STATE OF CLIMATE CHANGE ADAPTATION ACROSS DIFFERENT CASE STUDIES AND THE ROLE OF LEADERSHIP (Manuscript)

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Abstract

Large cities are usually the recipients of change as resources are concentrated in these areas. As a result, national policies on climate change action often do not translate to action at the local scale. This paper takes an exploratory approach to determine the state of climate change adaptation in three case studies (Ballina, Australia; Knysna, South Africa and Lemvig, Denmark) and investigate how leadership plays a role in adaptation plans of these cities. Data was collected through document analysis, questionnaires and interviews focusing on perceptions of the risks of climate change in the community, response plans in place, barriers to adaptation, and leaders in implementation. Findings suggest that funding is the biggest barrier to adaptation in these small cities followed by differences in vision between various levels of government. The progress of adaptation is different across the case studies regardless of socio-economics. For success, top-down approaches should be switched out for more holistic, interdisciplinary bottom-up methods. This will also result in the emergence of leaders in unlikely places. The results of this work will contribute to the increase in variety and quantity of research of climate change in urban areas with a focus on coastal cities.

1. Introduction

Climate change is one of the greatest threats to the planet with the magnitude of these impacts varying depending on different factors. Over 50% of the world's population lives in urban areas but attention is usually given to big cities with regards to funding, resources and planning. Policies are issued at the national level and it is usually bigger cities that have access to more resources for implementation and successful change. However, nearly half of those who live in urban areas don't live in large cities (United Nations Department of Economic and Social Affairs, 2014), these smaller cities and towns do not see the realisation of policies and plans issued at the national level (Major and Juhola, 2016). These overlooked smaller cities are numerous and account for a large proportion of the world's population and are as important to study as big cities. Data about these smaller cities adds to the variety and quantity of data available about urban areas, contributing to research and improving the coverage of data around the world. The coverage of these previously under studied areas is listed as a priority (to increase quantity and diversity of knowledge) for climate change and cities research by Bai *et al.* (2018).

Coastal areas are attractive places for settlements as they provide food, recreational, tourism, economic, and navigational benefits. A large proportion of the world's population lives in coastal areas and many of these areas attract seasonal visitors. These areas are usually exposed to hazards such as storm surges and erosion. The threats that coastal areas face will be exacerbated by the effects of climate change (Rosenzweig *et al.*, 2018). Although many of the world's large cities are on the coast, there are even more smaller coastal cities and not much attention has been paid to research of climate change in them (Major and Juhola, 2016);.

As planning and policy in climate change adaptation moves from scientific research into implementation, the key players shift from researchers to stakeholders in the communities (government, non-governmental organisations (NGOs), businesses, and individuals amongst others). Therefore stakeholders from all sectors in all urban settlements should be involved in climate change adaptation (Pasquini *et al.*, 2015). Cities are considered hubs of innovation and solutions – local governments are more involved, businesses are invested due to higher stakes and the concentration of NGOs/environmental agencies is higher. Most experimental projects

are implemented in larger cities. These solutions are specific to big cities, but it is unclear whether results are transferable to smaller cities. Projects that are implemented in small cities are often not given much attention and the effects are not often studied. This has led to a knowledge gap of information on small cities and towns, especially in the field of climate change adaptation.

The Urban Climate Change Research Network (UCCRN) has launched a 2-year project in the study of climate change adaptation in small coastal cities and towns as a way to quantify and provide knowledge to address the needs of these small coastal cities for climate change adaptation. An exploratory approach is taken in this paper to obtain a state-of-the-art of chosen case studies as a way to contribute to the initial stages of this project – providing background information and studies of selected coastal cities.

Kotter (1990) differentiates the difference between leadership and management: management produces orderly results while leadership is for useful change to occur. Adaptation requires change in current practices and this requires someone to take the initiative and spearhead the change therefore leadership is a crucial factor in climate change adaptation. In smaller cities and towns, a leader who can influence the community into change may be crucial for increasing the community's resilience against climate change impacts.

There is not much literature currently available on leadership in climate change adaptation. The most appropriate work in this field has been done by Meijerink and Stiller. In their 2013 work, the kind of leadership required for climate change adaptation was explored. They suggest that the role of leadership in climate change adaptation is to:

i. Influence policy - making processes to include adaptation
ii. Form connections between different sectors and policy-making levels for collaboration
iii. Increase capacity of society to respond to feedback effects from the environment and prepare for climate change in the long-term (deal with complexity)
iv. Increase adaptive capacity of climate change adaptation in governance networks

There are different leadership theories that have been found to serve climate change adaptation within the four areas listed above. The different theories relating to leadership suggest that key individuals may play a crucial role in preparing systems for upcoming change (Meijerink and Stiller, 2013). These leaders should not only be those who are already in a position of power to lead change (political / ideational leaders) but may be individuals who do not hold official leadership positions. From these theories, a framework was developed combining aspects of different theories with the tasks needed in climate change adaptation (Meijerink *et al.*, 2015). As this paper is a state-of-the-art look at climate change adaptation of different case studies, the framework has not been applied completely at this stage of the research. It has been included in ANNEX 1 together with the theories used to form the framework, for reference and possible use at a later stage for analysing the leadership roles of different adaptation projects in the municipalities.

To fully understand how different coastal cities are faring in terms of climate change and how leadership plays a role in the climate change actions of local municipalities, this paper aims to answer the question: **"How is the state of climate change adaptation in different small coastal cities and what role does leadership play in its current adaptation practices?"** This will be done through the different methods listed in the following section.

2. Methodology and Case Studies

To answer the research question, the question was broken down into sections. The different steps are listed below in Figure 1:

