections range, they could identify consistency in climate projections in specific areas, crops particularly sensitive (or non-sensitive) to this change, or areas particularly impacted independently of the crops considered for instance. The nation-wide information, directly related to policy relevant administrative boundaries, makes the dissemination relevant and provides a new basis for discussion, as well as improvement (e.g. new crops of relevance, irrigation option).

This in-country, simple, robust and modular nature of the platform makes it a useful and accessible tool for nation-wide, nation-relevant, collaborative and integrated assessment. This approach contributes to build more sustainable institutional capacities within countries, hence improving ownership, relevance and uptake of the assessment. It also enables national actors to periodically and independently revisit climate change information in response to new science and evidences. The local development and relevance of the evidence produced, more adequately supports the policy and practice changes effort at national levels, hence largely supporting FAO ambitions on that front.

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5 http://www.fao.org/in-action/mosaicc/on-the-ground/zambia/en/

6 http://www.fao.org/in-action/mosaicc/on-the-ground/malawi/en/

Can rural climate services meet context-specific needs, and still be scalable? Experience from Rwanda

James W. Hansen[1], Desire M. Kagabo[2], Gloriose Nsengiyumva[2]

Abstract

Investment in national climate services must address trade-offs between meeting context-specific farmer needs and providing cost-effective services at scale. In the context of an ongoing national-scale agricultural climate service initiative in Rwanda, we discuss approaches used to address five scaling challenges (capacity constraints of farmers, communication intermediaries, climate information providers, data gaps, and co-production with farmers) and the resulting lessons.

Keywords: *Climate services, Co-production, Scaling, Climate risk management, Agricultural extension, Rwanda*

Introduction

Efforts to develop agricultural climate services at a national scale face a trade-off between meeting the context-specific needs of farmers and providing cost-effective services at scale. The challenge posed by this research is viewed differently depending on whether one is looking from the supply side (*How can a National Meteorological Service (NMS) better meet framers' context-specific needs?*), or the demand side (*How can proven approaches for empowering farmers at a pilot scale be scaled nationally?*). In the context of the USAID-funded Rwanda Climate Services for Agriculture project, we discuss approaches and lessons from efforts to address five specific scaling challenges:

i) empower farmers to access, understand and act on climate information;
ii) scale up participatory processes through agricultural extension;
iii) increase NMS capacity to routinely provide tailored local information;
iv) fill gaps in historic meteorological data; and,
v) incorporate farmers' needs into co-produced services.

Methodology

Incorporating farmers' needs into co-produced services

Efforts to understand and incorporate farmers' needs into co-produced services started with a survey of >3000 farm households, implemented during the first project year (2016), designed to provide both insights about farmers' climate service needs and evaluation baseline data.

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Based on its features, the project adopted Participatory Integrated Climate Services for Agriculture (PICSA) as the primary approach for equipping farmers to understand and incorporate climate information into their planning. PICSA is a structured approach, developed by University of Reading, which combines the use of graphical representations of local climate information with participatory planning tools to support farmer decision-making around relevant options and risks (Dorward, et al., 2015). PICSA starts with an initial workshop where farmers evaluate their current farming and livelihood strategies in light of climate risk, with the aid of climate time-series graphs and participatory resource mapping and seasonal calendars, and analyse options for changing agricultural practices. Just before a growing season, facilitators introduce the downscaled seasonal forecast, review its interpretation, use it to update a table of crop/cultivar-specific risks developed earlier, and guide farmers to decide on any adjustments for the upcoming season.

PICSA is being integrated into Rwanda's *Twigire Muhinzi* agricultural extension service through training for extension professionals (district and sub-district Agronomists, local Socio-Economic Development Officers) and volunteer Farmer Promoters. As scaling out of PICSA accelerated, the number of intermediaries needing training quickly exceeded the project team's capacity. A training-of-trainers approach was implemented, providing advanced training to equip professionals to train and mentor sector-level staff and volunteer farmers. Four local NGOs were contracted in 2017 to facilitate intermediary training and implementation in farming communities in their respective provinces. Regular radio broadcasts of daily weather forecasts and new climate service programming (since 2017) complement the face-to-face PICSA communication.

The project adapted the IRI's ENACTS (Enhancing National Climate Services) approach (Dinku et al., 2017) to enhance Meteo-Rwanda's capacity to fill data gaps and provide tailored local information at scale. Data gaps were addressed by merging quality-controlled station records with satellite (for precipitation) and reanalysis (for temperature) data, resulting in long-term (>35 years for rainfall, >55 for temperature) gridded (~4km) complete daily datasets. A highly customizable software platform (Blumenthal et al., 2014) supports automated production of a range of derived historical analyses and downscaled seasonal forecasts, and their dissemination through online "Maprooms."

As a mechanism to sustain co-production of climate services by Meteo-Rwanda, and line ministries and agencies that represent climate-sensitive sectors (agriculture, water, health, disaster risk reduction) at a national scale, the project in 2017 partnered with the World Meteorological Organisation (WMO) to initiate development of a National Framework for Climate Services, under the UN Global Framework for Climate Services (GFCS).

Findings

Incorporating farmers' needs into co-produced services

Although the project baseline survey included questions on farmers' climate service needs, responses focused on existing generalised products and provided little insight to prioritise new or improved products or communication channels. Usefulness was constrained by farmers' limited capacity to articulate demand for potentially useful products or services that they have not yet been exposed to. As an alternative, the research is exploring an iterative co-design process that incorporates farmer's evolving understanding of needs and gaps into an annual planning

process. A Steering Committee, tasked with developing a national climate services governance framework, has been identified as an entry point for piloting such an iterative process.

Empowering farmers' context-specific risk management decisions

Participatory processes that facilitate interaction between farmers, researchers and information providers have proven effective at enabling farmers to understand and use local climate information. Although the structure of the PICSA process is consistent as it is being implemented across the country, its participatory nature provides flexibility to support farmers' context-specific communication needs and decisions. An assessment during the first implementation season, based on a survey of a random sample of 8% of the 2631 participating farers, confirmed the effectiveness of PICSA (Clarkson et al., 2017). Most participants changed management practice in response to the climate information and training (93%); perceived improvements in their confidence and their household food security and income; and shared information with an average of 13 peers.

Scaling up participatory processes

As of April 2018, two-thirds through the project, 1018 government staff and volunteer Farmer Promoters were trained, and in-turn trained and facilitated more than 75,000 farmers in the PICSA process. While this demonstrates the feasibility of scaling rural climate services through participatory processes, the process has been resource-intensive and perhaps slower than needed to reach a critical mass by the project end (December 2019). Opportunities to accelerate process include developing video and e-learning training materials for extension personnel and farmers, and using ICT-equipped local government offices as climate service resource hubs. Sustainability also depends on policy-level adoption of climate services into agricultural extension mandate, funding and training.

National Meteorological Service (NMS) capacity to provide tailored local information and fill data gaps

Effective early participatory work with African farmers on climate services, and the initial development of PICSA, incorporated information products derived through custom analysis of local historical daily station records. However, this intensive approach to producing tailored local climate information cannot be scaled out to locations without long-term station data, or scaled up by a resource-constrained NMS to locations across a country. Meteo-Rwanda faces similar resource challenges as other African NMS, and also faces a more than 10-year data gap from breakdown of its observing system during the 1994 Rwanda Genocide. The development of high-resolution, merged, historic, gridded precipitation and temperature datasets helped overcome gaps in historic records. The greater amount of station observations used (average of 99 stations/year vs. ≤ 20 for CHIRPS and ≤14 for ARC) since restoration of the observing network following the Genocide, evidence that the amount of station data incorporated largely determines the quality of a merged product (Dinku et al., 2014, 2018), and higher apparent skill of seasonal rainfall forecasts based on national data relative to forecasts based on other products (CHIRPS, ARC)[3], suggest that Meteo-Rwanda's datasets are of higher quality than the best global

[3] Presented in a CCAFS Blog: https://ccafs.cgiar.org/blog/local-beats-global-when-it-comes-national-climate-services-rwanda#.W2SE4y2ZMhA

products. Meteo-Rwanda now provides a rich suite of historical (i.e., frequency of rain days, dry/wet spells; season onset, cessation, duration, dynamic season total) and downscaled seasonal rainfall forecast (issued late August for September-December) products, derived from the gridded datasets, made available as maps or location-specific analyses for any administrative unit or 4-km grid cell. The degree of automation has enabled Meteo-Rwanda to routinely provide locally relevant climate analyses and forecasts at a national scale without over-taxing its human resources. Ongoing enhancements allow the Maprooms to serve as a portal for extension personnel to download all formatted PICSA graphs for their selected location.

Conclusion

Our efforts to strengthen rural climate services at scale in Rwanda suggest six lessons. First, recognise that some trade-offs between tailoring and scaling are inevitable and require compromises that manage those trade-offs. Second, participatory communication processes foster relevance by supporting farmer decision-making around options and risks that are important from their perspective. Third, scaling participatory communication process depends on the presence and buy-in of effective agricultural extension or other intermediary institutions. Fourth, gaps in historic climate records prevent provision of locally relevant information nationally, but good approaches are available to fill data gaps. Fifth, through advanced tools such as those employed in ENACTS, NMS can automate generation of a range of tailored products from their data without overtaxing their human resources. Finally, iterative processes that formally incorporate farmers' evolving understanding of their diverse needs into co-production of services are likely to be more effective than designing services around a one-time needs assessment survey.

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Local coping strategies for climate change around two Marine Protected Areas (MPAs) in Zanzibar

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Abstract

The adverse impacts of climate change threaten on-going development efforts, particularly in Small Island Developing States (SIDS). These impacts have already affected not only the national economic development but also local communities' livelihoods. This research investigates two selected Marine Protected Areas (MPAs) in Zanzibar, Tanzania, in order to discover local coping activities undertaken by communities when impacted by climate change. The collected datasets were analysed and interpreted; finding that local communities acknowledged that Jozani-Chwaka Bay Biosphere Reserve (JCBBR) and Ngezi Nature Reserve (NNR) complexes are exposed to the impacts of climate change, which have increased. Despite agriculture being a vulnerable sector to the impacts of climate change in Tanzania, local communities in the JCBBR and NNR prioritise innovative farming systems as the main alternative basic livelihood and coping strategy. Results also show that there is a discrepancy in the way men and women implement coping strategies.

Keywords: *Marine Protected Areas (MPAs), Livelihoods, Gender, Tanzania*

Introduction

According to the Intergovernmental Panel on Climate Change (IPCC) report (2014), some low-lying developing countries and Small Island Developing States (SIDS) are expected to face very high climate change impacts that could have associated damage and adaptation costs of several percentage points of gross domestic product (GDP). The adverse impacts of climate change threaten on-going development efforts in these countries, particularly in SIDS - which require climate change adaptation to enhance its developing economies - and are low-lying, thus vulnerable to climate-related impacts such as sea level rise and more extreme weather events (RGZ, 2012). In Zanzibar, extreme droughts and changing of precipitation patterns pose serious threats to the coastal environment which is the main source of local livelihoods (Hassan *et al.* 2014). These impacts have already affected not only national economic development but also local communities' livelihoods, such as tourism, agriculture, and small and large-scale fishing. Due to such impacts, indigenous people have developed coping strategies to survive with extreme variations of weather and climate. Despite significant adaptation initiatives currently undertaken in Zanzibar, no detailed information on local coping strategies adopted by different communities to protect against the climate change crisis around protected areas is being reported. The main objective of this study is to discover the impacts of climate change and what the related coping strategies adapted by local communities in Zanzibar are, particularly around two selected Marine Protected Areas (MPAs), Jozani Chwaka Bay Biosphere Reserve (JCBBR) and Ngezi Nature

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Reserves (NNR) complex. Specifically, the study focused on identification of impacts of climate change crisis surrounding the two selected MPAs, studying the local coping strategies adopted by the local communities surrounding the selected MPAs, and providing recommendations for the most beneficial local coping strategies that can possibly be applied to other similar locations.

Methodology

The investigation was undertaken at two selected MPAs; JCBBR, located about 35 kilometers from Darajani (Zanzibar town), and NNR, found approximately 25 km from Wete town in Pemba. The major livelihood activities of the local communities in the study areas are agricultural, petty trade and fishing. A desktop review of government reports and other literature relevant to the assignment was performed. Field data was collected by interviewing 80 respondents living within and around the two selected MPAs. To determine what local coping strategies to climate change impacts are exercised in the study areas, structured and semi-structured questionnaires were used. The collected datasets were analysed using Statistical Package for Social Sciences software. Statistics (averages and median), descriptive approach, paradigm interpretation, graphs, charts, tables and pictorial analysis was done and results discussed.

Findings

There are different perceptions on the impact of climate change on coastal environments. Impacts of climate changes and variability leads to changes in tidal waves, severe beach erosion, changes of coral reef conditions and bleaching, and inundation and displacement of wetlands and low-lying coastal zones in both JCBBR and NNR MPAs. About 40% of the respondents suggested that sea level rise is found to be major climatic factor that leads to multiple impacts on local people's livelihoods.

Image 1. The abandoned board walks at Jozani Chwaka bay complex due to sea level rise (Source: Authors own 2018).

For example, sea level rise resulted in intense coastal erosion, and inundation and displacement of wetlands and low-lying coastal zones. In NNR, sea level rise led to flooding of an important fresh water well that has caused the community dependent on it to abandon their traditional wells due to the fact that the area has been changed to beach. Thus, to fetch such water, they have to

wait for the ebb tides when the water recedes. On the other hand, at JCBBR sea level rise has affected community access and tourist visits to the mangrove boardwalks at Jozani, used by local and international tourists to visit the mangroves ecosystem and bird watch, which contributes to major economic activity, and which has subsequently been abandoned (**Image 1**). Research found that sea level rise caused the old fish market at Msuka (around NNR Pemba) to sink, thus local people have established a new fish market toward the seashore (**Image 2**).

Image 2: Shifting of fish market due to the damage caused by sea level rise (Source: Authors own)

In addition, increasing temperatures have been affecting sea grasses, coral reefs and other fishing grounds, with the result that local people leave their customary fishing grounds and go to fish in the nearby MPAs - or the deep sea for those with larger boats and better equipment. It was found that fishermen leave fishing activities and turn to agricultural or any other affordable, safe livelihood activities that are seen to be less vulnerable to climate change.

Despite agriculture being one of the more vulnerable sectors to the impacts of climate change in Tanzania, local communities in the JCBBR and NNR are turning to the agricultural sector as the main alternative basic livelihood and coping strategy due to such changes (**Table 1**). They use innovative farming as a coping strategy in responding to the impacts of climate change, either through the diversification of income-generating activities (including on and off-farm activities) (60%), or the use of improved crop varieties (drought resistant and short growing varieties (14%) and mixed cropping (8%).

Table 1: Proportion of different coping strategies used by community members to respond to the existing impacts of climate change variability (Source: Authors own, 2018)

No.	Coping strategies	JCBBR %	NNR %	Total %
1	Diversification of income-generating activities - on and off-farm activities	33	27	60
2	Improved crop varieties (drought resistant and short growing varieties)	8	6	14

3	Mixed cropping and crop diversification	5	3	8
4	Engagement in deep sea economic activities	1	7	8
5	Local irrigation systems	1	4	5
6	Engage in saving and credit schemes	2	0	2
7	Timing of growing season to cope with changing weather patterns	0	3	3

However, these farming interventions are known to draw much underground (aquifer) water for irrigation and use many chemicals to improve production, thus exacerbating environmental degradation in the water system. It is therefore important that every coping strategy or intervention must be screened before application.

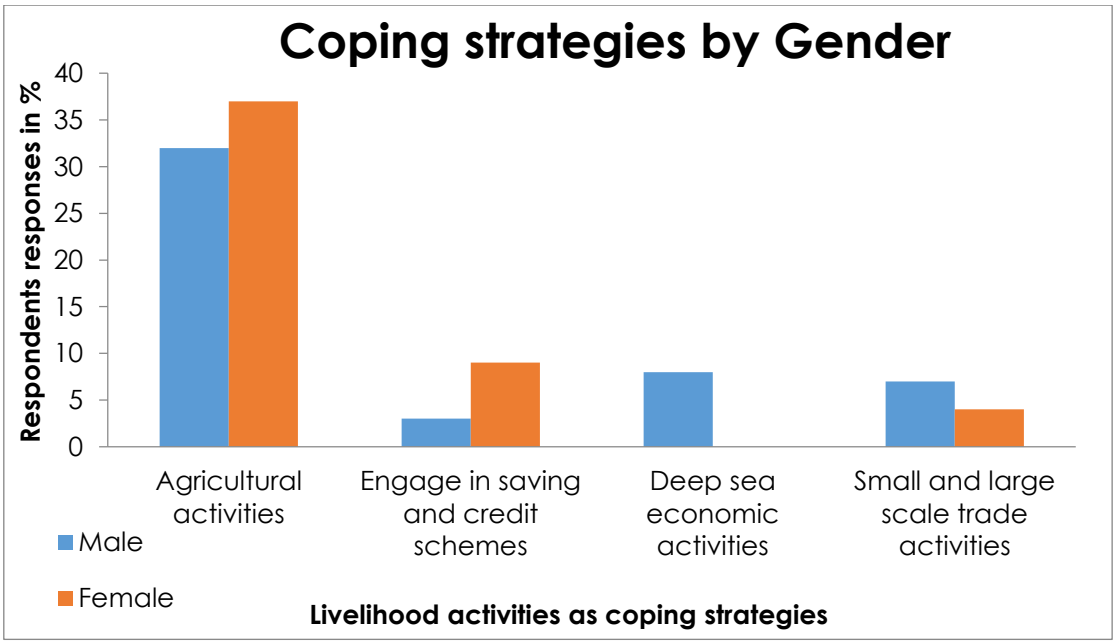

Figure 1. Coping strategies used to respond to the existing impacts of climate change by Gender (Source: Authors own 2018)

When examining the results from the survey in terms of gender, coping strategies used were differentiated by gender. Findings were that females (37%) overall lead males (32%) in using farming activities as coping strategies (**Figure 1**), and females also lead in engaging in saving and credit schemes as their main coping strategies (9%) as opposed to men (3%).

Conclusion

The local communities acknowledged that JCBBR and NNR complexes are under increased exposure and threat to the impacts of climate change, while the communities themselves are becoming more vulnerable to the impacts of climate change due to loss of incomes from abandoned traditional economic activities, such as small-scale fishing. This research provides preliminary information on the impacts of climate change on MPAs, and local adaptation measures relying primarily on innovative farming techniques. Despite the perception of respondents that coping activities do not differ between men and women, results show that

identified coping mechanisms of local communities are gender sensitive. Such a finding is significant, and should be integrated during policy preparation for local adaptation strategies; however, the result may differ significantly in other social-cultural settings. This work also provides a platform for learning experiences and scaling-up on appropriate adaptation strategies implemented by local communities, especially in locations of similar developmental needs and climatic impacts

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City-scan Rotterdam: a method to assess climate change vulnerabilities at street and neighborhood level

Rick Heikoop[1], **Floris Boogaard** [2,3,4]

Abstract

The international City-scan is a new method used to assess vulnerabilities at street and neighborhood level and create awareness about climate change adaptation. Adaptation measures to address the negative effects of climate change has to take place in our cities, our neighborhoods, our streets and even in our homes. Local authorities would like to have better insight into the level of exposure to climate change, the vulnerabilities at street level and the progress of climate adaptation measures, in a specific street or neighborhood. The City-scan method defines a set of measurement parameters that are relevant to a specific locality, which could, for example, determine if a street is climate proof. During a city climate scan, the current state of climate adaptation in a street and city and its vulnerabilities are assessed and the adaptation ambitions for the coming years are formulated.

Keywords: *City-scan, City climate scan, Rotterdam, Resilient, Plastic*

Introduction

The majority of the world's population is living in cities and urban areas. Persistent urban issues and emerging challenges due to increased urban populations include urban growth, increased residency in slums and informal settlements, increasing pressure on service delivery, such as water and sanitation, and climate change (United Nations Human Settlements Programme (UN-Habitat), 2016). As of 2018, 55% of the world population is urban, compared to 30% in 1950 (ABC news, 2018). In 2050, 68% of the world's population is projected to be urban. Experts of insurance company Munich Re have researched and documented 36 000 single loss events during the last 40 years worldwide in urban and rural areas. The rise in the number of natural catastrophes is predominantly attributable to weather-related events, like storms and floods (Hoeppe, 2016). Concentrations of urban population in cities make these cities and their citizens more vulnerable to the negative impacts of climate change. In addition to this cities are also increasingly vulnerable for heat stress and draught because of rising temperatures in our cities. The month of June 2018 was among the ten driest and hottest months ever recorded since 1906 in The Netherlands by Royal Netherlands Meteorological Institute (Royal Netherlands Meteorological Institute, 2018). Drought and heat make cities unpleasant to live in as cities increasingly becoming

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concrete jungles, becoming urban heat islands, where heat is captured - making it uncomfortable and even dangerous for its residents. The heat is trapped in the city at night, and vulnerable groups like babies, infants and the elderly are susceptible to heat-related health impacts (Sahadat, 2018).

Another major challenge is urban vulnerability to floods (Wu & Chiang, 2018; Runhaar et al., 2011), which is a serious threat in Rotterdam, where most of the city's territory is located below sea level. Extreme rainfall and sea level rise due to climate change may increase the risk of flooding and may threaten lives and property (Wu & Chiang, 2018). Chen identified the adaptation options and a list of urban adaptation assessment indicators for the primary urban hazards; flooding, heat wave and drought (Chen et al., 2016).

Local governments own just part of the land and can only partially decide about measures that should be taken 'on the ground' (Pieneman, 2018). Local governments are therefore highly dependent on individuals, communities and businesses to adapt, transform and to take action in their own garden, street or district (Wamsler & Raggers, 2018). Cities and their residents often do not know if a city or street is 'resilient', or 'climate proof' or what actions they could take at the local level. The aim of the City-scan method is to create awareness, connect practitioners, and generate data for policy makers and adaptation practitioners.

Methodology

The City-scan method was developed by Rotterdam University of Applied Sciences to gather essential data on primary urban hazards; flooding, heat waves, drought and pollution. The data is collected by young professionals and practitioners that helps them to assess the level of resilience of a specific neighborhood or city in a short period of time (1-2 weeks). The City-scan method is a combination of different data collection methods that together give a better insight in the degree of resilience in a street. In this article the following parameters are discussed:

Infiltration capacity

Infiltration capacity can be measured with an infiltrometer. The meter consists of two rings of metal or plastic. These rings should be placed at a location that is representative of the infiltration capacity of the (paved) soil. The bottom rim of the rings needs to be impermeable to prevent leakage. In unpaved areas this can be achieved by pressing the rings into the soil. In paved areas this can be done by using clay. The infiltration capacity of the surface in a number of streets in Rotterdam was measured using the infiltrometer. The different infiltration rates on different locations with different street surfaces gave policy makers and communities insight in the overall infiltration capacity of a street. This is valuable information which helps to decide if the infiltration capacity is sufficient to accommodate a certain amount of rainfall during an extreme rain event. The infiltration capacity can also indicate if measures should be taken at the street level to increase infiltration capacity or rainwater collection.

Heat stress

Heat stress was measured using heat cameras and infrared cameras. Temperature at different heights and at different locations was measured at set distances. The surface temperature of different horizontal and vertical surfaces was measured. The aim was to identify relationships between surface temperature and air temperature on local scale. Secondly, the measure aimed

to identify relations between surface material and surface temperature. Stone facades, green facades, lawns, streets and railroad tracks were examined (Heikoop, Boogaard, Sandt, & Oudendammer, 2017). The temperature measurements at different locations in a street gives an indication if the temperature in a street is acceptable to the users and the community (**Figure 1**), and could indicate if actions should be taken at the street level to create a (natural) cooling with vegetation, trees, shadow, open water or other adaptive action.

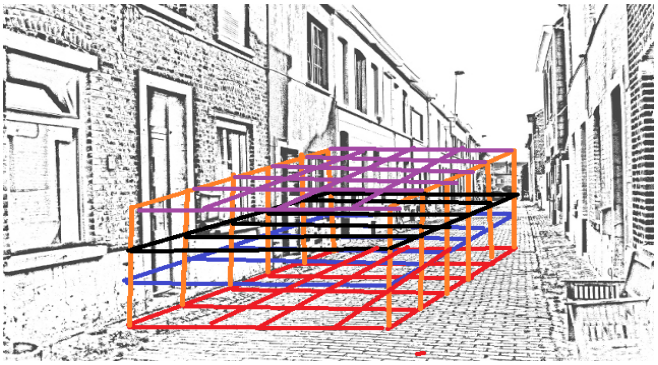


Figure 1. Example of experimental street temperature grid (Heikoop, Boogaard, Sandt, & Oudendammer, 2017)

Micro pollution, water quality strips

The micro pollution was measured using the Akvo Caddisfly water quality strips, using different parameters that can be measured with the Akvo test strips (**Table 1**). Samples of the water quality in different canals in Rotterdam were taken and the quality was tested on the spot using the Akvo app on smartphones. All the results were geo-located on a Climate Scan open source map (see **Figure 2** for the different transects), and more results can be uploaded - accessible to anyone with the Climate Scan application. At this City-scan, and for the purposes of this research, we focused on test strips nitrate and phosphate (N, P) and sensors for electrical conductivity and temperature.

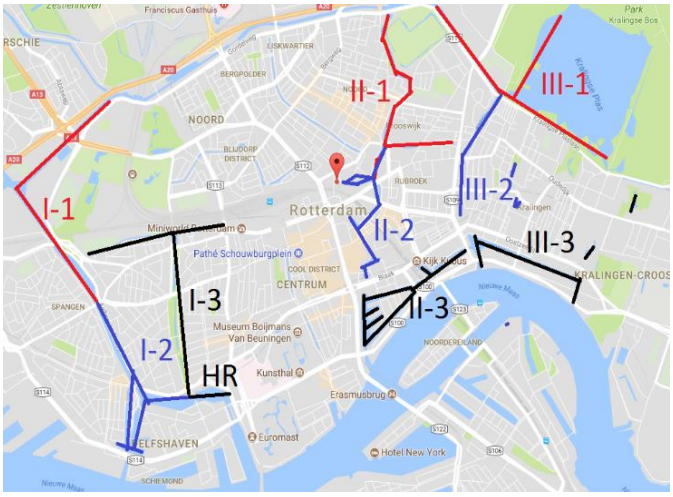


Figure 4. Transects for different water quality measurements of different canals in Rotterdam (Source: Heikoop, Boogaard, Sandt, & Oudendammer, 2017)

	Colorimetry	Test Strips	Tester	Sensors
Alkalinity	•	•		
Aluminium	•			
Ammonia	•	•		
Arsenic		•		
Chloride	•	•		
Chlorine	•		•	
Chromium	•			
COD	•			
Electrical conductivity				•
E. coli				
Fluoride	•			
Hardness	•	•		
Iron	•	•		
Nitrate	•	•		
Nitrite	•	•		
pH	•		•	•
Phosphate	•	•		
Potassium	•	•		
Sulphate	•			
Suspended solids	•			
Temperature				•
Turbidity	•			

Table 1. possible parameters for indication of water quality (Source: Akvo, 2018)

Macro pollution and plastic pollution

Plastic pollution in the world's oceans and seas is under growing attention and the full impact of plastics on the environment is only recently being studied. It is, however, known that much of this plastic pollution comes from urban areas, where disposed plastics are discharged through rivers and streams to finally end up in the oceans (Jambeck et al., 2015). How much plastic is actually discharged through rivers is debatable, because uniform monitoring data is lacking. The discharge can be measured by surface measurements (visual camera registration of floating items), river body monitoring (actual sampling in the water column using nets and filtration systems), and riverbank monitoring (monitoring of plastic litter deposited on river banks) (Gonzalez, et al., 2016). Since there is a strong variation in river morphology and amount of plastic discharged between rivers as well as within a river basin, a standardised method is needed to be able to validate recorded data on plastic riverine litter. For marine litter, the OSPAR beach monitoring method is long-standing (OSPAR commission, 2010). An adapted OSPAR methodology for rivers has been developed by Rotterdam University to be able to compare marine and riverine results. Three measuring methods were used.

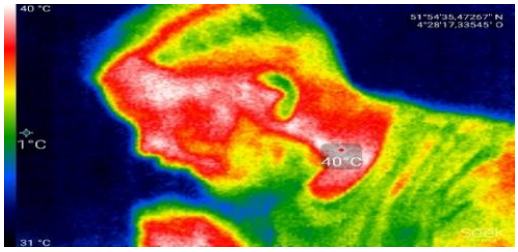
- Standard OSPAR riverbank monitoring
  For the length of a 50m transect parallel to the waterline all items found on the riverbank, using the OSPAR monitoring form, were registered. This was done for all visible litter while standing, up to 5m from the waterline.
- Randomised OSPAR riverbank monitoring
  For the length of 50m transect parallel to the waterline, all items visible when standing were measured within a 1m x 1m quadrat at 10 random locations. 10 quadrant locations every 5m along the transect were selected by throwing a dice, with the numbers on the dice corresponding to the relative distance to the waterline.
- High water level mark monitoring
  At 5 randomly picked spots along the high water level mark, samples were taken in a 50 x 50cm grid. Five unique random distances between 0 – 50m were generated by using www.randomiser.org. At these spots, all non-organic material was collected and categorised using the OSPAR form.

Results

Table 2 shows some of the City-scan methods that were used during the City-scan Rotterdam event and the results it generated. The city of Rotterdam was the host organisation of the event and was involved in the programming of the event and the locations where measurement took place. For the city of Rotterdam, more data is needed in general at street level and local level on infiltration capacity, heat stress, pollution levels, and plastic waste so that the city can undertake specific interventions to address these problems. The results were used in discussions and evaluations with the city of Rotterdam. Water quality mapping with free apps, such as Agpo Water quality app, gave detailed insight into the water quality in canals and water bodies at street or neighborhood level. Urban heat measurements at the street level provided insight into how heat differs in different neighborhoods and streets. Plastic waste measurements at riverbanks can now be systematically analyzed and the data will give insight and awareness on the contribution of plastic waste pollution in (urban) river systems. Infiltration capacity of open spaces and street surfaces and the contribution of infiltration capacity to reduce floods is not known in

detail, but the City-scan in Rotterdam with the infiltrometer clearly showed that open spaces have 3 to 6 times higher infiltration capacity than the paved surfaces in urban areas. More than 25 BMPs in climate adaptation are mapped on the open source web-based international knowledge exchange tool, Climate Scan.

Table 2: Challenges, approach and results City-scan Rotterdam 2017 (Source: Boogaard, et al., 2018)

Challenge	Monitoring method	Results
1. Flood risk 	• The infiltration capacity of different urban soils and surfaces is measured and bottlenecks are mapped using the infiltrometer.	• Measuring infiltration capacity. • Map with measurements and results are presented at www.climatescan.nl,
2. Heat stress 	• Dynamic and static measurements of the temperature of different urban surfaces using heat cameras and infrared cameras.	• Map that depicts temperature differences in the city and shows the temperature differences between urban areas and blue and green areas in the city.
3. Urban water quality, micro pollution 	• With apps and test strips and using underwater drones with cameras and sensors, the micro pollution is measured.	• Maps with the results of test strips of the water samples and results of the nutrient measurements. • 3-D scans of water quality and continuous sensor measurements, indicating the location and sources of pollution
4. Urban water quality macro-pollution 	• 'Quadrant method' which identifies the composition of the plastic pollution and sources of the pollution in water bodies and along river beds.	• Detailed insight in the plastic pollution per m2. • Detailed method that can help to create awareness and generate concrete data that can be compared to the pollution of rivers and water bodies worldwide.

Conclusions

The City-scan method is still in the process of being developed, but the preliminary results show that the tool gathers valuable multidisciplinary data at street- and neighborhood level, that gives new insights into the level of resilience at this level. It provides data that is currently not collected at all (such as infiltration), or on an irregular basis (plastic pollution), and on data of different variables that are not generally combined in this way. The analysis of these results shows that it could eventually lead to a resilience index at street level. The City-scan method is the first steps towards creating a toolbox of different measurement tools that are free or low-cost and of low-technology, and can be applied in cities around the world in a rapid appraisal. The results of the City-scan method gives better insights on infiltration capacity, pollution, plastic waste, heat stress and can help to creates awareness at community level, and gives valuable data and insights for policy makers.

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Adaptation finance ecosystem in The Netherlands

Bituen Hidalgo[5]

Abstract

This paper presents the adaptation finance ecosystem in The Netherlands, known to be active in climate action. The data used for this study is available online. The adaptation actions over the past two years were mostly undertaken by non-financial companies using the companies' own funds. Most of the adaptation actions used a project approach, which involved several stakeholders each with their own roles and bound by agreements.

Keywords: *The Netherlands, Climate action, Adaptation finance, Project finance*

Introduction

Over the past years, efforts have been made on establishing how to support climate change mitigation and adaptation using financial support from multilateral sources and grantors. This research aimed to explore the ways with which adaptation actions were realised and concretised in The Netherlands.

Methodology

This research is done using online, free and publicly available sources, chosen in order to replicate the information accessible to those with no access to expensive information sources. Included in the data gathering are economic entities operating in The Netherlands, projects or companies being funded from The Netherlands, and investment funds owned by Dutch companies and/or operated by Dutch entities. The data was gathered in August 2017. Adaptation actions, deals and transactions considered in this research were active in 2016 and 2017. The adaptation actions considered are the ones mentioned in the United Nations Environment Programme Adaptation Gap Report (2016). Data gathering involved looking at company annual reports. The published reports of the six largest financial institutions in The Netherlands and the largest Dutch pension funds were analysed first, with the expectation that financial companies would be involved in financing adaptation actions. Due to the lack of information on adaptation finance activities of these banks and pension funds, the data gathering was extended to companies which are part of the index of the Amsterdam Stock Exchange. In addition to the annual reports, also included in the data gathering were the latest news reports on, and the reported high-profile climate adaptation actions in The Netherlands. Data was collected on the finance sources, who the recipients of the financings are, what climate action was financed and how the projects were structured.

Findings

The data sources yielded 27 transactions that qualify as adaptation actions, which are activities related to "process of adjustment to actual or expected climate and its effects", based on the

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definition used by the Intergovernmental Panel on Climate Change (IPCC) in its report 'Climate Change 2014: Synthesis Report.

Adaptation financing for the selected transactions was undertaken in the form of bond, debt, equity and grants structures. Corporations had capital expenditures and operating expenses to adapt their operations. Data used by the corporations and possible adaptation solutions were from the consultancy firms. To build the infrastructure needed, EPC (engineering, procurement and construction) contractors were hired. The purpose of the funding was varied, with a focus on water and coastal management efforts. A number of adaptation actions involved financing of Research and Development, and innovations.

The Adaptation Finance ecosystem in The Netherlands is made up of parties from different industries with different focus and products, as follows:

i) Financing sources: National Government, Local Governments, Commercial Banks, the Netherlands Development Finance Company, named FMO, and Investors (Venture and Angel Investors);
ii) Corporations as grantors and capex/opex parties, and financing users;
iii) the innovators or the "builders of the solutions" companies and research institutions (universities); and
iv) the data providers, such as Consultancies.

National and Local Governments: are active in two ways - by mandating financial institutions to manage climate finance funds, and to act as sponsors for construction projects.
Investment Managers: No data was found on their investment holdings in green bonds and there are no funds invested solely on adaptation activities.
Development Bank: Of the Dutch financial institutions, only the Netherlands Development Finance Company has made public its investment holdings in climate finance. It invests in adaptation through its investment fund and directly in the companies in the form of loans and grants. As of December 2016, adaptation finance in its Sustainable Bond fund represented only 3% of the total amount.
Commercial Banks: The only public information available for an adaptation finance transaction is that of Anglian Water Company, where Dutch bank ING arranged an 8-year Green Bond. Other Dutch banks have also issued green bonds but no information on which companies or projects are included in these bonds was found.
Investors: While there were very few investments of this nature, the common factor was that the start-up/scale-up companies involved in adaptation action were initially funded by grants from the European Union via its grants to Small and Medium Enterprises, and from Dutch local governments via their innovation funds. Next round financings were with venture capital and angel investors. These start-ups and scale-ups have products already available in the market and are revenue generating.
Corporations: Non-financial corporations are likewise active in adaptation finance, through using financing from their own cashflows: (1) as a grantor for projects, and (2) spending in capex and opex to adapt their own operations to climate change.
Adaptation Consultancy Firms: With their expertise and available data, corporations use the services of these consultancies in order to decide on their climate action.

Receivers of the financing: the innovators and builders of the adaptation solutions, there was often mention of the "*Triple Helix Model of Innovation*" in various investors' events in The Netherlands - Engineering, Procurement, Construction Service providers, and other "triple helix" parties. This is the policy of encouraging interaction between the universities, government and industry to promote innovation, which is very much needed in tackling the climate adaptation problem.

Specific adaptation actions financed during 2016 and 2017 included:

- Biodiversity, ecosystem service, ocean clean-up, reef 3D printing
- Waste management (recycling, reduction)
- Water management (drought, resilience, water recycling, watershed, water supply)
- Coastal development (flood management, "sand engine" for coastline reinforcement)
- Agriculture (climate smart soil, agri micro-insurance, alternative food)
- Research & Development for climate action
- Snow harvesting

Discussion

The transactions in The Netherlands were not the usual or simple grantor-grantee arrangement. It may be because the Dutch approach to building objects or assets requires transparency and accountability, which could be easier monitored if there are actions and outputs that are specified before starting any activity. The adaptation finance activities observed often involved several parties, not just a grantor and grantee, and that part of the motivation to undertake the activities is driven by economic reasons and mitigation of business risks. As such, corporate investment, and not simply issuing a grant, would be encouraged by having these two elements included in planning for adaptation activities.

Additionally, the intertwined nature of the Dutch adaptation finance ecosystem, where financing involved projects with many parties, required the extension of the research to include non-finance corporations. A probable reason for the "inter-connectedness" of the transactions is that the "project approach" is common practice in The Netherlands since the 13th century, when dikes were built and land was reclaimed so communities in low-lying areas would not be flooded by rising water levels. This required the cooperation of different parties. The project approach to the adaptation actions may have helped in making these possible and successful. Based on recent reports, the projects included in this study, in general taking at least five years for implementation, have been delivered on time and on budget.

The adaptation actions done by corporations are mainly to mitigate the adverse impact of climate change on revenue streams and operational risks. Possible implications of this are (1) that areas where these corporations are present stand to benefit from adaptation actions from the corporations and (2) that areas where the corporations have no such link, such as economically remote areas, will not be considered for adaptation actions. Economically remote areas such as low-lying coastal villages and small islands stand a lot to gain if these also receive support for their adaptation actions.