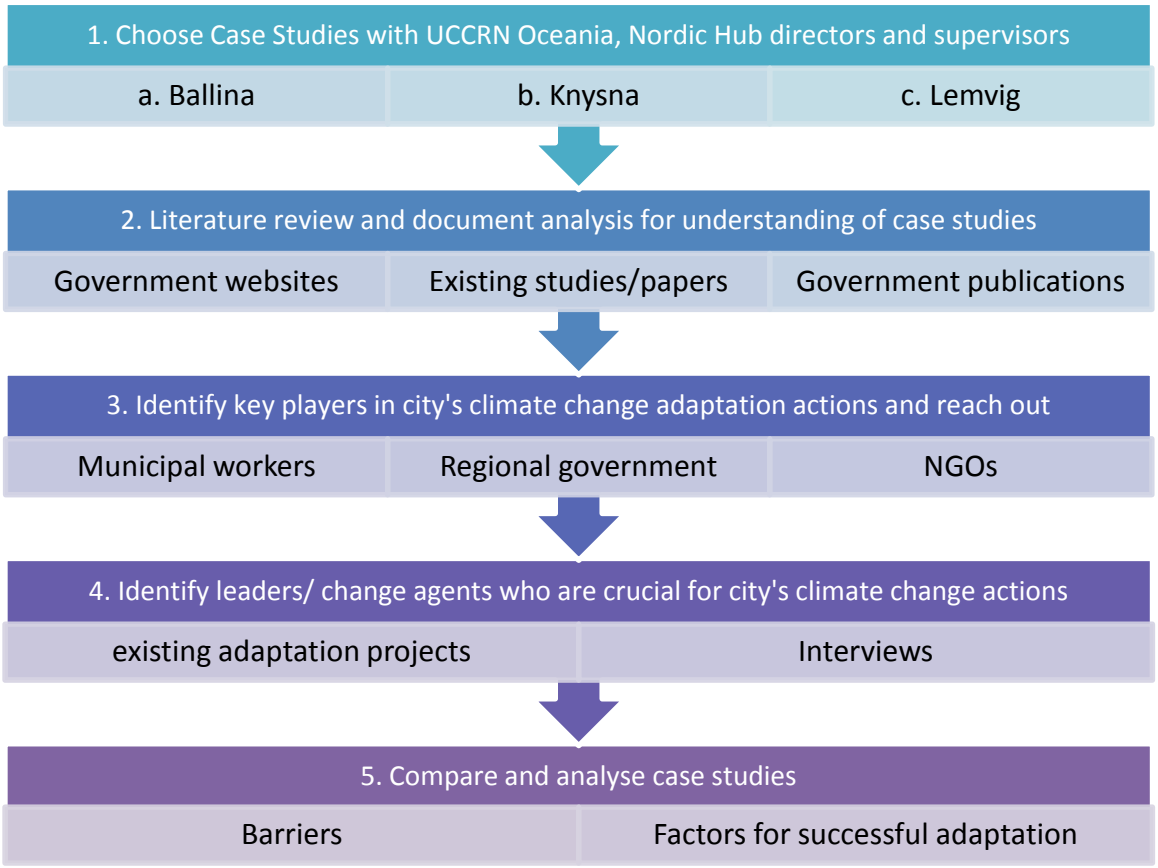


FIGURE 1 FIGURE DEPICTING THE METHODS USED

1. Case studies from countries of differing situations were needed. It was decided that these cities/ towns should differ in climate, location and socio-economic situations. These are the three cities chosen:

a) Ballina is chosen by the co-directors of the Oceania UCCRN hub based in Lismore, Australia. Ballina is situated to the east of Lismore and was chosen because the co-directors have established contacts within the local council, the council is typical of many small coastal cities on the coast of Australia in that it attracts many retirees in a phenomenon known as “sea change” – early retirees moving (lifestyle choice) to small cities along the coast to escape the fast-paced larger metropolitan areas (Department of Climate change, 2009).

b) Knysna was chosen for its location on a tourist route, attracting many visitors. It is also of different socio-economic standing and in a different climatic zone. Knysna is in the middle of a drought and the town is recovering from a major fire that destroyed a large part of the town last year.
c) Lemvig was chosen by the director of the UCCRN Nordic hub as Lemvig is part of the Coast to Coast project and has several projects coming up.

2. Gain an understanding of the case studies in terms of factors such as: climate, geography, socio-economics and population. This is done through document analysis of reports, census and municipal papers.

3. Identify relevant stakeholders who may be part of the city's climate change adaptation actions. These stakeholders, usually municipal workers, are then contacted and they can choose to answer a set of questions via a questionnaire or through a telephonic interview. The correspondences explored the following topics:
    - Climate change impacts perceived as the most important
    - Looking back: what the cities have already done to prepare for the impacts
    - Looking forward: what the cities are preparing to do in the next decade
    - Stakeholders involved in implementing actions and plans
    - Leaders in climate change adaptation projects and plans
    - Barriers of climate change adaptation in the city
    - Types and access to data used for planning for climate change

4. Identify leaders or change agents in the municipality and from literature on leadership, determine the type of leaders they are. Although the whole framework was not applied as no implemented projects were studied in detail from inception to after implementation.

5. Compare the results from the three case studies to determine similarities and differences. Looking at the points of success and determining if they could be transferred.

This research is carried out as part of a larger research project with the Urban Climate Change Research Network (UCCRN) and some results from interviews are obtained from ongoing research happening at the Oceania Hub hosted in Australia and the Nordic Node hosted in Aalborg, Denmark.

3. Results

The following section contains results on the background of the three case studies, the results from the interviews and the climate change actions the cities have planned. In the case of Ballina, the local government is referred to as the council; in Knysna it is referred to as the municipality; and in Lemvig it is referred to as the Kommune.

3.1. Ballina

Ballina is in the north coast of New South Wales, Australia (Figure 2). It is a municipality home to approximately 42 600 people over an area of 48 471.6 hectares (ha). The population pyramid is skewed to the aged – the median age is 40 and over 30% is over the age of 55 (Australia Bureau of Statistics, 2017). Ballina also has a 3% aboriginal population. The population is growing at a rate of about 1% a year. It is a popular location for retirement and retreats because of its seaside location, proximity to Queensland and the Gold Coast area and access to its own airport.

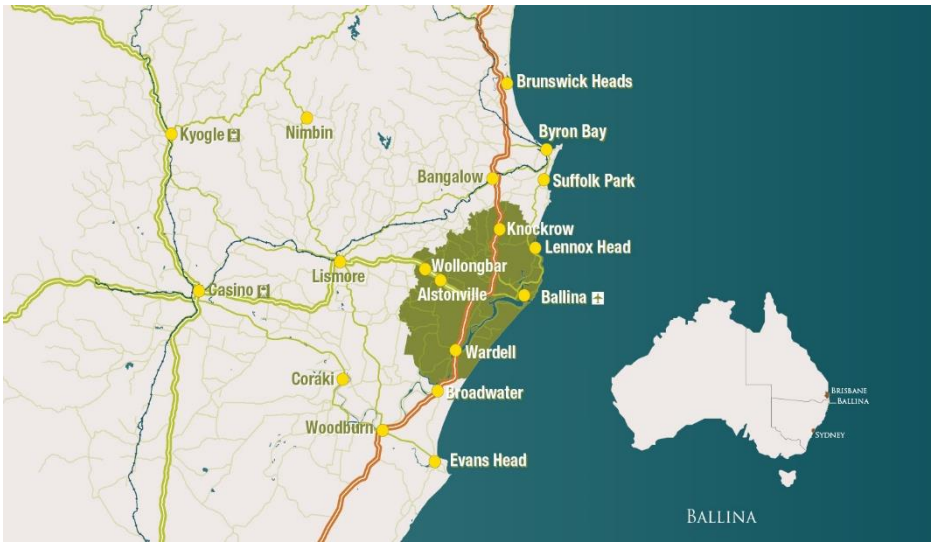


FIGURE 2 LOCATION OF BALLINA COUNCIL (SOURCE: WWW.PACIFICCOAST.COM.AU)