Conclusion

To improve monitoring adaptation finance, the following is recommended:

i) Focus should be given to the adaptation finance ecosystem and not only on the financial institutions
ii) Adaptation finance policy makers should make data more available, easily accessible and cheaper
iii) To entice investors, the regulators and rating agencies should add a "climate action" indicator in their reports, and
iv) For Sustainability Reporting, the rating agencies can require information on how much the investments are in adaptation projects and whether these are in Annex I or Non-Annex I country.

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The reality and rhetoric of integrating climate change adaptation into economic sectors in Zimbabwe

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Abstract

The impacts of climate change have become more frequent and severe in the last three decades. As emissions rise and the earth warms, the rhetoric on climate change is increasing. Transforming the rhetoric of climate change integration into realities around food, water and energy security is indispensable to enhancing communities' climate resilience. Using the institutional analysis and development (IAD)framework, this paper analyses the challenges and opportunities in enhancing climate resilience in Zimbabwe. To this end, the study shows that conceptual, institutional and sectoral silos reduce the creation of holistic policy and programme implementation in Zimbabwe. This paper concludes by recommending a resilience framework that can be used for integrating climate resilience into sectors by means of integrated systems thinking.

Key words: *Climate resilience, Integration, Institutional, Zimbabwe*

Introduction

Zimbabwe mostly consists of semi-arid land with a highly variable climate. The predicted increase in temperature and evaporation, the increase in rainfall variability and the increased frequency of floods and droughts will further exacerbate the existing challenges that are already being faced by Zimbabwe as a developing country (David &Hirji, 2014). Consequently, it is recognised as one of the most vulnerable countries to climate change (MEWC, 2017). Extracts from the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014) indicate that the impacts of climate change are projected to impede economic growth and efforts to reduce poverty. These impacts will have a widespread effect on socio-economic development, affecting the climate sensitive sectors such as water, agriculture, energy, health and environment (Browns et al, 2012). The increased frequency of droughts and floods has already affected food security (World Bank, 2018). It is therefore crucial to enhance climate action towards building the resilience of communities.

The concept of building climate resilience has emerged as a plausible pillar among humanitarian/development actors and Government entities as a longer-term and more efficient strategy for substantially promoting sustainable development at national or local levels. Whilst there are mixed views and concepts in understanding resilience, with some circles saying it is too

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broad a term or it has been over-used, there remains some common understanding that the enhanced capacity to withstand climate change impacts can ultimately lead to resilient communities (Manyena, 2009). Strong governance systems play a vital role in supporting resilience building (Zhakata, Jakarasi & Moyo, 2016).

Climate change adaptation can be protective in nature (proactive) or opportunistic(reactive), but with early adoption of well-planned adaptation strategies, both money and lives can be saved (GoZ, 2006; UNDP, 2015). Resilience analysis focuses on the capacity of individuals or systems being able to survive during an adverse situation or recover from such an event (Schipper and Langston, 2015). Resilience can be incremental, transformational, spontaneous or autonomous (IPPC, 2014). Climate change adaptation and resilience building have been discussed in five capacities - preventive, anticipative, absorptive, adaptive and transformative (Manyena, 2009) - which are important in dealing with climate shocks and disasters. Adaptive and transformative capacities allow to communities to cope and bounce forward after facing climate disasters (ibid).

This paper seeks to critically analyse the extent to which conceptual framing of climate resilience perpetuates a) institutional and sectoral silos, and (b)policy and programme implementation discord in enhancing climate resilience in Zimbabwe.

Methodology

This paper uses the institutional analysis and development (IAD) conceptual framework to analyse Zimbabwe's governance systems (Ostrom, 2004). This includes the review of existing policies, institutions and linkages which expose the rhetoric and realities that Zimbabwe uses to enhance climate resilience. Interviews were also conducted with key informants from the government and non-government sectors.30 key informant interviews were held with officials from the Ministries Agriculture, Mechanisation and Irrigation Development, Environment, Water and Climate, Transport and Infrastructure Development, Environmental Management Agency and Non-state Actors such as the United Nations Development Programme, World Bank, Infrastructure Development Bank of Zimbabwe, Environment Africa and World Wide Fund among others. 22 multi-level focus group discussions (FGDs)with sectoral and mixed participants were also held with stakeholders from government, civil society, academia, private sector and communities to discuss possible structures, linkages and enablers for building climate resilience. Nine FGDs were held at provincial and district level, eight FDGs were held at ward level and five FDGs were sectoral with at least 450 participants contributing to the process of consultations. One National Workshop was held in Harare with all stakeholders from different sectors and multi-level governance structures.

Findings

In Zimbabwe, incorporating climate resilience in various sectors has been hindered by a lack of integration. Firstly, the research showed that there are conceptual differences in the way terms such as 'adaptation' and 'resilience' are framed by different sector stakeholders (e.g. energy, agricultural, water and health). These sectors are managed under different Ministries and have different regulatory and legal frameworks governing them according to their various mandates. A case in hand was the construction of the Tokwe-Mukosi dam to support the agricultural sector through water provision for irrigation purposes, but with minimal consideration for the environment. The dam filled in one season rather than expected five years due to climate change, which saw

record rain fall during the 2013/2014 season. Due to lack of integrated planning, communities, property and livestock upstream had to be airlifted after being marooned whereas those downstream were also threatened with displacement during the construction as the dam-wall neared breaching. Planners were anticipating phased relocation over the years as they expected the dam to take at least 5 years to fill up. Another case is Zimbabwe's mining policy which overrides other policies, often at the expense of agricultural, environmental and cultural resilient issues. This is largely premised on the basis of its importance of the sector to economic growth which allows the Mines Minister to issue special grants for mining over any land use, including agriculture or housing. This threatens the adaptive capacity of communities who may be detached from their livelihoods or isolated in the planning process especially when the project proponent does not develop practices of equitable access and benefit sharing of mineral resources within the community or seek free, prior and informed consent of communities before project implementation.

Secondly, Zimbabwe only established the Climate Change Management Department in 2013, which became operational in 2015, hence there were no enablers such as climate policies and institutions with climate change being embedded in different sectoral policies. As a result, most actions on resilience were previously spontaneous and more reactive to extreme weather events, and climate-proofing each sector was incremental and done according to the relevant mandate. This meant that historically there has been a lack of integration of climate policies across sectors.

Thirdly, while the Climate Change Management Department has provided, high level coordination and cooperation towards resilience building, there is still need for an integrated approach and long-term commitment to strengthen the synergy between sectors and stakeholders. This will ensure that interventions are designed in an integrated manner that ensures multiple partners and sectors work together to address key leverage points and adopt complementary, transformational and effective strategies.

Lastly, the current system lacks monitoring, evaluation and strong feedback mechanisms that allow for sharing of experiences and lessons learnt. This has resulted in duplication of effort and inefficient use of resources as the outcomes continue to be undesirable in most communities.

Contribution to Policy and Practice

In order to deal with the above, a resilience framework that can be used in integrating climate change adaptation into sectors through integrated systems thinking is needed. Such a framework approaches resilience holistically, rather than thinking about it in individual parts (Moore et al, 2010).Hence, it is important to look at climate change adaptation and resilience building beyond the five capacities (preventive, anticipative, absorptive, adaptive and transformative) to include sub-capacities or sub-actions such as learning, planning, feedback mechanisms, allocation of resources, collaboration, networking, organising, improvising and innovation.

The proposed resilience framework provides a platform through which all stakeholders can work together to implement development interventions differently so that households, communities and wider systems are better able to manage the impacts of climate change (see **Figure 1**).

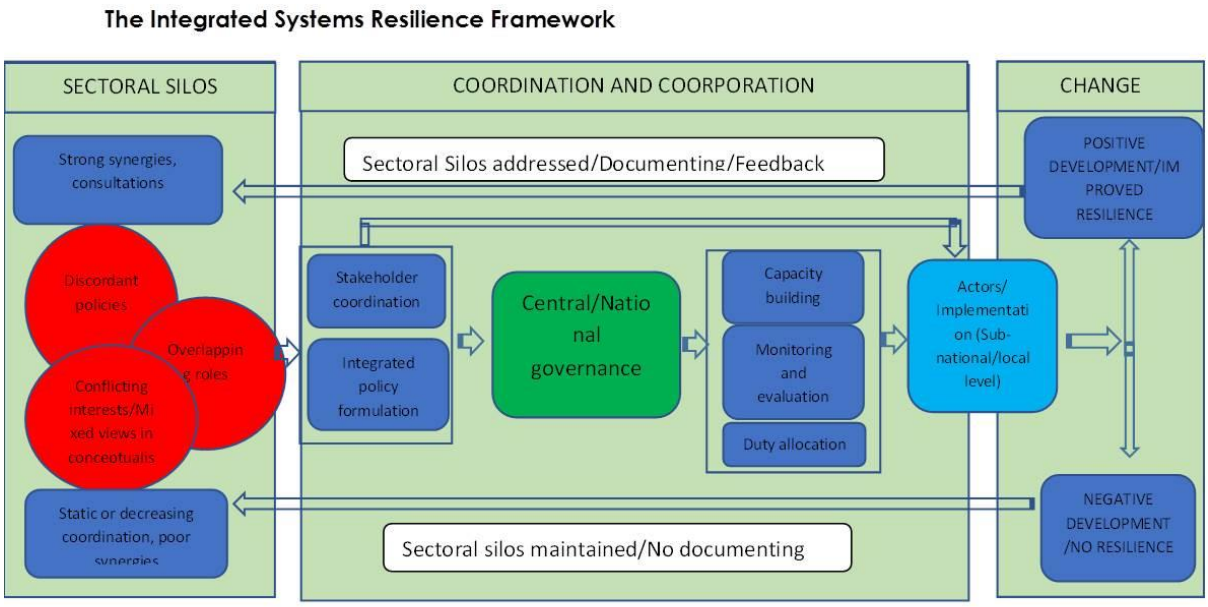

Figure 1. The Integrated Systems Resilience Framework
(Source: Adopted from Manyena, 2018, unpublished)

The framework highlights three key areas of focus:

i) Dealing with sectoral silos and institutions;
ii) Enhancing coordination and implementation; and
iii) Strengthening lessons learnt and feedback mechanisms (documenting empirical evidence of adaptation actions).

The National Government plays a key role in supporting the harmonisation and coordination of different sectoral policies and ensuring that the implementation of the established policies has positive outcomes and impacts. This framework provides for logical programming by providing a platform for stakeholder consultations and integrated policy formulation across different Ministries and other players. The ability for Ministries to talk to each other will assist in removing silos, building document evidence and knowledge sharing hence connecting the missing dots. Communities and practitioners will build on practices that have worked, hence advancing adaptation actions and making them sustainable.

Conclusion

Climate change adaptation and resilience building are long-term endeavours that require integrated coordination and cooperation. This framework approaches resilience planning and implementation holistically rather than thinking about it in individual parts. This framework will provide for transition from adaptation to resilience premised on engagement, lessons learnt and feedback loop to ensure that climate action is integrated into all socio-economic and political sectors and considers all players in a manner that does not subject other sectors to further stresses. The ability for resilience to look at the broader system of addressing climate change will enable discourse and engagement across different Ministries and stakeholders, eliminating the silos that adaptation had introduced in different sectors.

Resilience building may be improved by taking the following considerations into account:

- Strengthen multi-stakeholder engagement to enhance and reinforce integrated action and eliminate duplication of efforts;
- Provide platforms for information sharing and inform decision-making, policy formulation, coordination and alignment;
- Strengthen existing institutions by providing platforms for exchange of information and capacity building such as having climate change focal points in different ministries/sectors or cross-pollinated project boards that bring in diversity of expertise;
- Support technology development and transfer to manage the challenges that are faced by communities; and
- Measure the level of change after project or programme implementation. Enhanced resilience will show positive development supported by integrated governance systems and negative change will show discordant policies, poor planning and implementation.

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Climate change adaptation and women's property rights in East Africa: creating legal pathways for building the resilience of women

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Abstract

In Africa, women are more vulnerable to climate change effects compared with men. Women largely depend on natural resources for survival and constitute the majority of the poor and those working in agriculture. Women, however, have limited land rights to enhance their adaptive capacity. This research analyses the connection between women's land rights and climate change adaptation in East Africa, specifically in Kenya and Uganda. The research argues that while the law guarantees women's right to land, there is poor implementation due to socio-cultural dynamics such as deep rooted cultural beliefs and gender-based discriminatory practices that limit women's ownership of, and access to land for productive purposes. The paper concludes that safeguarding women's land rights is critical in enhancing their adaptive capacity to the impacts of climate change in the selected countries.

Keywords: *Women, Gender, Land rights, East Africa, Resilience, Agriculture*

Introduction

Developing countries, especially in Africa, are more affected by climate change because of their low adaptive capacity, defined as '*the ability to prepare for hazards and opportunities in advance and to respond or cope with the effects*' (IPCC, 2001). Climate change impacts include '*sea level rise, increasing temperatures, ocean acidification and glacial retreat, as well as related impacts such as salinization, forest degradation, drought, biodiversity loss and desertification*'(UNFCCC, 2012). These impacts affect basic needs like water, food, housing, energy, health and transportation, among other assets and resources. The high risk factors for East Africa include dependence on rain-fed agriculture, high levels of poverty, high reliance on natural resources like land, forests and water bodies, as well as poor infrastructure, which create a low adaptive capacity. Adaptive capacity influences vulnerability to climate change. The poor, especially those who depend on land and weather patterns for subsistence survival, are more affected by climate change. Women largely depend on natural resources for survival, make up the majority of the world's poor, and are therefore more vulnerable to climate change effects (Kameri–Mbote, 2013; Atapattu, 2015). The majority of people working in agriculture are women (Atapattu, 2015), yet they lack effective access to land because of poor enforcement of their right to property. This research explores the connection between women's property rights (the

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power to own, possess, use and enjoy a determinate entity, such as land or cattle) (Garner, 2009) and their adaptive capacity to and resilience[5] in the face of climate change in East Africa.

Methodology

The research employs the doctrinal research method. Legal instruments, laws, policies and credible reports at the international, regional, sub–regional and national levels was analysed. Secondary literature on climate change adaptation and women's access to land resources was reviewed. For the purposes of this research, the focus is on Kenya and Uganda due to the constitutional reforms to address gender inequality undertaken in 2010 and 1995 respectively. Both countries apply legal pluralism whereby customary law is applied alongside statutory law and both countries are dominantly patriarchal societies in which women still face discrimination in terms of property ownership.

Findings

Legal pathways for enhancing resilience

International and regional efforts to safeguard women's right to land have culminated in the adoption of human rights instruments such as the Universal Declaration on Human Rights (UDHR), which provides for every person's right to own property (Article 17), and the International Covenant on Economic, Social and Cultural Rights (ICESR) which, in Article 3, provides for equal enjoyment of economic rights for both men and women. Article 14 of the Convention on the Elimination of all forms of Discrimination Against Women (CEDAW) (1979) provides the condition that states are obliged to ensure equal treatment of men and women in land and agrarian reform. Article 16 states that land tenure reform must ensure women's property rights during marriage, at divorce and in the event of her husband's death. The African Charter on Human and Peoples' Rights (ACHPR) (1981) has no direct provision on land rights, but provides for non-discrimination against women on any grounds (Article 2 and 3). The Optional Protocol to the African Charter on Human and People's Rights on the Rights of Women in Africa (Maputo Protocol 2003) recognises women's right to land and environmental resources (Article 15). Although these provisions are progressive, many state parties in Africa are still facing challenges in enforcing them. Atapattu (2015) emphasises that '*despite efforts to improve gender equality the world over, gender discrimination still persists*' , noting that such inequality worsens women's vulnerability in the face of climate change. As states are mandated to protect human rights without discrimination on any grounds, they are required to address the vulnerabilities of those who are more affected by the climate in order for them to be able to easily adapt to climate change impacts (Lewis, 2016). This is especially so in the face of climate change where some groups of people, such as women, are more vulnerable to its impacts due to the fact they rely on climate-sensitive natural resources. This implies that states are to ensure the protection of land rights of women, being more vulnerable to the effects of climate change than men, in order for them to be able to adapt to the impacts of climate change. Hall and Weiss (2012) argue that human rights are an avenue through which groups vulnerable to climate change can hold state actors accountable, because human rights instruments place enforceable legal obligations upon states. They, however, note

[5] IPCC (ibid) defines resilience as, 'degree to which a system rebounds, recoups, or recovers from a stimulus.'

that the challenge with most international human rights instruments is a lack of thorough enforcement mechanisms, creating a hurdle for victims of human rights violations.

Until 2001, international climate change law (specifically, the United Nations Framework Convention on Climate Change (UNFCCC)) (1992) and the Kyoto Protocol (1997)) did not recognise gender and its relevance to the climate change discourse; however, various Conferences of Parties (COPs) under the UNFCCC and the Paris Agreement (2015) now recognise gender equality and women participation as a key factor in all climate change action. The Paris Agreement provision is, however, pre-ambular and hence non-binding. Atapattu (2015) points out that the efficacy of the COPs is yet to be witnessed, as many policies still lack gender provisions. Atapattu further states that gender issues have not attracted much attention in the climate change discourse, noting that this is not surprising as gender equality is a human rights issue and the recognition of the intersection between human rights and climate change is, itself, a hurdle. Likewise, the CEDAW committee[6] noted that women are the world's biggest producers of food crops and are more affected by climate change, yet they have limited access to productive resources, like land, due to discrimination. The committee recommended the recognition of gender equality in UNFCCC agreements. Prescott (2014) argues that the '*lack of the recognition of gender equality and climate change is not an oversight, but rather an issue of women marginalisation by societies and governments*'. It is thus not surprising that gender equality has not been reflected in the international climate regime, especially because the marginalisation of women is historical, and often a human rights issue. In addition, since climate change has become a contentious issue, there is need of deliberate effort in reconciling climate change and human rights. Unless this is done, women's property rights will continue to be downtrodden, making it difficult for women to cope with climate change effects.

Women's property rights and adapting to climate change in East Africa

In Kenya, women constitute 70% of the agricultural workers and contribute 80% of food production labour (Ellis, et al., 2007). In Uganda, over 70% of the agricultural labour force is constituted by women (Acidri, 2014). Despite the fact that women in East Africa are widely involved in agriculture, they culturally have limited land rights and do not make decisions concerning land in most households. Limited land rights, which includes limited access, control and ownership due to cultural restrictions, exacerbates the vulnerability of women in the face of climate change and lowers their adaptive capacity (Demetriades and Esplen, 2010; Atapattu, 2015). Prescott (2014) emphasises that one of the reasons why women are more vulnerable to the effects of climate change is because they lack access to economic resources, unlike their male counterparts. Women are consequently often unable to obtain credit to invest in lasting solutions to climate change, such as drought resistant crops, agricultural machinery, tree planting and/or soil conservation techniques. As a result, women are unable to invest in adaptation actions, and their resilience to climatic impacts is lower. Women farmers also fear to make investments on land available for use, for fear of losing their investments to the land owners.

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[6] Statement of the CEDAW committee on Gender and Climate Change, CEDAW 44th session, New York, 20th July-7th August 2009. Available at unfccc.int/resource/docs/2009/smsn/igo/064.pdf. Accessed on 2nd August, 2018.

In Kenya, the 2010 Constitution in article 40 (1) provides that, '*every person has a right, either individually or in association with others, to acquire and own property of any description*'. Kenya has a Climate Change Act (2016) which establishes a Climate Change Council and requires women representation on the Council. In article 8 (2) (c), the cabinet minister is also required to promote gender and climate change-related education and awareness. Although progressive, these provisions are not being implemented because women in Kenya are still discriminated against due to deep rooted culture and customs (Kameri-Mbote, 2005).

In Uganda, the 1995 Constitution in article 26 (1) provides that every person has a right to own property, individually or in association with others. The Uganda National Climate Change Policy (2015) recognises women as one of the vulnerable populations and provides for mainstreaming of gender issues in climate change adaptation and mitigation approaches to reduce the vulnerability of women and recognise their key role in tackling climate change issues. Abebe (2014) and Kanika (2005) emphasise that even if women in East Africa have statutory rights to own land, the region is still marred with gender gaps which continue to place women in a subordinate position, due to the predominant patriarchal society where women are still viewed as subordinate to men and are denied access to productive resources like land. In the absence of strong human rights, vulnerability to climate change cannot be reduced, and adaptation and resilience might remain a far cry (Barnett, 2009). Whereas the law guarantees gender equality and women's right to own property, implementation of these laws is a challenge due to the widely spread concept of patriarchy across the globe and in East Africa, which promotes wide-spread gender inequalities (Kameri–Mbote 2005; Atapattu, 2015).

Conclusion

Gender discrimination in the area of land rights affects women's adaptation and resilience in the face of climate change. Strengthening women's land rights in East Africa is therefore pivotal to enhancing their adaptive capacity. As a result, there is the need for effective implementation of the relevant laws and to reconcile climate change with human rights issues, such as gender discrimination, at both an international and national level. Governments need to put in place law enforcement mechanisms that will dismantle historical inequalities between women and men, as well as customary beliefs and practices which discriminate against women. This will make it easier for laws and policies on women's land rights to be implemented, hence enabling women to own land. This way, women will be able to use their land to invest adaptation measures. This will enhance their adaptive capacity and resilience.

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A tipping point for policy transformation: case studies of water management in South Korea and Germany

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Abstract

This paper compares the adaptation policies of South Korea and Germany with a particular focus on water management. While South Korea pursued technical methods for flood control and drought prevention, Germany has turned its policy direction from river modification to re-naturalisation. The difference between the two countries can be explained by discourses and institutions which interact with each other affecting the policy process. This study can provide implications about the process of policy transformation to adaptation researchers and practitioners.

Keywords: *Water management, Policy transformation, Governance, South Korea, Germany*

Introduction

Effective adaptation measures are essential not only on the individual level but also across society. This PhD research project in progress rests on the assumption that national governments are the major actors with paramount importance for adapting to climate change.

Water is one of the major subjects in the adaptation literature. Due to more extreme and frequent weather events resultant from climate change, both floods and droughts are being intensified all around the world. Thus, many governments deal with water management measures in their adaptation plans. However, national policies on water are diverse and this cannot be attributed to geographical differences only. South Korea, for example, pursued the Four Rivers Project which put a high emphasis on technological solutions that included building 16 dams and dredging the riverbed of the major rivers aiming for better flood control and drought prevention. Meanwhile, for the same policy purpose, Germany has underlined re-naturalisation of its rivers that have been formerly modified by dams and canals. Why do Korea and Germany pursue different adaptation policies for water management while similar climate change effects are expected? This study analyses the factors that influence the policy-making process in both countries.

South Korea and Germany are interesting cases for comparison. They are industrialised countries with a high level of income. Particularly, after the Second World War, both countries have experienced a period of fast economic growth. This point is notable considering the relevance of economic development and environmental politics. In the political aspect, the two countries show a high level of democracy (e.g. Democracy Index 2017 by the Economist Intelligence Unit). In addition, increasing flood risk and water stress as a result of climate change is a crucial problem for both countries because they are densely populated. Nevertheless, the water management

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policies in their first adaptation plans established between 2008-2010 show substantial differences as aforementioned.

Methodology

In order to analyse the policy process of the case countries, this study takes two analytical frameworks that are widely used in political science: discourse and institutional analyses. Discourse can be defined as "*a specific ensemble of ideas, concepts and categorisations*" (Hajer 1995), and discourses are closely related to political practices and power (Dryzek 2013). The focus of discourse analysis is the frames, symbols and narratives that actors use in their speeches or written statements. Meanwhile, understanding the institutional context of the policy process is a necessary step when analysing policies (Polski and Ostrom 1999; Hall and Taylor 1996). Formal institutions such as laws and regulations as well as informal institutions such as rules-in-use and norms are analysed in this study.

In addition to the literature review of academic papers, media reports and government documents, 46 semi-structured interviews were conducted in South Korea and Germany between February 2017 and April 2018. Interviewees include government officers, journalists, researchers, scholars and NGO activists specialized in adaptation and/or water management. The content of the interviews is analysed qualitatively, focusing on the keywords and narratives used by the interviewees.

Findings

In South Korea, many interviewees pointed out that the discourse based on techno-centrism and developmentalism is dominant in the country and consequently influence the implementation of technical solutions for adaptation, such as the Four Rivers Project. The government framed the project as a technology-based measure which could boost economic growth, and this frame matched the prevailing discourse. In terms of institutions, the policy-making process in South Korea has been heavily under the control of developmental-state institutions developed in the fast economic growth period. A developmental state can be characterised by a coalition of the government bureaucracy and major companies (Woo-Cumings, 1999). The government has a strong control over finance, and channels resources to big business with the aim of effective economic growth. Decisions are made within a top-down structure for state-driven economic plans. Developmental-state institutions did not disappear after the fast growth was over in South Korea, and they have continued to influence various sectors, including environmental policies. Many interviewees argued that the Four Rivers Project is a result of such institutional practice because major construction works involved in the project were beneficial to the big business.

Germany straightened its major rivers and made a number of dams from the mid-18th century until the 1960s, with the purpose of flood control, navigation and hydropower. Strong belief in science and technology was common among the public and political leaders (Blackbourn, 2006). However, the high level of river modification resulted in severe pollution. Environmental movements in Germany since the 1970s created discourses in favour of the restoration of natural rivers for better water quality and ecosystem protection. Furthermore, the Sandoz chemical spill on the Rhine River in 1986, alongside major flood events, provided momentum for policy change. Consequently, the combination of increased environmental awareness and external shocks led to changes in the river management policy. Furthermore, the multi-level governance from EU to

local governments in Germany allowed alternative discourses to be brought into the policy-making process. The EU Water Frame Directive promotes the natural state of rivers and this policy direction is reflected in the German adaptation strategy.

In the two cases, it can be found that both discourses and institutions influence the adaptation policy making process. Discourse plays a critical role as a power to change (in the case of Germany), or sustain the policies (in South Korea's case). But discourse is not the only driver in the policy process. A 'tipping point' for policy transformation may be created when the growing discourse meets a window of opportunity, such as a substantial accident or regime change. While historical institutionalism highlights the impact of external shocks on the policy process, the cases investigated in this study show that the role of social discourses as well as the interaction between discourses and institutions need to be equally considered when discussing policy change.

Conclusion

This study can give insight into the possible drivers of policy transformation which are sought by many adaptation researchers and practitioners. Regarding adapting to climate change, transformation emerged as an alternative framework that addresses the need for profound changes in the social system. In order to facilitate transformation in practice, concrete case studies of policy transformation and the policy process behind the changes are critical. In this regard, the historical cases from South Korea and Germany can provide not just theoretical but also practical implications: policy transformation can occur when an alternative discourse is mature and the policy institutions are able to allow the alternative discourse to be considered in the policy process. In addition, the case study of South Korea could be useful for some participants in Adaptation Futures 2018. Although South Korea is now seen as an industrialized country, the political and social legacies from the fast development period are still affecting its environmental policies. Thus, the Korean case can be an intriguing example when discussing the future of sustainable development in the Global South. Lastly, in order to learn from each other across different countries and regions, international knowledge sharing and mutual exchange of opinions among various actors is crucial.

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Risk perceptions and adaptation decision-making at farm-scale: a Nordic case study

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Abstract

Nordic farmers are tackling climate risks with adaptation measures that also hold potential of negative outcomes ranging from economic and ecological losses to food insecurity. These adaptation processes are scarcely studied yet. In this study, the risk perceptions, adaptation assessments and adaptive actions of Finnish farmers are examined through interviewing farmers and extension officers. With a qualitative take on adaptation decision-making, the study shows how climate risk perceptions generate adaptive action in Nordic agriculture.

Keywords: *Climate risk, Adaptation process, Maladaptation, Nordic agriculture*

Introduction

Farmers continuously make adaptation decisions at farm-scale based on knowledge and experiences and guided by policies and legislation, in addition to other internal and external norms, limitations and intensives (see e.g. Grottham and Patt 2005). In the Nordic region (Finland, Sweden, Norway, Denmark), climate change induces increased precipitation and temperatures, and longer growing season which enable introducing new crops and higher yield expectations. The opportunities are hampered by the direct and indirect climate risks, related to increased weather extremes and variation, as well as the maladaptive (i.e. unintended negative) outcomes of adaptation (Noble et al 2014).

Adaptation measures in Nordic agriculture are targeted mainly towards reducing risk, increasing adaptive capacity and capitalizing on climate change (Juhola, et al. 2017). Their maladaptive outcomes are most likely to affect negatively the practitioners themselves, but also other actors, sectors and the environment (Neset et al fc). With limited research on adaptation decision-making in the Nordic context, attention needs to be aimed at the practitioners and their risk perceptions, to better understand farm-scale adaptation processes and related maladaptation outcomes. In this paper, preliminary findings about the relation between the climate risk perceptions and adaptation decision-making at Finnish crop farms are presented.

Methodology

Theoretical Framework

Protection motivation theory (PMT) (Norman, Boer & Seydel 2005) defines adaptation as action following an individual assessment of risk and the risk-response capability. In the context of

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agriculture and climate change adaptation, the theory has been used to explain adaptation behavior as a logic model (Dang et al 2014; Grottham & Patt 2005) presented in **Figure 1.**

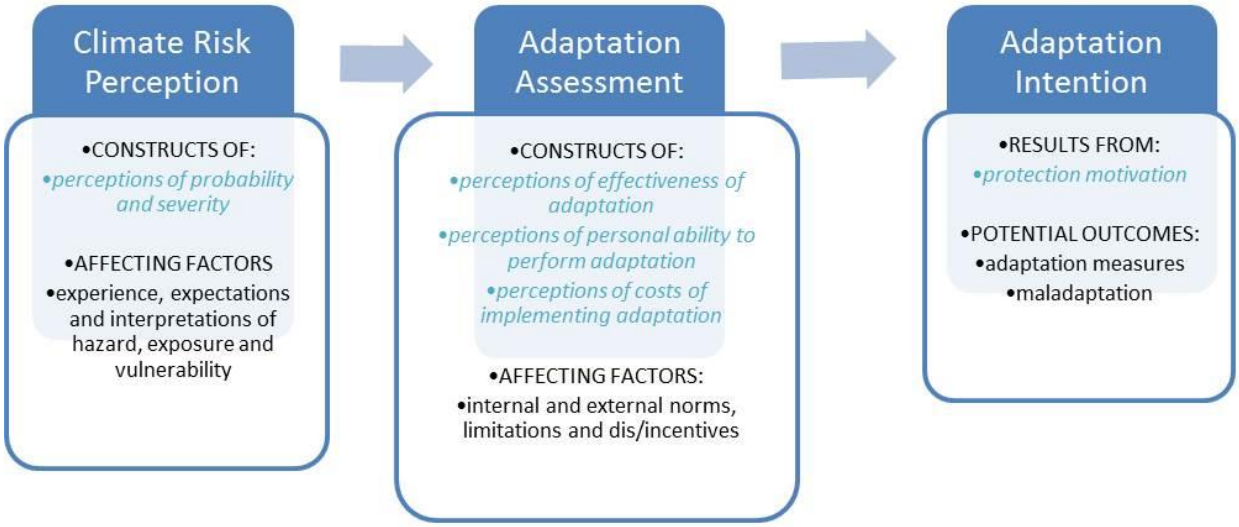

Figure 1. Risk perception driven adaptation decision-making model based on protection motivation theory (PMT). Original PMT variables are in italics (Source: Applied from Dang et al 2014; Grottham & Patt 2005).

The climate risk perception is a personal reflection of contextual and spatially specific risk factors, such as the occurrence of hazardous events and sectoral vulnerability. It is affected by psycho-socio-cultural variables, such as experiences of vulnerability. When the risk is perceived high enough, an assessment of the adaptation success may follow. The assessment is directed towards the effectiveness of personal capabilities to perform and the costs of adaptation. Factors like financial incentives, social norms and personal beliefs affect the setting of boundaries to the assessment. Adaptation intention rises from the motivation to protect against the climate risk when adaptation is perceived possible and beneficial. As a result, adaptation measures may be implemented with potential consequence of maladaptation.

Methods and materials

Due to the novelty of the study topic, a case study approach and in-depth semi-structured stakeholder interviews were applied. The case of the Finnish Uusimaa region offers an agricultural context that is claimed to be vulnerable to, but also potentially benefiting from, climate change. Adaptation measures with potential maladaptive outcomes are implemented in the region (Neset, et al. fc).

The interviewed farmers and extension officers were snowball sampled until a saturation point at 13 interviews was reached. The interviews were held one-on-one at interviewees' homes or workplaces; recorded, and transcribed in verbatim. The theoretical framework was used in designing the interview guide and in detecting the variables and affecting factors of the adaptation decision-making. Qualitative content analysis and explanation building (Yin 2014) were iteratively used in analyzing the relation between risk perceptions and farm-scale adaptation.

Results

The climate risk perceptions in the study region are based on expectations of climate risks becoming more severe and probable, with variation in the nature and time-scales of the expected risks. Experiences, values and preferences cause the main differences between perceptions. For example, vicinity of a flood on the best field combined with a strong preference on cultivating flood-sensitive crop variety correlates with a risk perception highlighting the severity of increased precipitation and floods. An experience of vulnerability in failing to protect another asset from another type of climate hazard changes the perception.

Knowledge on adaptation is poorly disseminated among the agricultural practitioners in the study region. The global markets and EU agricultural policies are perceived as an important external factor in the adaptation assessments. However, the internal factors causing varying perceptions of the costs and efficacy of the adaptation measures affect the assessment significantly. For example, taking up a new crop to cultivation was assessed as a low-cost measure for a large-scale conventional farmer, who has financial buffer via other assets, and option for using effective pesticides in case of an alien pest invasion. A small-scale organic farmer with limitations of space, finance and pest control, on the other hand, assessed the costs of introducing a new crop to circulation much higher.

The identified intentions for adaptation in the region derive from motivation to protect firstly the farm practice, investments and assets. However, the logic behind intended measures vary regarding the aims and time-horizons of the adaptation outcomes and the related maladaptation. Risk reductive measures, such as irrigation during a dry-spell, reflect short-term oriented risk aversive logic, which holds potential for maladaptation in the longer term. The adaptive capacity building measures, such as enhancing sub-soil drainage or investing in precise machinery, result from a logic driven by the aim to adapt to climate change in the long-term with an experimental approach. Measures for capitalizing on climate change - for example, introducing new varieties - are firstly targeted for profiting regardless of the time-scale of the expected adaptation. The trial and error logic of experimental adaptation, as well as the risk-seeking logic of profit-oriented adaptation, pose potential to maladaptation related to failed adaptation. For example, a novel crop attracting new pests to the region or an investment on direct-sowing machinery causing financial losses, along with unfavorable regulation or market condition changes.

Conclusions

The study shows that climate risks are deliberated at farm-scale and they generate the implementation of adaptation measures that reflect the farmers' risk-response logic. The results underline the dynamic and contextual nature of adaptation at farm scale. Depending on factors such as personal experiences with climate extremes, preferences for crop varieties, and on how dependent the production orientation is to, for example, market fluctuation, the risks are perceived and adaptation assessed differently.

The study also shows how adaptation is addressed without adaptation policy guidance on farm-scale in a Nordic region that plays a significant role in national crop yield production. This implies an impact of climatic risks beyond the regional population and economy. It thus implies that farmers are put into a responsibility position regarding national food security and agricultural

productivity. In that pressing position, they are facing challenging climatic changes without sufficient knowledge, nor economic resources for implementing well-scheduled, long-term adaptation that would also avoid maladaptive outcomes. This study hence points towards the need of adaptation policies that acknowledge the varying logics behind adaptation decision-making. More importantly, the practical adaptation skills and knowledge of farmers should be acknowledged. Co-operating with stakeholders in participatory policy planning, and acknowledging the experimental farmers as "early adopters" are suggested for practical next steps.

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Participatory vulnerability assessment and identification of Ecosystem-based Adaptation (EbA) measures: a field Experience from the mountains of Nepal

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Abstract

Vulnerability assessments have been gaining much attention as a tool to identify solutions to adapt with the impacts of climate change. Although many methods to assess vulnerability exist, we have found that a Participatory Vulnerability Assessment (PVA)[2] helps to identify the real problems of local communities, and particularly their relation to needs and challenges that are not necessarily climate-related. This participatory vulnerability assessment method was developed based on our experience of the Mountain Ecosystem-based Adaptation (EbA) Flagship Programme and focuses on analysing current vulnerabilities and predicting future trends. In this approach, we work closely with local communities to describe and analyse the environmental and social characteristics and processes, ensuring that the measures to be implemented are nature based adaptation solutions. This approach has been found to empower communities in the process of identifying problems and their solutions, and also increases ownership of measure planning as the communities identify measures based on their need and urgency, implementation and maintenance. Thus, we anticipate that the learnings of this assessment approach can be integrated into existing planning guidelines for community development so that climate change issues can be mainstreamed in any development effort.

Keywords: *Participatory vulnerability assessment (PVA), Mountain Ecosystems, Ecosystem-based adaptation (EbA), Nepal*

Introduction

With the increasing risks of climate change, the need to identify adaptation and planning options has never been so pressing. For this, vulnerability assessment as a tool have been gaining much attention to identify the specific risks and vulnerability posed by changing climate and identifying solutions to adapt to those changes (GIZ, 2014).

In recent years, EbA, a strategy that uses biodiversity and ecosystem services to help people adapt to the adverse impacts of climate change, is considered particularly promising for mountain regions because it is cost-effective and can be implemented by the communities themselves (Colls et al., 2009. Although many methods to assess vulnerability exist, we have found that Participatory assessments help to identify the real problems of local communities, and particularly their relation to needs and challenges that are not necessarily climate-related.

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[2] PVA is a climate change vulnerability assessment through the involvement of local people

Participatory assessment is a process of building partnerships with local men and women of all ages and backgrounds by promoting meaningful participation through structured dialogue. The assessment includes holding separate discussions with interest groups in order to gather accurate information on the specific problems they face and the underlying causes, to understand their capacities, and to hear their proposed solutions

Understanding both current and future challenges helps us to identify and prioritize nature-based solutions that will be effective both within the current reality (e.g., limited food availability, limited income, limited job opportunities or labour resources) and in relation to additional challenges resulting from a changing climate (e.g., increased erosion, reduced water availability). This assessment helps to evaluate the susceptibility of multiple systems (water, forests, pasture land, agricultural land, wetland etc.) to climate change, and enables a better understanding of the factors (climate and non-climate related) driving the vulnerability.

Objectives

The main objectives of this participatory vulnerability assessment are to identify the current and potential climate-related and other vulnerabilities of local communities of the mountains of Nepal, and to identify ecosystem/ecosystem service measures that could help them adapt to these changes. This helped to identify the intervention measures that are needed to help local people adapt using nature-based solutions.

Method

Up-scaling Mountain EbA is a follow-on program to the Mountain EbA Flagship Programme, which established mountain EbA demonstration sites in Nepal, Uganda, and Peru. This program is being implemented jointly by The Mountain Institute (TMI) and IUCN in Peru, Colombia, Uganda, Kenya, Nepal and Bhutan. It aims, in part, to demonstrate, on a multi-country scale, how EbA can help mountain communities and ecosystems adapt to climate change. This PVA method was developed based on the experience of the Flagship Programme and focuses on analysing current vulnerabilities (climate and non-climate related) and predicting future trends.

In partnership with representatives of local communities, we describe and analyse the environmental and social characteristics and processes that need to be understood to ensure that the measures to be implemented are truly robust and favour adaptation based on ecosystems and ecosystem services. To do this, we adopted a combination of both quantitative and qualitative methods using participatory assessment tools such as participatory resource mapping of their settlements, ecosystems and the services they get from those ecosystems including their exposure and sensitivity. Key informant interviews and community consultations were used to assess local adaptive capacity, and a series of local consultative workshops were organised to help identify vulnerabilities and potential solutions.

We organised such workshops in four villages in the Chilime Watershed in the central Himalayan region of Nepal. In total, more than 150 people of all genders, castes, ethnicities, and age groups participated and worked together with facilitators to identify vulnerabilities and suggest EbA measures that considered both the local context and the climate-related challenges.

TMI led the whole facilitating process, whereas the specialists from the Tribhuvan University and local experts were involved in participatory mapping, identifying the exposure, sensitivity and adaptive capacity of local community and ecosystems.

Our PVAs included the following three steps:

i) Local communities oriented on climate change and its causes (general and specific to mountain region), impacts of climate change in local communities and ecosystems in their respective villages and climate change adaptation options, including CbA, EbA, Disaster Risk Reduction (DRR).
ii) PVA conducted, using participatory tools in the community workshops focusing on gathering qualitative data and information on local climate vulnerabilities and contexts. The assessment ensured active participation of youth, elderly, women and marginalised groups to identify underlying causes of vulnerability at the community level based on their local knowledge, skills and capabilities. We adopted the practical guidance on tools for assessing community vulnerability as mentioned in Table 1.

Table 1 Practical guidance on tools for assessing community vulnerability (Source: Practical Action, WWF, IUCN Nepal, CECI Nepal & NAVIN (2010))

Vulnerability Component	Practical guidance on tools for assessing community vulnerability
Exposure	Seasonal calendar, historical timeline, rain calendars, climate diaries
Sensitivity	Hazard mapping, hazard trend analysis, hazard ranking, hazard impact ranking, mental models, transect walk for risk identification, climate hazard impacts on livelihood matrix, participatory scenario development for potential risks
Adaptive capacity	Community resource mapping, livelihood resource vulnerability assessment, livelihood asset assessment, vulnerability and capacity matrix, Venn diagram, stakeholder identification, coping and adaptation strategies assessment matrix, effectiveness of coping adaptation strategies assessment, communication maps, preference ranking, wealth ranking, benefit cost ratio, multi-criteria assessment

The participatory tools we used in this assessment were mapping historical timeline, hazard mapping, climate hazard ranking, seasonal calendar, vulnerability assessment, forced field analysis, vulnerability matrix, stakeholder identification and EbA measures identification (Maharjan et al., 2017).

Sharing of the PVA findings and prioritisation of EbA measures was conducted through a watershed level workshop. Participatory approach was used involving diverse stakeholders representing communities, community groups, private sectors, political leaders, district and local government agencies. The participants were involved in group exercise in which each group prioritized the identified EbA measures that addresses their needs and challenges through a priority ranking matrix.

Findings

On comparing the costs of science based modelling of climate change vulnerability assessment conducted in the mountains of Nepal with this participatory method, we found that the participatory method is both cost and time effective. The vulnerability assessment carried out during the Flagship Mountain EbA Project was scientifically grounded and consisted of exhaustive assessments and took almost all the project period due to which project partners had to move ahead with implementation through identification of no-regret EbA measures using participatory approach. The approach also was found to identify local vulnerabilities of the particular area that is being studied rather than the larger area, which would otherwise weaken the good understanding of the local context. Moreover, the approach was found to empower communities and enhance their capacities to identify their challenges and the nature based solutions to address them. For example, PVA undertaken by TMI for the Mountain EbA Project identified poor water availability in high pasturelands which had been impacting their traditional transhumance practice. This would not only restore water availability in pasturelands but also preserves their traditions. It also increased ownership of measure during planning, implementation and maintenance. Besides, the mountain landscapes are a result of the interaction of both the social and environmental factors, thus, the approach also contributes to address the issues affecting resilience of the socio-ecological systems in these areas.

Conclusion

This assessment has shown that local people's participation in the vulnerability assessment and the identification of key and local ecosystem-based adaptation measures is key to the successful implementation of EbA projects. Following the findings of this assessment, the national government could develop a policy framework for community participation in vulnerability assessment and adaptation planning. The learnings of this assessment can be integrated in existing planning guidelines for community development so that climate change issues which might also exacerbate the effects of other non-climate risks can be mainstreamed in any development effort.

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Can designing 'spaces for learning' inform collective learning in transboundary river management processes?

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Abstract

In transboundary river basin management, social learning is relevant to support collective understanding and problem framing, addressing conflicting perspectives, and in co-production of knowledge. Still, little is understood about the relational dynamics of social learning processes. This paper examines the relational dynamics of social learning processes in transboundary water management processes. We argue that learning occurs in learning spaces and within these learning spaces, actors navigate relational features. We categorise relational features as: trust, power, identities and conflicts. Understanding these features contributes to understanding what is needed to foster collective learning within transboundary river basin management. Practically it could also contribute to designing learning processes that support collective learning, co-production and reframing.

Keywords: *Social learning, Transboundary river management, Collective learning*

Introduction

Transboundary river resources are not only challenging to manage due to the vastness of the resources, but equally due to the diversity of actors with competing or conflicting interests (Pahl-Wostl, 2015). Processes that enhance collaboration, ownership, representation and responsibility for all are popular within transboundary river management (Evely et al., 2011). Yet transboundary river management is challenging due to varying management practices, competing interests, conflicting perspectives, cultural values, institutional frameworks and political histories (Cundill & Rodela, 2012; Reed et al., 2010). This inherently makes it difficult for actors to develop a shared understanding on the issues at stake.

Social learning processes have thus become popular in trying to address complex management challenges, with the idea that if actors are able to learn together, they can inherently support each other to develop a shared understanding and hence manage the resources together (Ridder, Mostert & Wolters, 2005). For example, in natural resource management, social learning can be useful to support actors when they differ on resource use, address conflicting interests by building relational capacities, overcoming power asymmetries, supporting problem framing by questioning the underlying values and perceptions; and providing spaces for perspective taking among actors. Studies have shown that social learning is best facilitated in environments that stimulate deliberation, interaction and representation (Muro & Jeffery, 2008). These environments

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act as 'learning spaces' in which learning is fostered. While this seems to be the case, little is understood about the 'learning spaces', as well as the relational dynamics of learning processes. Therefore, this study aims at evaluating 'learning spaces' and relational dynamics of social learning in transboundary water management processes.

Methodology

Using qualitative interviews, we analysed transboundary river basin management processes in two river basins in Africa; Omo basin and Zambezi basin. In both basins, we used in-depth interviews and analysed project reports, river basin management protocols, plans and technical reports. Interviews focused on actors within transboundary river basin processes such as scientific researchers, boundary organisations and national actors within key sectors such as water, energy, food and environment. In both case studies, social learning in transboundary river basin management could support problem framing on water-energy-food nexus integration, developing joint basin planning, and developing joint basin development projects.

Discussion

Conceptual framework

We understand social learning as '*learning by all stakeholders to manage the issues in which they have a stake*' (Ridder et al., 2005). As learning is a relational process, we understand that actors learning together requires actors engaging within their relational capacity in a learning space. A learning space is thus defined as an '*arena where diverse actors with multiple frames and knowledge plurality interact and deliberate on a shared understanding of the issues or potential solutions thus providing an opportunity for reframing*'. Actors within these learning spaces navigate through relational features such as trust, power asymmetries, shared identities and addressing conflicting views and perspectives. These processes are important aspects of learning and they influence how actors interact and deliberate in a learning space (Sol et al., 2012).

Relational dynamics in a learning space

Trust acts as the backbone for learning and impacts the level of actor's interaction and learning within learning spaces (de Vries et al., 2017). Trust can shape actors' interaction and ability to transfer knowledge and also in interpersonal relationships. While power asymmetries have a direct relationship with learning experiences, they impact decision making processes (Albert et al., 2012). Identity influences not only how actors view themselves and others, but equally how they interact and make decisions (Wenger, 1998). Within these processes conflicts may arise. Conflicts could incorporate conflict of interest, conflicts of problem framing or conflicts of opinions; these could either stimulate learning by providing space for these conflicts to be addressed or could be an indication of the state of the process. Either way, conflicts play a critical role in understanding social learning processes (Beers et al. 2016).

These four relational features, embedded in a cultural, historical or institutional context, form the basis of actor interaction and deliberation within a learning space. This interaction would, in the long-term, lead to three main groups of outcome: relational outcomes which result from improved relationship and trust building, which in turn supports cognitive outcomes, such as improved knowledge in basin management as actors are open to share and co-create knowledge, eventually leading to changes of values and underlying governance norms in water management. This is represented in **Figure 1** below.

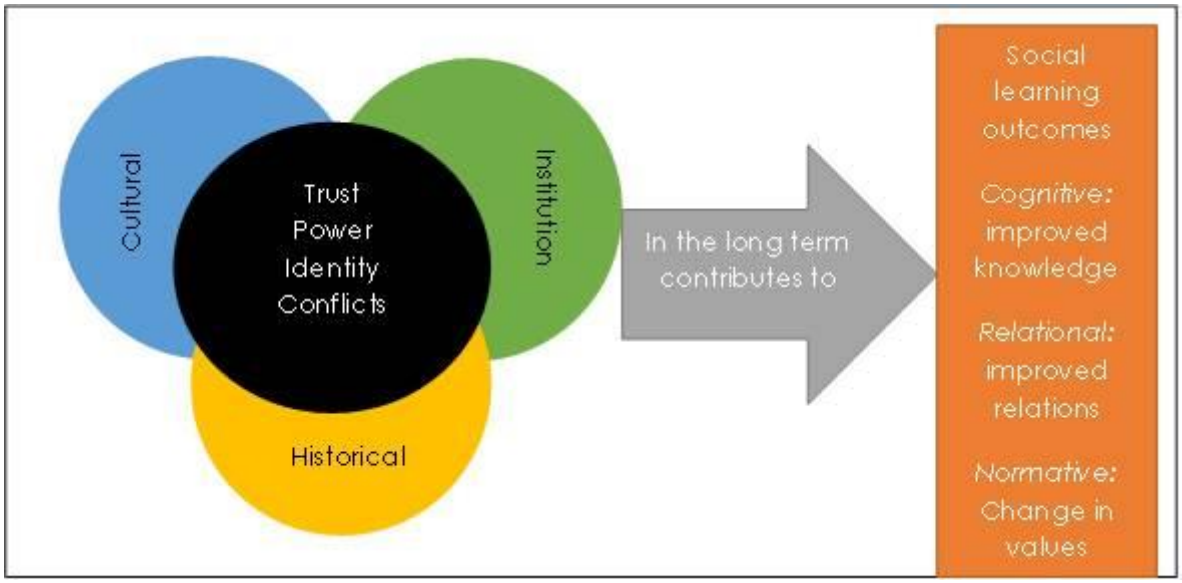

Figure 1: Relational features in a learning space are embedded in a context of culture, histories and institutions that stimulate or hinder social learning (Source: Authors own).

From our case studies, it was noted that shared identities were based on actors shared culture and mutual engagement in transboundary processes. Actors shared identities shaped trust relations and impacted on knowledge sharing.

Conclusion

For effective collective learning among diverse actors in transboundary processes to occur, there is need to understand learning spaces and how actors navigate relational features within these learning spaces. Transboundary river basin management processes should pay attention to the features that could stimulate or hinder learning. Understanding these dynamics could support designing effective collective learning processes within transboundary river basin management processes.

Acknowledgements

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Optimising the de Martonne aridity index using adjustment values

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Abstract

In 1926, Emmanuel de Martonne designed an aridity index to enable quantification and classification of climate conditions. It was originally best optimised for areas with temperatures greater than -10 degrees Celsius (Maliva & Missimer 2012). Given that temperatures could be negative, de Martonne (1926) proposed to adjust the index by adding 10 to temperature. However, due to differences in local climates from region to region, estimation of aridity was poor since the index was adjusted using a constant. As a result, there was a need to identify a method to determine the best suited adjustment value to optimise the index, heedless of an area's temperature range. In this paper, the chi-square (χ^2) goodness of fit test, and the Root Mean Square Error (RMSE) are used to identify the best-suited climate adjustment value between 10 and zero that optimises the de Martonne index. Results showed that it is possible that more than one value may be a suitable adjuster. However, the best optimising adjuster should have the lowest $\chi^2$and RMSE statistics. The findings also revealed that 10 may not always be an adequate adjustment value as this would lead to a misclassification of the climate.

***Key words**: de Martonne aridity index; Chi-square test; Root mean square error*

Introduction

Modern research has conclusively established that climate is rapidly changing due to global warming, such that the need to pen the most suited description of the level of dryness is rising (Lungu *et al.* 2011; Alam & Iskander 2013). A variety of methods are available to quantify climatic dryness. One such aridity index is the de Martonne index (MA). The MA is computed as a ratio between annual rainfalls (*Pa)* to annual mean temperature (*Tam)*as shown in Equation 1.

$$MA = \frac{Pa}{Tam+10} \qquad (1)$$

Initially, the index could not be used in areas where temperatures are below zero. To resolve this, de Martonne (1926) proposed to adjust temperature with 10. This made the index useful only in areas where temperatures are greater than -10 degrees Celsius (de Martonne 1926; Paltineanu *et al.* 2006; Maliva & Missimer 2012; Quan *et al.* 2013; Barbara *et al.* 2014; Haider & Adnon 2014). However, this method of adjusting the temperature with 10 has never been proven to be universal. It is important to correctly classify climatic regions in order to respond adequately to issues surrounding climate variability within the context of the individual climatic regions. Arid regions stand a greater chance of experiencing extreme drought events than humid regions (Maliva & Missimer 2012). Therefore, it can be anticipated that in these regions farmers, water

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resources, and the overall ecosystem would frequently be at risk of extreme drought (Mniki 2009; Collins *et al.* 2009; Maliva & Missimer 2012; Kumar *et al.* 2015). The objective of this paper was to optimise the MA to better identify different climatic zones. Within the context of water security, food security, or adaptive capacity of farmers to a changing climate, it is important to identify areas vulnerable to intensive dryness (Verchot *et al.* 2007). A method that can describe climate conditions at a higher scale for specific regions could empower decision makers in monitoring climate change moving from a general or global scale to a site-specific scale.

Methodology

Given that this paper aims to improve the MA to be able to differentiate between small climate differences, it was important to use areas with nearly similar climate conditions. The climate of Cape Town varies between Mediterranean to semi-humid, with annual rainfall ranging between 400 mm to 600mm. Buffelsfontein is the coldest area in South Africa with the lowest mean temperature recorded is 2.8 degrees Celsius (SAWS 2017). Alice has semi-humid to humid climate with rainfall occurring all year through (Boumis 2017). After computing the index on the three towns based on Equation 1, the three towns were classified as semi-dry, Mediterranean, and humid as shown in **Table 1**.

Table 1: Classification of the climate of Cape Town, Alice and Buffelsfontain by the original de Martonne Index (Source: authors own)

Town	rain(mm)	T (c)	Index	Class
Cape Town	528.46	17.12	19.48	Semi-Dry
Alice	599.22	17.84	21.51	Mediterranean
Buffelsfontain	622.96	11.39	29.11	Humid

This shows that, if temperature is adjusted using 10, some areas might not be appropriately classified. Hence, the need to identify an optimising value to improve the MA. This paper explores the application of the Chi-Squared test and the Root Mean Square Error (RMSE) to identify the best-suited adjustment value.

Results and discussion

Results from a comparison of chi-square tests at different adjustment values from 10 to zero confirmed that the MA can be optimised using different values in each area apart from the theoretical 10 proposed by de Martonne (1926). The MA will be optimised if temperature is adjusted using 10 or nine for Buffelsfontein, between six and three for Cape Town, and between four and one for Alice. In cases where multiple values are found suitable to optimise the MA, the RMSE and the test statistic should be used as an indicator to identify the best adjuster (**Table 2**). Results presented in **Table 2** revealed that the three towns where suitably classified using all optimising values.

Table 2: Classification of the climate of Cape Town, Alice and Buffelsfontain using the max, min, and best adjustment value (AV) (Source: Authors own)

Town	Rain	T(c)	AV	Index	χ^2	RMSE	Class
Cape Town	528.47	17.12	6	22.85	5.70	0.67	Mediterranean
	528.47	17.12	5	23.89	5.29	0.58	Mediterranean
	528.47	17.12	4	25.02	1.37	0.25	Semi-Humid
	528.47	17.12	3	26.26	2.76	0.39	Semi-Humid
Alice	599.22	17.85	4	27.43	6.53	0.58	Semi-Humid
	599.22	17.85	3	28.74	4.53	0.43	Humid
	599.22	17.85	2	30.19	5.83	0.46	Humid
	599.22	17.85	1	31.79	10.97	0.67	Humid
Buffelsfontain	622.96	11.40	10	29.12	10.17	0.49	Humid
	622.96	11.40	9	30.54	5.48	0.35	Humid

This proves that even though it is optimal to use the best adjustment value, all suitable adjustment values would still adequately optimise the MA in most cases. **Table 1** presented a classification of the three areas using 10 as the AV. The results showed that Alice and CT were misclassified following the classification method proposed by Baltas (2007). Based on the classification proposed by Baltas (2007), an area receiving about 600 mm of rainfall is said to be a humid region. Therefore, Buffelsfontein is rightfully classified following this logic. An arid region is measured by the balance between the amount of rainfall and evapotranspiration (Tilahun 2016). This means, regions with high temperatures will likely evaporate the rainfall and leave the area dry. However, in the case of Buffelsfontain, the low temperature causes less evapotranspiration, making it a relatively humid region. This justifies that the test effectively identifies the best AV and should be used in any study.

Conclusion

Climate variability plays a considerable role in farming practices, water resources management or even public health. It is important to be able to understand climate conditions more precisely than approximately in order to plan adaptive measures. This is valid especially for projected long-term adaptation scenarios such as the one implemented by the South African Department of Environmental Affairs (DEA) (Ziervogel *et al.* 2014). So far, they are aiming to develop national and sub-national adaption measures based on different possible future climate scenarios. However, it is still important that the method used to classify climate condition is optimal and does not excessively generalise information. The MA as proposed in this paper is able to identify climate conditions more precisely, which will permit the implementation appropriate adaptation measure. In a global equation of water balance, differentiating arid regions from humid regions becomes very important. This permits decision makers to tackle dynamics related to the different regions more appropriately. The report from the economic research services sponsored by the United States Department of Agriculture stated that, according to their findings, farmers in drought prone areas are likely to enroll in the conservation program as arid region are prone to drought (Wallander *et al.* 2013). This shows the importance of classifying climatic regions more precisely.

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Using the Standardised Precipitation Index (SPI) for short-term drought: a review

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Abstract

This paper compares the binomial distribution (BD), the plotting position (PP), and the original method (OM) to identify the best method to estimate *q*. The adjustment factor (*q*) is a value used to adjust for probabilities accounting for periods of absolute dryness (PAD). The method should ensure that *q* is small enough to avoid large alteration of the probabilities regardless of the sample size, increase the positive correlation between rainfall and their SPI, and detect PAD. Results showed that the BD was able to minimise *q*, and positively increase correlation between rainfall and SPI. Although the PP approach better normalises the SPI, it sometimes underestimates drought intensity. Results also showed that the OM and BD methods have similar behaviour in estimating the probabilities in the absence of PAD. However, during PAD, the BD sufficiently minimises *q*, consequently not causing large changes in the probabilities of each events.

Key words: *Standardised precipitation index (SPI), Adjustment factor, Periods of absolute dryness*

Introduction

McKee *et al.* (1993) created the Standardised Precipitation Index (SPI) to monitor drought, used in different studies. For example, Hayes *et al.* (1999) used SPI to monitor the 1996 drought in America, and concluded it was able to predict drought at least one-month prior in comparison to the Palmer Drought Severity Index (PDSI). Lana *et al.* (2001) monitored patterns of monthly rainfall shortage and excess in terms of the SPI for Catalonia- Spain. Seiler *et al.* (2002) monitored drought and floods in Argentina, and others monitored drought intensity in Africa and found conclusively that there was a relationship between location and drought variations (Rouault & Richard 2003; Ntale & Gan 2003).

Methodology

The main objective of this paper is to identify a method that could minimise *q,* increase the correlation between rainfall events and SPI values, and identify PADs. The study used climate data provided by the South African Weather Services (SAWS) of Alexander Bay and Matiwa, the driest and wettest areas in South Africa respectively, to compute SPI using the Gamma distribution for short terms varying from two to 12 months.

The first step in computing the SPI is to use the Gamma distribution model to generate probabilities G(x), which are later converted using the inverse Gaussian distribution into SPI (McKee *et al.* 1993). Originally, the index did not consider a case when no rainfall occurs, as the Gamma distribution

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cannot account for the probabilities of zero. To resolve this, Edwards & McKee (1997) suggested the use of adjustment factor *q* to adjust G(x) when x = 0 to obtain the probability of non-exceedance H(x) (Equation 1):

$$H(x) = \begin{cases} q & x = 0 \\ (1-q)G(x) + q & x > 0 \end{cases} \quad (1)$$

where x is the average rainfall corresponding to a time frame that may vary between two to 12 months referred to as smoothing window. G(x) is the Gamma distribution.

Edwards& McKee (1997) suggest to divide the number of zero by the sample size to estimate *q*. Ntale & Gan (2003) suggested the use of plotting positions (pp) to estimate *q* (Equation 2). The pp method is preferable when the time scale is longer than 90 years and requires a different classification method for different smoothing window due to the variability of the sample skewness:

$$q_i = \frac{i-0.42}{n+0.3\gamma+0.05} \quad (2)$$

where *i* is the rank order of x, *n* the sample size, γ is the sample skewness when$-3 \leq \gamma \leq 3$.

Due to the shorter time-scale of data, this paper proposes the use of the Binomial distribution (*BD*) to estimate *q* and a controlling factor (*k)*. In this case, *r* is the number of zero values in *n* number of years. *K* accounts for the number of zero values lost after smoothing by using the size of the smoothing window adding those present in the dataset after smoothing (Equation 3). In addition, given that it can either rain or not, *p* is set to a half.

Therefore, the adjustment factor becomes as in Equation 9 below:

$$q = \begin{cases} Bin(r,n,p) kn \leq 20;\ r > 0; p = 0.5 \\ Bin(0,n,p) kn \leq 20;\ r = 0; p = 0.5 \end{cases} \quad (3)$$

The paper compares the three methods of estimating q in order to identify the best method that can improve SPI. Drought contributes negatively to food insecurity, water depletion, health and even the economy. Farmers are usually more vulnerable, especially in rural areas as they have limited resources to withstand the pressure of extreme weather events (Manyever *et al.* 2014). To be able to formulate adequate policies to adapt to drought, it is important to use a method that can differentiate between drought intensities and determine the duration of a drought period.

Results

Table 1 shows correlation results between the SPI generated from G(x), referred to as SPI, and the SPI generated from H(x) using the BD (SPIB), the PP (SPIP), and the OM (SPIO) between two and 12 months. Results revealed that the relationship was consistently stronger between SPI and the SPIB than it was for the other methods for all time frames. Given that *q* is set to zero for the OM in the absence of PAD, OM becomes irrelevant, thus, making SPIO similar to SPI. However, BD still correlates better with SPI than the PP (**Table 1**). This illustrates that BD is a better method to use in comparison to OM and PP, as it is a better representative of rainfall events.

Table 2: Correlation between the Gamma SPI (GSPI) and the SPIB, SPIP, and the SPIO for Alexander Bay (AB) and Matiwa (MA) (Source: Authors own)

	SPI								
	Months	SPIB	SPIP	SPIO		Months	SPIB	SPIP	SPIO
AB	2	1.000	0.999	0.995	MA	2	1.000	0.997	0.999
	3	1.000	0.998	0.999		3	1.000	0.993	0.998
	4	1.000	0.993	1.000		4	0.996	0.972	1.000
	5	1.000	0.998	1.000		5	1.000	0.997	1.000
	6	1.000	0.938	0.995		6	1.000	0.986	1.000
	12	1.000	0.997	1.000		12	1.000	0.983	1.000

Time series plot of a three month SPI in AB (**Figure 1**) and MA (**Figure 2**) showed that SPIB was able to detect PAD better than SPIO and SPIP, and clearly differentiate between PAD and Periods of Lower Rainfall (PLR). Results also showed that the SPIB described a more intensive drought than the SPIO or the SPIP. For studies focusing on drought classification, all three methods may be acceptable. However, for studies aiming to isolate drought events, investigate their intensity and impact on other variables such as water resources, the *BD* would be the best method.

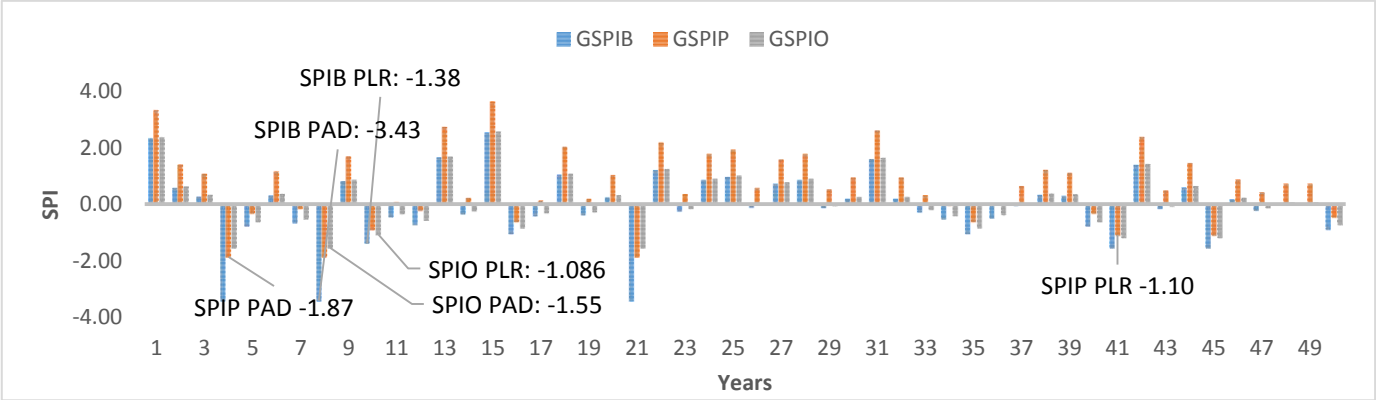

Figure 2: A 3-month time series plot of Alexander Bay over 50 years (Source: Authors own)

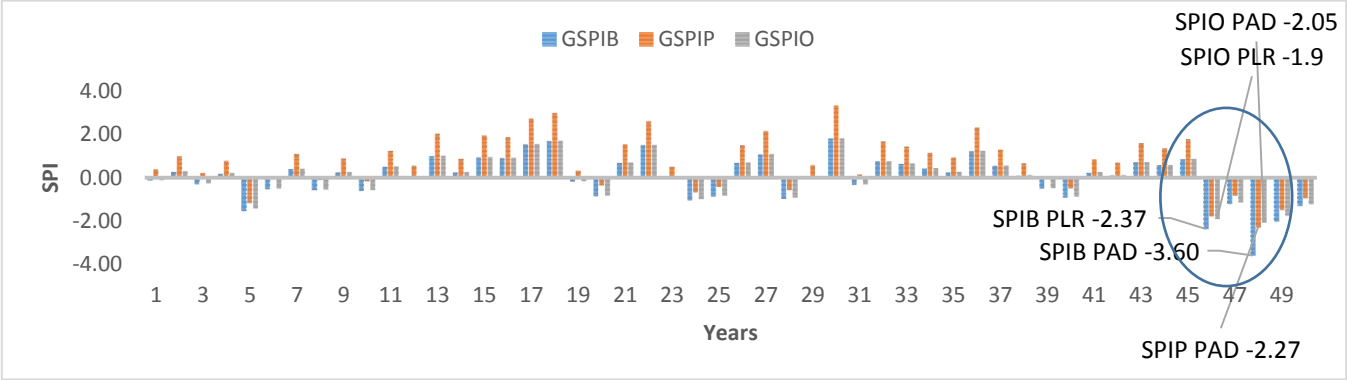

Figure 3: A 3-month time series plot of Matiwa over 50 years (Source: Authors own)

Conclusion

The results proved that the BD was able to minimise *q*, detect PADs, and increase correlation between rainfall and SPI values for short-term drought between two and 12 months better than the PP or the OM. For adaptation and water conservation practices, it is very important to understand the intensity and duration of drought. Climate is rapidly changing around the world, and planning adaptation is a concern in South Africa. IPCC report indicates that climate projections pins extreme weather events. This will affect greatly water resources, infrastructure, health, food security, and the entire ecosystem (Ziervogel *et al.* 2014). Previously, it was proposed that as long as the index falls within the right class it does not matter how low or high the index score is. However, this concept does not take into account intensity and duration of drought (Ntale & Gan 2003). Each weather events influences other variables in a different way. For example, a drought event of -1 would affect water resources differently from a drought event of magnitude -3. The method proposed in this paper addresses drought in terms of intensity and duration, it is able to differentiate between PLR and PAD. This should enable policy makers to track PAD and how they affect the environment. At the same time, take into account other drought events.

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The relationship between crop yield, the SOI and rainfall data in the Ngqushwa local municipality, South Africa

Sonwabo Perez Mazinyo[1], Wernel Nel[1], Leocadia Zhou[1]

Abstract

The study determines the correlation *r* between crop yield and rainfall variability, and mean annual rainfall scores were compared with the mean crop yield for 30 years (1982 to 2011). The Pearson Correlation indicates that the rainfall for Grahamstown and Peddie are strongly correlated (r=0.63; P<0.01) with both lagged and unlagged SOI values showing a strong correlation for the prediction of rainfall trends. The study area has experienced several dry spells. The study recommends adaptation alternatives such as large-scale irrigation schemes and SOI aligned Information and Communications Technologies (ICT) interventions as tools for an integrated early warning system.

Keywords: *Rainfall, Crops, SOI, Variability, Correlation, Adaptive capacity, ICT, South Africa*

Introduction

In South Africa, crop production is crucially dependent on precipitation - even more so than on temperature (Province of the Eastern Cape, 2011). Historically, the Ngqushwa Local Municipality (NLM) has experienced numerous drought spells which have adversely affected crop-farming, leading to wide-spread agricultural field abandonment (Wenhold, 2007). This study focuses on the biophysical changes, including scientific analysis of the prevailing climatic regimes, particularly rainfall trends, as well the relationship between rainfall variability and crop yields for the small-scale and subsistence farmers in this rural locality.

Methodology

Rainfall data was collected from the South African Weather Services (SAWS). The monthly rainfall data from Grahamstown spans 112 years (1900-2011) while at Peddie the data are from 1900-1987 (88 years) and from King William's Town the data range from 1970-2011 (42 years). While Grahamstown is outside of the Ngqushwa Local Municiaplity jurisdiction, data from the Grahamstown rainfall station was utlilised to cater for the missing data from the other stations. Grahamstown's rainfall station is in relatively close proximity to the Ngqushwa rainfall station. To determine the correlation *r* between crop yield and rainfall variability, the mean annual rainfall scores were compared with the mean crop yield for 30 years (1982 to 2011). To analyse the long-term trend in inter-annual rainfall variability at the station for the individual recording period, the annual absolute deviation from mean annual rainfall (absolute deviation) was computed. The

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Southern Oscillation Index (SOI) values were also correlated with the rainfall data. To obtain qualitative data ten(10) focus groups were conducted with the small scale farmers.

Results

Figure 1 shows the Z-Scores for Crop Yield over 30 years. The Pearson's correlation coefficient between mean annual rainfall and estimated mean annual maize crop yield is 0.69 (**Figure 2**), which indicates a strong positive linear relationship between rainfall and crop yields. This co-efficient implies that 69% of crop yield is attributable to rainfall variability. The study area has experienced several dry spells over the 30 years.

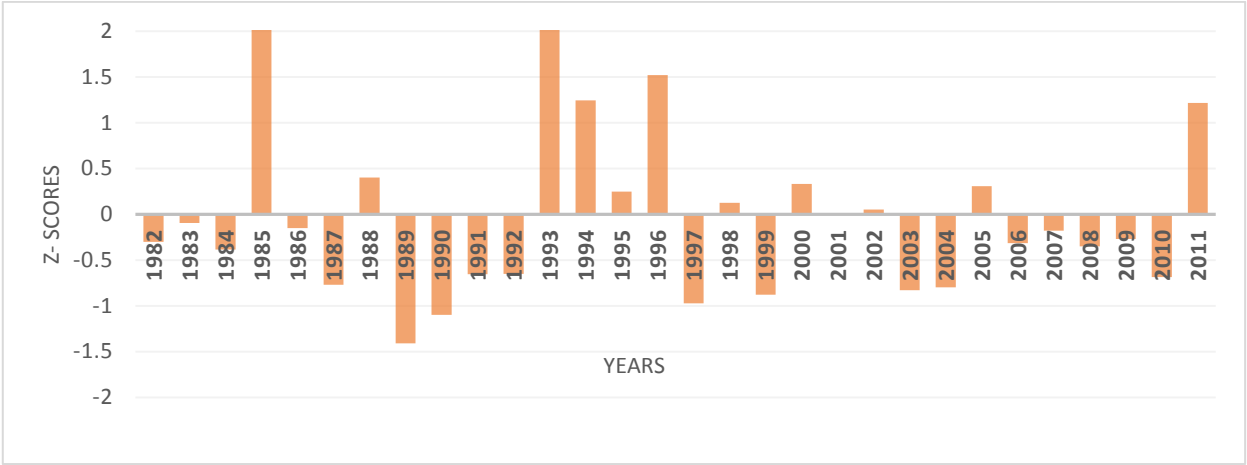

Figure 1: Z-Scores for 30 Year Crop Yield (1982 -2011)
(Source: Department of Agriculture- DoA)

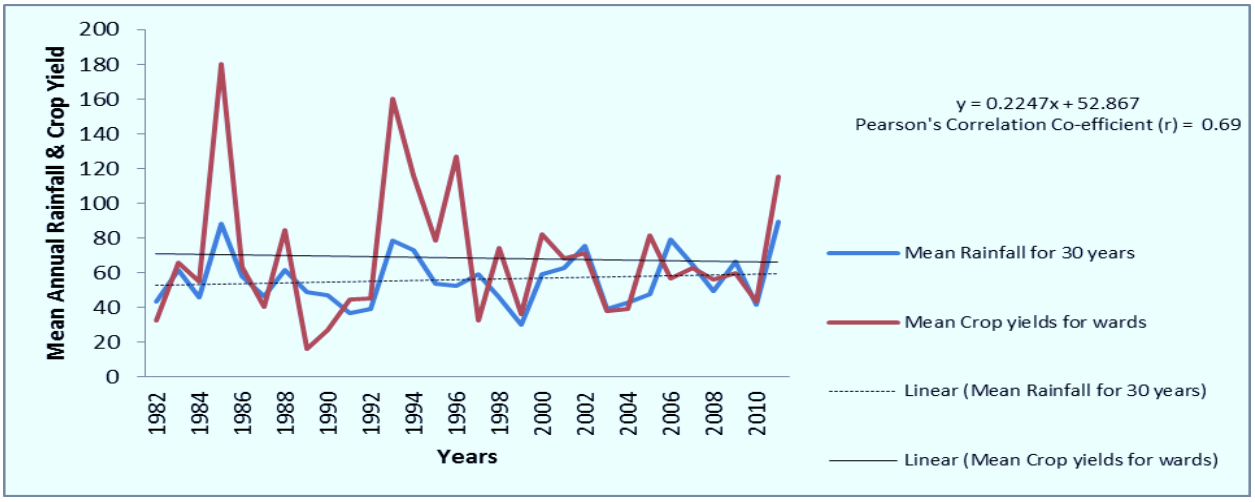

Figure 2: The 30-year Mean Annual Rainfall and Crop Yield Estimates
(Source: South African Weather Services (SAWS),DoA)

Even though both stations show an increase in precipitation concentration index (PCI) values from 1900, the increase is not statistically significant. To further test the changes in intra-annual rainfall the monthly rainfall linear trend for Grahamstown and Ngqushwa (Peddie) for the recording period were analysed (**Table 1**) and (**Table 2**). The Pearson Product Moment Correlation indicates that the rainfall of Grahamstown and Ngqushwa are strongly correlated at the 99% confidence

level (r=0.63; P<0.01). From linear regression the absolute deviation around the mean has increased from 85mm to 170mm over the 112 years. Pearson's correlation coefficient between mean annual rainfall and mean annual maize crop yield is 0.69 - which indicates a strong positive linear relationship between rainfall and crop yields.

Table 1: Intra-Annual Rainfall and Monthly Linear Trends (Source: SAWS and DoA)

Month	Linear correlation (r)	Significance (P)
January	0.02	0.87
February	0.01	0.96
March	0.14	0.16
April	0.03	0.76
May	0.06	0.52
June	0.04	0.67
July	0.12	0.20
August	0.20	0.04
September	0.06	0.52
October	0.04	0.67
November	0.05	0.59
December	0.01	0.93

The SOI values (both lagged and unlagged) have both a strong correlation and a statistically signicant relationship with rainfall trends, as well as with the crop yield trends particularly during the spring rainfall months (J-A-S-O) (**Table 2**). Therefore, the values can be used to predict rainfall trends as well as crop yields (Hyden & Sekoli, 2000; Wang & Robetson, 2011; Cobon & Toobs, 2013; Gutierrez, 2017; Muza, 2017).