The area is characterized by fertile soils along the Richmond River, deltaic floodplains and beaches on the coast, and mountains of the Great Dividing Range in the hinterlands. The town experiences mild winters and hot summers with annual rainfall averaging over 1600mm as it is located humid subtropical climatic zone.

Ballina's temperatures have been consistently rising over the past 5 decades. The rainfall is projected to increase while sea level is expected to increase by 0.4m by 2050. For a full list of expected impacts in the three case studies, refer to ANNEX 2. The increase of hot days (with maximum temperature above 35°C) will increase the vulnerability of the population, especially the older age groups as heat has been proven to increase mortality and illness amongst the aged (Black *et al.*, 2013).

The council has implemented sea walls as physical measures against floods. Ballina experiences some flooding from excess rainfall, storm surges and during king tides. However, it has not been severely impacted and has thus not warranted for extra measures. Looking forward, the council listed flooding, shoreline erosion, saltwater inundation and the change in rainfall pattern as the most important impacts for Ballina to work with.

The Ballina council has a Climate Action Strategy (2012) in place. Two stakeholder engagement activities contributed to the drawing up of the strategy. In addition, there are separate plans for coastal and floodplain management (2016 and 2015 respectively).

In terms of implementation of projects and plans, responsibility is usually shared between strategic planning and engineering departments of the council. This is then in conjunction with neighbouring councils when plans are for transboundary issues (i.e. Rous Water projects).

The leadership for actions in Ballina is from the local government. Community apathy was one of the adaptation barriers brought up in the regional vulnerability assessment. There does not seem to be active leadership from the local community for change. The citizens are reliant on the local government to take the actions necessary for adaptation, they may agree with the changes but only if they do not have to fund it themselves. In the stakeholder engagement meetings held to draw up the adaptation plan, there were participants who attended but did not believe in climate change. These are challenges that impede adaptation. The council could take action by assigning different roles to different sectors and communicating climate information in a more relatable way.

3.2. Knysna

Knysna is a small city with a bay located in the Western Cape of South Africa (Figure 3), along the scenic Garden Route. It is surrounded by the Outeniqua Mountains, the Indian Ocean, dunes, rivers and estuaries (Knysna Municipality, 2015). It has an area of 110 900 ha. In 2015, the population of Knysna was 72 169 living in 24 295 households. Knysna has 19.6% of people living in poverty (Western Cape Government Provincial Treasury, 2015).

FIGURE 3 LOCATION OF KNYSNA (SOURCE: WWW.VISITKNYSNA.CO.ZA)

The municipality experiences hot and humid summers while winters are cool and rainy (although rainfall occurs throughout the year). The annual average rainfall for the region is about 770mm. Knysna forms part of the greater Eden District and the region has regularly experienced climate change related extreme events such as: flooding, fires, coastal inundation and drought (Eden District Municipality, 2014).

The impacts of climate change in Knysna point to hotter days and more intense storm events. Models predict different projections for rainfall, so it is unclear whether it will increase or decrease overall. Sea level rise is one of the most pressing issues for the municipality as many properties on the coast are experiencing damages during storm surges. Overall climate is expected to shift to a warmer and more subtropical climate with warmer conditions. This will allow alien vegetation, which are causing problems in biodiversity, water and fires, to thrive and create more problems. Water supply is a particularly important concern now too because it is a limit to growth in the municipality. This is because of inappropriate land use, droughts, and insufficient storage as population increases. The town is currently on level 3 water restrictions although some in the environmental sector believe that restrictions should have remained at level 4. The restrictions were relaxed at the request of the tourism sector.

Tourism is an important industry in the town as it generates a large portion of the income. Results from Knysna showed that all sectors realize that there is a need for adaptation to climate change, especially after the fire disaster in 2017. Individuals and businesses are now all onboard with climate change adaptation – they would like to see change and would like to participate in the changes.

In environmental protection plans such as the wetlands protection plan for 2017-2022 (Robinson, 2017), the key actions for focus areas needed included actions against climate change (mitigation and adaptation) but there are no clarifications on what these actions will entail. The Eden District has a climate change adaptation plan published in 2014 but Knysna itself does not currently have a plan or policy targeting climate change. However, they are working on one that is expected to be released in the next financial year.

The municipality has built sea walls in some areas and some residents have built gabions on properties despite being advised against it by the municipality. The national environmental minister had given approvals for individuals to build gabions. This is a result of differing opinions between the national government and the municipality which can create tension and impede reform.

Knysna municipality intends on moving towards a greener economy and greener infrastructures. The fire of 2017 destroyed many buildings after which would have been a good opportunity to implement new building codes. These building standards were given as guidelines, the municipality is unable to enforce it considering how much the citizens had lost in the fire.

The municipality has implemented adaptation projects despite not having a plan. They are currently implementing two sustainable urban drainage systems (SUDS) projects to redirect Stormwater with NGO BioWise. BioWise is leading in many adaptation projects in Knysna: zero waste, eco-bricks, nature-based solutions education, workshops and the establishment of a discovery park. The organization works collaboratively with the municipality, other organizations and independently to develop, fund and implement projects.

3.3. Lemvig

Lemvig is a small municipality on the west coast, in the Midtjylland region of Denmark (Figure 4) with a total population of 20 293 people in 2017. The kommune shows negative population growth (one of the highest in the country) and more than 50% of the residents are aged over 40. While the overall population growth is negative, the predictions for population growth amongst those age 65 and above are increasing (Lemvig Kommune, 2017). The population in Lemvig centre is 7 000. The municipality occupies 50 817 ha of land. The biggest concern for the Lemvig is flooding: overflow of sewers in cloud burst events, flooding from increased storm intensity, groundwater levels rising and causing flooding, flooding along streams (Lemvig Kommune, 2014).