Table 2: Correlation coefficient r with the relevant level of significance P between station summer rainfall and the mean SOI values for certain periods (Source: SAWS)

Rainfall period	Period of SOI values (non- lagged)	Grahamstown		Peddie	
November-March		r	P	r	P
	Nov+Dec+Jan	0.60	<0.01	0.41	<0.01
	Nov+Dec+Jan+Feb+Mar	0.22	0.02	0.40	<0.01
	Period of SOI values (lagged)				
	May+Jun+Jul+Aug+Sep	0.61	<0.01	0.35	<0.01
	Jun+Jul+Aug+Sep	0.41	<0.01	0.36	<0.01
	Jun+Jul+Aug+Sep+Oct	0.80	0.02	0.36	<0.01
	July+Aug+Sep	0.74	<0.01	0.35	<0.01
	Jul+Aug+Sep+Oct (J-A-S-O)	0.77	<0.01	0.35	<0.01

This correlated relationship is useful for determining the small-scale farmers' agricultural output, sustainable livelihoods, and viable food security. The challenge is that the study area has experienced several dry spells over the 30 years. One of the foremost applicable solutions under

such circumstances is the use of irrigation systems (IS) which are known to be relatively sustainable and predicable sources of water resources in the face of extremely desiccating climate events (Roco et al., 2017). However, in the study area there is a dearth of irrigation systems (IS). To address the absence of the IS this study finds that the relationship between SOI values, rainfall events and crop yields can be translated into a user-friendly language/ communication system which can be achieved through the use of an integrated ICT system that incorporates the ubiquitously existing communication tools which include indigenous knowledge systems, cell phones and radios. Access to climate information is crucial to achieving lasting adaptive capacity (Zamasiya et al., 2017).

Qualitative data collection revealed that the approximately situated community radio stations were suitable platforms for communicating weather/climate forecasted events for the purpose of building resilient agricultural systems and adaptive livelihood practices. In addition, the small-scale farmers use cell-phones to communicate the climate news to their peer small-scale farmers. In small-scale farmer community fora, the currently known indigenous climate prediction information is communicated. Such information still needs to be achieved, stored and broadly disseminated. There is general acknowledgement and consensus that further studies on the integration of diverse data sources are pivotal to an inclusive climate information communication system that utilises both quantitative and qualitative data sources (Loewen & Kinshuk, 2012; Myeza & Kaya, 2016; Mafongoya & Ajayi, 2017). This study shows that there is a need for the relationship between SOI, crop yield and rainfall data to be synergistically analysed and disseminated to reflect a comprehensive approach towards the achievement of localised access to climate information, as opposed to the reliance on national, regional and global quantitative climate information.

Conclusions

This study shows that while the inter-annual and seasonal rainfall trends are highly variable, there is a strong correlation between SOI values (lagged and non-lagged), rainfall trends as well as with crop yields. Therefore, the relationship betwen SOI and rainfall trends is useful for the prediction of crop yields for the NLM small-scale/subsistence farmers. Small-scale farmers in rural communities depend on rainfed agriculture, but such reliance increases vulnerability and reduces resilience for their crops and further threatens their livelihoods (Akpalu et al., 2008, Ayanlade et al., 2009). The study confirms the causal link that the limited crop yileds experienced by the small-scale farmers are the consequence of the many dry spells which had visited the farmers in the 30 years under study. In order to build adaptive capacity, this study recommends the restoration of the Peddie/NLM weather station, as well as the erstwhile alternatives of the locality such as large-scale irrigation schemes (Muza, 2017) and (ICT) interventions as early warning systems, which would be coupled with SOI aligned forecasting. This study recommends that such ICT data should include the integration of indigenous climate prediction knowledge and that the data are translated into a language which is end-user friendly for the rural small-scale farmer. The findings of this study could compel policy–makers to up-scale rural sustainable development to include the restoration, development and implementation of multi-hazard early-warning systems.

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CMIP5 GCM Selection for future climate simulations over Zvishavane, Zimbabwe

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Abstract

This study applies an objective method to select a sub-set of General Circulation Models (GCMs) that capture the diverse projections from a large multi-model ensemble. Results shows that the Fifth Coupled Model Inter-comparison Project (CMIP5) GCM projections in southern Africa are broader than the Intergovernmental Panel on Climate Change (IPCC) global averages - or inter-GCM differences are wider than single models' inter-Representative Concentration Pathways (RCPs) projections. The projections have a cool/wet versus hot/dry skewness, and a hot and dryer tendency during the period 2040-2069 under RCP8.5.

Key words: *CMIP5, CSI, AgMIP GCM Sub-setting approach, Southern Africa, Zimbabwe*

Introduction

Although *ex ante* model-based climate projections are essential in solving several societal issues, past efforts have been hampered by model selection biases which sometimes lead to policy inconsistencies and mal-adaptation (Cubasch et al., 2013; Ruane and McDermid, 2017). Past studies have also often used few General Circulation Models (GCMs), selected based mostly on availability of model outputs or reproduction of past climate. This was due to the absence of methods to evaluate GCM performance in a future climate to justify selection of one model in place of the other, given the non-linearity between past and future climate due to climate change. Despite an increase in GCMs under Fifth Coupled Model Inter-comparison Project (CMIP5) and new emission scenarios, uncertainties still exist (Lutz et al., 2016). Furthermore, using all GCMs for climate projections, vulnerability assessment and adaptation is difficult as this require substantial resources. An objective way to select a sub-set of GCMs that represent the diverse climate projections, model uncertainty and ensure that critical model properties and projections are not lost is therefore critical.

Methodology

This study uses the GCM sub-Setting approach, developed by the Agriculture Model Inter-comparison Project (AgMIP) to objectively select a practical sub-set of representative GCMs for future climate and impacts assessment without losing the model spread (Hudson & Ruane,

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2013, Ruane and McDermid, 2017). The method is similar to Semenov and Stratonovitch (2015)'s Climate Sensitivity Indices (CSIs), where each CSI is calculated as differences between GCM absolute future and baseline mean air temperature, or percentage change in precipitation against baseline values for a specific RCP and site. Temperature and precipitation change projections are selected because of their indicative large-scale energy and water budget changes which consequently affects other climate variables and thus the importance in assessing sectoral climate impacts (Semenov and Stratonovitch, 2015).

This paper analyses 29 CMIP5 GCMs' mid-century (2040-2069) projections relative to 1980-2009 baseline for Zvishavane, Zimbabwe (Lat -20.32°, Lon 30.07°), representing southern Africa during October to March period which captures the southern hemisphere/austral unimodal summer season which is determined by rainfall, under RCP8.5. The chosen site represents a large portion of southern Africa which is semi-arid.

It is a confluence of the regional climate systems as it is affected by both tropical and mid-latitudes systems, such as the Inter-Tropical Convergence Zone (ITCZ), transient westerly cloud bands and the Temperate—Tropical Cloud bands. The methodology used and parameters investigated are the most critical for southern Africa, and is applicable to southern Africa. The site is part of a DPhil Thesis which investigated three sites for many future periods under RCP4.5 and RCP8.5.

Each GCM's projected percentage precipitation change is plotted against projected temperature changes and assigned to a quadrant by classifying it as either cool or hot and wet or dry relative to the 29 CMIP5 GCM multi-model ensemble's median precipitation and median temperature absolute change, respectively. This creates four quadrants (see **Figure 1a**): "cool/wet", "cool/dry", "hot/wet", "hot/dry". An additional fifth "Middle"/"Central" quadrant is created by grouping models whose projections are within the ensemble standard deviation and multiplied by a factor (σ=0.50), meant to ensure an estimated 1/5th of GCM projections is selected.

One model (ideally closest to the quadrant centre of mass shown by a coloured dot in each quadrant in **Figure 1b**) is selected to represent GCMs in each quadrant. Some degree of subjectivity is allowed in the choice of representative after considering issues such as model consistency across time scales and RCPs, availability of comparative studies, models' ability to represent atmospheric circulations, or better representation of the class of model. For example, choosing a dryer and hotter model (than centre of mass) is preferred for dry/hot quadrant than choosing the wettest and coolest model in that quadrant. Diagonal and extreme skewness of each site's projections is assessed by checking if more than 60% (#GCMs>17.4) of the GCMs are in one diagonal orientation and if any quadrant has less than 20% of GCMs (GCMs<5.8), respectively. Skewness and spread of projections which reflect model uncertainty is quantified by calculating each quadrant's weighting factor ($W_{quadrant}$) i.e. dividing the number of GCMs in each quadrant by the total number of GCMs in the ensemble ($W_{quadrant} = N_{quadrant}/N_{Total}$).

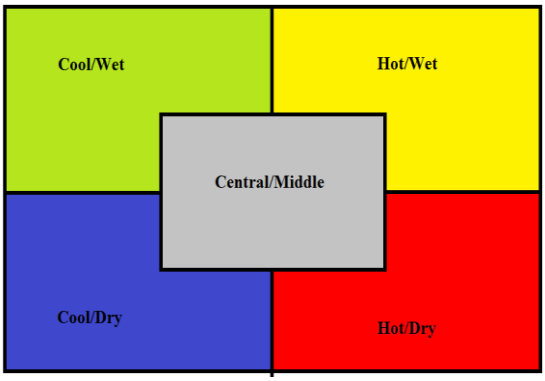

Figure 1a. Characterisation of GCMs using T &P Sub-setting Approach (Source: after Ruane and McDermid, 2017)

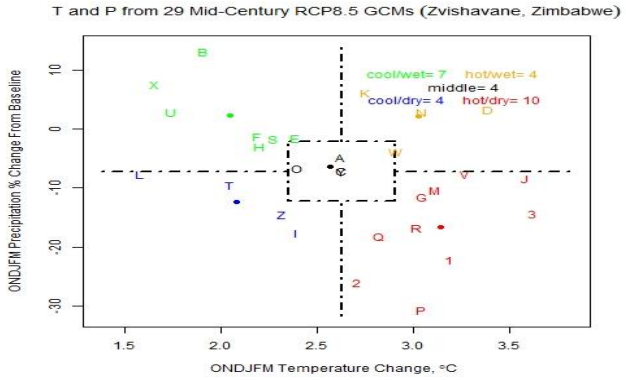

Figure 1b. Zvishavane RCP8.5 CMIP5 projected temperature and precipitation change (represented by AgMIP GCM IDs[4]) for the 2040-2069 period against 1980-2009 baseline (Source: Authors own, after Ruane and McDermid, 2017)

Findings

Based on the model selection criteria described above, selected GCMs are: HadGEM2-ES (Hot/Wet), GISS-E2-H (Hot/Dry), GFDL-ESM2G (Cool/Wet), NorESM1-M (Cool/Dry) and ACCESS-1-0 (central), **Figure 1b**. Projections are exhibiting *hot/dry vs. cool/wet diagonal skewness* with the quadrant weights (W_q) suggesting the highest probable projections being hot/dry conditions (34%) (see **Table 1**).

Furthermore, the projected ensemble precipitation median is -8% and 'dry' models' precipitation reductions are much larger projections than the wet models' projected precipitation increase as the entire ensemble range is+12% to –34%. Precipitation projections are also more variable than temperature. All GCMs project varying degrees of temperature rise ranging from 1.6°C to 3.7°C with a median of 2.7°C. It is therefore critical to note that even GCMs regarded as cool according to the Approach are still projecting absolute temperature rise and GCMs regarded as wet may still be projecting precipitation reduction given the precipitation and temperature ensemble medians are -8% and 2.7°C respectively. The projected rates of warming and precipitation changes are above the Inter-governmental

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4 Legend

AgMIP CMIP5 GCM IDs

A = ACCESS1-0
B = bcc-csm1-1
C = BNU-ESM
D = CanESM2
E = CCSM4
F = CESM1-BGC
G = CSIRO-Mk3-6-0
H = GFDL-ESM2G
I = GFDL-ESM2M
J = HadGEM2-CC
K = HadGEM2-ES
L = inmcm4
M = IPSL-CM5A-LR
N = IPSL-CM5A-MR
O = MIROC5
P = MIROC-ESM
Q = MPI-ESM-LR
R = MPI-ESM-MR
S = MRI-CGCM3
T = NorESM1-M
U = FGOALS-g2
V = CMCC-CM
W = CMCC-CMS
X = CNRM-CM5
Y = HadGEM2-AO
Z = IPSL-CM5B-LR
1 = GFDL-CM3
2 = GISS-E2-R
3 = GISS-E2-H

Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) global projected average precipitation rates(1 to 3% $^{o}C^{-1}$) (Cubasch et al., 2013).

Table 1: Zvishavane CMIP5 representative GCMs and quadrant weights for 2040-2069 under RCP8.5 (Source: Authors own)

Quadrant	Representative GCM	RCP8.5 Mid Century Wquadrant
Central	ACCESS 1-01	0.14
Hot-Wet	HadGEM2-ES	0.14
Cool-Dry	NorESM1-M	0.14
Hot-Dry	GISS-E2-H	0.34
Cool- wet	GFDL -ESM2G	0.24

HadGEM2-ES and GISS-E2-H models' distinct and consistent hot/wet and hot/dry respective projections concur with Ruane and McDermid (2017)'s findings for southern Africa. Results, however, bring out the masking effect of averaging large regions; comparisons with Lutz et al. (2016)'s precipitation CSIs for 18 CMIP5 GCMs for southern Africa show projected precipitation decrease (-27%), even for models such as HadGEM2-ES which are projecting rise (+7%) for these parts of the same region. This further stresses the need to understand models' projections for specific sites, seasons and periods, each model classification (relative to other GCMs within the ensemble), and possible sources of uncertainties before use of results in adaptation planning.

Conclusion

The approach allows objective selection of manageable representative GCMs which preserves the projection spread and enables passing on the confidence levels to impact assessments and adaptation planning. It enables determination of climate risk and possible adaptation solutions by showing probabilities of specific type of projections, including any skewness for specific geographic sites, Representation Concentration pathways (RCPs) and seasons. It also overcomes the masking effect of multi-model ensembles or averaging large spatial areas since the result shows that the projected precipitation changes for the specific sites vary greatly with GCMs and location in southern Africa. Furthermore, it also helps to design further analyses to understand the model physics, probability of certain projections and determination of current and future climate risks (climate prediction). CMIP5 projections show higher chances of a hot and dryer future climate for southern Africa which increases future climate predictability for better adaptation planning and policy-making. Whereas adaptation efforts consider the projections diversity and probabilities in adaptation planning, further research is needed to understand the physical basis of the differences in projections.

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Monitoring vegetation dynamics and ecosystem service provision in semi-arid Bobirwa sub-district of Botswana using MODIS-NDVI time series data from 2000-2015

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Abstract

Our study uses freely available, remotely-sensed Normalized Difference Vegetation Index (NDVI) data and participatory processes to examine the links between vegetation dynamics and recent changes in the delivery of key ecosystem services in the semi-arid Bobirwa sub-district in the Limpopo Basin, Botswana. The results show that degradation in the study area is provoked by both human activity and adverse climate with pronounced consequences on the delivery of key local ecosystem services.

Keywords: *NDVI, Remote Sensing, Time Series, Semi-arid Regions, Provisioning Ecosystem Services, Botswana*

Introduction

Vegetation dynamics provide critical information for both explaining and understanding land degradation and recent changes in the delivery of local ecosystem services. More so, changes in remotely-sensed vegetation conditions provide a novel way to further understand both climatic and anthropogenic drivers of change in the flow of benefits from ecosystems and the changes in human dependence on the natural environment. Despite this importance, there exists a knowledge gap in southern Africa, particularly in Botswana, regarding the use of freely available remotely-sensed time series data to study vegetation dynamics over space and time, and how this can be linked to changes in human well-being. Coarse scale analyses using GIMMS NDVI3g data fail to fully account for local level trends. This paper presents a step-by-step methodology to authenticate recent trends (Brandt et al., 2014), and explain the implications on the delivery of provisioning ecosystem services in semi-arid Bobirwa sub-district, Botswana.

Methodology

This research examines the temporal and spatial dynamics of surface vegetation in semi-arid Bobirwa sub-district (Botswana) in the Limpopo Basin, using time series remotely-sensed NDVI data. It was undertaken in order to understand the effect of local climate and human activity on vegetation conditions, as well as draw implications of the observed changes on the delivery

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of provisioning ecosystem services which constitute an important part of human well-being and a potential adaptation strategy to changing climate.

The study complements non-participatory techniques with participatory methods through use of remote-sensing and focus group discussion techniques in data poor regions. Global Inventory Monitoring and Modeling Studies (GIMMS) and Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) time-series data is used to examine vegetation dynamics over Bobirwa sub-district, as well as to identify the underlying drivers. The Maximum Value Composite (MVC) is used to examine the spatial and temporal trends in vegetation conditions using GIMMS and MODIS NDVI data.

Results

Long-term time series data

Initially, long-term, coarse-scale vegetation trends were derived and analyzed. Composites of the Global Inventory Modeling and Monitoring Studies (GIMMS) dataset, covering the period 1982-2015 with a temporal resolution of 15 days and a spatial resolution of 8km was used. GIMMS is currently thought to be sensor-corrected, being consistent with NDVI from SPOT Vegetation and MODIS Terra satellites (Tucker et al., 2005).

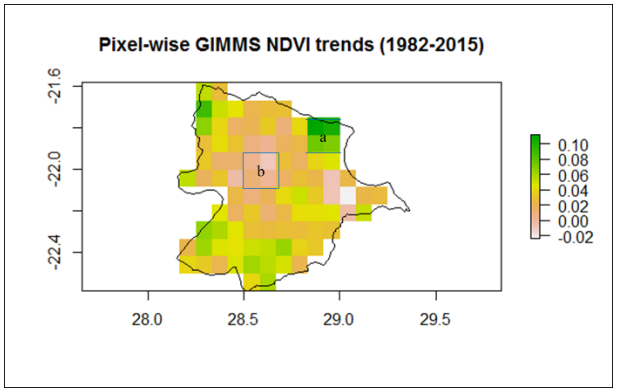

Figure 1. (a) Spatial trends in annual maximum GIMMS NDVI for Bobirwa sub-district for the period 1982-2015. Spatial variations can be observed at a scale of approximately 9km (Source: Authors own)

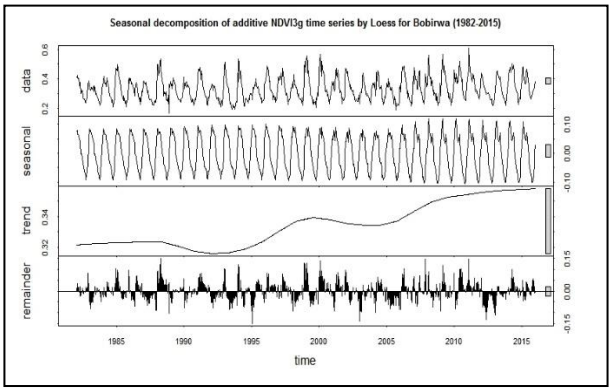

Figure 1. (b) Decomposed trends in annual maximum NDVI for Bobirwa sub-district using GIIMS data (1982-2015)(Source: Authors own)

Figure 1 (a) shows that greening and browning is spatially distributed, while **Figure 1 (b)** shows gives an idea of a generally increasing trend in vegetation conditions for the 34-year period. While **Figure 1(a)** shows areas undergoing degradation (browning), as well as those where vegetation conditions are improving (greening), the increasing NDVI trend shown in **Figure 1(b),** a spatial average of **Figure 1(a)** masks these dynamics. This masking of actual trends also exists in the pixels due to the coarse resolution; hence the need to refine the analyses on those portions undergoing significant greening and browning.

Medium resolution time series data

Areas showing both positive (greening) and negative (browning or degradation) trends (portions marked *a* and b in Figures 1 (a) and 2(a), respectively) were further analyzed using Moderate Resolution Imaging Spectroradiometer (MODIS) time-series dataset. The MODIS dataset has a spatial resolution of 250m, hence trends can be observed at the village/community level. We used a smoothed Maximum Value Composite (MVC) for the period 2000-2015.

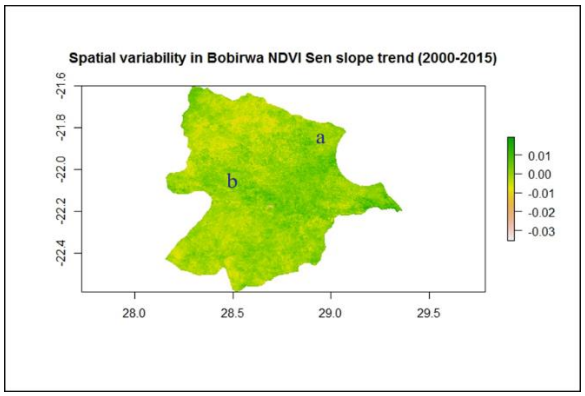

Figure 2. (a) Spatial variability spatially (Source: Authors own)

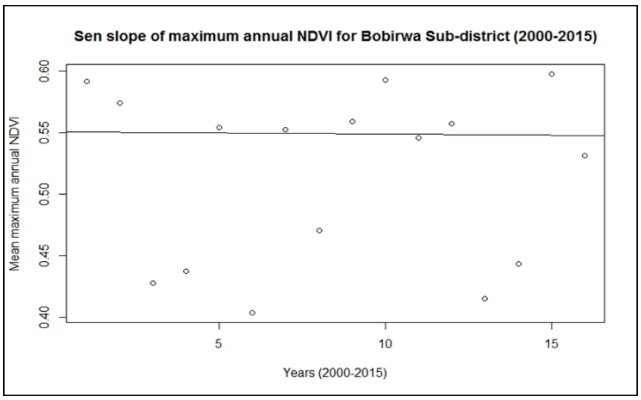

Figure 2. (b) MODIS NDVI Sen slope trends for Bobirwa for the period 2000-2015. Spatial variations can be observed at a scale of 250 m for smaller areas (Source: Authors own)

For the 16-year period, **Figure 2 (a)** also shows that greening and browning are spatially distributed and non-uniform. However, the Thiel Sen Slope in **Figure 2 (b)** reveals an overall decline in the maximum NDVI value for the same period, indicating declining vegetation conditions.

Field observations

Field observations around 8 villages revealed various land-use and/or land-cover types, vegetation types and prevailing ecosystem conditions. Signs of the impacts of climate extremes, drought and human pressure were also visible. Vast areas of bare land, gullies and spreading Acacia trees were observed around the villages. It was common practice to leave important trees (e.g. *Colophospermum mopane* and wild fruits) around the village settlement, homesteads and on crop fields. Trees and shrubs around crop fields were also left uncleared. Dry land farming was also being illegally practiced at the 'cattle posts' (communal grazing area). Irrigated farming on private farms and protected areas were also other land-uses observed. Nonetheless, actual cause of the trends was not obvious.

Key provisioning ecosystem services

A total of 15 key provisioning services were identified. These were cultivated crop production, livestock production, fresh water fish, wild fruits, wild foods (Mopane caterpillars and game), timber and poles, thatch, palm plants, natural pastures, natural medicines, fresh water, biomass fuel, dyes, sand mining and precious stones. The land-use and/land-cover types providing these ecosystem services were woodlands, crop lands, grasslands, water bodies, barren land, built-up areas (settled areas) and privately owned-farms.

Community insights

A combination of participatory mapping exercises, focus group discussions and one-on-one interviews with the local communities concurred that the surrounding environment was deteriorating. The local communities explained vegetation loss and degradation as mainly due to:

- Recurring droughts almost every 3-4 years
- Erratic and poorly distributed rainfall (both spatially and temporally)
- Legal and illegal clearing of woodland for crop production and firewood
- Overgrazing especially from increasing livestock population

- Erosion and gullies from sudden heavy downpours
- Damming of major rivers upstream

However, the local community also explained the greening in some parts as due to:

- Proliferation and spreading of more drought tolerant vegetation species (especially Acacias and *Hyphaene petersiana*)
- Conservation of woodlands and important tree species
- Several river channels in the sub-district, some of which drain into Limpopo River

The community expressed concern that recurring droughts, damming of rivers upstream, FMD-induced overstocking and population pressure could further deteriorate vegetation conditions. This also meant a decline in water availability, cultivated crop yields, natural pastures, natural medicines, livestock production, Mopane caterpillars, palm leaves for basketry, wood fuel, timber, wild fruits and thatch. With Botswana being among the top African countries expected to surpass the 1.5°C threshold set by the Paris Agreement (Nkemelang et al., 2018), the decline in vegetation and key ecosystem services reported in our study may perhaps become magnified not only locally but also globally in other semi-arid regions.

Conclusion

Our study highlights the importance of integrating participatory and non-participatory techniques to validate research findings. Local knowledge is critical for explaining observed trends in remotely-sensed vegetation conditions, especially in data poor regions. As a proxy for environmental condition, vegetation trends were linked to reported trends in the delivery of key ecosystem services in semi-arid Bobirwa sub-district. Although climate is shown to be an important driver of vegetation condition, human pressure is also contributing to these spatial variations. However, we showed that the actual drivers of change can be revealed through field observations and community insights. As such, vegetation greening patterns alone give inconclusive evidence as discussions with local communities revealed contrasting patterns concerning the delivery of certain key provisioning ecosystem services. Further studies should therefore investigate changes in species composition and distribution to explain the greening and browning of vegetation.

Acknowledgements

This work was carried out under the Adaptation at Scale in Semi-Arid Regions project (ASSAR). ASSAR is one of five research programmes funded under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DfID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.

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Responses to dynamics in ecosystem service provision in semi-arid Bobirwa sub-district, Limpopo Basin part of Botswana

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Abstract

This research investigates the drivers of ecosystem degradation and the associated consequences on rural livelihoods, including how the local people have been responding to fluctuations in key provisioning ecosystem services in Bobirwa sub-district, Botswana. Household survey, participatory mapping exercises and a review of national policies were used to assess local adaptation responses. From the findings, we conclude that current individual responses are reactive, haphazard and unsustainable in the long-term, while government initiatives are constrained by several technical capacity and implementation challenges.

Keywords: *Provisioning Ecosystem Services, Semi-arid regions, Barriers, Transformation, Botswana*

Introduction

The close connection between human well-being and local ecosystem services depends on well-functioning ecosystems. However, alterations in cultivated lands, woodlands, grasslands, wetlands, water bodies and built up areas imply variable consequences on the delivery of local ecosystem services and hence livelihoods, well-being and adaptive response capacity to additional impacts emanating from climate change. Among other consequences, changes in the provision of ecosystem services modify the close connection and dependence between human livelihoods and their surrounding environment in significant ways. Environmental change is also modifying ecosystem functioning, human-nature relations as well as both human and ecological systems.

In Bobirwa sub-district (and Botswana in general), smallholder farming (crop and livestock production) and exploitation of the natural environment remain the most dominant livelihood activities among the rural people, and significantly contribute towards employment, food and income for many households (UNDP-UNEP PEI, 2013). Like much of Botswana, Bobirwa sub-district is a semi-arid hot spot, with mean annual rainfall ranging from 300-400 mm, while mean annual temperature is often greater than 22°C. Previous research has shown that there is growing evidence of ecosystem deterioration and degradation (Dube and Sekhwela, 2007, 2012).

Using Bobirwa sub-district as a case study, this research identifies ways through which local people in semi-arid regions have been responding to recent changes in the delivery of local provisioning ecosystem services and assesses the effectiveness of their responses to both the impacts and the drivers of recent changes. A special focus is given to the challenges and

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barriers to current adaptation initiatives at the local level, which consequently constrain their adaptive response capacity. Lastly, some concrete measures which may be implemented in order to transform current adaptation initiatives at the local level to modes which are more effective, widespread and sustainable are outlined.

Methodology

This research aimed to understand how shifts in the delivery of provisioning ecosystem services affects livelihoods of semi-arid communities and to understand how the local communities are responding to these shifts in ecosystem services.

This paper uses a case study approach. Eight participatory mapping exercises and focus group discussions, 310 household interviews and numerous field visits were conducted in 8 villages in Bobirwa sub-district in the Limpopo Basin part of Botswana between February 2016 and March 2018. Data analysis for participatory mapping, focus group discussions and key informant interviews was achieved through thematic analysis, while Statistical Package for the Social Sciences (SPSS) ver. 24 was used to summarise and analyze data from the household interviews. A review of related government policies and programmes was carried out to further understand local adaptation initiatives.

Results

Changes in ecosystems in Bobirwa sub-district over the past decade can be summarised by these trends:

- Adverse impacts of climate and weather variability e.g. frequent droughts,
- Increased demand of agricultural land and other forest resources leading to land-use changes and over exploitation, and
- Degradation of the natural environment leading to declining ecosystem capacity.

Through fieldwork undertaken, almost all the key ecosystem services considered were reported to be declining (see **Figure 1**). Several factors interacting in different ways ranging from adverse weather, droughts, land-use and land-cover change, overexploitation and overgrazing were identified by local communities as the major drivers of change.

The linkages between several drivers of change and key provisioning ecosystem services often results in several adverse impacts on both the delivery of ecosystem services and local livelihoods, as shown in **Figure 2**.

Figure 2 shows the various drivers of change (column 1), which were reported to be driving changes in key local ecosystem services (column 2). The influence of one or more of these drivers of change were reported to directly or indirectly result in fluctuations in the delivery of important ecosystem services (column 3), with several adverse consequences on local livelihoods and well-being (column 4).

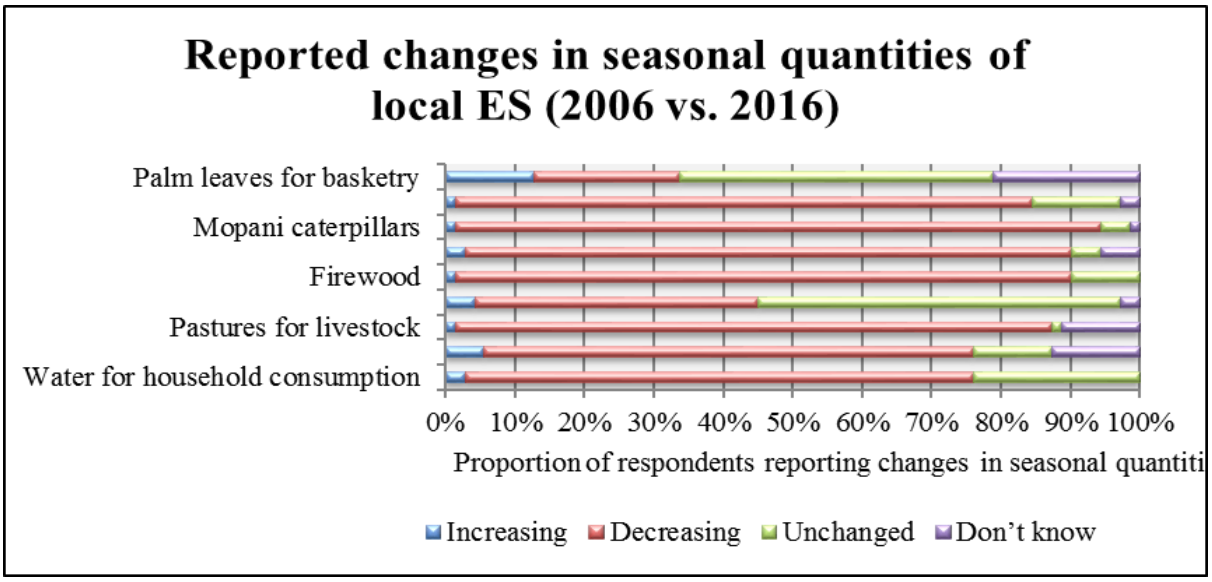

Figure 1. Reported changes in seasonal quantities of selected local provisioning ecosystem services (Source: Authors fieldwork, 2016)

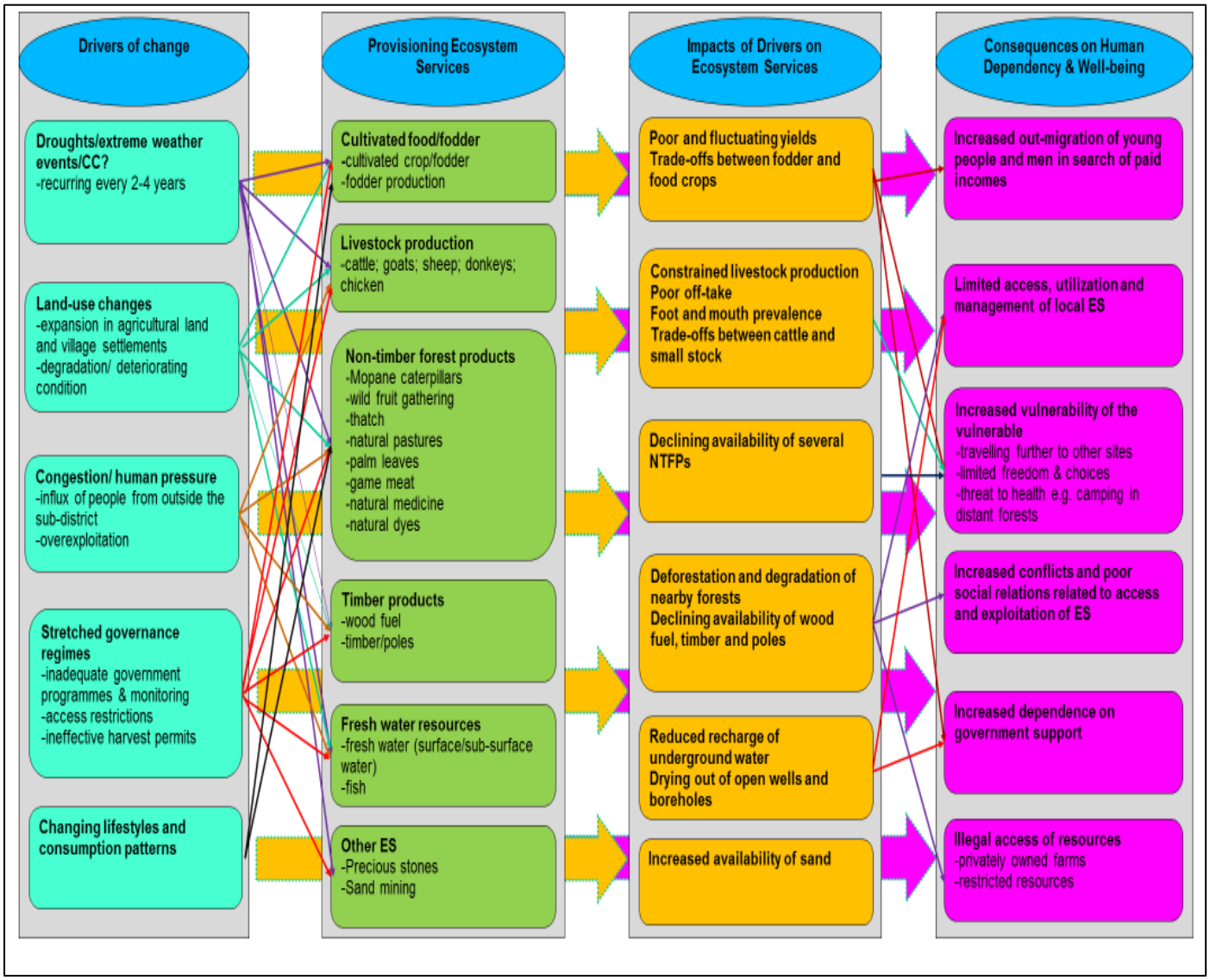

Figure 2. Linkages between drivers of change, provisioning ecosystem services, human responses and well-being consequences (Source: Authors fieldwork, 2016)

Similar to other semi-arid regions, **Figure 2** simplifies what in reality are complex interactions and feedback mechanisms which often result in unanticipated and undesirable consequences on local livelihoods and human well-being. Consequently, this often triggers individual, haphazard, reactive and uncoordinated responses by local people - some of which further expose their livelihoods and well-being to climate impacts, as explained in the next section.

Community level responses to changes in provisioning ecosystem services

As evidence and consequence of adverse changes in local ecosystems, local people now need to walk longer distances to sites providing some of the key provisioning ecosystem services (**Figure 3**). Such changes often affect women and children, who are typically more vulnerable and exposed to various risks. For instance, as ecosystem service sites become further and further away, locals end up spending more days and weeks camping in distant forests to collect food resources, such as Mopane caterpillars. This exposes them to harsh weather conditions, snake bites, conflicts around resource access and diseases due to a lack of sanitation facilities.

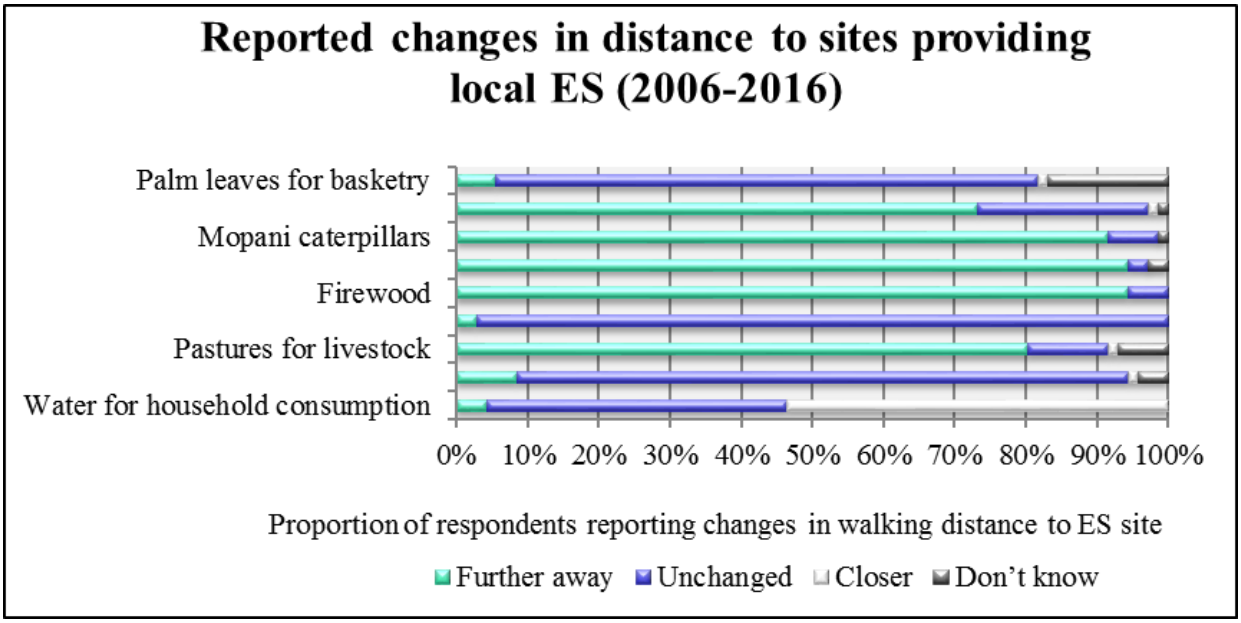

Figure 3. Reported changes in distance to sites providing local provisioning ecosystem services (Source: Authors fieldwork, 2016)

In addition to the response in **Figure 3**, other reactive, haphazard, unplanned and unanticipated responses reported by the local communities include:

- Overexploitation of local resources such as firewood, Mopane caterpillars and thatch and stowing away for future use,
- Migrating to other villages to explore uncongested ecosystem services sites, or urban areas seeking alternative livelihood opportunities,
- Coping with the reduced quantities of local resources,
- Camping in distant forests/woodlands for longer periods than previous years,
- Spending more time and effort to harvest same or reduced quantities than before,
- Taking up government agricultural assistance programme packages, such as the Integrated Support Programme for Arable Agricultural Development (ISPAAD) and fail to utilise all inputs and/or to adhere to stipulated guidelines for improved yields, and

- Legal (area designated for crop fields) and illegal (area designated for communal grazing) clearing of woodlands to increase area under crops.

Government support programmes

The Ministry of Agriculture Integrated Support Programme for Arable Agricultural Development (ISPAAD), initiated in 2008 with the aim of improving smallholder farmer grain productivity and food security through input subsidies, is failing to yield intended results. Despite providing farmers with free inputs and extension services, grain yield has largely remained stagnant around 333kg/ha against a target of 1000kg/ha with previous study showing high preference for growing maize compared to the more drought tolerant sorghum, millet and cow peas (MOA, 2013). Failure to recognise the agro-ecology of crops grown, lack of adequate agronomic knowledge among farmers, inadequate extension services and underutilisation of inputs have been cited as the main challenges to this programme.

Another government Poverty Eradication Programme through the Department of Forestry and Rangeland Resources which assists poor households with food baskets, transport costs and harvesting materials to harvest Mopane caterpillars (*Imbrasia belina*) at distant communal grazing areas has its own challenges. Inappropriate human and other waste disposal around the camping sites has often led to conflicts with livestock farmers after their livestock consumed the waste, and thereafter the farmers suffered economic losses from livestock diseases and deaths. More so, the harsh weather conditions, unhygienic environment and snakes at the campsites increase the vulnerability of young children and women. Inadequate monitoring mechanisms and stretched resources implies overexploitation of Mopane caterpillars, thatch and firewood continues unmonitored, further threatening future availability.

Conclusion

Evidence gathered in this paper is critical for local people, government and organisations interested in local adaptation initiatives to the impacts of climate change on the natural environment. Some of the outlined measures to influence specific action to respond to the adverse impacts of climate on the delivery of local provisioning ecosystem services can be an important entry point for influencing policy and practice with regards to the management of local ecosystem services. However, the extent to which this can be achieved depends on the level of government commitment to supporting local initiatives to addressing the climate change threat.

Our study shows that the current individual responses at community level are reactive, haphazard and unsustainable in the long-term. Unplanned and sporadic responses clearing of woodlands to increase area under dry land crops often create several adverse trade-offs on the delivery of other ecosystem services such as Mopane caterpillars (from Mopane woodlands), natural medicines, natural pastures and thatch. Although targeted at the poor, our study noted that government assistance programmes such as ISPAAD have been less effective and often suffer from sub-optimal utilisation of inputs as well as failure to adhere to recommended guidelines for better yields. If well-implemented, government assistance programmes have the potential to effectively support local communities adapt to changing climate while contributing towards rural development, including the well-being aspirations of the poor households and vulnerable social groups.

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Aligning theory and practice in urban resilience: development of a roadmap for climate resilient cities in the Netherlands

Robin Noordhoek[1], Robin S. de Graaf[1], Marcela F. Brugnach[2]

Abstract

Many cities around the world struggle to implement measures that make them more resilient to pluvial flooding. Scientific literature describing successful interventions in practice is scarce. Three case studies were carried out to analyse cities that have successfully managed to implement a resilience strategy. The findings from these case studies were used to develop a roadmap for climate resilient cities in the Netherlands. The roadmap provides municipalities with practical advice on how to develop an adaptation strategy and implement measures.

Key words: *Climate adaptation, Resilient cities, Urban governance, Roadmap, The Netherlands*

Introduction

The world is urbanising at a rapid rate. Currently, half of the world's population is living in urban areas, and this figure is expected to increase to 68% by 2050 (United Nations, 2018). Climate change can increase the vulnerability of these urban areas to floods, heat stress and drought (IPCC, 2013). Cities are already vulnerable to extreme rainfall due to the dominance of impervious surfaces. These impermeable surfaces (such as roads, roofs, etc.) are less capable of absorbing rainfall and therefore increase the intensity of rainfall run-off. Given these trends, pluvial flooding is likely to increase in both occurrence and intensity for many cities around the world (Hunt & Watkiss, 2011).

Therefore, drainage and stormwater systems need to be improved to counteract the effects caused by urbanisation and climate change. Studies show that extreme precipitation cannot be dealt with efficiently through conventional sewage systems alone, but that other approaches should be considered as well (Ahiablame, Engel, & Chaubey, 2012). This implies that public space should be designed in such a way that it has a beneficial impact on retention and infiltration capacities, calling for a more holistic approach to urban water management by integrating the entire water cycle into the urban design process. This includes promoting local stormwater retention and infiltration measures, reuse, and blue-green infrastructure (Wong, 2006). Ideas about ways in which cities could become more climate resilient are abundant. However, local governments struggle to put these theories into practice and lack guidance in developing concrete climate adaptation plans that are catered to their area's specific characteristics (Qiao, Kristoffersson, & Randrup, 2018). Moreover, actual implementation of measures remains troublesome (Aylett, 2015).

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This gap between theory and practice is problematic for local governments because the available literature is not well aligned with the characteristics and contexts of actual projects carried out in urban areas. In general, cities need more information in three stages of the process to better align theory and practice: 1) knowledge about local effects of climate change and suitable solutions, 2) setting clear (future-proof) goals that are effective and feasible and 3) knowledge about how to successfully implement their plans (Tyler & Moench, 2012). This research aims to contribute to the domain of climate adaptation by proposing recommendations to bring theory closer to practice, improving the ability of local governments to develop solutions that are tailored to their specific characteristics.

Methodology

The objective of the research was to show how local governments can make their public space more resilient by developing a roadmap that clarifies how they can successfully implement sustainable stormwater management measures to decrease flood vulnerability. First, the most important barriers and drivers to municipal climate adaptation were distinguished from a literature study. Then, three cases studies were carried out in order to assess if these barriers and drivers were also encountered during the development of resilience strategies for the cities of Rotterdam (NL), Amsterdam (NL) and Hoboken (USA). The case studies consisted of a thorough study and summary of secondary data such as policy documents from each city, which was validated by conducting semi-structured interviews with city officials. The results of the literature study and the case studies were then compared using a 'pattern matching' technique (Cao, 2007). Pattern matching compares theoretical patterns (derived from literature) with observed outcomes from empirical research (the case studies). This led to the identification of matches and mismatches between theory and practice. These findings were then used as input for the development of a roadmap for climate resilient cities, of which the outline was jointly developed by Arcadis and a number of Dutch municipalities and water authorities over the course of three workshops.

Results

To distinguish the theoretical and empirical patterns for successful adaptation, the classification of barriers and drivers as defined by Measham et al. (2011) is used, as it specifically targets municipal implementation of climate adaptation. Three main categories are distinguished: information, resources and institutional arrangements. In total, 11 theoretical patterns were identified from literature. These patterns served as an *a priori* framework of analysis for the case studies. A number of similarities and differences between best practices from theory and everyday practice were identified. In **Table 1**, an overview of the pattern matching results is presented.

Table 1: Overview of matches, partial matches and mismatches between theory and practice (Source: Authors own)

	Theoretical pattern	Empirical pattern	Match?
Information	Raise awareness through a public campaign.	Awareness was created not only through campaigns, but also directly after flooding took place (window of opportunity).	Yes
	Gather knowledge about (projected) climate change impacts and available solutions. Collaborate within established innovative networks.	Knowledge about impacts and solutions is gathered through internal and external networks. Collaboration takes place within established innovative networks.	Yes

	Assess exposure, sensitivity, and adaptive capacity to prioritise the most important impacts. Set up a decision-making framework to select and prioritise adaptation actions.	Extensive assessment of exposure and sensitivity has taken place. Adaptive capacity focuses on physical aspects, but not on governance. This impairs the implementation decision-making process.	Partly
	Design a monitoring and evaluation framework that uses both process-based and outcome-based indicators. Periodically review and update the plans.	Output-based indicators are often used, municipalities struggle to formulate outcome- and process-based indicators or use them only implicitly. Periodical review takes place.	Partly
Resources	Build organisational capacity to assess vulnerability, risk, and adaptation options by appointing a dedicated municipal adaptation team or department.	Building organisation capacity can take place through setting up one specialised municipal department, but also through smart internal networks ('mainstreaming') or by engaging with external parties.	No
	Ensure political commitment and financial resources by addressing the urgency and the positive effects of adapting on the short term.	Awareness and sense of urgency are key to maintaining political commitment and allocation of financial resources. Co-benefits are stressed to make the issue tangible.	Yes
	Facilitate implementation by involving private parties to gain access to money and experience.	Different approaches. Rotterdam and Hoboken have a history of implementing mainly large-scale, centralised solutions. This minimises the complexity of implementation, but also limits cooperation. Amsterdam co-designs with private parties and stimulates them to invest.	Partly
Institutional arrangements	Establish one clear team leader who connects all parties necessary.	One clear team leader who connects all parties necessary was established.	Yes
	Set clear goals, objectives, and targets, incorporating time and location. Develop them jointly with key stakeholders.	Goals, objectives, and targets are set, yet sometimes somewhat vaguely formulated. All cities prefer effect-oriented rather than normative approaches. Joint development of goals with external stakeholders does not take place.	Partly
	Explicitly investigate stakeholders and state with whom, when, and how to communicate and collaborate.	Detailed stakeholder analyses take place. Detailed communication plans are in place, but participation receives less attention in one case. Cities have trouble differentiating between informing, consultation, partnerships and co-creation.	Yes
	Establish tools and strategies for the integration of adaptation activities within municipal departments	Integration of adaptation activities depends on the way the programme is organised (centralised vs. network approach).	Partly

The pattern matching results indicate where the main gaps between theory and practice can be found. These gaps were addressed in the roadmap. In order to synthesise the findings from this research into workable advice for municipalities, two further steps were undertaken. First,

workshops were organised with municipalities and water authorities to find a suitable way of representing the climate adaptation process. Secondly, based on the outcomes of the pattern matching, tangible recommendations for municipalities were presented which were used during the development of the roadmap.

The roadmap distinguishes 8 steps, divided over two cycles: a strategic cycle in which policy development takes place, and an operational cycle that takes into account the actual implementation or construction of adaptation measures. The participants of the workshops indicated that the connection between these two cycles proved problematic in their current day-to-day routines. The roadmap incorporates loops to connect strategic (policy development) and operational (implementation) aspects. Furthermore, the roadmap provides concrete recommendations on how to utilise other drivers for successful adaptation, such as improving the adaptive capacity of municipal organisations and increasing citizen engagement. It is intended that the use of the roadmap is evaluated with its users to further improve effectiveness and applicability.

Conclusion

A large number of actions to successfully implement sustainable stormwater management measures have been identified from both literature and the case studies. Pattern matching proved useful to identify and understand differences between theory and practice in climate adaptation. A number of mismatches between theory and practice were found. In order to improve successful implementation of sustainable stormwater management measures, a number of recommendations were made to align theory and practice. These include three main takeaways for cities:

1. Focus on paradigm changes instead of meeting regulatory standards,
2. Assess governance as part of the adaptive capacity analysis and
3. Improve citizen engagement.

Main takeaways for researchers and policy-makers include acknowledging the context-specificity of climate adaptation to ensure efficient engagement and strategy development, and providing more guidance for municipalities in developing outcome-related adaptation indicators. So, in order to successfully align theory and practice, there are both challenges for science and local governments that need to be overcome. The challenges and recommendations that apply to municipalities were then incorporated into a roadmap for climate resilient cities, offering municipalities practical advice on how to develop an adaptation strategy and implement measures. Recommendations for further research include application of the methodology to more case studies in order to improve the validity of the research, as well as evaluating the use of the roadmap. This could possibly bring to light further recommendations on aligning theory and practice for policy-makers.

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Towards creating actionable knowledge in rice farming systems in Northern Ghana: the role of information systems

Andy Bonaventure Nyamekye[1], Art Dewulf [1], Erik Van Slobbe[2], Katrien Termeer[1]

Abstract

Information systems have been estimated to contribute to information provision and actionable knowledge creation for decision-making in rice farming systems. This, however, has been questioned within literature; suggesting not much impact on actionable knowledge creation for decision-making in rice farming systems. The study launches a probe into what information systems exist in rice farming systems in northern Ghana, their characteristics, their role in actionable knowledge creation, and opportunities to improving their relevance and impact in rice farming systems.

Keywords: *Information System, Actionable Knowledge, Decision-making, Ghana*

Introduction

In Ghana, farmers operate in a knowledge-based system with information systems playing a central role (Agyekumhene et a l, 2018; Annan and Dryden, 2015). Farmers, water managers and other actors at the local level interact with these information systems that are set-up with the aim of eliminating spatio-temporal barriers encountered by rice farmers. Although being found in a web of information systems presents opportunities, rice farmers must make sense of what information is communicated and adopted in their decision-making when confronting challenges such as water scarcity, pests and diseases. This study adopts an exploratory approach in answering the key question "what information systems are currently enabling actionable knowledge creation for decision-making in rice farming systems and to what degree is the knowledge produced actionable"?

Cross and Sproull (2004) suggest that information seekers do not only seek to obtain input from providers, but also undergo a process of constructing understanding based on social and physical circumstances. Cash et al. (2003) indicate that salience, credibility and legitimacy are three key characteristics of actionable knowledge. In borrowing from Cash et al., we use salience to refer to when scientific information is made responsive and context sensitive to the needs of decision-makers (see also Kirchhoff et al., 2013). Credibility delves into information being made accurate, of high quality and valid in a given system. Legitimacy is interpreted as where information is translated into knowledge in an open and unbiased process. In the end, knowledge that is actionable should translate into uptake and use in decision-making.

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Methodology

The study uses an exploratory design in establishing insight into the subject of information, knowledge creation and how actionable these are in enabling adaptive decision-making in rice farming system. Exploration is essential in validating scientific conclusions (Jebb et al., 2017). A total of 27 rice farmers were selected from nine communities around the Bontanga scheme in the Kumbungu district (See **Figure 1**). Thus three farmers (1 rainfed, 1 irrigated, 1 practicing both) were interviewed in each community. Two Focus Group Discussions (FGDs) were organised in each community; one with rice farmers and the other with leaders of the community. FGDs were to provide further understanding on information flow and use, and how decision-making is locally contextualised. Data was cleaned and analysed using Atlas.ti software.

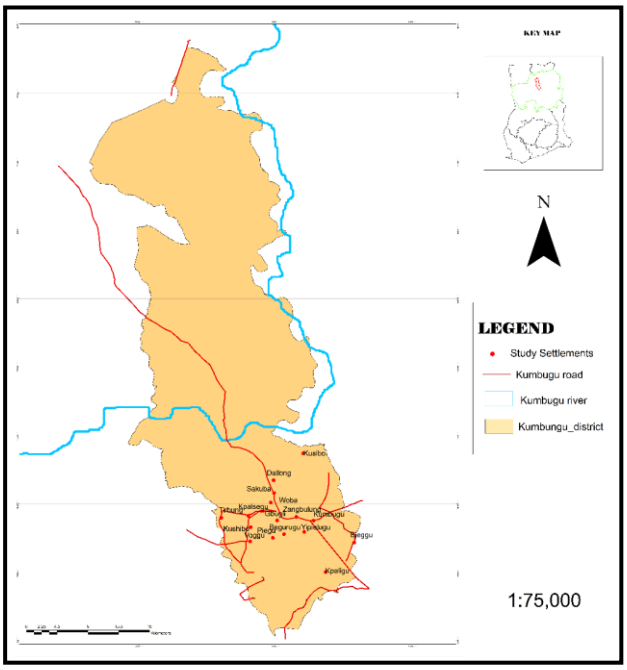


Figure 1: Map showing sampled communities in the Kumbungu District (Source: Nyamekye et al., 2018)

Findings

Information Systems Network

Farmers interact with four types of information systems in the study area. These include Virtual ICT Platforms, Commercial Radio, Community Radio and Farmer-to-Farmer systems (see Figure 2). Community Radio and Farmer-to-Farmer systems enabled knowledge creation with a greater reference to indigenous information. For example, for meteorological information and knowledge, indigenous indicators like direction of the wind and movement of ants is a cue to predicting weather and seasonal conditions which relevantly informs actionable knowledge creation relevant for adaptation to climate conditions. For both aforementioned systems, actionable knowledge meant highly salient knowledge. On the other hand, Commercial Radio and Virtual ICT Platforms, provided such information based on scientific forecast which is further interpreted on such media as part of studio discussions on radio towards contributing to knowledge for informed adaptation amongst farmers.

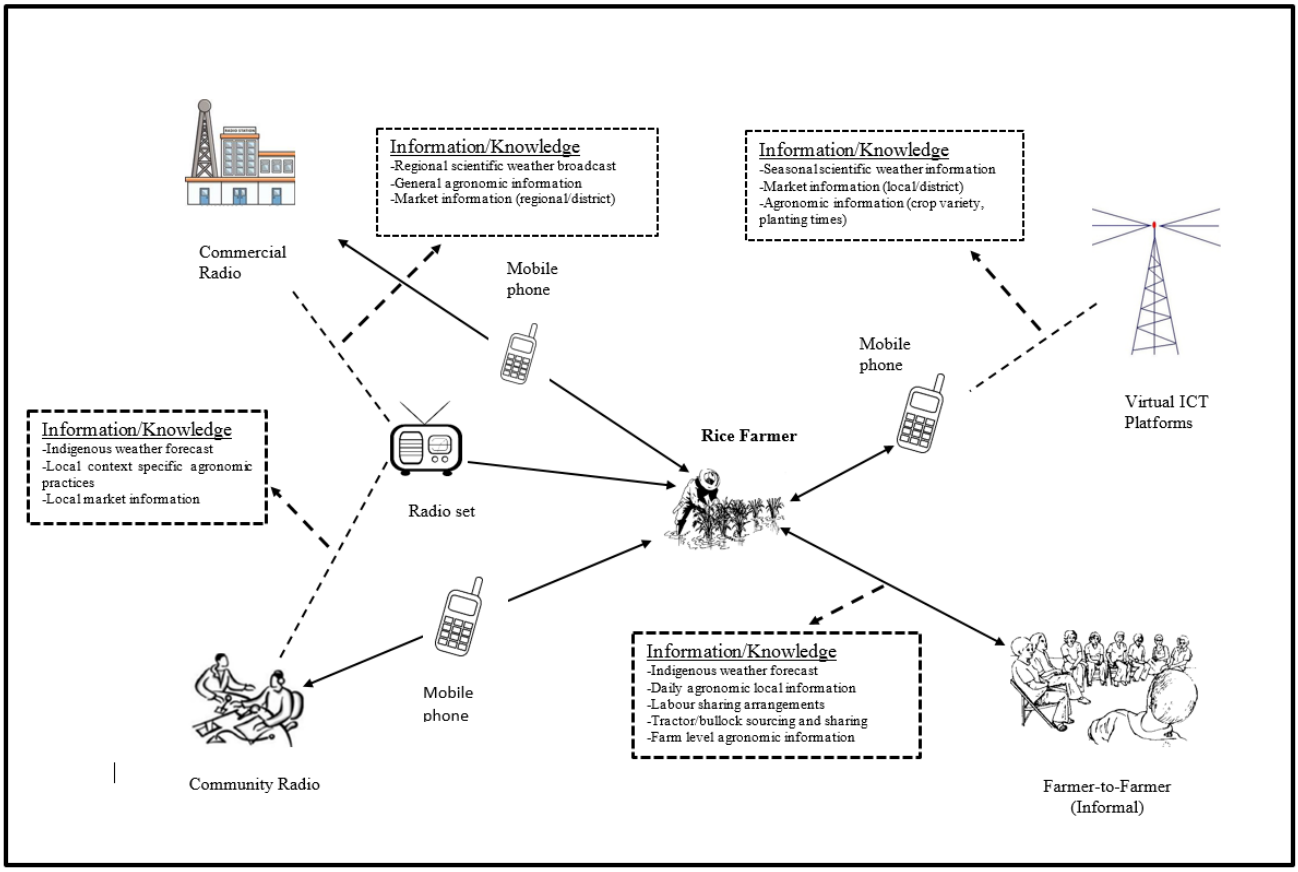
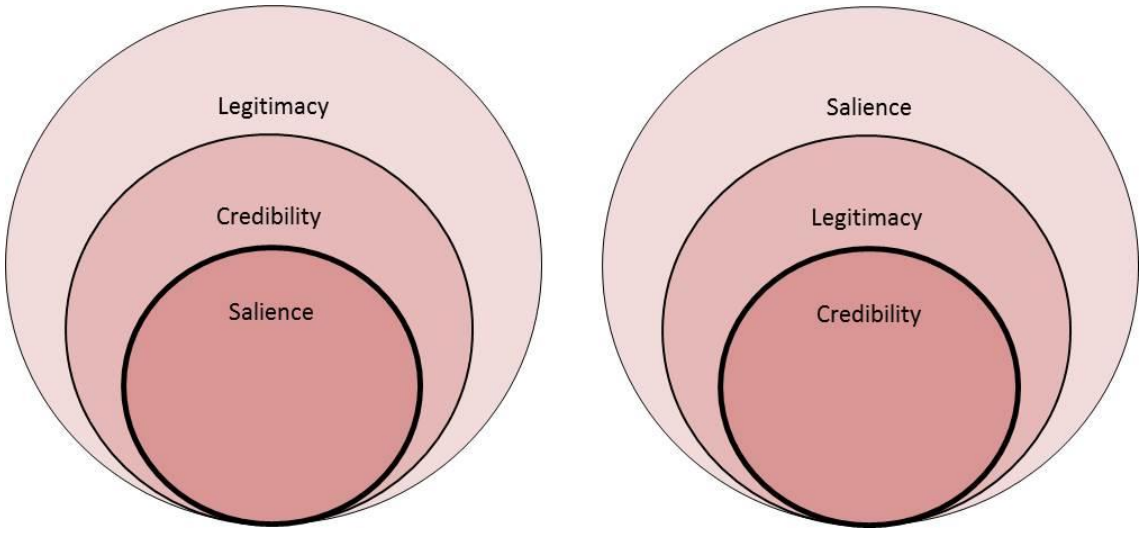


Figure 2: Information Systems Network for rice farmers in the Kumbungu District (Source: Authors' Fieldwork, 2017)

Information Systems and Actionable knowledge Creation

With the presence of a network of information systems, actionable knowledge creation is not limited to a particular information system since farmers engage with all systems identified within the study area. In an attempt to identify or create locally salient knowledge for farm level decisions, Farmer-to-Farmer systems and Community Radio Systems are driven by the factor of salience in creating actionable knowledge. For example, in such a setting, farmers decide on what variety of rice is suitable for the soil type in the area. Farmers who had a good harvest in the previous year share relevant information which informs discussions towards new actionable knowledge. Virtual ICT based systems and Commercial Radio on the other hand have credibility as the point of departure in ensuring information is made useful in the form of new knowledge.

In **Figure 3**, we emphasise what dimension of actionable knowledge is central within each of these systems and the transition process involved.



Community Radio and Farmer-to-Farmer Systems

Commercial Radio and Virtual Platforms

Figure 3: Creating Actionable Knowledge in Information Systems

Which System Contributes Most To Actionable Knowledge Creation?

Farmer-to-Farmer systems are observed to contribute most to overall actionable knowledge creation followed by Community Radio, Commercial Radio and Virtual Systems respectively. The Pre-season period is characterised by farmers interacting with these systems to ascertain which knowledge is readily actionable and hence relevant for their seasonal decisions. Adaptation at this stage requires actionable knowledge on water availability conditions for farm decision-making. Indigenous information based on observed indicators such as direction of the wind and movement of ants are translated into meteorological information as part of dialogue especially in Farmer-to-Farmer systems in the pre-season period. Within the season, Farmer-to-Farmer Systems continuously contribute to more salient actionable knowledge with Virtual Systems rather enabling the creation of more credible actionable knowledge. This is summarised in **Table 1**.

Table 1: Capacities of Information Systems to Create Actionable Knowledge, where 1 = Somewhat, 2 = Moderately, 3 = Very, 4 = Most (Source: Authors own)

Information System Factor	Farmer-to-Farmer	Community Radio	Commercial Radio	Virtual Systems
Pre-Season				
Salience	4	3	1	2
Credibility	3	4	2	1
Legitimacy	4	3	2	1
Remarks: Farmer-to-Farmer systems greatly provide salient actionable knowledge whereas Community radio systems enable creating of more credible knowledge for pre-season decision-making.				
In-Season				
Salience	4	3	2	1
Credibility	2	3	1	4
Legitimacy	3	4	1	2
Remarks: Farmer-to-Farmer systems contribute most to salient actionable knowledge whereas virtual systems present most valid actionable knowledge integrating local and indigenous knowledge systems.				
Post Season				
Salience	4	3	1	2
Credibility	3	4	2	1
Legitimacy	4	3	2	1
Remarks: Farmers need actionable local knowledge since farming is small scale and hence less outputs in terms of scale. Local actionable marketing knowledge is created and made salient mostly in Farmer-to-Farmer systems. Community Radio also contributes to validating knowledge through an interactive process of sharing.				
Overall Score (A)	31	30	14	15
Average (A/90)	0.34	0.33	0.16	0.17
Rank	1st	2nd	3rd	4th

Discussion

Adaptation in rice farming systems is hinged on useful and usable information towards managing changing conditions (Wilby et al., 2009). As presented in the results, information systems were central to knowledge brokerage and actionable knowledge creation (Bryan et al, 2008). Given the availability of numerous information systems, integrating information from all systems was keen for adaptation. As such, co-creation is key to ensure uptake of information in adaptation. Climate Services for instance, must engage farmers in a participatory process where indigenous information is integrated with scientific information in hydro-climatic models. Farmers must feel a sense of ownership of information systems if service providers intend to make the needed impact. The classification of farmers as 'end-users' and operators of information systems as 'producers' limit the creation factor which is relevant in defining actionable knowledge. Klerkx et al., (2012) argue for a shift from knowledge development to learning and adaptive capacity framed through collaboration (see also Kristjanson et al., 2009).

Breaking spatio-temporal barriers will also require a coordination of the process of information sharing (Luseno et al., 2003). Information service providers could explore more collaborative opportunities in sharing information. For example, Commercial and Community Radio systems could collaborate for more local level dissemination in the local dialects of farmers (Rees et al.,

2000). Community Radio Systems could identify communal gatherings which were a source of farmer-to-farmer knowledge for more coordinated interaction with farmers to increase trust, reliability and usefulness of information provided to farmers (Arbuckle et al., 2015).

As boundary objects (Carlile, 2002), information systems bring together numerous actors who would have possibly had limited room to interact in farming systems. In the governance of adaptation, such boundary objects could be made an integral part of policy and programme design for cross-level engagement in adaptation within rice farming systems.

Conclusion

The findings from this study present relevant knowledge for adaptation literature. Firstly, it emphasises earlier studies suggesting information as a key component of adaptation. It further establishes the connection between information, knowledge creation and decision-making in adaptation within farming systems. Thus for policy and programme design towards adaptation, there is the need for governments and private actors to explore an integration of information systems as well of participatory design and adoption of information systems. Local knowledge systems such as Community Radio and Farmer-to-Farmer systems must also be emphasised and tapped to increase the success rate of operationalising information systems.

Acknowledgements

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How gender and culture affects natural-resource Based Livelihoods: the case of the Baka community in Cameroon

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Abstract

With the impact of climate change, men and women could be affected differently due to place-specific circumstances in the environment. The study examined the role of culture within households and minority groups, and its impact on livelihood outcome for different household types, taking power relations into consideration. A mixed method approach was used to provide a complete analysis of the objectives. The results indicate that culture affects gender structured households differently and highlights the challenges faced by marginalised forest-dependent communities whose culture is often not understood within the climate change discourse.

Key words: *Gender, Culture, Natural resources, Livelihoods, Cameroon*

Introduction

Sub-Saharan Africa has been depicted as one of the most vulnerable regions to the impacts of climate change (Niang et al., 2014), with average temperatures in Africa predicted to rise by 1.5 – 3 °C by 2050 (Gemeda & Sima, 2015). Given that this region still has the largest proportion of people reliant on natural resources to meet livelihood demands (Shackleton & Shackleton, 2012) and who live below the poverty line (Serdeczny et al., 2017), the implications of this trend, and the associated climatic and non-climatic challenges, are likely to be considerable (Pettengell, 2010; Shackleton & Shackleton, 2012).

The literature indicates that different types of households will be affected differently by the impacts of climate change (Babugura, Mtshali, & Mtshali, 2010), with issues linked to gender inequality and, specifically, the marginalisation of women which is central to vulnerability to climate-related shocks and stressors (Djoudi & Brockhaus, 2011; Shackleton, Cobban, & Cundill, 2014). In this study we unpack the complexities of climate change, gender, and natural resource use within and across different gender-structured household types through an understanding of power dynamics and the role of culture in natural resource access and use, using the Baka community in Cameroon as a study (Permunta, 2013). We then discuss what this means for livelihoods outcomes in the face of a changing future climate.

For the broader study we worked in two parts of Cameroon, namely the South West and East regions. Here we present results from villages of the Baka communities in the East region of Cameroon. The Baka are forest-dwelling people sometimes referred to in the literature as 'pygmies', now considered a derogatory term meaning 'primitive' (Permunta, 2013). The Baka

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are mainly involved in hunting and fishing, as well as collecting wild fruits and non-timber forest products (NTFPs) from the forest to secure their livelihoods (Pyhälä, 2012).

Methodology

The study considered Social ecological systems theory, the feminist political ecology theory, as well as the social justice lens as grounded theoretical and conceptual framings. The Moser gender planning and the Harvard analytical tools were considered appropriate in shaping the research objectives related to gender power relations, division of labor and access and control over resources. In this light, a mixed method approach was used, where surveys were collected from 70 households comprising of 29(41.4%) female respondents and 41(58.6%) of male respondents above the ages of 18 years (Creswell, 2014; Leavy, 2017). We also used in-depth interviews and focus group discussions to address the research objectives for this study. We used the purposive sampling technique to identify the households to get a representative data, especially as the study focused on specific household types. The data was gender disaggregated and analysed using SPSS and NVivo as quantitative and qualitative tools respectively. The table below (**Table 1**) shows the different categories of participants both male and female placed in the order of headship considered in this study as gender household types.

Table 1: Gender household types for participants (Source: Authors own)

Household structure types	Numbers	Percentages (%)
Male headed households only	2	2.9
Female headed households only	12	17.1
Male headed households with adult females	48	68.6
Female headed households with adult males	8	11.4
Total number of households	70	100%

The total number of households (70) were further categorised to show respondents who fell within the different age group as shown on **Table 2**.

Table 2: Age group of respondents across household types (Source: Authors own)

	Male headed household only		Female headed household only		Male headed household (with adult female		Female headed household (with adult male	
Ages groups (years)	***Frequency***	***%***	***Frequency***	***%***	***Frequency***	***%***	***Frequency***	***%***
18 - 27	0	0	1	8.3	11	22.9	0	0
28 – 37	1	50	4	33.3	17	35.4	1	12.5
38 – 47	0	0	4	33.3	10	20.8	4	50
48 – 57	0	0	0	0	8	16.7	3	37.5
58 – 67	1	50	3	25.0	1	2.1	0	0
68 – 77	0	0	0	0	0	0	0	0
Above 78	0	0	0	0	1	2.1	0	0
Total	2	100%	12	100%	48	100%	8	100%

Findings and Discussions

A wide representation was reflected with (92.9%) of all respondents from the 70 households indicating that women must adhere to the cultural norm that restricts them from hunting, which has always been a male assigned task (**Figure 1**). However, other respondents (7.1%) felt it was about time such a cultural practice be dropped. In-depth interviews with male respondents felt it was appropriate for women to follow the customs and further explained by stating that women were able to do fishing near to the house. The implications for this are huge, especially as communities are fast experiencing climate change impacts on local resources, with rivers drying out and deforestation reducing animal numbers for hunting, making it difficult even for the men who hunt. This scenario presents a challenge for both men and women who may want to stick to cultural practices that might not prepare them for better adaptation options.

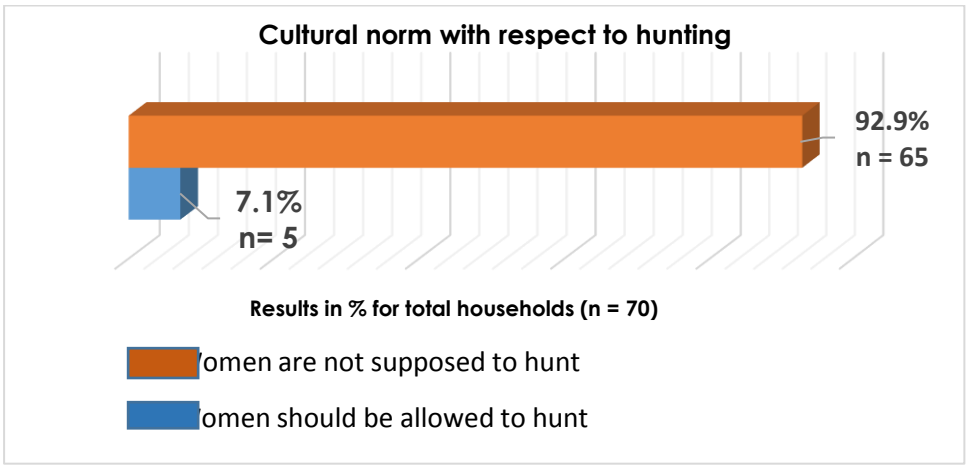

Figure 1: Cultural norm with respect to hunting (Source: Authors own)

The findings with regards to land access showed that most of the respondents from male-headed households with adult female(s) present (37.1%) could easily access land. While 4.3% of respondents from "female only" headed households (with no male present) expressed the difficulty they encountered in accessing land. Surprisingly, 8.6% of respondents from female-headed households, where male family member(s) were present, indicated that they easily had access to land. This could mean that women found within these households had access rights as widows or had financial capital that enabled them to rent land as shown on (**Figure 2**).

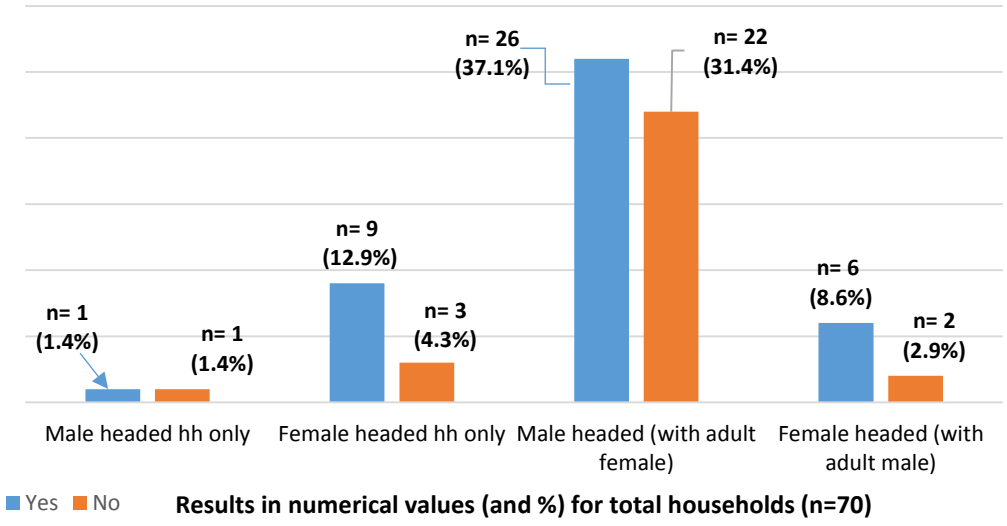

Figure 2: Access to Land (Source: Researcher's data analysis).

Further findings revealed that women within the male-headed households had a bigger challenge accessing land (31.4%) as compared to those in only female-headed households. This means that their access could mostly come through their husbands or adult male relatives. Such a situation might be problematic if marriages ended. In terms of decision making by households on what, how and when to use available land, the results indicated that men in male headed households (79.2%) made decisions without consulting their wives or other adult female member(s) as shown in **(Figure 3).**

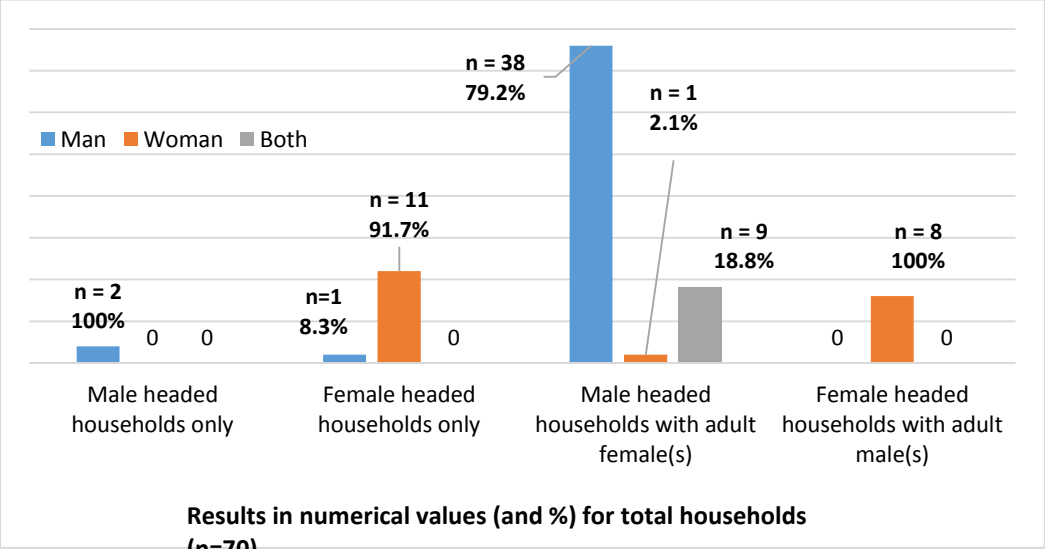

Figure 3: Decision over land use (Source: Researcher's data analysis)

In our qualitative results, a man in a male-headed household with an adult female present (his wife) had this to say: "*Well, it is normal for me to control everything about land in my house. I don't see anything wrong in deciding what to plant, when and how without talking to my wife…… Remember, she is a woman and is under me no matter how young I am……. that is how it has been made…… We have to follow it*".