FIGURE 4 THE LOCATION OF LEMVIG IN THE CENTRAL DENMARK REGION (SOURCE: WWW.MTIC.DK)

The Limfjord next to which Lemvig is situated experiences flooding regularly, the water levels can rise up to 2.25m as experienced in a flood from storm surges in December 2015. Water levels in the fjord are projected to rise up to 60cm by 2060 during storm surges (from 2005 levels). In addition, there are threats from the groundwater levels rising because of sea level rise and increased rainfall (Sorensen, 2018). There are no concerns with shortage of water supply, in fact, fresh water supply is expected to increase in some areas (European Commission, 2009)

Lemvig had developed a climate change adaptation plan for the years 2014 – 2017. However, only the issues relating to water are discussed – the focus was on reducing floods. Flood risk mapping and modelling was used to determine areas that need attention. The main types of flooding considered to be of significant threat were flooding from cloudbursts and due to storms. Flooding from the watercourses and groundwater were left out as these are not expected to cause enough damage at present and will be targeted in later plans or in other sectors of planning (Lemvig Kommune, 2014).

The aim of the climate adaptation plan was to 1) establish co-operation between different stakeholders, 2) communicate and inform the citizens about the risks of climate change and advise them on how they can respond, 3) include climate change management into other functions of the Kommune, and 4) manage the city's water drainage so that it does not increase the severity of existing problems.

As the plan was done as an agreement with national and regional government for the period of 2014-2017. There was no further agreement to draw up a plan for after 2017. However, climate change adaptation actions are now done with the Coast to Coast Climate Challenge(C2C) project that started in 2017 with funding from the European Union (EU).

Lemvig and Lemvig Van dog Spildevands (utilities company) are both part of the Coast to Coast Climate Challenge (C2C) where they have several actions related to climate change actions in coastal towns. Lemvig is part of 3 projects: C9 – Thyborøn channel and western Limfjord, C17 – Thyborøn city and harbour, and C21 – the klimatorium focusing on innovation in fjords, rivers and sea (C2C Climate Challenge, 2018). An overview of these actions can be found in ANNEX 3.

An example of a successfully implemented climate change adaptation action is the harbour at Lemvig. When presented with two options on dealing with rising sea levels and annual floods in the town, the kommune chose one that could manage flood waters and serve the citizens of the town. The project is a rejuvenation to the commercial harbour. The promenade on the harbour now connects the sea, the harbour and the town by incorporating recreational spaces and implementing ideas by residents (Environmental Protection Agency, 2014). In addition to the

flood protection wall already implemented at the harbour, there are pumps and water storage areas in progress to handle the increased amount of water the kommune will receive.

This project was proven to be a success as the Kommune have had no issues with flooding since implementation. It is also a popular place for the residents to gather when the weather is warmer and is a place of many public events.

Individual leadership is needed when wanting to climate proof private buildings against climate change in Lemvig. The Kommune does not provide subsidies for those wanting to protect their houses against floods. Homeowners can obtain data and approval for improvements from kommune and if the location of the property is eligible, they can then implement the changes. The leadership that drove the funding for the C2C projects came mainly from the Central Denmark Regional government and kommune staff. An individual who works for the kommune has been instrumental for determining the type of work done on this project and driving the change.

In the table below, the responses from the different case studies is summarised for comparison:

TABLE 1 SUMMARY OF RESPONSES FROM CASE STUDIES

	Ballina	Knysna	Lemvig
Climate Change impacts	• Flood • Change in rainfall pattern • Shoreline erosion • Saltwater inundation	• Drought • Fire • Flood • Sea level rise	• Flooding from storms • Cloudbursts • Sea level rise
Implemented plans	Climate change adaptation risk assessment (2009) Climate Action Strategy (2012)	Eden District Climate Change Adaptation Plan (2014) No plan specifically for Knysna	Lemvig Climate Change Adaptation Plan (2014-2017) Central Denmark Climate Change

	Cities for Climate Protection Local Action Plan (2006)		Adaptation template (2013)
Future actions	Review current plans to improve, continuous implementation of current plans	Climate Change Action Plan for Knysna planned for next year	C2C Projects
Leaders in adaptation	Local government		
Biggest barriers	Funding Consistency in policy at higher levels of government – lack of policy direction or benchmarks Communicating of climate change information Access to specialist knowledge at the local scale	Funding National governing party and provincial governing party different Effort of municipality prioritises the provision of basic services (housing, water, sanitation)	Funding People who may not be 100% behind physical solutions (i.e. losing view of sea) Access to data at a local level prior to funding from C2C

3.4. Adaptation barriers

The barriers to climate change adaptation in Ballina is mostly due to lack of funding. Some other factors include: information not downscaled to local context (lack of access to specialists and

knowledge at this scale), format in which information communicated is not relatable for the public. Furthermore, the information is always changing due to changes in science, politics and policy, making it more difficult to communicate as information may be out of date by the time it has gone through the process and published. Another point brought up from the questionnaires is that there is a lack of consistent policy from government at higher levels. It would be useful to have benchmarks for planning to address the lack of policy direction at both state and federal levels of government.

The issue of funding was also the biggest one in the other two case studies. Knysna's environmental management department is small and short on staff. The budget is only for implementation which makes it difficult to make as many changes as desired. Much of the municipality's budget is used towards basic services and housing. Lemvig also had the issue of funding until they obtained the external funding from the EU life program for the C2C projects. Actions that are not related to these projects may prove to be challenging to start if the municipality does not secure extra funding.

The second biggest barrier would be the access to data that is specific to the city/town at a local scale. Many of the assessments and projected impacts are for a bigger scale (either regional or provincial), there are only a few variables that may be available to the individual cities if models are available. In addition, the situation is always changing (with regards to climate, policy and politics) making it difficult to plan and keep up with the changes. Lemvig no longer has that problem as the first phase for all three C2C projects are to obtain the relevant data. For Ballina and Knysna, it is challenging to plan for the impacts when planners do not have the projections for the town specifically.

Another main barrier mentioned in Ballina and Knysna is the lack of clear direction from national government. The differing priorities at various levels of government make it difficult to fully understand what needs to be done. This will also create confusion among the public. In Knysna, the municipality is run by a different political party than the national one. This can create further planning and adaptation barriers due to the differing views of the different political parties.

There are other barriers relating to climate change adaptation in these towns. Ballina took part in a vulnerability assessment of the settlements sector of the North Coast Region and the barriers to adaptation (Office of Environment and Heritage, 2014), but the barriers can be relevant to other sectors. A study done by Pasquini, Cowling and Ziervogel (2013) on the barriers to mainstreaming climate change adaptation at the local government level in Western Cape, South Africa also point out barriers to adaptation that may be applicable to other cases. The most applicable barriers mentioned besides those already mentioned are listed below in Figure 5

Individual

- Coomunity apathy
- People not believing or understanding the science of climate change
- People dont believe that they, as individuals, can change anything

Local

- local governments not having enough power to manage many of the actions happening in and around town as it is under the jurisdiction of government at a higher level
- Information of climate change not communicated well (unrelatable) to the public

Other

- government positions from term-to-term, there is no long term sight or goals
- historical planning decisions not taking climate change into consideration creating problems now

FIGURE 5 CLIMATE CHANGE BARRIERS FROM PREVIOUS ASSESSMENTS

4. Discussion

While there are many statutes relevant to environmental management of Knysna (relating to agriculture, planning, chemicals, governance, sustainable development of mineral resources, water, fires and more), none target climate change specifically. Although this is not a measure of how successful a municipality's adaptation is, as Ballina has a climate action strategy but experiences barriers in terms of funding and lack of benchmark targets to work towards. The issues of funding and access to relevant data for specific municipalities are expected in majority of small coastal cities or towns.

The high proportion of people above 50 staying in Ballina are more vulnerable to the effects of climate change. Many of these are migrants who move to the coast with all their accumulated assets and invests it in a property. They move to small seaside towns for a more relaxed lifestyle. When these properties are destroyed by flooding or erosion events, they often lose everything. The issue of insurability is complicated in Australia and most the houses bought by these retirees are not covered by insurance, so damages often create huge financial losses for the owners and they often cannot afford to invest as much money to repair. Together with the aboriginal minority, the council should consider the vulnerability of different groups when planning, they should be included in the process of reform.

Knysna faces an array of challenges with regards to climate change adaptation. In addition to those mentioned above, Knysna struggles with balancing all its priorities. In a country where there is a large proportion of people still living in poverty. Government services will tend to be biased towards basic service delivery. People who do not have the means to live a comfortable life are unlikely to have time and effort to care about climate change (Pasquini, Cowling and Ziervogel, 2013). Their energy is focused on basic needs but they are the group that is most vulnerable to climate change. Houses in the informal settlements are usually built in the most undesirable areas of municipality: on steep hills and low-lying flood prone areas. The municipality's priorities are providing formal housing and basic services. In these cases, it is extremely vital to have leadership from the non-governmental sector (Meijerink and Stiller, 2013), in the local community. BioWise in Knysna started the initiative of "Naturally Knysna" in 2010 but the town was not yet ready for it and there were challenges that prevented the implementation of the project. The project has now been changed to "Waste Nothing". The uptake of it has been much better because the terminology has been simplified and better communicated to the public. It aims to use the concepts of biomimicry to help Knysna function as a forest and producing no waste. BioWise has also received funding for the creation of a Discovery Park. The Discovery Park will be composed of various education and tourism nature parks in the Garden Route area. These parks will be developed under the principles of biomimicry.

The changes proposed by BioWise are not slow gradual changes but evolutionary leaps. Even though most changes take place through minor changes over longer periods of time, perhaps

planned transformational changes could catalyse the process of adaptation and shift development pathways. One of the research priorities for cities and climate change as mentioned by (Bai *et al.*, 2018) is to support bold strategies and transformation. This local innovation project could be supported, implemented and if successful, could be scaled up for transformation at the larger scale.

4.1. Leadership

Ideational leaders and policy entrepreneurs are important for pushing the agenda of climate change adaptation into policy making. These leaders discover the need for new solutions, are catalysts for policy innovation and are usually politicians, expert groups or representatives from specific interest groups (Meijerink and Stiller, 2013). Change agents, champions of new causes often start with politicians or people with influence in their communities. For example, in the "Waste Nothing" project, the change agents will be firstly, the environmental department of the municipality and secondly, every municipal worker including the mayor. One of the reasons why the project was able to be successfully implemented was because the mayor was a champion for the cause. Those in higher positions will have a further reach into the community. Change agents could also be individuals in the community who actively participate and to whom the community is exposed.

Leadership could also come from unlikely places rather than from the traditional top-down approaches. Knysna is home to many retired professionals and academics whose industry knowledge is an under-utilised resource. There are plans to form community groups with these individuals to meet regularly, discuss about environmental issues in Knysna, exchange ideas and find solutions together. The substantial proportion of older aged people in both Lemvig and Ballina provides a similar opportunity for finding unlikely leadership within the community, especially within this more vulnerable age group. This may be especially important in Lemvig as the population of those above 65 are expected to increase 14% by 2026 while the proportion of working group aged people are projected to decrease (Lemvig Kommune, 2017). Although the new C2C projects may draw younger residents to settle in the town, it is not clear yet if it will

stop the negative growth in population numbers. In addition, the projects are done with existing organisations and companies who have worked in the area previously, so it is likely that the permanent population will not increase drastically. Therefore, it is especially important to involve the citizens that are already living there in the projects and increase their capacity to deal with climate change.

With the realization that the traditional hierarchical leadership layout is not effective anymore (Meijerink and Stiller, 2013). The use of more holistic, interdisciplinary and connected thinking is being used more. The stakeholders in climate change adaptation are from different government levels, different sectors and different backgrounds. There is a need for leaders to connect these different stakeholders, encourage collaboration and implement solutions. The case of the Coast to Coast project in Denmark is a good example of connectivity leaders driving the change and bringing together stakeholders from academia, governments, businesses and communities to create a nation-wide project working towards a better adapted Denmark.

The leadership in the case of the "Waste Nothing" project is from a variety of stakeholders. Firstly, the director of BioWise fulfilled the leadership function of connectivity of promoting the problem of waste, mobilising and bringing together stakeholders to search for solutions. The dissemination function was fulfilled when the information was presented to the mayor and other politicians in the town. The political-administrative function involves the securing and allocation of resources (fulfilled by the National Lottery Fund by granting funding to BioWise). The other functions may have been fulfilled but it is unclear by which leaders as it is not completely implemented yet and as not all the details of the project are known.