This too was noted in female-headed household with adult male(s), where all the respondents (100%) of the women said they made decisions without the consent of the male relatives(s) since they were in a position to make decisions.

Evidently, there is a kind of conflict of interest as seen in both household types and this could have negative consequence in securing food where land has a major role to play. These findings highlight challenges faced by marginalised forest dependent communities whose culture is not understood in light of climate change.

Conclusion

In a context where adaptation strategies must be achieved, considerations of vulnerability should not only be restricted to binary categorisation of 'male' or 'female'. Our results have highlighted that hidden inequalities exist beyond this categorisation, with the manner in which households are i) gender-structured, and/or ii) mediated by culturally-ascribed gender roles affecting the adaptation options available to them.

Our study therefore, enabled us to understand how vulnerability could be influenced by gender structured households and be limited by cultural practices. Many found it difficult to diversify livelihood activities, due to such entrenched cultural and gender biases, especially in the face of a changing climate. This could be challenging where many communities are dependent on natural resources for their livelihoods and are heavily affected by climatic impacts. Thus, there is need to evaluate cultural dimensions within communities to better understand their limits to adaptation whilst building on the positive cultural roles that some communities exhibit.

Acknowledgements

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Climate change and migratory practices of pastoralists: challenges and implications for planning in Nigeria

Popoola Kehinde Olayinka [1]

Abstract

The study explores climate change and migratory practices of pastoralists, their challenges, and implications in selected rural communities of Okeogun, Oyo State, Nigeria, using focus group discussions of Indigenes and Interviews with Pastoralists. The study also explored and showed the need for planning intervention in climate change/variability induced migratory practices of pastoralism by specifically emphasizing the need for a shift from the traditional migratory practice of pastoralism to a modernized ranching method.

Keywords: *Climate variability, Pastoralist, Migration, Planning, Nigeria*

Introduction

Climate change and variability is consistently on the increase and its impact constitutes major challenges in many communities in Nigeria. In Nigeria, several studies have shown and confirmed the increase in climate change/variability and resultant impacts as major problems in many of the communities in the country (Agbola and Fayiga, 2016; Ozor et al, 2015; Odjugo, 2010and Nwafor, 2007). For instance, studies by Odjugo (2010) and Adefolalu (2007) revealed that there is an increase in temperature and decrease in rainfall in the semi-arid region of Nigeria. In addition,research confirmed decreasing rainfall in Nigeria especially in the northern region of the country (Odjugo2005;Odjugo, 2009). Pastoralism is one of the many livelihood activities that is being seriously affected by climate change and variability in Nigeria. This is because of reduction in rangeland productivity, forage quality and rainfall in the Sahel region, which increases the vulnerability of livelihoods of pastoralists, and therefore triggers their southwards movement towards Guinea Savannah region (Basset and Turner, 2007).

Olabode and Ajibade (2010) explained that during the dry season, when there is scarcity of pasture for livestock to feed on, the herders move their animals to places where they can get enough pasture and migrate back once rainy season sets in. Pastoralism is discovered to be a good adaptive strategy because it enables sufficient access to pastures and water resources under dry land conditions. Arilesere (2014) explained that for cattle to have any chances of survival as the grazing regions become hotter and drier, herders will have to migrate southward. In other words, declining rainfall and reduced rangeland productivity contribute to the migratory practices of pastoralists in the country and this has its challenges and also implications for planning in the country. Based on this, a study became necessary to assist planners in developing the direction to which initiatives could be tailored in order to manage climate change and migratory practices of pastoralists in Nigeria. Using focus group discussions of Indigenes and Interviews with selected Pastoralists, the study explored the indigenes' and pastoralists' perspectives of climate change and pastoralism, their challenges, and climate

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impacts in selected rural communities of Oke-ogun, Oyo State Nigeria. The study explored and made recommendations for planning implications/interventions to manage climate change and migratory practices of pastoralists in the country.

Methodology

The research was undertaken by using a multistage sampling technique. The first stage was identification of Areas where pastoral activities were dominant in Oyo State. Okeogun area of Oyo State was selected. Three Local government areas (LGAs) were purposively selected because of the predominant activities of pastoralist in the areas. These LGAs are Saki-East, Oorelope and Atisbo Local Government Areas (LGAs). The third stage involved the selection of four rural settlements from each of the LGAs where pastoralism is practiced by local communities. The fourth stage was the identification of the compounds where the pastoralists reside. This was done using snow balling approach. A household head representing the household in the selected houses were respondents to the interview. Focus Group Discussions (FGDs) were also organised for Indigenes in selected households in each community.

Findings

The study revealed the indigenes' and pastoralists' perspectives of climate variability and pastoralism that recently, there has been rainfall variability (delayed rainfall, reduced rainfall and early stoppage of rainfall), high wind and high temperature, affecting the availability of pastures and water for animals. The study also discovered that the major reason for migratory practices among the pastoralist in Nigeria were due to climate change induced drought and desertification, affecting the availability of water and pasture, as well as the Boko-haram Insurgence in the Northern part of the country.

The study also revealed the challenges and implications of climate change induced migratory practices of pastoralists to include conflict between herders and farmers due to competition for water and arable land, pastoralists invasion and aggressive claims of land, epidemiological risk-contact and spread of contagious diseases, and degradation and overexploitation of the natural resources needed for pastoralism. Based on these findings, it was evident that challenges - and effects - of climate variability induced migratory practices are enormous, and therefore have far-reaching implications; hence, the need for planning interventions to be undertaken in the country to reduce the impacts. The study explained the planning implications of climate change and pastoralism by suggesting the need for a paradigm shift from the usual traditional migratory practice of pastoralism to a modernized ranching method.

According to Paul, Mathew, Eliahman and Zephaniah (2014), modern ranching method is a better option compared to the traditional migratory pastoralism because ranching method due to its fencing is able to control the transfer of livestock diseases from one zone to another. Also cross border migration and inter-clan territorial conflict is reduced. Finally, paddocks within the fenced ranches make livestock and rangeland management easy to undertake. There are evidences of countries where modernised ranching method has been successful. For instance, Argentina is an example of country where cattle ranching has been successful. Cattle ranching has persisted in Argentina for years despite strong challenges like political, economic (market shift) and environmental forces (climate change issues like drought). However, they have reduced their vulnerability to stresses and increased their resilience to climate change through maintaining small herds, professionalising (modernising) ranching activities through a more intensive use of land, and in some cases, diversification to non- ranching activities (Benjamin,

2012). Another case of successful ranching method is Wajir in Somali. Here pastoralists adapted to the changing climate by using hay and corn to feed the ranched livestock during the dry and drought spells; truck water to access pasture areas far away from watering point during drought; introducing Cushitic breeds, as well as harnessing technical assistance from livestock extension workers and NGOs; breeding improved (and smaller) herds; and growing fodder for use during drought (Fat- ha, 2016). Bostwana is also another country where modern ranching was successful. This fencing model was used to control degradation in the rangelands, through better range management and to reduce grazing pressure, enhance the quality and quantity of livestock production (Paul et al, 2014).

Based on these evidences, there is therefore the need for a paradigm shift from the usual traditional migratory practice of pastoralism to a modernized ranching method. This can be done by planners by doing inventory of land to ascertain the quantity, quality and suitability of land to be used for the modernized ranching, and identifying and locating accessible surface and groundwater sources in the ranch zones. Acceptability of this ranching method by pastoralists who have maintained their traditional migratory method, may require further insight from learnings from where ranching methods have been accepted by pastoralists, established and successfully implemented. Also vulnerable pastoral communities should be informed of weather and climate information including all the other stakeholders. Finally, there is need to embrace participatory planning approach by involving all the stakeholders in every stage of the planning process.

Conclusion

The study concluded by conversing the need for urgent planning intervention in climate change/variability induced migratory practices of pastoralism by suggesting: the need for a shift from the traditional migratory practice of pastoralism to a modernised ranching method; creating awareness on the implications of climate change and pastoralists migratory practices; and the need for pastoral communities to be considered in all the various interventions and decision making that are organised for them by planners in the country. This can be made effective by embracing participatory planning approach by involving all the stakeholders in every stage of the planning process; and finally the need to inform and distribute weather and climate information to vulnerable pastoral communities and all the other stakeholders.

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Agricultural sustainability and food security in the 21st century: a review of Climate-Smart Agriculture (CSA) in Africa

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Abstract

There are suggestions that the adoption of climate-smart agriculture in many African countries will not only help farmers adapt to climate change but also bring about increased productivity. This study, therefore, investigated the climate-smart agricultural practices in different African countries and examined the effect on their agricultural productivity and food security. Findings reveal practices like agroforestry and conservation agriculture, and climate-smart agriculture are improving agricultural productivity and food security in countries like Kenya, Uganda, Tanzania and some Western African countries.

Keywords: *Africa, Agricultural sustainability, Climate-smart agriculture, Food security*

Introduction

Agricultural activities in Africa are more susceptible to climate change than activities from other sectors due to the level of dependence of the agricultural sector on climate and climate-sensitive resources (Bryan et al., 2011). The vulnerability of African agriculture to climate change is of great concern and there is an increasing need for prompt and effective responses to the pressing challenge of climate change. As a response measure, the Food and Agriculture Organisation of the United Nations (FAO) designed the concept of Climate-Smart Agriculture (CSA) to achieve agricultural sustainability, adaptation and resilience to climate change, and reduction of greenhouse gas emissions simultaneously (FAO, 2013).

The concept of CSA operates on three major pillars; sustainability in increased agricultural productivity, adaptation to changes in climatic conditions and reduction or removal of greenhouse gas emissions (FAO, 2013). The concept jointly handles food security issues, ecosystems management and the problem of climate change, as "*an approach for transforming and reorienting agricultural development under the new realities of climate change*" (Lipper et al., 2014).

While there are suggestions that the adoption of CSA in many African countries will result in increased productivity (Dooley and Chapman, 2014), there are few studies supporting this assertion (Bryan et al. 2011; Dooley and Chapman, 2014). The dearth of study on CSA as an adaptation measure against the challenge of food security makes it difficult to evaluate the impact of climate-smart agriculture on food security. It is due to this lack that this research investigated the nature of CSA practices in different African countries and examined the effect of climate-smart agriculture on agricultural productivity and food security of these countries.

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Methodology

This study was carried out through a systematic review of peer-reviewed literature related to climate change, climate-smart agriculture (CSA) and food security. A realist review method was used. The realist method focuses on explanation rather than on empirical findings (Pawson, 2005), and often includes tighter inclusion criteria and a smaller number of documents than other review approaches, with an emphasis on 'depth' rather than 'width' (Thompson, 2010) of research. This method provides a suitable tool to understand agricultural productivity and food security as they are rooted in complex social, cultural, and ecological systems, which will affect vulnerability and adaptive capacity of the communities that depend on agriculture.

Findings and Discussion

This study identified CSA practices such as intercropping with nitrogen-fixing legumes, composting, agroforestry, conservation agriculture, and use of resilient varieties of crops (Bryan et al., 2011; Dooley and Chapman, 2014) as intensive farming practices which boost productivity. The findings also revealed that the adoption of CSA practices limits the expansion of cultivated areas into forests and enables new agricultural production systems that can restore ecosystem services and values to be established (Wollenberg et al., 2012). The need for CSA opportunities in African countries arose from a growing but food-insecure population, for whom increasing agricultural productivity does not only enhance food security but also preserves scarce forest resources (Dooley and Chapman, 2014).

In Nyando, West Kenya, the establishment of climate-smart villages reduced the proportion of households experiencing hunger months from 81% in 2011 to 23% in 2014, while the proportion of those that could boast of food all year-round increased from 1% in 2011 to 3% in 2015 (World Bank, 2016). In Uganda, the use of shade trees is helping Ugandan farmers in their coffee production. Shade trees help reduce the temperature in coffee growing areas, while simultaneously addressing the Ugandan drought problem. The crop losses that are averted in Uganda because of the use of shade trees could exceed more than US$100 million per annum (Jassogne et al., 2013).

A CSA Project in Tanzania supports small-scale irrigation to boost productivity and help farmers become more climate resilient. About 228,000 farmers have benefited from the project, and it has led to increased rice productivity from 4.5 metric tons to 5.8 metric tons (World Bank 2016). Further, the West Africa Agricultural Productivity Programme funded by the World Bank is making agriculture more climate-smart across 13 countries in West Africa, among which are Mali, Benin and Cote d'Ivoire (World Bank, 2016). The programme has developed and distributed 160 climate-smart crop varieties and trained farmers on climate-smart practices such as agroforestry and composting. Assistance from the programme has helped over 7 million farmers to be more productive, climate resilient, and lower greenhouse gas emissions. There has been an increase in productivity by about 150%, food production has increased by more than 3 million tons and hunger period has reduced by 50%. Incomes of beneficiaries of the programme have grown by an average of 34%, while staple food and nutrition standard has increased.

Conclusion

This study will serve as a reference for researchers and policy makers. With respect to policy implications, understanding the adaptation mechanisms (Climate-Smart Agricultural practices) employed by farmers and its impact on food security by policy makers and non-governmental

organisations would aid the development of programmes that would strengthen farmers' resilience to climate change.

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Towards promoting urban governance to make climate resilient intermediate cities in Latin America

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Abstract

Cities are the main source of greenhouse gas emissions but are also vulnerable to climate change. The UN-HABITAT III conference highlighted the potential role that intermediate cities could play to implement energy efficiency measures, encourage the development of renewable energy, and contribute to the minimisation of climate risks. Based on a literature review, this study presents sustainable initiatives in intermediate cities of Latin America. The review suggests that good urban climate governance should promote the interaction between different levels of government, with close participation of civil society organisations, NGOs and international cooperation.

Key words: *Urban governance, Intermediate cities, Latin America*

Introduction

Latin America and the Caribbean (LAC) has experienced the highest urban growth worldwide since 1950: in approximately 100 years, the population grew from 60 million inhabitants to more than 600 million today, and of those, it is estimated that almost 80% lives in cities (CDKN, 2017a). Contrary to the last century, when large settlements determined urbanisation patterns, in the last 20 years the trend has been characterised by a network of smaller emerging – or 'intermediate' - cities, with less than one million inhabitants. This dynamic has contributed to reducing the high poverty indices in the LAC region, but it continues to be a challenge to achieve a balance between supply and demand of natural resources (ECLAC & IAI, 2013).

Although urban centers cover only 2% of the planet's surface, around 70% of greenhouse gases are produced there (UN-Habitat, 2011): urban expansion leads to displacement from rural areas, the generation of complex pollution problems, an increase in waste production and the rise in natural and anthropogenic risks, such as climate change (Ruiz et al., 2017). Thus, there is a need to reconcile the adaptation and mitigation dimensions of climate change with respect to cities (Solecki, et al., 2015).

The UN-HABITAT III conference has contributed in motivating academics and international organisations to turn intermediate cities into strategic territories for urban sustainable development, in order to correct past planning mistakes of large-scale urban settlements. Since intermediate cities of LAC are still in the process of including climate change considerations in their regulations and technical instruments (ECLAC & IAI, 2013) there is a potential to integrate new environmental issues in their planning and in domestic policies such as energy efficiency measures, encourage the development of renewable energy or to contribute to the minimisation of climate risks(CDKN, 2017b). Despite the importance of intermediate cities, local governmentsare still facing difficulties in managing urban growth and attracting public and private investment towards tackling social and environmental problems.

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Methodology

The present study discusses the nexus between urban settlements and the fight against climate change. In this context, the aim of this study is to conduct a synthesis of best practices and urban management models that guide local public policies for effective urban climate governance in intermediate cities of LAC; in additions it also encourages the continued implementation of international agreements such as the New Urban Agenda, as well as the Sustainable Development Goals (SGDs) and the Paris Agreement on Climate Change.

Within the framework of the project "*Cities and Climate Change: Innovation and Leadership for the Construction of Transformational Resilience in the Cities of LAC*", funded by the Canadian International Development Research Centre, this study was undertaken through a literature review of academic publications, peer-reviewed publications, web pages and blogs of international organisations, such as the Climate and Development Alliance, Inter-American Development Bank, Cities Alliance, Climate Leadership Group Cities C40, UN-HABITAT and the World Bank. Based on 10 case studies in Latin America and the Caribbean, the selected initiatives were classified into three categories ("soft", "intermediate" and "hard") that include both mitigation and adaptations measures in urban spaces. Furthermore, the following four criteria were also used in the categorisation: availability of financial means, time-frame, cooperation between stakeholders groups and types of products that they promote. The main reason to present an alternative categorisation is to not separate *a priori* selected action into adaptation and mitigation, since often this action can represent both strategies: for example, a technical instrument or local standards could cover strategies of mitigation and adaption or implementing actions for flood risk management could be carried out through planting trees on slopes (see **Figure 1**).

In this context, soft measures usually have a time-frame of up to four years and require lower financial resource investment; they include products such as studies, public policies, adaptation or mitigation plans and institutional norms empowering local governments. Intermediate measures have execution times of more than five years and investments could be higher; here adaptation measures could promote a sustainable management of water and soil resources and new forms of crops within food security policies. Finally, hard measures focus on improving green infrastructure, sustainable transport systems or building renovation requiring higher costs and more time for implementation.

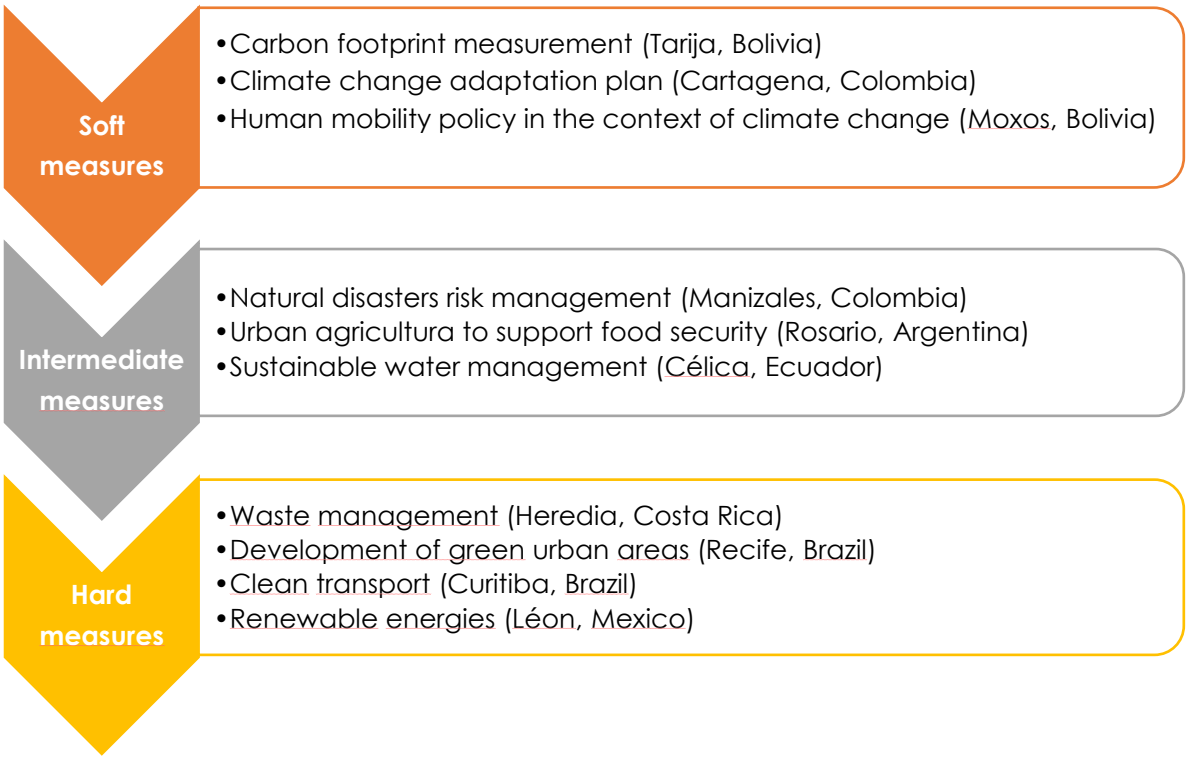

Figure 1: Best practice and urban management models in 10 selected intermediate cities in LAC (Source: Authors own)

Results

The main protagonist for implementing soft measures are urban governments who often receive technical or financial support from NGOs or international cooperation to elaborate such instruments. On the other hand, civil society plays a crucial role implementing intermediate initiatives, since they receive the benefits of ecosystem services or contribute to increase social resilience in disaster risk situations. Finally, initiatives concerning green infrastructure or waste management cannot be carried out without the private sector because of high investment costs. Due to the complexity of the topics and the high transaction costs for implementing actions, none of the initiatives has been solely executed by local authorities.

In implementing different initiatives, a number of involved parties with specific roles and responsibilities are needed to support these measures. Non-governmental organisations (NGOs) and many bilateral international cooperation organisations have a preponderant role as "promoters" in many of the initiatives: in the case of the implementation of soft measures, they usually act as drivers of new ideas, so it is also usual that they finance or provide technical support. For implementing intermediate measures, they also play an important role in promoting dialogues, and enabling meetings and workshops for the participatory construction of processes. Furthermore, the role of academic bodies is indispensable for the generation of information supporting public decision-making, but can also assume the role of trainers with courses aimed at both the technical units responsible for municipalities and the civilian population. Private companies play a crucial role in investment, mainly in guaranteeing investments for waste management (Heredia, Costa Rica), setting up green urban areas (Recife, Brazil) or promoting clean transport (Curitiba, Brazil). The private sector´s inclusion represents a potential which, at the moment, is underutilised both by promoters and by decision-makers. This group must not only be composed of large private companies, as the case of intermediate measures showed; civil society actors can form economic groups that

support the processes. Civil society also plays the role of "beneficiary" or "recipient" mainly of intermediate measures, benefiting from ecosystem services that avoid the contamination of water and air, or that increase resilience to disaster risk (Ruiz, 2018).

Conclusion

From the available information it is not possible to conclude if the origin and implementation of all initiatives were planned as adaptation measures. Rather, local authorities still tend to favor the implementation of measures that meet social and economic needs. So, effective urban climate management could be the result of positive externalities of transport management or municipal solid waste management, or they may be the result of coincidences, rather than deliberate actions of policy makers.

Either way, effective climate change management is the result of the interaction between different levels of government, with close participation of civil society organisations, NGOs and international cooperation. In this context, it is important to rethink the prevailing perception of the roles of local authorities and other stakeholders, recognising their interdependence and the need for cooperation. The sustainability and successes of all initiatives depended on the interaction and cooperation between all parties.

New initiatives should be supported by local governments in leading and promoting the implementation of best practices; urban authorities can also assume commitments to facilitate dialogues and cooperation with other stakeholders, as well as making available financial and technical means for promoting actions. Although the selected studies reveal the interest of local authorities, not all governments have the same resources (human, financial) to support initiatives. The progress in elaborating policies and actions is closely related to the experience or interest of local authorities, for example, local governments that are promoting short-term measures generally have less experience in climate management. Likewise, it is possible that governments that work with hard mitigation measures or intermediate risk management are those that have more experience in the development of internal strategies and policies, presenting the best advances in the establishment of climate management.

Due to missing examples that link both adaptation and mitigation strategies, good urban climate governance demands more empirical studies that do not apply mitigation or adaptation measures separately. Moreover, a comprehensive perspective of local policy action is required to put co-benefits for the urban population, such as for example public health or well-being, at the forefront.

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Reflecting on the role of local governments, academic and international cooperation for developing actions on climate migration in Latin America

Sergio Antonio Ruiz[1]

Abstract

Latin America is among the most vulnerable regions to climate change. Combining all natural disasters, an estimated 8 million people were internally displaced between 2000 and 2015. Most of these displacements frequently happen from rural areas to urban areas. As a result, local level governments should play a decisive role in improving socio-economic conditions of affected people. This study contributes to the deepening of concepts, approaches and discussions on the link between human mobility and climate change; it also calls for more coordination between local governments, academic and international cooperation for developing actions on climate migration.

Key words: *Climate migration, Multi-level governance, Latin America*

Introduction

Latin America and the Caribbean (LAC) are among the most vulnerable regions to climate change. Projected variations in rainfall patterns will bring changes in the water cycle, such as sudden floods, and droughts and the associated risk of forest fires. In addition, rising temperatures are leading to glacial melt in the Andes, leading to shrinking drinking water reserves and causing supply-related tension between inhabitants in the long-term. At the same time, in the Caribbean, the frequency and intensity of hurricanes are increasing at an alarming frequency and causing considerable economic and human losses. For example, Hurricane Maria (2017) caused an estimated $90 billion in damages and more than 5000 deaths in Puerto Rico alone, making it one of the most dangerous tropical hurricanes in the United States since 1900 (Kishore, et al., 2018). Combining all natural disasters, an estimated 8 million people were internally displaced between 2000 and 2015 (Rodriguez, 2015). Although historically migration has occured naturally as people left to seek better economic and social opportunities, estimates are revealing that "climate migrants" could number over 17 million in the LAC region by 2050 (Rigaud, et al., 2018). Even this figure is expected to be an underestimate, as no official records - especially of internal movements or displacement - are available. Thus, climate change is emerging as a potent driver of internal and cross-border migration.

Affected people frequently migrate from climate change hotspots, often housing rural populations more vulnerable to impacts, to urban areas. Climate migration, together with other forms of internal movements, are contributing to increasing rates of urban growth in LAC, especially in intermediate and small cities. According to the UN-HABITAT (2012), it is estimated that up to 90% of the region´s population will be concentrated in urban settlements by 2050.

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Despite the importance of climate migration, both temporary and permanent, there is a lack of commitment from the international community to resolve social problems caused by forced migration: a lack of recognition of an international category for climate migrants is obstructing the construction of a proper protection regime that allows migrants to receive necessary assistance, both in origin and destinations places (see Berchin, et al., 2017). In most cases, national migration legislation limits the entry of climate migrants into other countries and even in the case of internal displacement, state policy does not fully recognise their rights as citizens (Oetzel & Ruiz, 2017).

Methodology

This study aims at promoting the discussion between both political and academic communities on climate migration in the LAC region in order to improve the formulation of public policies, particularly at the level of sub-national governments. Moreover, it encourages international cooperation to support the implementation of international programs on the links between migration and climate change, within the scope of international agreements.

The method used is based on data gathering and empirical observations from three sources:

i) the agenda-setting process in public spheres of the Provincial Government of Pichincha in Ecuador from 2015 and 2017;

ii) round table and expert discussions in two regional meetings within the framework of the Workgroup "Environmental Migration" of the working group of Deutsche *Gesellschaft für Internationale Zusammenarbeit* (GIZ); and

iii) a literature review from documents and studies from international organisations working on climate migration in the region; many of these documents were published in close cooperation with sub-national governments, academic centers and NGOs.

The collected data was analyzed and presented by the author in three publications and this paper strives to present a summary of the main results. A preliminary characterisation of climate migrants in LAC identifies two main affected groups: the low-income population in the rural Andean region, and the group living in unplanned (informal) urban settlements, or slums.

Results

Drought is considered as one of the mayor climate drivers in the Andean region affecting the livelihoods of local population and influencing internal displacement. The main migration pattern is characterised as slow and gradual, rather than abrupt or defined as mass displacement. This could explain why public authorities and international community still do not consider climate migration as a serious social problem. Moreover, climate migration is still considered as an adaptation strategy and does not sufficiently take into account the human rights aspects of the situation; for example when people are forced to migrate under conditions that put their lives in danger.

The main category of migrants from rural to urban areas are youth and economically active people, leading to reduced adaptive local capacities in the poor areas they leave behind. It was found that, initially, this demographic may decide to move temporarily to an area with greater employment or livelihood prospects, with the help of good personal contacts. Migration can become permanent when income generation improves. Additionally, a lack of

property rights over land in the areas of origin reinforces the decision of climate migrants to stay indefinitively at the destination.

While climate change is affecting the livelihoods of the rural population in the Andean region by reducing the quality and quantity of natural resources, the urban population living in informal settlements faces high ecological risk due to urbanisation in vulnerable slums areas. In intermediate and small cities the increase of population density turns this group to the most vulnerable especially against landslides and floods. Informal settlements usually house poor people coming from rural areas who probably once again suffer climate change impacts. For the group living in slums there is less information and research regarding to the social and economic structure, or gender roles in case of migration.

For both groups of migrants, sub-national governments have been assuming high responsibility to guarantee human security and to grant basic socio economic conditions and public services. Local administrations often fulfil their public functions without any technical and financial support, and it is frequently beyond their capacity to address environmental and social problems in an integral way. For example, limitations exist in urban planning where standards relating to the prevention of new settlements in areas with steep slopes, little vegetation cover or edge of rivers are not upheld.

Conclusions

Due to the social and environmental complexity of climate migration, the challenges to overcome this topic require a holistic approach and call for developing a series of transdisciplinary actions and strategies involving several stakeholder groups such as local governments, academic and international cooperation.

This research focuses on 'internally displaced' climate migrants, thus sub-national governments but especially "city governments" need to play a decisive role for improving social integrations of newly arrived urban inhabitants (Ruiz & Carvajal, 2015). . In LAC, the focus of action should be put on intermediate cities that currently play an important role as connection nodes between urban and rural areas. Steps should be taken to facilitate new residents' access to social services and infrastructure and to improve urban management of climate change and natural disaster risks. It is therefore crucial to support local capacity building, both to prevent and respond to climate risks and to guarantee human rights of affected persons. All these actions also contribute to the implementation of relevant international agreements that increasingly call for reinforcing tasks and responsibilities of local authorities, such as the Sendai Framework for Disaster Risk Reduction. At this level, further topics to promote include: incorporating the migration dimension into climate change adaptation plans and programs, but also into urban planning. Additionally, for cross-border migration the public policies should be based on agreements of integration and on domestic constitutions aligning existing norms with new migration directives.

International cooperation agencies and international bodies could contribute not just as technical advisers or providers of financial resources, but also to encourage the exchange of South-South experiences, for instance with Africa and Asia where significant progress to better understand the topic has already been made. Here main topics for exchange could be the following: regional agreements of rights protection within the framework of the Nansen Initiative; adaptation strategies both in place of origin and in places of destination; and the

promotion of research studies making visible the fact and reality of migration in climate change hotspots.

Furthermore, this study calls on international bodies not to underestimate the problem of climate migrants in LAC, even if climate conditions currently are not identified as extreme in many regions; however territory could be affected either as places of origin or destinations of climate migrants (Ruiz & Carvajal, 2015). Lastly the role of academic centers should concentrate on closing the gap in empirical evidence and data on climate migration. In the short-term research and studies should respond to the following questions: What are the socioeconomic characteristics of the group of climate migrants?; What is the social structure of the group of trapped population?; What are the main drivers for climate migration?; What are the gender roles both in the migration group as well as in the trapped population? And for whom and under what kind of conditions could climate migration be considered a successful process?.

All these aspects could contribute to eliminate negative prejudices on climate migration as a global crisis, but in addition, they could help the main stakeholders to design and elaborate tailor-made policy instruments both at local and international level.

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A MOOC on climate change mitigation and adaptation for Spanish primary and secondary teachers: education as a tool for increased action by Spanish-speaking students worldwide

Santiago Andrés Sánchez[1], et al.*

Abstract

Education capacity building and awareness have been identified as major tools towards mitigation, adaptation and building climate change resilience. There are three big problems in the education of the science of climate change in the Spanish language (of which there are 477 million native speakers): lack of high quality resources in Spanish, the material related to mechanisms of climate change in the curricula of climate change is not connected with socio-economic aspects, and a gap between hard science and classroom contents. In this project, we propose to elaborate a massive open online course (MOOC) in Spanish to explain the main factors of climate change to primary and secondary teachers, in order to help them to participate in the debate on how to mitigate and adapt to climate change, and pass on this knowledge to learners.

Keywords: *Education, Primary school, Secondary school, MOOC, Knowledge*

Introduction

Adaptation, according to Intergovernmental Panel on Climate Change (IPCC, 2014), is "*the process of adjustment to actual or expected climate and its effects*". This adjustment should be in terms of ecological, social and economic structures and should be a response of expected changes in the climate and their impacts in order to take advantage of new opportunities (Adger et al., 2005). Education capacity building and awareness have been identified as major tools towards mitigation, adaptation and building climate change resilience (UNFCC, 2007). Lyth et al. (2007) said that the objectives of education are to increase knowledge of the context and the science of climate change and to educate about its potential mitigation. The education on climate change will develop the critical skills necessary to understand climate change (Lyth et al., 2007), increase the ability of individuals or groups to adapt to climate change and to implement the adaptation decisions (Davidson & Lyth, 2012). Education on climate change adaptation and mitigation in primary and secondary schools the world over is needed to mobilise society towards this planetary issue.

In our work as teachers of Didactics of Natural Sciences, we have identified an important lack of high quality, evidence-based educational resources about this matter in the Spanish, a language spoken by 477 million native speakers. Parallel to this finding we observed that the curriculum for Natural Sciences usually contains material related to the physical mechanisms changing the climate, but there is no discussion connecting them to the actual situation of the

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planet. Finally, we found a gap between hard climate change science and classroom contents.

In order to solve these three big problems for Spanish students, in this project we propose to elaborate a massive open-access online course (MOOC) in Spanish to explain the causes and the effects of climate change to primary and secondary teachers.

MOOCs are designed to allow for unlimited participation responding to an important social demand in specialized matters (in our case climate change). Students could be located in different spaces and work at different times, allowing them to study independently and without following a schedule. MOOCs favor the development of new didactics resources and provide interactive elements that ensure the interaction among participants and with the teachers, encouraging collaboration among them. Via MOOC learning, learners play a more important role in their own education and self-evaluation (Kaplan and Haenlein, 2016; Valverde Berrocoso, 2014). These characteristics make such kinds of courses appropriate and attractive for many people, helping to raise awareness and capacity about climate change in society.

Methodology

The MOOC was produced keeping in mind the contents of Natural Sciences from the Spanish public education curricula. We highlight the global aspects of the problem and encourage the discussion between Spanish speaking students all over the globe.

The methodology that we propose for this project is made of four well defined stages:

i) **Diagnostic**: the MOOC is designed around the principles of evidence-based facts, scientific rigor and actuality.
ii) **Content design**: aligned with the consensus emanated from the IPCC and public education curricula.
iii) **Content creation**: high quality videos, figures, graphs and other didactic resources which could be used by teachers in their classrooms.
iv) **Delivery and evaluation of the impact**: using big data analysis to precisely measure the reach of our material and establish a good estimation of the impact of our project.

Finally, the MOOC is based in the following principles: It is written in a positive narrative by a multidisciplinary team, including experts in Science Education, Biology, Chemistry, Didactics, Geology, Mathematics and Physics; the course is built over the scientific consensus (IPCC), avoiding controversy; and focus on primary and secondary teachers, but not only. The MOOC will be offered by the platform Miríadax (https://miriadax.net/home).

Results

The selected contents of the MOOC are:

- The causes of the climate change: the science, physics and chemistry, behind them.
- The consequences of the climate change and how scientists can predict the near future.
- The solutions and strategies that can be implemented and how education can help.
- Resilience, and how to promote climate resilient development.
- Vulnerability, and how to reduce the vulnerability of the communities in the face of an uncertain future.
- Competences in the field of mitigation and adaptation.

These contents were organised in seven modules:

- Module 0: Welcome.
- Module 1: A changing climate - A scientific perspective.
- Module 2: Evidences of climate change.
- Module 3: Mechanisms of climate change.
- Module 4: Human activity as a cause of climate change.
- Module 5: Future scenarios
- Module 6: What we can do from education?

Conclusions

This project aims to provide high quality information to Spanish-speaking teachers to help them to participate in the debate on how to mitigate and adapt to climate change through education and awareness. Additionally, by preparing teachers, schools and communities will be better equipped to face natural hazards and reduce disaster risk. This project will help to mobilise society through education, and due to increased knowledge about climate change, the project will also help to create a new positive narrative around young climate leaders that convey urgency and hope, away from pessimism, and through to imperative action.

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Monitoring and evaluation (M&E): are local government actions contributing to successful adaptation?

Helen Scott[1]

Abstract

Climate change adaptation is an emergent field of practice for local governments, thus it is necessary to understand how their initiatives are contributing to successful adaptation, and if funds have been invested wisely: this is the role of monitoring and evaluation (M&E). Recent research of Australian local governments finds that M&E is challenging, and that many M&E efforts track implementation, rather than evaluate effectiveness and efficiency. This paper presents the preliminary findings of a survey and interviews with Australian local governments. It argues there is need for greater evaluative capacity in the sector.

Keywords: *Monitoring and evaluation, Local government, Evaluative capacity*

Introduction

Local governments (LGs) in Australia have been active in climate change adaptation for the last decade, noting that climate change adaptation is a perceived as a particularly local phenomenon that is context specific (Baker et al. 2012; Measham et al. 2011). Many LGs have conducted impact, risk and/or vulnerability assessments (Collins 2016), and over one third have a current adaptation plan (Scott 2018). As these plans are implemented, there is an imperative to understand if and how adaptation initiatives are reducing climate risk and vulnerability, increasing adaptive capacity, and contributing to successful adaptation. Although there are many documented challenges of monitoring and evaluation (M&E) (Bours et al. 2014; Villanueva 2011), it provides an essential contribution for learning what works, for whom, and in what context (Spearman & McGray 2011). However, M&E of climate change adaptation is not perceived to be widely undertaken by the LG sector (Woodruff & Stults 2016), with little documented evidence of the use of M&E frameworks at the local level (Turner et al. 2014). The objective of this research (the first stage of a PhD project investigating the influence of M&Es on adaptation decision-making and practice) was therefore to determine the nature of M&E of adaptation undertaken by LGs in Australia. This paper presents findings of a national survey of Australian LGs, and follow-up interviews with selected respondents, investigating how they are monitoring and evaluating their adaptation plans and initiatives. While there are insights around governance of M&E of adaptation, as well as methodological insights, this paper focuses on the competence of LGs to undertake M&E of climate change adaptation, and the apparent need to develop evaluative capacity within the LG sector.

Methodology

Following a literature review and compilation of a database of Australian LG climate change adaptation plans (building on Collins (2015)), the research was conducted in three phases. First, an online survey was developed with both closed and open-ended questions. The questions

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identified if the LG had an adaptation plan, which department had responsibility for the plan, and queried the nature of M&E undertaken. The survey was distributed to nearly 200 (of 540) LGs in Australia through direct email and targeted promotional channels (such as group emails distributed by regional LG associations). LGs that were identified as having a current adaptation plan (per the database) were targeted; however, emails distributed by associations reached beyond this audience. There was a 46% response rate to the survey. The second phase involved initial statistical and thematic analysis to determine emerging themes, and the third phase was semi-structured interviews with five respondents to further explore initial survey findings. The results of the initial analysis of both the survey and interviews are presented.