4.2. Smaller cities as the new hubs of knowledge and innovation

Ballina does not yet have large climate change projects that it forms part of. This may be because the town has not yet been severely impacted by climate change. The most effective driver of change may be a severe event. Another reason could be the power dynamics between different levels of government. The local governments in Australia do not have a lot of autonomy and power in terms of what they implement. Many of those decisions sit with the New South Wales

government. The council, however, has smaller local projects targeting six different key functions of the council as described in the Climate Action Strategy (Ballina Shire County, 2012). These are all managed by the council. It may be helpful for Ballina to identify champions of the cause in the state government to secure new projects, and to engage the citizens to encourage the emergence of individuals who are critical for success stories. It is also useful to turn these threats into new opportunities, presenting climate change projects as business cases and incorporating climate change into the council's core business could attract more funding and ensure that climate change is planned for in all sectors of the council's functions.

Big cities were considered to have been the centres of innovation and change because there is a wealth of resources. On the other hand, small cities have smaller departments with less resources. However, because the departments are smaller, collaboration within and between smaller cities and between different departments may happen at a higher and faster rate. Decisions could be reached faster and if there is available funding, these smaller cities could be the new hubs of innovation and home of successful adaptation projects.

There is still some data lacking with regards to the effectiveness of these implemented actions. In the example of Lemvig, the harbour was built in 2014 and although there have been no flood incidents since then, the time lapsed has not been long enough to see the bigger events (1-in-10 year to 1-in-100-year events) occur and determine how well the harbour is faring in the longer term. Therefore, it is important to start monitoring the results now to understand the full effect of the intervention and to understand its mitigated effectiveness to know how successful it is.

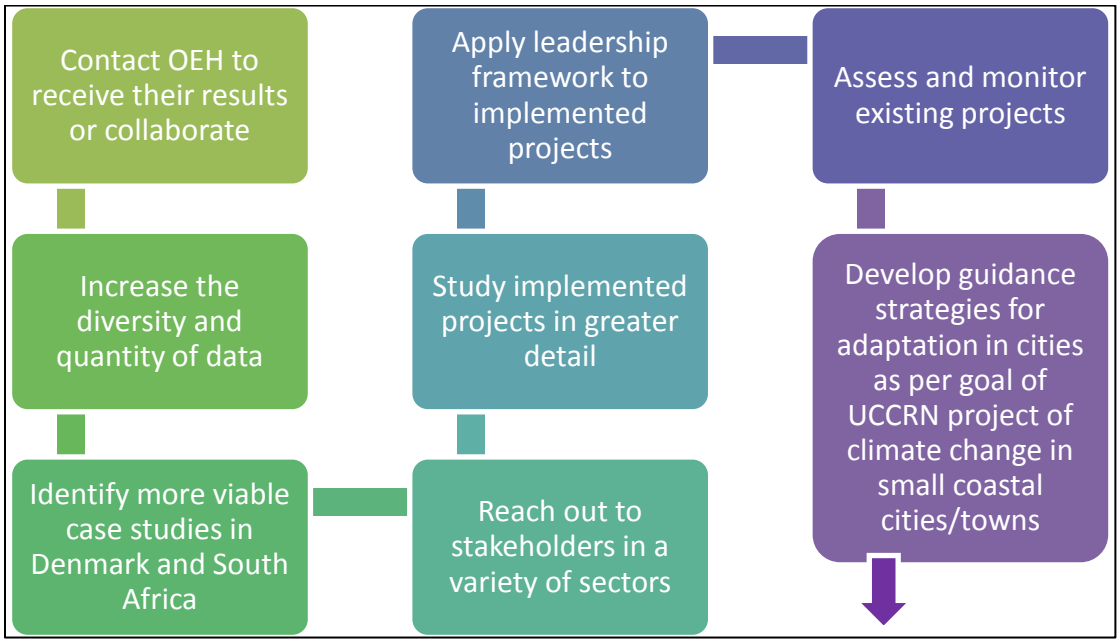
5. Reflections

The ideal plan was to get a cross section of responses from each city – to have several people in the municipality fill out the questionnaire and then having in-depth interviews with those who had unusual answers. However, some cities preferred to answer one questionnaire collectively. The collection of one response instead of a variety of responses could create a bias as responses will be of the respondent's experiences.

The interviewing of mostly municipal workers also creates a slight bias as they tend not to point out many of the faults of the municipality. The failures of projects implemented by the municipality are also not likely to be brought up. With the interviewing of other stakeholders such as environmental NGOs or consultancies, a more well-rounded response could possibly have emerged.

The research is still ongoing at UCCRN. The questionnaire to determine the state of climate change adaptation has been sent out to more coastal cities in Australia. The Office of Environment and Heritage (OEH) in New South Wales has conducted research into climate change adaptation previously with similar questions. Collaboration with the OEH will assist in getting a wider spread of data and contacts of more councils.

Possible next steps for the research could include the following:



This research contributes to the project on climate change adaptation in small coastal cities and towns by providing insight into the state of the art of different coastal cities. Data on the towns are provided in ANNEX 4, filled in with data that was able to be found. The typology variables can be used for modelling small coastal cities around the world.

6. Conclusion

All the data and research of big cities have created siloes, isolating the research from smaller cities and towns. Smaller cities are important to research to increase the diversity of climate change data in urban areas. Small cities are interesting to study because their size makes the policy makers more connected to the communities. This intimacy allows for more holistic, bottom-up approaches when it comes to planning. When top-down approaches are removed, it creates a space for collaboration for a wider range of people, and through these interactions, for leaders to emerge. These leaders who are not in political positions have been proven to be important for driving change, both in planning and implementation. There is still limited research on leadership and climate change adaptation, individual projects should be assessed to get an in-depth perspective on the leadership involved through the various stages. However, the study of the different case studies and related projects have proven that small cities can also be hubs of innovation and change. These small cities are also able to lead in research and climate change adaptation if there are individuals who are willing to break the adaptation barriers and through collaboration with different stakeholders.

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SUPPLEMENTARY INFORMATION

ANNEXE 1 – ANNEX 4

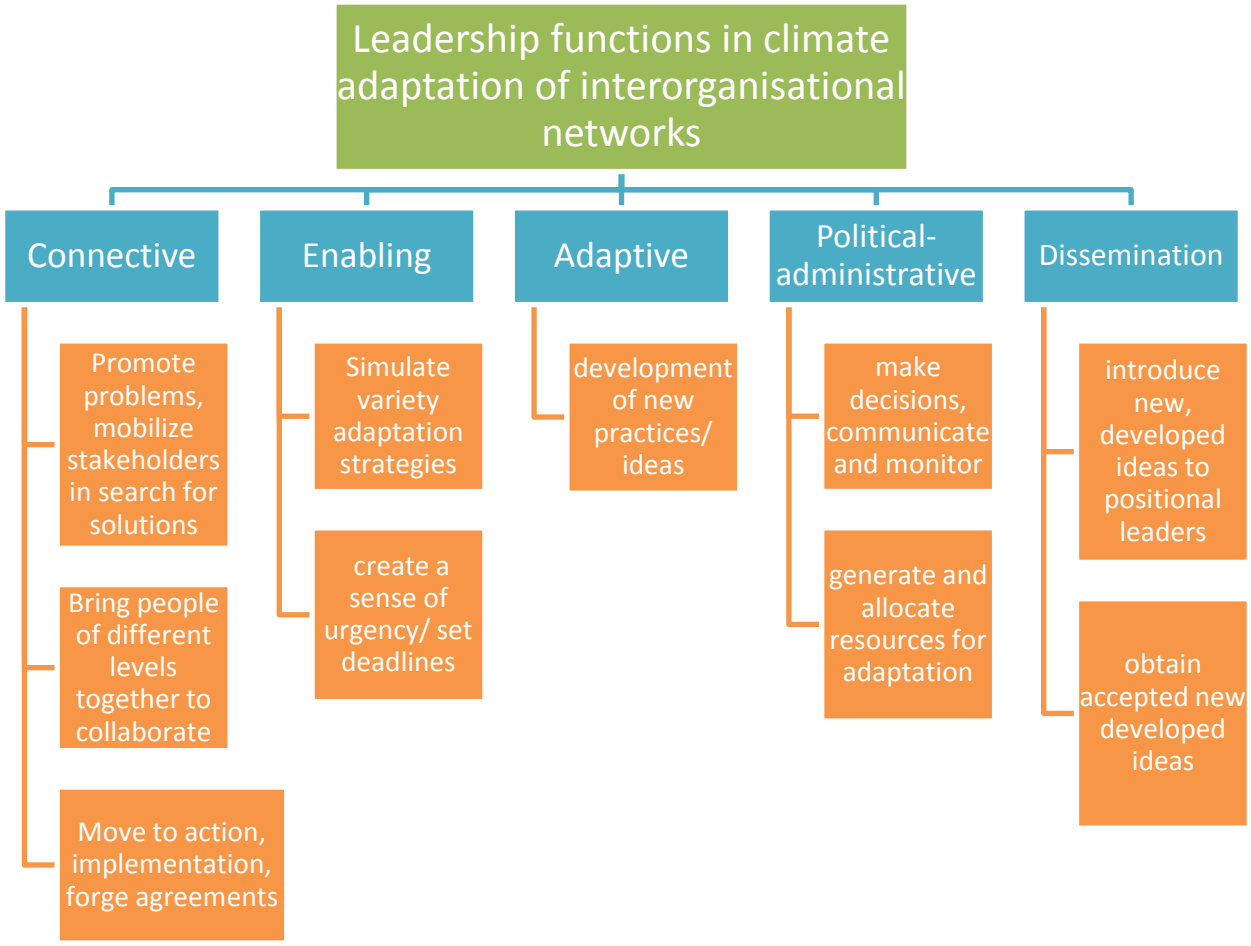
ANNEX 1: LEADERSHIP THEORIES & FRAMEWORK

(adapted from (Meijerink and Stiller, 2013; Meijerink *et al.*, 2015)

The table below show the different roles of leadership needed in climate change adaptation, the theories the authors used to address the roles needed and the objectives of each type.

	Leadership in policy-making	Leadership in connectivity	Leadership in complexity	Leadership in sustainability
Theories used	• Ideational leaders • policy entrepreneur	• Catalytic; • collaborative; • integrative leadership	• Complexity leadership theory	• Eco-leadership; • socio-ecological systems theories
Who leads	• politicians; • key individuals,	• Positional leaders, • key individuals (champions, sponsors)	• Positional leaders, • key individuals,	• Positional leaders, • key individuals
Objective	Initiate and implement new policies for the cause	Collaboration, establishing connections across different sectors and levels	Enhance adaptive capacity of society to react to feedback cycles and complexity	Adaptive management of social-ecological systems and increase adaptability of governance netoworks

This leadership framework developed by (Meijerink and Stiller, 2013) based on the different leadership functions shown above. The framework is divided into several key functions with the objectives and tasks of those serving in each function. Projects can be examined by applying this framework and identifying leadership in its various functions.



ANNEX 2: PROJECTED CLIMATE CHANGE IMPACTS ON THE THREE CASE STUDIES (WHERE AVAILABLE)

variables	Ballina	Knysna	Lemvig
Temperature	Daily averages to rise in all seasons by 0.4°C – 2°C by 2070	Increase of an average of 1°C – 2.5°C. Longer summer months	Warmer summers and milder winters
Rainfall	Expected to decrease in winter. Decrease projected for summers in the near future (2030) but increase for the far future. Projected overall increases in the other seasons.	Uncertain whether it will increase or decrease (annual rainfall). Projected that peak winter rainfall may decrease but increase in autumn and spring.	Increase by 1.6% - 6.9% for Denmark, higher increases in winter.
Sea Level	0.4m rise by 2050; 0.9m rise by 2100 (based on 1990 levels)	Best case scenario is a 0.35m increase by 2050.	0.3 m – 0.6m rise by the end of the century
Run-off	Increase is likely in the summer	Increase in seasons where higher rainfall is expected due to inadequate Stormwater management	
Floods	Frequency of floods to increase due to sea level rise and catchment-driven flooding	Increase in frequency and severity	Increase from an increase in sea level, groundwater level and more frequent storms
Hot days	Hot days (max. above 35°C) per year will	Days above 32 will increase	

	increase while cold nights (min. below 2°C) per year will decrease		Warmer days
Fire	Fire weather and severe fire weather days are both projected to increase in summer and spring	Hotter summers and droughts will increase frequency of fires	-
Drought	More severe short-term droughts but less severe medium to long-term droughts	In a severe drought now,	-
Coastline	Erosion likely to increase on steeper slopes in the upper catchments	Storm surges more severe and frequent – higher erosion	Erosion ongoing but there are protection interventions installed by the Danish Coastal Authorities
Settlements	Severe impacts on settlements, infrastructure, properties and public spaces such as beaches	Informal settlements and properties on the shoreline will be at higher risk	Thyboron at high risk because it is built on reclaimed land
Ecosystems	Most vulnerable: low-lying coastal ecosystems, fragmented forests in the hinterland and saline wetlands in the area	Knysna estuary at threat from pollution and changes to ecosystem as salinity increases	-