Findings

Studies of government adaptation plans have found that M&E is not comprehensively represented (Baker et al. 2012; Woodruff & Stults 2016). This survey supports this notion with just over one third (37%) of councils identifying that their adaptation plans contained an M&E framework. These were mostly developed internally, using resources such as international guidance documents and other council's adaptation or sustainability M&E frameworks. One interviewee noted their framework was evolving as their knowledge and skills increased.

The survey indicated approximately half the respondents (49%) monitored their adaptation initiatives – either as part of an adaptation plan or independent of a plan. Initiatives were both implemented and monitored across council departments, but were coordinated by a single department or team, predominantly the environment or sustainability team. Only 18% of respondents had conducted an evaluation, with approximately half of these conducted internally, which some considered more an informal 'review'. Most indicated it was "*generally too early in our climate change adaptation journey to have considered this [evaluation]*" (respondent).

The majority of monitoring was tracking implementation; that is, checking whether initiatives were implemented according to plan. Many initiatives that were monitored were consequently reported through councils' risk, annual and strategic reporting. For example, one council noted that adaptation implementation was "*included in quarterly reporting of the Council Plan actions, via the Council's Risk Management System*" (respondent). Interviewees elaborated this was often undertaken as "traffic light" reporting, noting whether the initiative was completed, on-track, or behind schedule. Spearman & McGray (2011) note that while it is important to monitor and report implementation, the focus on accountability limits the opportunity of cross-organisational learning. It was promising that many councils were seeking to develop their M&E efforts further, recognising that they were currently limited. However, 13 respondents stated they were not monitoring adaptation efforts at all, or only in a haphazard manner.

The lack of a common indicator framework to measure adaptation interventions, outcomes, and impacts is a recognised challenge of adaptation M&E (Bours et al. 2014), and survey respondents and interviewees concurred. A variance of indicators was reported. Some councils had developed output and outcome indicators in relation to specific initiatives such as building adaptive capacity through staff training (number of staff trained), or reducing urban temperatures through increased tree planting (number of trees or percentage canopy coverage). Others were monitoring changed conditions and impacts, for example, coastal erosion. Two councils were undertaking processes to measure changed community vulnerability and adaptive capacity through regular, longitudinal surveys.

Many respondents noted governance challenges, such as lack of leadership for adaptation M&E, poor resourcing and competing priorities (which is supported by other research, see for example Measham et al. 2011; NCCARF 2017). However, what also emerged was a challenge around the competence of LG practitioners to develop appropriate M&E frameworks, identify indicators, and to broadly undertake M&E for adaptation activities. It was revealed that LGs' understanding of the broad range of M&E tools and methods and how to apply them was limited. Interviewees noted that while competence in planning and implementing adaptation was growing, M&E of adaptation was a newer area for them where they felt they had to further develop their skills. This suggests the need to build greater evaluative capacity within the LG sector – where 'evaluative capacity' refers to the capacity within an organisation to understand and engage in evaluation concepts and practices, to think evaluatively and to use M&E in planning and decision-making (Preskill & Boyle 2008).

Conclusion

This research provides empirical evidence of current M&E efforts at the local level. It demonstrates the majority of monitoring undertaken is tracking progress, rather than assessing effectiveness and efficiency, and that little evaluation has been done. The research shows M&E of adaptation is a new and challenging area for LG and it points to a need for greater understanding of the value of M&E and how it can effectively inform future adaptation planning, decision-making and actions. Improving evaluative capacity within the sector is one way we can understand if efforts are contributing to successful adaptation.

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Adaptation to climate change and public policy in Mexico: operability review

Stephanie Victoria Ascencio Serrato[1]

Abstract

Climate change adaptation is a cross-cutting issue, which in practice tends to be mainstreamed into other sectorial policies. However, due to the increasing activity within the field, the question of whether adaptation should constitute a new field of policy, arises. The aim of this paper is to discuss if adaptation should become a new field of policy or if it should be mainstreamed into other sectoral policies, and what the implications of each of the two options are. To this end, it studies the case of Mexico as a developing country.

Keywords: *Adaptation policy, Policy field, Operability, Mexico*

Introduction

Adaptation to climate change can stand-alone as a sphere of policy, or be mainstreamed into other existing policies. The cross-cutting nature of adaptation has led to its mainstreaming into other sectorial policies such as water resources, disaster risk reduction, and agriculture, amongst others (Dovers and Hezri 2010; Moser y Ekstrom 2010). Moreover, at the international level, the Paris Agreement[2] (2015) and the Sustainable Development Goals (SDGs)[3] call for action to address climate change and integrate adaptation measures into national policies, strategies and planning. However, given the greater political activity and the relevance that adaptation has gained worldwide, the question of whether it is possible to consider adaptation as a new field of policy and what would the implications of such a move be, has arisen (Massey and Huitema 2013; Massey et al. 2014). In addition, new approaches to traditional mainstreaming or integration have been sought with the aim of creating new structures and institutions for transformative change (Henstra 2016; Helgeson and Ellis 2015).

Methodology

This research is part of the author's doctoral thesis developed with the support of the Mexican National Council for Science and Technology (CONACYT), and of the project "Global climate constitution: governance and law in a complex context" (CONCLIMA) from Rovira i Virgili University (Spain). This research aims to discuss both strategies from a practical standpoint to argue that a mixed approach is more suitable for effective adaptation. In this sense, it studies the case of Mexico as a developing country considered as a leader in designing climate change policies to assess the evolution and trend of adaptation in this country. For this purpose, a document review of climate and sectoral policies and its analysis was undertaken. The official webpages of the Government were reviewed and the information that was not available online was requested from governmental entities exercising the right of access to

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[2] See paragraph 5, art.7 Paris Agreement «…with a view to integrating adaptation into relevant socioeconomic and environmental policies and actions, where appropriate».

[3] See target 3, goal 13 SDGs «Integrate climate change measures into national policies, strategies and planning».

information. Once the information was collected and organised, a desktop study was conducted.

Adaptation was analysed from a mainstreamed perspective, both vertically and horizontally, through three stages of the policy-making process: agenda setting, policy formulation and policy implementation (Huq et al. 2017), but focused on the federal planning and programming for the 2013-2018 period (policy formulation stage) (**Figure 1**).

For the horizontal analysis, the most relevant Mexican sectorial policies were selected according to their adaptation urgency and their synergies with mitigation such as health, agriculture and urban sector policy. This was done in order to answer the question on and what are the sectoral policies and the federal programs considering climate change adaptation criteria.

Regarding vertical integration, the question is on how development policy and climate change policy have been planned and what formal institutions for meeting adaptation objectives exist, and how they relate to each other; or if there are sufficient mechanisms available for policy and institutional articulation and coordination. Finally, the research examined what the policy instruments for adaptation were that are covered by identified programs. The aim was to determine the level of integration and the meaning of such integration in a practical sense.

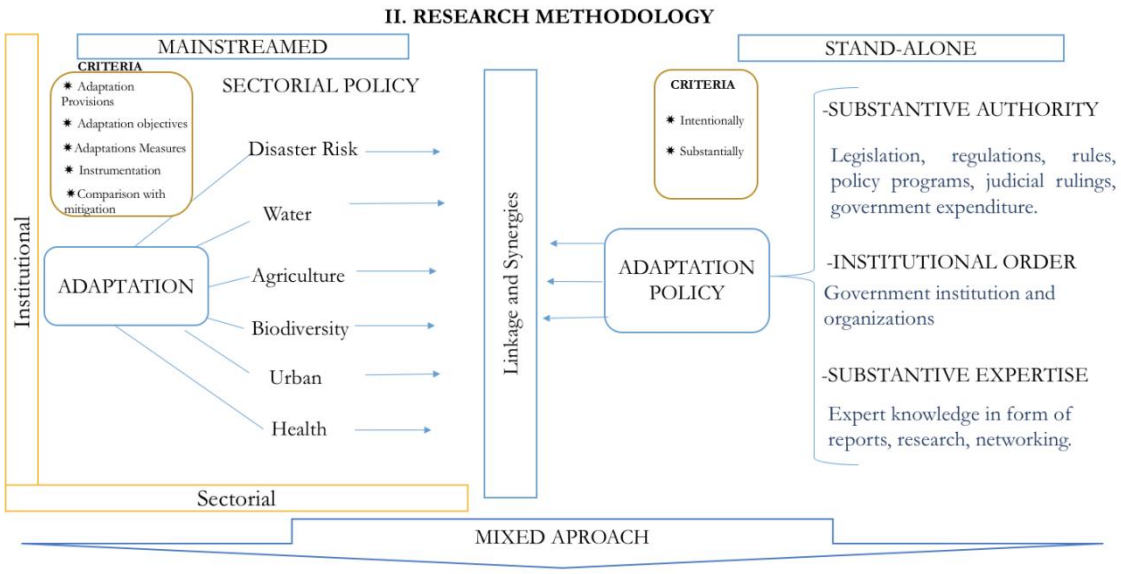

Figure 4. Methodology (Source: Authors own)

From a stand-alone perspective, the constituent elements of a new policy field (Massey and Huitema, 2013) and Mexico's activities and efforts for climate adaptation were analysed in order to establish whether it could be considered as an independent policy field. Only those efforts aimed at substantially and intentionally improving adaptation were taken into account (Dupuis and Biesbrock 2013).

Results

From a mainstreamed approach, the sector of ecosystems and biodiversity (Ecosystem-based Adaptation, or EBA) is one of the most developed. In this sense, objectives and goals as well as concepts such as adaptation, resilience, vulnerability and climate change have been

included in the sectoral planning. Sectors that are at a beginning phase of integration are the health and urban sectors. In the case of water sector, it is embedded in the language of policy and programming, but implementation has been weak considering its significance for adaptation.

From a stand-alone approach, there are some elements of a new adaptation policy field such as programs, government institutions, reports or researches. However, in general these embrace both adaptation and mitigation. By looking closely at these elements, we can establish that there is a predominance of mitigation over adaptation in policy planning and implementation. Mexico, like many other countries, favors mitigation as the core of its climate policy, in the sense that there has historically been much more development of programs, researches and tools of policy focused on mitigation. Therefore, it considers that adaptation policy is still in its infancy. In other words, it has not yet developed a robust adaptation policy; however, activities are growing fast, particularly in the field of research. This is relevant in the sense that adaptation needs a greater technical knowledge.

Conclusions

Both the mainstreamed and the stand-alone perspectives are valid and relevant, and each one has its virtues and criticisms. After reviewing both approaches, we could say that a hybrid or mixed model is the most suitable option to address adaptation planning and to achieve an effective adaptation. On one hand, when adaptation is mainstreamed, it can take advantage of the already existent institutions from other sectoral policies, such as disaster risk reduction, and create synergies to foster adaptation. It also implies a more comprehensive vision of the problem and its solution. However, merely mainstreaming of objectives or considerations is not always guarantee for its practice or implementation as in the case of water sector. The main criticism of this approach is that adaptation prerogatives run the risk of being diluted amongst the pressing objectives of the others sectors, without truly contributing to a change or transformation that can lead to improved adaptive capacity in that sector. Thus, it needs an extra coordination effort and greater awareness about the priority of adaptation.

On the other hand, given that the different policy fields might be insufficient to address all relevant adaptation issues, it may be required to strengthen issues related to adaptation through the creation of a new policy field. By treating it as an entirely separate field, adaptation could guide and boost the creation of new instruments, such as particular adaptation strategies in natural reserves or where new forms of governance for addressing climate change are required. The critical point in this aspect is coordination and communication to avoid institutional fragmentation and bureaucratic issues. Hence, adaptation requires to be mainstreamed but also to have an overarching framework that regulates, clarifies and defines its different aspects.

In summary, this research contributes to the need to have a broader idea on how adaptation can be constituted in practice. It also contributes to knowing what the trends and evolution of adaptation within public policies are, and its linkages with mitigation for establishing a greater synergy. Moreover, it verifies the degree of readiness of Mexico's public policies for adaptation and sets up a base line for future assessments.

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City level water forums: exploring innovations to address 'too much and too little water' in Dharan, an urbanising city of Nepal

Suchita Shrestha[1], Kaustuv Raj Neupane[1]

Abstract

Cities are facing water scarcity due to uncertainties on biophysical as well as social factors. The paper examines a "water forum" as a social learning platform in case study of Dharan, city of Nepal, which helped to bring stakeholders together through a common platform. This was done in order to derive suitable climate adaptive water policies and programs by drawing from local experience and scientific evidences. It is replicable to other similar cities to assist decision-makers in framing policies and interventions.

Keywords: *Urbanisation, Water scarcity, Social learning, Stakeholder engagement, Nepal*

Introduction

Many cities are facing pressure on their water resources due to uncertainties posed by climate change, increased populations and complexities due to weak governance and planning (Yang and Zhu, 2017). The challenge of water issues in urban areas can be summarised as "*too little, too much, too dirty*" (Hoekstra et al., 2018). A recent global study shows that 1 in 4 cities is already water stressed, and climate change and urbanisation will aggravate the risk for water shortages - particularly in peri-urban river basins (McDonald et al., 2014). For such vulnerable areas, climate change adaptation planning is crucial to cope with the impact of weather extremes (Hughes, 2015). Climate change adaptation needs a social learning mechanism or a stakeholder engagement to build new knowledge, relationships, and practices in response to complex environmental challenges (Ensor and Harvey, 2015). Koeppel has identified flexible forums for communication, discussion, decision-making, and improving learning capacity to increase adaptive capacity within water governance regimes (Honkonen, 2017). Social learning amongst stakeholder is required for achieving sustainable or resilient cities (Herk et al., 2011; Rijke et al., 2013). The Organisation for Economic Co-operation and Development (OECD, 2015) has also focused on promoting stakeholder engagement for informed and outcome-oriented contributions to water policy design and implementation.

The paper examines the mechanism of a 'water forum' in the case study of Dharan town of Nepal, which helped to bring stakeholders in a common platform to derive suitable climate adaptive policy and programs in water issues. It contributes as empirical evidence of how the engagement of stakeholders can be useful for devising strategies and policy for natural resource management, such as water resources.

The forum was devised as an innovative platform to foster *science - policymakers-society* interaction for decision making, by exploring solutions to water-related issues through dialogue

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and deliberation with key stakeholders supported by evidences of environmentally sustainable and more resilient policies and practices. Traditionally, in the case of water-related problems, instrumental interventions or engineering works have been considered as solutions; however, the forum recognises that for the management and good governance of water resources, stakeholders' opinions and socio-economic factors are as important as the biophysical indicators. The paradigm of 'consulting' local communities has been shifted to 'engaging' them for transparent decision-making processes and ensuring the needs and views of stakeholders in policy decisions are included. The emphasis has been given to the partnership of local government with academic institutions to foster an evidence-based decision making process. Nevertheless, it has not failed to recognise that stakeholders' engagement is equally important in dealing with resources for concerted action. Nepal is transitioning to the federal structure and local government has been exercising decision making power; however, with limited thematic expertise. Therefore, the water forum provides the unique opportunity to discuss water issues and help the city to be water secure. This is replicable nationwide to assist decision-makers in framing policies and interventions.

Methodology

The experiential evidences were generated from engaging identified stakeholders in the case study city, Dharan, while facilitating water forums. Five of such forums were reviewed. Dharan is a rapidly urbanising town in eastern Nepal characterised by acute shortage of drinking water and events of extreme rainfall at the same time. Self-reflection of authors from water forums and systemic co-inquiry embedded in water forums were the mode of data generation. Apart from these forums, informal meetings with stakeholders and expert consultation, as well as a secondary literature review were made during the period.

The Dharan Water Forum, locally known as "*Dharan Pani Chautari*", was formed as an informal and open deliberative platform of multi-stakholder engagement for sharing research findings and deliberating on climate adaptive water management plans and strategies. Diverse stakeholders participated, including the Mayor, Deputy Mayor, Municipal officials, other government officials, local citizens, representatives from academic institutions, journalists, private sector groups and women groups, amongst others. These meeting were usually of two hours duration and were organised in the interval of three months, or as needed. In the first 30 minutes of the forum, research findings were put forward as an issue. Most of the issues either touched on problems being faced by local people, best practices that can be replicated, or policies that need to be revised. Open discussion was facilitated so as to promote the discussion among stakeholders, which later was streamlined as solution-oriented conclusive action points. Discussions were made on different options for prioritizing the actions that need to be taken by municipality and other stakeholders. Finally, agendas were set for review and discussion for upcoming meeting.

Results

Collective learning and development of the shared view

The water forum helped to understand needs of stakeholders and identify prioritized adaptation options, based on local experience and scientific evidences to make a water secure city. To build a common vision for adaptation strategies, consensus on implementation activities was built through discussion. In the first water forum, 55 stakeholders discussed and prioritized declining groundwater as an important issue. Stakeholders expressed their commitment to contribute and cooperate. In the following forum, around 60 people gathered

and identified effective ways to implement groundwater recharge policy. Constructing recharge pits, combined with rainwater harvesting structures already installed in 13,000 households in the city, was proposed and finalised. Recharge pits not only recharge groundwater, but reduce volume of stormwater.

Engagement promotes leadership, ownership and leverage resources

The process of engagement with stakeholders is continuous, localized and reflective, boosts co-learning and co-creates knowledge, hence provides better decisions with local ownership. It also strengthens the capacity of city governments to plan and implement adaptive actions that help ensure future water supplies of the town. The pilot action of constructing recharge pits was planned to scale out for which the resources have been allocated by city local government.

Develop conducive policies

Understanding a situation can lead to appropriate policy and practice. This forum gave local government an opportunity to interact with relevant stakeholders to develop local adaptation practices and mainstream it within policies. Local government endorsed groundwater recharge policy as mandatory while building new houses through municipal council in 2018.

Designers, municipal engineers and construction workers were invited to another water forum in order to orient them about construction and regular monitoring of recharge pits.

The brief process of the water forum series in Dharan, the emergence and development of stakeholder engagement and social learning and its impact has been shown in **Figure 1**.

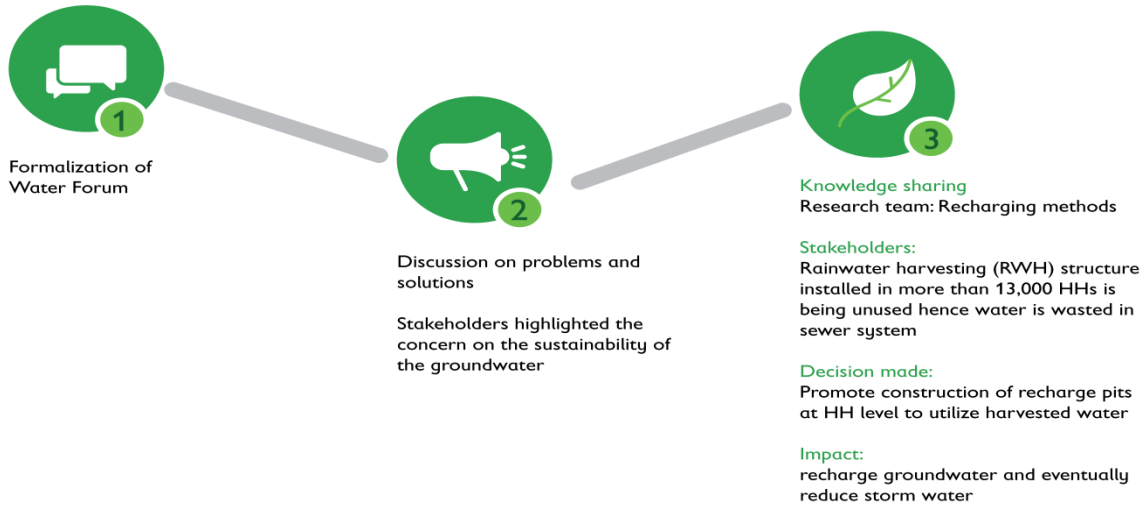

Figure 1: Process of internalisation of the problem (1), uptake of research (2) and outcome of engagement in the water forums (3)(Source: Authors own)

Conclusion

City level water forums are an effective tool which serves the multiple benefits of co-creating knowledge between community and scholars and ultimately supports the development of conducive policies and programs, with full local ownership and sustainability. It is replicable to other similar cities to assist decision-makers in framing policies and interventions.

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Monitoring of short-lived snow coverage by SAR data around Livingston Island, South Shetland Islands in Antarctica

Temenuzhka Spasova[1]

Abstract

Snow is the component of the Cryosphere with the largest seasonal variation in spatial extent. Because of the large extent of terrestrial snow cover and the difficulties in obtaining ground measurements over cold regions, remote sensing represents an important tool for studying snow properties at regional to global scales. In fact, accumulation and rapid melt of snow are two of the most dynamical seasonal environmental changes on the Earth's surface. The large scale changes in snow cover are useful as indicators of climate changes. Snow also affects other components of the Earth's climate system as rainfall, air temperature, atmospheric pressure and others. The main aim of this research is to trace the use of different satellite data and approaches to track the dynamics of the development of short-lived snow coverage and its seasonal dynamics around Livingstone Island, South Shetland Islands, in Antarctica. Natural objects like water, snow and wet snow were analyzed and mapped according to the European Space Agency data (ESA) Copernicus program (Copernicus Scientific Data Hub). Results have been obtained for quantitative changes of wet snow cover and its dynamics. It has been proven that even for a short time span there has been an expansion of the areas taken up by wet snow, which is an unequivocal evidence of climate changes. The demonstrated results are a representative sample of the last two years, but the study is based on a longer period and the focus is on the data provided by SAR (Synthetic Aperture Radar). The presented monitoring methodology is financially accessible and irrespective of the economic developments of the regions and the place of research. The monitoring results can be used not only to monitor wet snow, snow, water , but also to monitor vegetation and soils.

Keywords: *Snow cover, Radar satellite data, Optical range, Sentinel-1 SAR, Antarctica*

Introduction

Because ice and snow reflects sunlight (whereas oceans absorb it), the Antarctic ice cap is one of the Earth's natural defense mechanisms, helping to regulate the temperature of the oceans and the atmosphere. An increase in temperature in this region could cause a positive feedback loop (melting ice and snow causing a further increase in temperature, etc.), and this has the potential to influence climate patterns all over the world. Copernicus ice monitoring services keep an eye on the poles and give us insight into the rate at which the wet snow coverage extent is changing over time (Copernicus. Europe's eyes on Earth, 2018). The subject of the study is monitoring of short-lived snow coverage, or so-called wet snow, and its dynamics for Livingston Island, South Shetland Islands in Antarctica.

Each natural object or entity reflects the sun's radiation that has fallen on it in a specific way, characteristic of itself and its condition. This unambiguous correspondence is the basis for

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identifying the type and condition of the Earth's natural objects in the reflected solar radiation (Mardirossian G., 2000; Spasova T., R. Nedkov., 2017).

Figure 1 demonstrates test areas on an optical image of Sentinel - 2. Spots were taken to reflect the spectral reflectance of water, wet snow and ice. Before composing points, a composite of the image was made and using 4, 3 and 2 spectral bands using the RGB model. Spectral characteristics are curves that distinguish natural objects. These test points are arbitrarily made to calibrate with SAR images for much better quality monitoring.

The main purpose of this study is to track the use of different types of data, Synthetic Aperture Radar (SAR) data and approaches to study the dynamics of wet snow cover by remote sensing and the importance of this monitoring of climate change.

Methodology

Verification and validation of SAR images is done using the Tasseled Cap Transformation (TCT) model used and based on pre-selected test areas with ice, wet snow and water. The selection was made using terrestrial data from Livingston Island near the Bulgarian Antarctic Base, St. Klement Ohridski (located at 62 ° 38 '29 "S, 60 ° 21' 53" W), East Coast of the South Bay, in Livingston, South Island. Terrestrial data are only used for calibrating aerospace data (Correia, A., et al. 2017; Mardirossian G., 2000). Test areas were selected from locations without field data. When different climatic phase transitions occur, different changes occur in the snow coverage, therefore the evaluation indicators also change.

One of the indexes in the study is Wetness from TCT with components BR - Brightness,GR - Greeness, W - Wetness suitably, composed in RGB model. In that case, the achieved results have a changed structure in comparison to the primary received data. It allows more precise recognition and classification of the different components (vegetation, soil, water) of the land cover (Nedkov R.,2017).

The observation of the spectral changes observed in the melting of snow and wet snow through the use of spectral characteristics requires the use of different spectral channels. The methodology of this study includes selection of satellite data as input data (Sentinel -2 optical data) to obtain TCT images and SAR images from Sentinel -1 SAR, including the selection of appropriate time series with the appropriate resolution for tracking the snow cover (presence of snow , wet snow, water) (Spasova T., R. Nedkov, 2017). Verification of SAR images with hh-polarization is based on representative TCT test areas. The melting snow and short-lived snow coverage can be investigated and recorded by the C-band of Sentinel-1, but as an indicator it is necessary to study the wetness from TCT. The lack of qualitative data from an optical image is compensated sufficiently by SAR images and Merge approach (Sentinel -1 in dB (decibel) and TCT from Sentinel- 2) and the use of SAR in dB can be clearly used as a validation method (Spasova T., Nedkov R., 2017). The resolution and hh - polarization in the area is also absolutely sufficient (Nedkov R., Spasova T., 2016) to map the dynamics of wet snow or short-lived snow coverage during phase transition seasons, the presence of constant snow cover and ice for the rest of the year. The radar data does not depend on the weather conditions in the Antarctic and is of high quality and resolution for climate change monitoring.

Results

The comparative analysis of the results of TCT image and SAR images indicates the presence of more wet snow, which is a clear evidence of climate change. Data from Sentinel -2 MSI

(MultiSpectral Instrument) can be used to clearly locate the presence or absence of water, snow and ice. Optical images from this area have a lower temporal resolution, making them less suitable for monitoring, as wet snow melts faster. Spectral bands used to detect snow cover are 4, 3, 2, (**Figure1**).

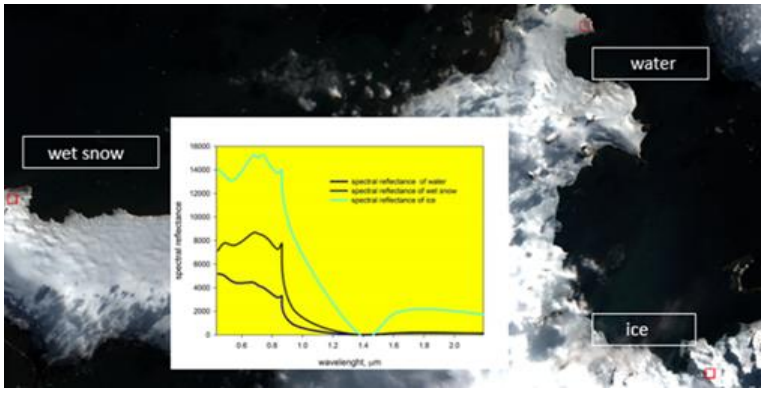

Figure1: Composite image from Sentinel-2 with the test areas – bands 4, 3, 2 date: 30/03/2017 and spectral characteristic of water, wet snow and ice for the test areas (Source: Authors own)

The SAR images with hh - horizontal polarization (**Figure 2**) from two consecutive years (from the same period of the year), the spectral and reflectance distribution of wet snow in dB(decibel) are also reliable ways to validate wet snow data and locations with large change in values 22 - 25 dB, which is a sure sign of climate change. This is a representative sample of a period of more than five years and the values are being studied. Values between 25 and 28 dB indicate wet snow or short-lived snow coverage (Spasova T., Nedkov R. 2017), values above 30 dB are an ice indicator (Gochev D., Nedkov R., Dimitrova M. 2017). Among the presented SAR images from 2017 and 2018, certain segments can be observed where the climate change tendency, even for a period of one year, is considerable. Although the image is 20 days later, it can be assumed that in 2018 the areas of wet snow and water have a much larger area, which is a tendency for unfavorable climate change in these latitudes, and which could affect drinking water worldwide.

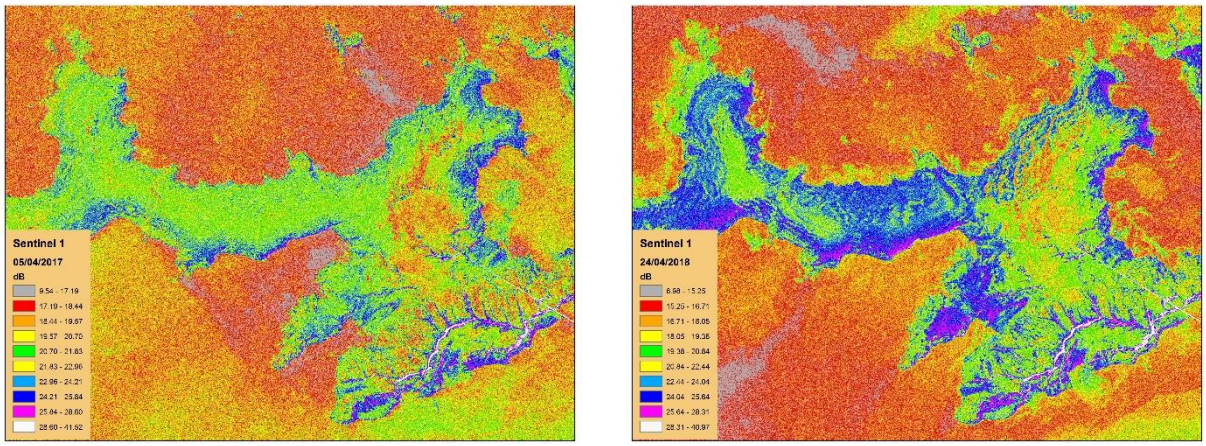

Figure 2: SAR images in dB, Sentinel -1 (2017, 2018) (Source: Temenuzhka Spasova)

In **Figure 2** in bright and dark blue color (or values between 22 - 25 dB) are the places depicting wet snow and covering quite large areas in 2018.

Conclusion

The year-round monitoring, conducted in in hard accessible places like the Antarctic, is difficult and expensive but the impact of this area is not only local but global. Therefore, the SAR-validated database study, which has a good enough resolution, attempts to show the real melting trend of snow as much as possible. This trend can be explored on the basis of the presented methodology as the ESA gives free access to its data. The survey data is representative of samples and can be used not only for wet snow monitoring but also for all other natural objects. With a rise in temperature, the sea- level will rise and this is a threat to a large number of island and lower-lying countries. Wetlands are likely to become wetter and droughts will become more common. One of the main things in "Adaptation to Climate Change" is to prevent or reduce human's negative impact on climate change. There is no way to prove that there are impacts and significant changes in the environment without constant monitoring.

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Cost of climate change adaptation in semi-arid regions – estimates from Maharashtra, India

Arjuna Srinidhi[1], Arpan Golechha[2]

Abstract

While estimates do exist for the costs of adaptation at a global level ($200 billion to $500 billion per year), there are few studies that provide bottom-up costs of adaptation (Gray & Srinidhi, 2013). The data presented here is from Watershed Organisation Trust (WOTR)'s climate change adaptation (CCA) project in the Ahmednagar district of Maharashtra, India. The costs cover over two decades of both adaptation and development activities and attempts to differentiate between them to find a climate change relevance to the investments.

Keywords: *Development, Climate finance, Costs of adaptation, Semi-arid, India*

Introduction

This study seeks to establish a range of bottom-up adaptation costs in semi-arid regions of India (The World Bank Group, 2010). These regions cover 69.6% of the total land in the country (Ministry of Environment and Forests, 2010). The focus area of analysis is in Ahmednagar district of Maharashtra in central India. Known to be a drought prone area with about 400-450 mm of rainfall, the primary concern in the region was securing water resources (Central Groundwater Board (CGWB), 2014). Thus, the first step to building resilience began with the watershed development project under the Indo-German Watershed Development Programme (IGWDP) in 1992 (1992-2005).

A climate change adaptation project was implemented between 2009 and 2014. The list of activities include 14 broad categories of interventions including activities under Biodiversity, Livestock, Disaster Risk Reduction, Water Budgeting, Agriculture, Agro-advisories etc. (Watershed Organisation Trust, 2014) (Bhushan, Srinidhi, Kumar, & Singh, 2014).

Methodology

The CCA project by WOTR has been carried out in 25 villages in the Ahmednagar district of Maharashtra and the monetary data around it pertains to the investments made towards these activities. We have used two ways of differentiating costs that address development or adaptation deficits.

i) **Objective-based method:** involves classifying an activity as development or adaptation based on stated objective (explicit / implicit) of the activity. It also takes into consideration whether the activity was historically being carried out in development projects or if it is a new and 'additional' activity (Resch, Allan, Alvarez, & Bisht, 2017). The key variable being estimated is the sum of the costs which are meant for activities that have "adaptation" as the goal.

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ii) **Benefits-based method:** an assessment of the total benefits generated from that particular activity and the proportion of which is associated with adaptation or mitigation. This assessment is based on a number of Cost Benefit Analyses (CBA) under 'business-as-usual' and 'climate-change' scenarios (Resch, Allan, Alvarez, & Bisht, 2017). The key variable being estimated is the sum of the investments that have clear climate change adaptation benefits.

These costs are then compared with the area of the land under treatment and the ratio of cost per unit area is derived. These figures can be used to estimate costs of Adaptation over the wider semi-arid areas of the region.

Findings

Objective-Based Approach

Under the objective-based methodology, activities and their sub-activities were classified into the following categories based on the primary vision behind the activity:

i) Purely Adaptation (A)
ii) Purely Development (D)
iii) Purely Mitigation (M)
iv) A mix of the three (AD/AM/DM/ADM)

Summing-up the costs for each category and then calculating their ratios led to the following split between the three objectives:

Table 1. Split between Adaptation, Development and Mitigation under the Objective-Based Approach (Source: WOTR's CCA financial records, 2014)

Category	Project level
Adaptation	25%
Development	46%
Mitigation	30%

Another important feature of the costs was that they were very sensitive to changes in the ecosystem and terrain. The comparatively hilly areas required much higher costs as compared to plateau areas for development as well as adaptation activities. The resulting split between the adaptation, development and mitigation costs are as follows:

Table 2. Adaptation, Development and Mitigation costs for plateau and hilly regions (Source: WOTR's CCA financial records, 2014)

Objective based Division	Ratio	Project Level (INR)	Plateau Region (INR)	Hilly Region (INR)
Adaptation	25%	3587.15	2729.66	6674.59
Development	46%	6641.34	5053.77	12357.51
Mitigation	30%	4334.23	3298.16	8064.68
Total (INR)	100%	14562.73	11081.59	27096.77

Note: 1 USD = 66.19 INR (3-year average exchange rate)

Thus the costs of an integrated development-adaptation project in semi-arid parts of South Asia (Objective-based method) range from about 11,080 rupees (US$168) to about 27,100 rupees (US$410) per hectare, and adaptation costs amounting to about 25% of the total.

Benefits-based Approach

The benefits-based approach recognises that each type of activity contributes a certain proportion of benefits towards development, adaptation, and mitigation. Based on several cost-benefit analyses (CBAs), proportions for standard activities (development, adaptation and mitigation) have been calculated by Resch et al. (2017). These analyses ae based on various projects in the Indian sub-continent and so would be applicable to WOTR's CCA project in Maharashtra too.

Table 3. Range of benefit-based contribution towards Adaptation, Development and Mitigation (Source: WOTR's CCA financial records, 2014)

Overall	**Lower Bound (LB)**	**Upper Bound (UB)**
Adaptation Ratio	5%	26%
Mitigation Ratio	1%	6%
Development Ratio	68%	93%

Note: Sum of all LBs or UBs will not add-up to 100. LB case for Adaptation and Mitigation + UB case for Development will be equal to 100.

The earlier differentiation in costs between the hilly regions and the plateau region applies – leading to a broad range from the lower bound-Plateau region regions costs to upper bound-hilly regions.

Table 4. Split between Adaptation, Development and Mitigation costs based on ratios mentioned in 'Table 3' (Source: WOTR's CCA financial records, 2014)

Division based on Benefits	**Plateau (INR)**		**Hilly (INR)**	
	Lower Bound	***Upper Bound***	***Lower Bound***	***Upper Bound***
Adaptation	647	3051	1507	7114
Mitigation	176	698	411	1627
Development	8075	11001	18826	25648
Total	11824		27566	

Note: 1 USD = 66.19 INR (3-year average exchange rate)

Thus the costs of an integrated development-adaptation project in semi-arid parts of South Asia (Benefits-based approach) range from about 11,820 rupees (US$179) to about 27,570 rupees (US$417) per hectare, with adaptation costs amounting to about 7,110 rupees (US$108) or 26% of the total at the higher end.

Discussion

The delineation of adaptation, development and mitigation costs is a cause for concern and active debate in the climate finance sphere where the determination of how adaptation finance can be calculated has been a much deliberated topic.

Although this paper points to quite a detailed segregation of the costs, based on objectives and benefits, we should not lose sight of the broader fact that these distinctions (in most cases) are purely academic and often, in reality, adaptation and development will go hand-in-hand. The distinction between the two is less of a 'definitional question' and more of an 'operational process' that establishes the 'adaptation function' of any action based on locale-specific climate information (Hammill & McGray, 2018).

Conclusion

- The adaptation and development splits from both the methods (objective- and benefits-based) are not too divergent and have a very similar upper bound and average value.
- The integrated project costs (adaptation + development) compares well with the budget for national watershed development activities - INR 12,000 and 15,000 per ha respectively (Government of India, 2011) - and is expectedly higher than those.
- A large part of Maharashtra, and the rest of India (69.6%), fall into the category of semi-arid, sub-humid regions. Such per hectare cost estimates will be very useful for climate proofing of agriculture (Ministry of Environment and Forests, 2010).
- UNEP Adaptation Gap report assesses that adaptation costs in developing countries between $140 billion to $300 billion (UNEP, 2017), and such bottom-up analyses could be an excellent basis for validating top-down Climate finance estimates.

Conflicts of Interest (Declaration)

The data pertains to WOTR's CCA project, supported by NABARD and SDC. The use of the data for this study has been sanctioned by the concerned organisations.

Acknowledgements

The study would not have been possible without the support of the various knowledge partners and donors of the CCA project, including the Swiss Agency for Development Cooperation (SDC) and National bank for Agriculture and Rural Development (NABARD).

Notes

This study is based on data from one project and can only be roughly extrapolated to similar contexts.

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How climate change adaptation interventions (trans)form the human-nature relationship: The prolonging of environmentality in Panchase, Nepal

Julian Swinkels[1]

Abstract

Different scholars have emphasised different aspects of environmentality: some have explored how people come to intimately interact with their environment, others have explored how power/knowledge formations within disciplinary measures of government inform the human-nature relationship. This paper argues that these different perceptions of environmentality can co-exist. The data collection methods consisted of post-intervention fieldwork analysis of an ecosystem-based adaptation (EbA) project that was implemented in Panchase, Nepal. The findings illustrate that disciplinary spaces are not only capable of fabricating new states of environmentality, but can also be used to restore the resilience of pre-existing states of environmentality that are being threatened by climate change. I conclude that a more embedded framework can be constructed which will ultimately make it easier for the social sciences to imagine what types of interventions make subjects emerge that make both humankind and nature (more) resilient to climate change.

Keywords: *Ecosystem-based Adaptation, Environmentality, Power, Knowledge, Nepal*

Introduction

Most environmental movements within the discipline of geography follow the basic discourse of Foucault's concept of governmentality. Agrawal (2005: 166) extended the framework of governmentality to explore how "*technologies of the self and power are involved in the creation of subjects who are concerned about the environment*". The body of literature that is concerned with such 'environmentality' marks the emergence of a distinctly new form of exercising power in a way that makes subjects care about their environment.

This research explores two aspects of environmentality; the first is the limited understanding of the relationship between institutional interventions and the human-nature relationship. To explore this relationship, I investigate the impact of adaptation intervention measures – which environmental governance institutions promote, crystallise and co-produce – on the interaction that communities have with their environment. Secondly, I look at what relationships exist between interventions of environmental governance institutions and the people living in rural mountain communities. As Jasanoff (2010: 249) states, "*institutional norms influence fundamental choices that define the boundary between nature and culture, determining who has authority to represent natural objects, and selecting the rules for resolving controversies*." So far, little concern has been expressed towards the power/knowledge formations within which the social construction of (adaptation to) climate change takes place in concrete geographical places (de Wit, forthcoming). Following the narrative that institutions construct

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power/knowledge structures, this paper seeks to address how these structures (trans)form the interactions between authorities, knowledge and subjects.

Objectives

Nepal, being one the lowest economically developed countries, means it will be one of the main countries that will be targeted by climate change adaptation projects (Ojha, et al. 2016). As human-induced climate change is starting to alter climate patterns, the three-quarters of Nepal's population that is currently engaged in small-scale and subsistence agriculture will need to find a way to enhance their resilience to these changes (Maharjan and Maharjan, 2017). Panchase is an example of a remote region in Nepal where people are highly dependent on subsistence agriculture.

Following Randalls (2016), I view climate change as an integrated process that cannot be detached from its discursive formations. With the latter, it is meant that climate change adaptation interventions can enact different ontological realities to be managed depending on the different assemblies of practices, sciences, interventions, policies and ideas that are constructed. These articulations may then give further insight into how communities are triggered to respond to the current and future effects of climate change. The following two questions are explored in the integrated context of the adaptation interventions that the International Union for the Conservation of Nature (IUCN) is conducting – in partnership with Machhapuchhre Development Organisation (MDO), UNEP and UNDP - in Panchase, Nepal:

i) How do the interventions of environmental governance institutions inform the human-nature relationship?
ii) What relationships exist between climate change adaptation interventions and the formation of environmentality in local communities?

Methodology

For the data collection, the following was conducted:

i) participant observation;
ii) informal interviews;
iii) focus group discussions, and
iv) expert interviews.

The participants all live in rural mountain communities in Panchase, Nepal. The expert interviews were held with representatives of IUCN and the MDO. Together, they give a good sense of what types of subjectivities are being formed in the interaction between authorities, knowledges and subjects in Panchase.

Findings

What emerged from the interviews was that 'environmentality' had long been part of the existing way of life in Panchase. Older generations in particular were able to talk about the relationship they had with the environment before the intervention period. One effusive elderly man expressed "*When I was young, things were much easier! We lived off what the forests provided and did not have to worry about anything! Life was good before climate change*". His friend agreed, saying "*It is true, we were able to grow more and better crops before; every year it is becoming harder*". When asked about why he cared for the environment, the first man stated "*It is our way of living here, if we do not care for our environment, then how can we live here? Everything we need for survival comes from our land*."

Unfortunately, this traditional ontological perception of the environment, that allows the people in Panchase to intimately engage with their ecosystem services, is being threatened by climate change.

Prior to the adaptation interventions, the IUCN held consultation meetings with various village groups (mothers, farmers, community forest users, elderly, MDO, village leaders and university members) to help understand the local context and voice their opinion on the project (IUCN, 2012). Each stakeholder was asked to contribute their specific knowledge, experience or disagreements they had with regards to the interventions. Local people were therefore not subjected to the gaze of one single authority, but rather the decisions that were made came out of an assemblage of authorities, knowledges and subjects. This indicates that the power inherent in adaptation is formed through dynamic patterns of power relations between actors.

The findings post-intervention show that the techniques which give people in Panchase more knowledge and control over their land are most successful. These include, but are not limited to: pond conservation, bee farming, agro-forestry, ecotourism, such as home stays, and improvement of livestock sheds. While these intervention techniques lay the foundation for a neo-liberal perception of the environment, it does enhance resilience by identifying new ecosystem services that allow livelihoods to sustain a living in rural mountain areas.

Conclusion

What has been established is that the adaptation interventions in Panchase have (re-)shaped the human-nature relationship in the sense that they have allowed the people of Panchase to prolong their environmentality and improve the resilience of their community. Moreover, the findings show that there are multiple environmentalities which are enacted by different foundations, discourses and perceptions vis-à-vis the environment. On the one hand, a traditional environmentality has existed long before the occurrence of anthropogenic climate change, and is deeply rooted within the culture of the people living in Panchase. On the other hand, a newly introduced neo-liberal environmentality introduces a more resilient stance towards climate variability. The hybrid space in which the different types of environmentality interact opens up the possibility for future research to explore how and in what ways climate change adaptation may fruitfully inform the human-nature relationship in different localities and institutional contexts. While it is evident that the neo-liberal environmentality has provided the space in which individuals can continue to intrinsically care for the environment, the opposite may also be possible. In western culture, where neo-liberalism has become a deeply rooted characteristic, intrinsically caring for the environment may fruitfully inform the human-nature relationship.

Either way, a durable and healthy relationship between nature and humans demands more than just objective claims and technological input. Instead of dichotomy, we need duality; the human-nature relationship achieves robustness through co-production between people and institutions. Whether is by preserving, transforming or shifting to new ontological understandings of the environment, it is ultimately about transforming our attitudes and behaviour in a way that ensures a healthy planet for generations to come. To do so, the social sciences will need to explore ways in which we can get a more comprehensive understanding of the links between human and ecological systems. It is towards such an end that this research has proceeded.

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An assessment of determinants of adaptive capacity of livestock farmers to climate change in Omusati Region, North Central Namibia

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Abstract

Livestock is a source of wealth, status and cash reserve in rural areas in Namibia, and contributes over 60% to agricultural GDP for the country. The sector faces several challenges attributed to climate change which forces farmers to employ several strategies to sustain their livestock. However, their ability to do so is influenced by their adaptive capacity – which, in turn, is influenced by several factors. Research finds that farmers' adaptive capacity to climate change is very low and seems to be influenced by both their cultural beliefs and the unattractive market prices for their livestock.

Keywords: *Adaptive capacity, Culture, Drought, Livestock, Namibia*

Introduction

Livestock are negatively affected by the impacts of climate change (Kebede, 2016) - climate variation is a major risk to the sustainability of livestock systems globally. Climatic extremes and seasonal fluctuations in pasture quantity and quality and water demand affects the well-being of livestock, and leads to declines in production and reproduction efficiency. The impact of climatic changes is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are already affecting livestock production systems (Anim, 2013). Livestock losses may force households dependent on livestock into chronic poverty and have a lasting effect on livelihoods (Calvosa, Chuluumbaatar, & Fara, 2010).

In many rural communities in Namibia, especially in the north, livestock is a source of livelihood and wealth of many households, and is the major asset of the poor used as a cash reserve, dowry and/or gift for traditional ceremonies and offerings; however, the sector is highly vulnerable to climate variability and extremes (FAO, 2008). Losses have been increasing due to droughts/floods and other climatic related conditions which threaten livelihoods of many. Rangelands are degraded and pastures last only for a few months, while carrying capacities have long been exceeded which compounds the shortage of pasture. Many farmers have been experiencing livestock deaths especially during prolonged droughts and sometimes during floods (ORC, 2010). It is thus imperative to find ways that may improve livestock production and adaptation to these effects of climate change for the livestock farmers.

Adaptation to, and mitigation of, the detrimental effects of extreme climate can play a major role in combating the negative impact on livestock (Belay, Recha, Woldeamanuel, & Morton, 2017). Adaptive capacity enables a system to adapt effectively and to cope in relation to the impacts. High adaptive capacity may reduce the system's vulnerability to disturbances that

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might occur in the future (Kelly, Anwar, Macadam, & Liu, 2012), in an anticipatory manner or to disturbances that occur slowly, either reactively or separately (Abid, Scheffran, & Scheider, 2015). A focus on increasing adaptive capacity highlights the resources available for adaptation within a specific context, rather than the most desirable adaptation actions (Belay, Recha, Woldeamanuel, & Morton, 2017). The purpose of this research is to identify livestock farmers' perceptions on climate change and to determine the level of their adaptive capacity, as well as the factors influencing the adaptive capacity.

Methodology

A purposive sampling method was used to select households that keep livestock in seven villages in the Omusati region using a survey questionnaire and mixed gender group discussions to enable researchers to obtain information from relevant farmers who own livestock. Data was collected on the farmers' observations on the changes in climate, availability of grazing, changes in livestock numbers and causes of those changes, the actions that they take to deal with these changes, and the assets available to them. Moreover, information was collected on perceived factors that influence their adaptive capacity to deal effectively with changing climate and variability. The determinants that were used to measure adaptive capacity on a Likert scale of 1(low) to 5 (high) were: information, technology, economic resources, institutions and social networks, infrastructure and equity. The categorisation was determined as: 1-2.9 - low, 3 – moderate, and an average ranking of 4 and above is high. These factors where then ranked to determine their strengths on whether they become barriers or enablers to adaptation to climate change and variability. Implications of factors that are barriers are that more will need to be done to remove the barriers so that farmers are enabled to adapt, and where enablers are identified, they need to be enhanced and extrapolated to other areas.

Findings

The respondents were gender balanced, with the head of the households being equally split (50% female and 50% male), of which 66.7% were married and 10% single. The majority (50%) of household heads only had basic education, 30% had secondary education, and 16.7% had no formal education. The majority of households acquired livestock through purchases (67%), inheritance (23.3%) and 13.3% kept livestock on behalf of other family members. The majority of respondents kept livestock for home consumption and traditional purposes (93.3%), while only 6.7% kept for commercial purposes.

Table 2: Respondents' socio-economic characteristics (Source: Authors own)

Variable		Percent
Gender	Female	50
	Male	50
Marital status	Married	66.7
	Single	10
	Widowed	23.3
Source of livestock	Bought	66.7
	Inherited	33.3
Reason for keeping livestock	Home consumption, traditional and other	93.3
	Commercial	6.7
Number of livestock	Current numbers (average)	Deaths in the last 5 years (average)
Goats	25	17
Cattle	16	14
Sheep	4	4

Respondents also indicated that selling livestock, especially cattle, to formal channels was equivalent to making "*an offering to the church*" as they do not get the value that their livestock is worth which is an average of R45.95/kg for A grade while C grade fetches R40/kg per carcass weight with a penalty of R8.50/kg for 0% fat (MeatCo, 2018). Most animals were required to be quarantined and during the process the loose body condition thus graded lowly and then fetches low prices as a result. Farmers on the other hand perceive that they get higher prices on their cattle if they sell to individuals as they are able to put whatever price they want and negotiate with the buyer (ranging from R4000-R12000 per live animal depending on size) compared to the formal market where the price is fixed based on grade of animal. Farmers also believe that the bigger the size of an animal the higher the price it should fetch but formal market uses meat quality and tenderness for grading. The more tender the meat of an animal (young animal) the higher the price and vice versa. On average, farmers owned 16 head of cattle, but experienced an average mortality rate of 14 cattle in the previous 5 years, and 25 goats with an average of 17 goat deaths in the previous five years. When asked about availability of pasture, the respondents indicated that pasture lasts for between 3 to 5 months in a year due to shortened rainfall seasons, which have late onset and early cessation compared to past years. The farmers indicated that the major effect of drought was livestock deaths due to limited grazing and possibly caused by God, not necessarily climate change and do not perceive the increasing livestock numbers to be of any effect on the environment.

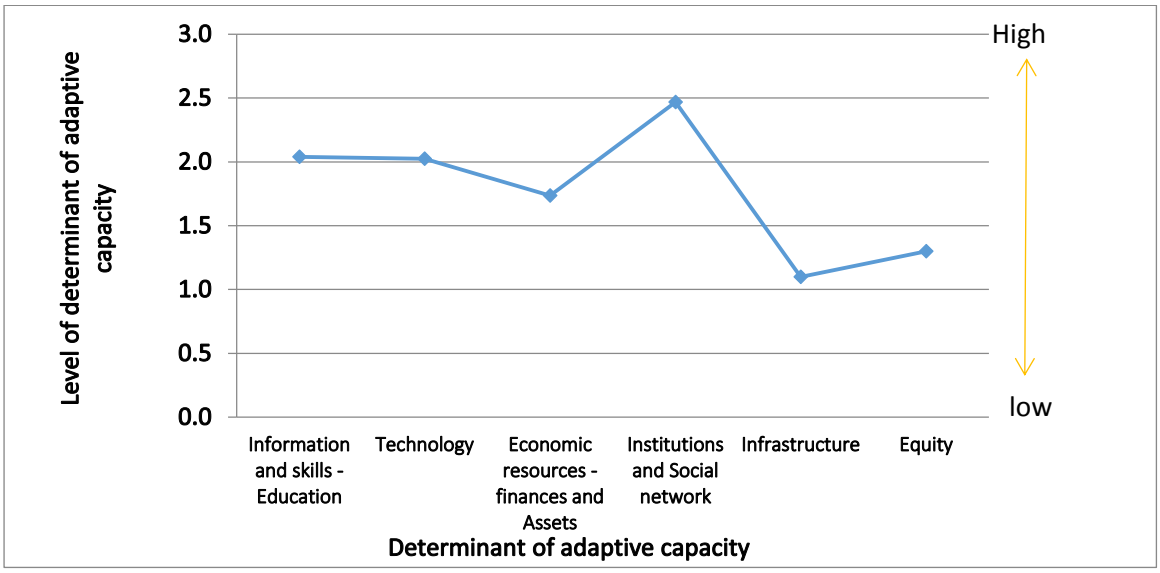

Figure 5: Determinants of adaptive capacity (Source: Authors own, Survey data using Likert scale (1, low and 5 high))

Overall, the adaptive capacity of livestock farmers varies according to gender and age, as well as diversity of incomes and level of education, but is very low (an average ranking of 1.8 across the 6 determinants). Farmers perceive that their level of education is an impediment to the improvement of their livestock production as they feel that there are many aspects of livestock production which they do not understand and often when information is shared it is sometimes too complicated for their level. Moreover, the majority of the farmers felt that they often find it difficult to market their livestock when the need to sell arises as there is inadequate marketing infrastructure which when available is very far (**Figure 1**). However, farmers felt that they rely on their social networks for information and assistance when required for their livestock as neighbours and relatives often chip in to assist. Their resource endowment was perceived to be low making it difficult to fall back on them when need for diversification or purchase of vaccines arises. They also felt that better off households are better equipped to take care of their livestock and are always at an advantage as far as livestock production is concerned as they will be able to supplement feeding to their animals as well as fence off grazing areas at the expense of the rest of the farmers.

Adaptive Capacity and determinants

- **Economic resources:** Most farmers lack financial resources to purchase fodder, vaccinations, and restock and diversify their livelihoods due to social constraints and poverty.
- **Technology:** most livestock farmers are not able to access technology that is required for improvement of livestock production such as supplementary feeding formulas and breeding material such as synchronised production.
- **Informational and skills:** Although information is available, the format in which it is shared is not easily accessible due to language barriers and the media used, as some farmers have limited levels of literacy.
- **Infrastructure:** Available infrastructure, such as auction pens, markets and veterinary services, is often far away and inadequate to serve the purposes of the farmers.
- **Institutions and social networks:** Institutions such as extension and veterinary services are available but often do not address the farmers' specific needs, such as feed or water for

livestock, as these require resources; however, they are reliant on social networks when in need of assistance with livestock production, especially from their kin and neighbours.

- **Equity**: some well-off and influential farmers have fenced off huge tracts of land meant for communal grazing to the detriment of the majority, thereby limiting their available options to take action when their livestock need grazing.

Conclusion

Livestock is kept for cultural and traditional purposes like weddings, funerals, special occasions, and social status - most livestock farmers are not driven by income. While droughts are experienced as the most detrimental climate impact, affecting livestock mortality, some farmers are fatalistic, believing that climate change is an act of God and they do not need to do anything in response to impacts. Adaptive capacity of livestock farmers is very low as a result of socio-economic and cultural factors. Farmers that have limited resources are not able to improve their adaptive capacity when the need arises, particularly if financial resources are required. When livestock belongs to family members that are far away or the livestock was inherited, the ownership of livestock often impedes decision making, because decisions need to be taken collectively. There is a need to understand the needs of farmers and also consider their cultural perspectives before offering incentives or subsidies to them. Favourable market prices alone are not adequate – farmers have other trade-offs to consider such as traditional obligations that include wedding gifts and funeral contributions, thus need to be involved in planning for solutions.

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Working towards climate-resilient cities in southern Africa through an Embedded Researcher approach

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Abstract

Transdisciplinarity is a well-documented approach to finding solutions to complex problems. The research project Future Resilience for African CiTies and Lands (FRACTAL) uses an experimental 'Embedded Researcher' (ER) approach to facilitate the co-production of climate information with researchers and city decision-makers. This paper introduces the concept of the ER; describes the model; and shares the benefits and limitations of the process.

Keywords: *Transdisciplinary, African cities, Embedded researchers, Urban decision making*

Introduction

The gap between scientific knowledge and the development and implementation of policies and actions are well described, especially with regards to so-called 'wicked problems', such as sustainability, environmental management, and climate change adaptation (Moser and Dilling, 2011; Lang et al., 2012; Swilling, 2014). According to Reyers et al. (2010), transdisciplinary approaches can bridge the gap between science and action, by not only bridging disciplines, but also through making research a more inclusive social process of resolving problems involving the participation and mutual learning of stakeholders in various sectors.

The Future Resilience for African CiTies and Lands (FRACTAL) is a four-year project led by the Climate System Analysis Group (CSAG) at the University of Cape Town (UCT). FRACTAL aims to provide accessible, defensible and actionable climate information to decision-makers at the city-regional scale in southern Africa. This transdisciplinary project uses an experimental 'Embedded Researcher' (ER) approach to facilitate a variety of stakeholders working together to co-produce relevant knowledge needed to navigate climate resilient development pathways in five cities, namely Durban (South Africa), Lusaka (Zambia), Harare (Zimbabwe), Maputo (Mozambique), and Windhoek (Namibia).

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According to Jenkins et al. (2012), an embedded researcher can increase research impact by spending an intensive period enmeshed in the culture and operations of other work communities. The embedded experience creates the opportunity to build relationships, facilitate the spread of ideas, reframe research questions, and learn the constraints and initiatives specific to a particular organisation – all of which may improve the impact of research on policy and practice, as well as shape the research agenda based on knowledge needs within the policy and practitioner communities. Embedded researchers are 'knowledge brokers and boundary spanners' (Vindrola-Padros et al., 2016).

The aim of this paper is to introduce the concept of the ER approach in FRACTAL; illustrate the operational model; comment on the expertise required, and share the benefits, and limitations that the team experienced through the process.

The approach and purpose of the ERs in FRACTAL

African cities are considered important fast-growing, partially regulated, and climate-vulnerable centers of decision making and action. In response to this, FRACTAL placed seven early career researchers in the six partner-municipalities on the project to act as ERs. Each ER is employed by a local university and is deployed to work within the local municipality. They are directly supervised/managed by two FRACTAL Principal Investigators (one at the local university and one at the local municipality), who are also team members of FRACTAL.

The objectives of the FRACTAL ERs are to facilitate and contribute to:

- Co-exploring existing knowledge and co-producing new knowledge on urban climate sensitivities and processes of building climate resilience in southern African cities between scientists and decision-makers;
- Advancing the integration of contextual climate information by creating and sustaining learning forums and mechanisms, with the long term goal of shifting the way urban development, resource management and infrastructure investment decisions are made in southern African cities;
- Strengthening urban governance networks across different sectors, within and between southern African cities, and building a culture of learning within these networks;
- Sharing lessons about adapting to a variable and changing climate across southern African cities in and beyond the FRACTAL network.

The activities of the ERs include: acting as link between university and municipal partners; mapping relevant stakeholders and knowledge-holders and building and maintaining relationships with them; investigating entry points of climate information into policy-making; organising and documenting FRACTAL Learning Labs; conducting interviews, site- and exchange visits; facilitate interactions and communication between the decision makers, practitioners, the climate scientists and other researchers; reporting FRACTAL activities to City officials, university colleagues and other partners; conducting research into decision-making processes; and documenting learning. These cannot be achieved by the ERs alone - strong support and commitment is required from all individuals, partner organisations and stakeholders involved.

Operational model

The ERs operate within a set space between the local university, local government, and the FRACTAL project lead partner (**Figure 1**). This negotiated space is governed by formal

agreements between the three institutions. Within the 'embedded space' between the local university and local government, the ERs carry out their work; which involves trust- and relationship building, and facilitating co-exploration and co-production of knowledge.

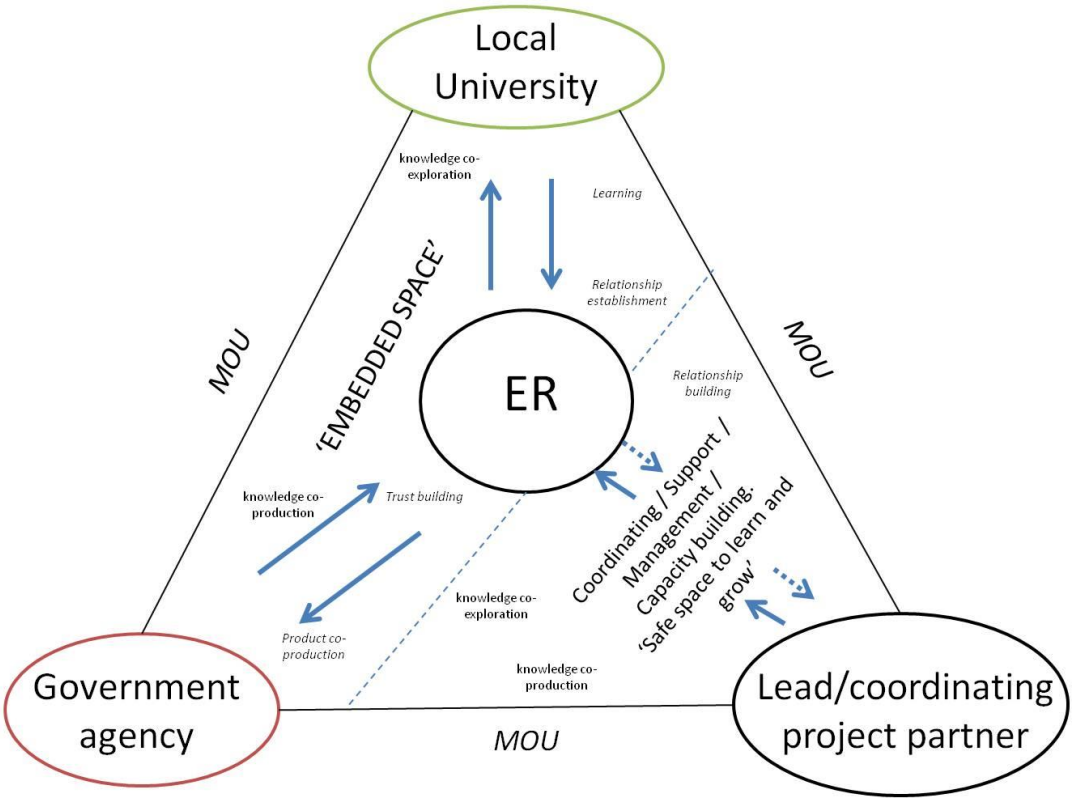

Figure 1. Operational model of the trilateral partnership creating the space within which the ERs function (Source: Authors own).

The ERs are supported in their engagements in the embedded space through being connected via the lead FRACTAL partner with a network of ERs and various project teams or clusters in other cities. This trilateral partnership is key to the success of the FRACTAL ER approach, because the two city-based Principal Investigators ensure the contextual and conceptual relevance of the ERs' work; while the coordinating partner - through an employed ER coordinator - provides structure, guidance, support and learning opportunities relating to the ER approach and the broader themes of the FRACTAL project. Although the ER approach can be implemented through a bilateral partnership, it has become clear that the trilateral approach, as well as having more than one ER to support and learn from/with each other, enhances the efficacy of the approach.

Findings

Aligning city contexts with individual expertise

Despite the established operational approach, the various cities with their unique contexts had flexibility in the defining of the specific roles, responsibilities and organisational positioning of the ERs. These were negotiated and re-negotiated on a case by case basis between the university and city government in each city, together with the FRACTAL lead partner throughout the project. The ERs are drawn from a variety of professional and disciplinary backgrounds - their success depends as much on the willingness of the ER to work across boundaries, be proactive and open to learning, as it does on a specific list of experiential requirements and professional qualifications.

Successes and challenges

The main benefit of the approach thus far has been the availability of an interdisciplinary person who facilitates opportunities to connect a diversity of people, projects, information and knowledge across organisations, cities, sectors and scales. There are challenges, however, which concern the ERs getting embedded in two very different organisations, balancing diverse demands, adhering to different reporting requirements, coming to terms with new technical content, and dealing with continuously changing institutional capacities.

Conclusion

The FRACTAL project is still in process; however, it is evident from feedback obtained thus far that the approach is potentially a successful method to bridge the gap between scientific information and the formulation and implementation of policy. The approach has been shown to efficiently build relationships and trust between researchers and local authorities, improve receptivity towards the uptake of climate information, and build capacity among young African leaders. We argue that this is a critical component of enabling transformative climate action in cities, because it serves to bridge communities who all have a stake in dealing with climate change despite having different mandates, knowledge, values, expertise and resources.

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A Case Study on multi-level governance between central and local Governments - an example of New Taipei City

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Abstract

New Taipei City is the largest and most populous city in Taiwan. Being very active on climate change policies, the City also received assistance from the Environmental Protection Administration (EPA) to integrate climate risk assessments using the Taiwan Climate Change Adaptation Technology Knowledge Platform (TaiCCAT), a supportive system for decision-making developed by the Ministry of Science and Technology (MOST) since 2015. The City's adaptation strategy and plan were devised through Bureau interviews, inter-departmental discussions and numerous opinions collected from various stakeholders. In 2016, the City government further established 'The platform of mitigation and adaptation for climate change of New Taipei City', which host regular meetings chaired by the vice-mayor. In addition to incorporating a citizen participation mechanism to actively demonstrate more effective, transparent and trustworthy policies, the platform also acts as a bridge amongst the City's authorities to develop effective mitigation and adaptation strategies.

Keywords: *Government policy, Adaptation strategy, Multi-level governance, Taiwan*

Introduction

Taiwan is an island country with a total population of 23 million people. Its terrain is diverse and mostly mountainous which, along with abundant water vapors, creates a complex and unique ecosystem, covering special flora and fauna of the cold to temperate, subtropical and even tropical zones within an area of about 36,000km^2.

According to observational data, the occurrence of dry years has significantly increased from 1960 to 2017, and extremes in annual precipitation have also increased (Water Resources Agency, Ministry of Economic Affairs, 2017). According to the Taiwan Climate Change Science Report (2011), changes in rainfall are likely to increase with further warming from the greenhouse effect. Under RCP 8.5 scenario, the precipitation during rainy season will increase by 14% to 20% by the end of the 21st century.

In terms of temperature in Taiwan, observation data indicates that annual temperature (land temperature) has risen by about 1.3°C over the past 100 years (1900-2012), and the warming rate has accelerated. In addition, it is estimated that the temperatures in Taiwan may increase by 3.0 to 3.6°C under the RCP 8.5 scenario by the end of the 21st century, especially in the northern regions (Taiwan Climate Change Science Report, 2017).

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In 2009, in response to forthcoming impacts of climate change, central authorities in Taiwan have begun preparation to review relevant policies, carry out systematic restructure or reinforcements, and conduct risk assessments based on their respective responsibilities. In 2010, the National Development Committee (NDC) invited relevant ministries, experts, scholars, NGOs, and industrial representatives to set up a Task Force for "Formulating and Promoting the Climate Change Adaptation Policy Framework and Action Plan" for rigorous policy-planning, whilst MOST was assigned the task to summarise studies from Taiwanese academics, along with reference to definitions and scenarios from IPCC's fourth assessment report (AR4), which led to the publication of the 'Taiwan Climate Change Science Report 2011'. The report became the foundation for the taskforce to subsequently develop the 'National Climate Change Adaptation Policy Framework' and the 'National Climate Change Adaptation Action Plan 2013-2017', and finally the local adaptation assessment in 2013.

On 1st July 2015, Taiwan promulgated the "Greenhouse Gas Reduction and Management Act" (the Act), allocating responsibilities to all relevant authorities, whilst EPA serves as the competent authority for climate change policies in Taiwan (**Figure 1**). In accordance to the Act, the 'National Climate Change Action Guideline' was announced on the 23rd of February, 2017, setting explicit objectives for the country, outlining general principles where related strategies must refer to, and policies to be adopted when tackling climate change topics.

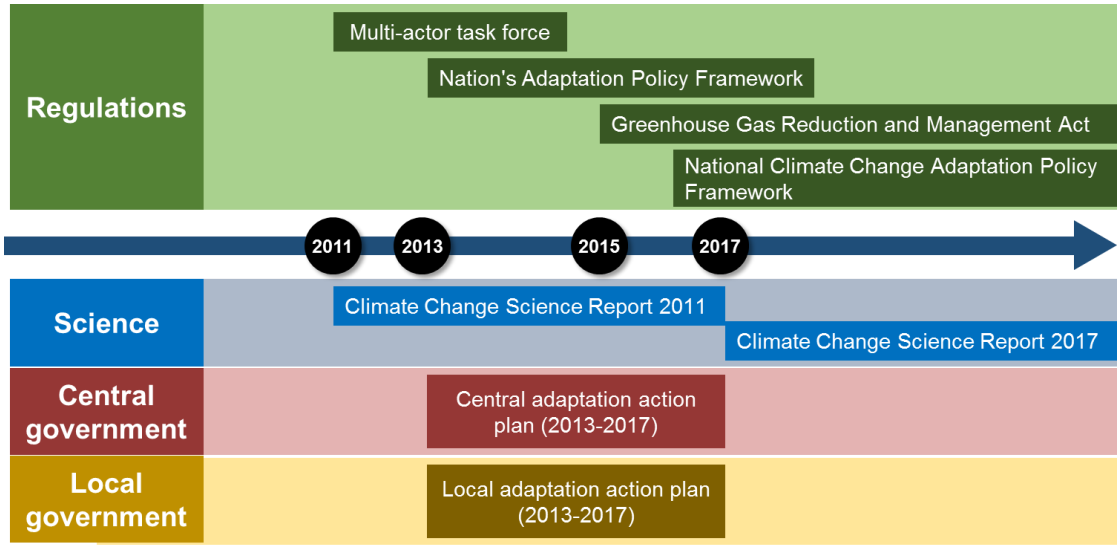

Figure 1. The timeline of Taiwan's adaptation policy (Source: Authors own)

Methodology

While it is generally agreed that adaptation policies must be devised according to local conditions, local governments often encounter problems such as lack of funding, resources, and manpower to implement. Therefore the Central government in Taiwan has the overall responsibility of budgets, legislation, guideline and scientific database, while local government has to prioritize collaboration and implement action.

In New Taipei City, the adaptation assessment framework developed by TaiCCAT (Taiwan integrated research program on climate change adaptation technology)(**Figure 2**), which is dedicated to generate dynamic scientific approaches that can assist the public and private

sectors to develop effective adaptation strategies. TaiCCAT was utilised as a standard operating procedure, where central or local authorities can assess adaptation options.

More than thirty bureau interviews and six inter-departmental meetings were held to accelerate communication and coordination amongst bureaus, which as a result achieved further understandings to the City's priorities and successfully developed the adaptation strategy and plan for New Taipei City.

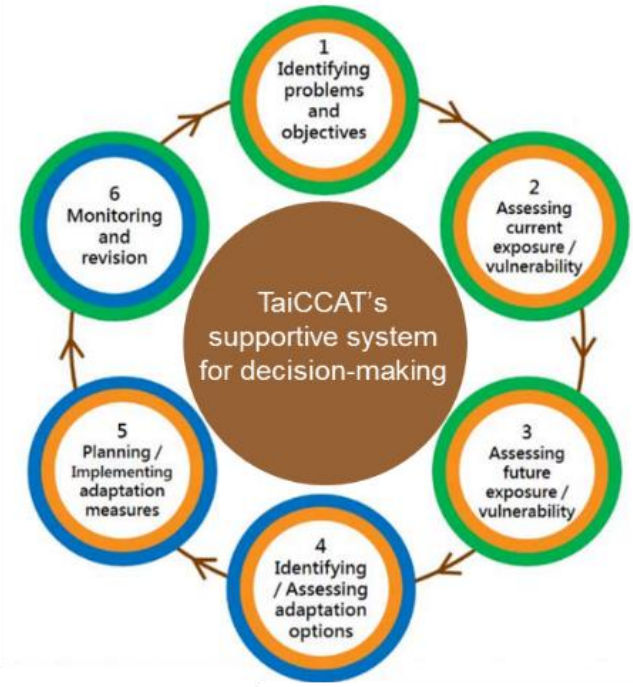

Figure 2. TaiCCAT's supportive system for decision-making (Source: Ministry of Science and Technology, 2014)

Results

In order to effectively enhance horizontal communication amongst local authorities, the City Government established the 'The platform of mitigation and adaptation for climate change of New Taipei City', which includes 17 bureaus, such as Environmental protection bureau, Urban and rural development bureau, Economic development bureau etc. The platform hosts meetings at least once every season, with academic and NGO invited depending on the agenda. Because the responsibilities of each bureaus is unique, the platform chairperson has to be the deputy mayor or personnel of similar status, in order to achieve effective coordination and collaboration amongst bureaus, and according to the 'National Climate Change Adaptation Policy Framework' as well as 6 cross-office meetings with different bureaus, academics and environmentalists. Out of the eight adaptation topics outlined by the taskforce, the platform identified four key topics and major bureaus including "disaster (fire bureau)", "health (health bureau)", "land use (urban and rural development bureau)", and "energy supply and industry (economic development bureau)" (see **Figure 3**), where respective bureaus develop corresponding local strategies, and may invite relevant bureaus for assistance.

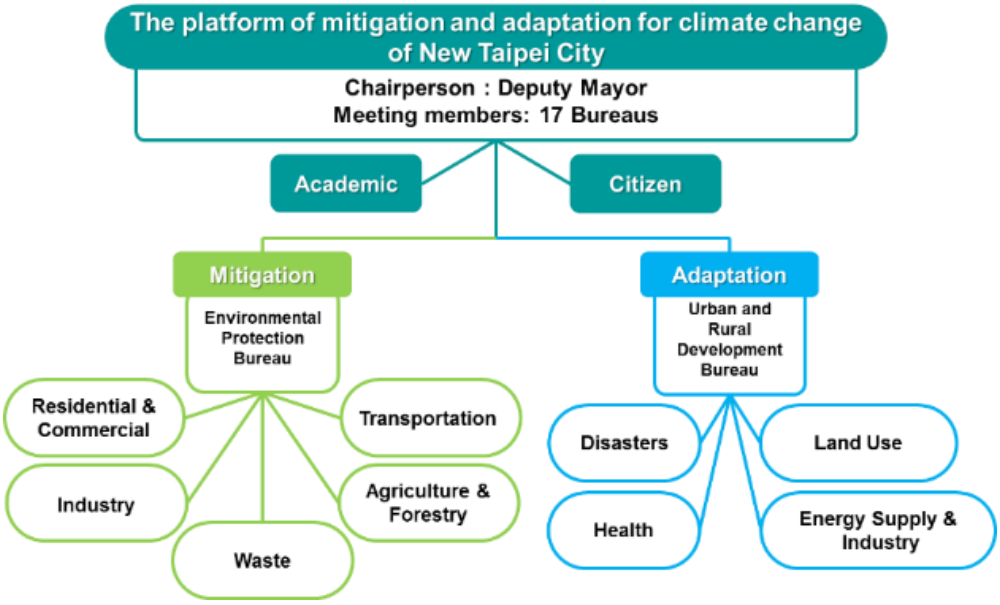

Figure 3. The platform of mitigation and adaptation of New Taipei City (The Environmental Protection Bureau, 2016)

Taiwan's multi-level governance identifies the roles of central and local governments. The central government should establish scientific foundations and policy frameworks which can guide for local adaptation policy-making . The local authorities can strive for budgets and collaborate with central authorities to implement strategies. Taking the New Taipei city as an example, the platform has identified 'health' to be a key adaptation sector, the 'Health bureau' is mainly responsible, with related bureau invited (such as the environmental protection bureau) to jointly devise strategies. After vigorous discussions, the Health bureau follow the infectious disease prevention guideline made by the Ministry of Health and Welfare to implement dengue fever monitoring and local community environment cleaning.

Conclusion

Taiwan has completed the first national five-year adaptation phase, made progress on local adaptation efforts, but there are also obstacles that must be identified. Communication is critical to collaborations amongst authorities. Although successful executions have been carried out in New Taipei City, there are incidents where stakeholders were unable to reach a consensus, thus affecting the final outcome of adaptation actions. The next phase of adaptation will require authorities in Taiwan to consult the proper expertise, collaborate more effectively, converge available resources, focus on local issues, and must recognise that it is imperative to devise policies in a non-exhaustive approach towards critical topics. It should also be noted that EPA is currently developing a national adaptation information platform, currently focusing on synthesizing information from central authorities, in the hope to ultimately promote adaptation transparency and wisdom. Now, Taiwan is currently revising previous adaptation policies, and on the verge of starting a new phase, the promulgation of the Act weighs clear responsibilities on central authorities to assess, design and implement adaptation strategies, whilst promoting collaboration with local authorities and private sectors to practically enhance localised adaptation action.

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