ANNEX 3: C2C PROJECTS THAT LEMVIG IS PART OF

	C9: The Thyborøn Channel and the Western Limfjord	C17: Thyborøn City and Harbour	C21: Climatorium
Project manager	Lemvig Municipality	Lemvig Mun	Lemvig Vand og Spildevand
Problem	Rising water levels in Limfjord	Heavy, prolonged rain events in Thyborøn	Need for innovation and business development in Climate Change Adaptation
Proposed Actions	Develop projects that address climate challenges in the Western part of Limfjord	Develop solutions for climate challenges in Thyborøn and Haroøre, including innovative pipelines with longer lifetimes	Development of an innovative showroom for climate development and tourism
Sub-project 1	Mapping of secondary effects on project area	Provide data of the project area and build a dynamic model	Analysis of company types suitable for climatorium and set up interviews
Sub-project 2	Form ew cooperation with emergency management	Dialogue with citizens and other stakeholders	Do feasibility study for tourism
Sub-project 3	Financial Planning	Development of innovative pipelines	Prepare zoning plan
Sub-project 4	Develop conceptual designs and their requirement specifications	Providing the basis for decision-making	
Budget	€1 158 598	€651 545	€376 107
Expected finish date	30 June 2021	30 April 2022	21 August 2018
Municipal stakeholders	Lemvig, Holstebro, Morsø, Skive, Struer, Thisted, Vesthimmerland	Lemvig	Lemvig
Utilities stakeholders	Lemvig Vand og Spildevand , Morsø Forsyning Skive Vand Struer Forsyning Thisted Spildevand Vestforsyning A/S Vesthimmerland Vand	Lemvig Vand og Spildevand	
Other stakeholders		Central Denmark Government	Geopark West Jutland Danish Coastal Authority Plastix of TripleNine

ANNEX 4 TYPOLOGY TABLES FOR CASE STUDIES

Elements have been filled in with as much as could be found. The Danish case study proved to be more difficult as most of the documents are in Danish. Some information could not be found without extensive search through literature.

Ballina

Typology Elements	Indicator	Description
Ballina		
A. Hazard and Susceptibility		
Settlement location	28.86°S 153.56°E	Centre of Ballina
Coastal erosion	20 – 45m inland shift of coastline by 2100	Coastal Zone Management Plan
Located in tropical storm zone	No, but have been hit by cyclones in the past. Also flooding due to cyclones out at sea	
Slopes and angles on or near the shore		
Inland Rainfall	1842.8 mm	Annual mean from 1992 - 2017
Base Rock	Lismore Basalts Alluvial plain soils Coastal & dune systems	
Köppen–Geiger climate classification system	Cfa	
Inland rivers	Richmond River North Creek Emigrant Creek	
Isostatic rebound		
Subsidence		
Local/regional mass density changes		
Extent and likelihood of coastal and/or fluvial flooding	Last major flood event in 1980s Regular flood threats from king tides	

Groundwater salination		
B. Exposure and Vulnerability		
Population	42 600	
Future Population Change	Increase, projected 51 238 by 2036	
Infrastructure	Large portion of buildings on low elevation, on alluvial sands and on floodplain	
Historical coastal and/or fluvial flooding		
Available geographic/GIS data	17 995 dwellings in 2011; 27 251 projected by 2016	Ballina 2035 Housing Needs & Opportunities Analysis
HDI index (national)	0.939	Rank: 2
GNP (probably national)	Gross regional product: A$ 1.895 Billion GNP: 45 970 US PPP per capita	(0.36% of NSW Gross State product)
Proportion of national population that is coastal	85% living within 50km of the coast	
Governance	democratic	
Historical areas		
Environmental areas	1311 ha	Nature Reserves
Cultural areas	861 ha	indigenous protected area
Tourism areas		
Relationships to larger governmental entities	In NSW State	
Relationships to international entities	ICLEI: Climate Protection Program	
Minority status	Bundjalung Aboriginal people and Torres Strait Islander population 1372 (3.3%)	2016

KNYSNA

Typology Elements	Indicators or metrics	Sources	Note
KNYSNA			
A. Hazard and Susceptibility			
Settlement location	34.03 S 23.04 E	Records, satellite, local data, GCMs	Link to CC forecasts, assistance agencies' programs
Coastal erosion		Satellite, records, literature, local knowledge	To determine if the settlement is located on/near erodible coasts
Located in tropical storm zone	Extratropical cyclones in the winter months	From records and forecasts	Nature and frequency of impacts
Slopes and angles on or near the shore	Steep mountain slopes to the north, slopes up to 10% on inland plains, coastal dune areas around built-up area have steep slopes	Satellite, records, literature	Suggest/determine adaptation methods
Inland Rainfall	Storms will become more intense, uncertain if average rainfall will increase or decrease	Records or local knowledge, GCMs	Need for interior protection
Base Rock	Fluvial sands, unconsolidated sands and aeolianite as cover sands but lies on rocks dating back to Gondwana	Records	Determine physical impacts through salination
Köppen–Geiger climate classification system	Cfb	System, literature	Guide choice of adaptation methods
Inland rivers	Knysna River, Gouna River, Karatara River, Goukamma River	Hydrologic data, literature	Determine whether there is a threat from simultaneous coastal and fluvial flooding

Isostatic rebound	cm/year	From literature	Add/subtract from SLR forecasts
Subsidence	cm/year	From literature	Add to relative SLR forecasts
Local/regional mass density changes	0.35 Sea level rise by 2050	From GCMs and literature	Adjust global or large region SLR data
Extent and likelihood of coastal and/or fluvial flooding	Increase, already quite frequent	Records, local knowledge, GCMs	Assist in design of adaptation measures
Groundwater salination		Records, local knowledge, literature	Assist in design of adaptation measures
B. Exposure and Vulnerability			
	Indicators or metrics	**Sources**	**Rationale**
Population	72 169	Records, satellite, local knowledge	Size of adaptation challenge
Future Population Change	5.5% increase from 2015 to 2020.	Western Cape Government Provincial Treasury (2015)	Whether greater or fewer adaptations needed
Infrastructure	Mostly in Knysna centre with decentralized settlements throughout municipality, mostly on coast	Records, literature	Ascertain the potential assets that are exposed
Historicalcoastal and/or fluvial flooding		Records, local knowledge	Assist in design of adaptation measures
Available geographic/GIS data	Housing, population, elevation	Records, literature	Assist in planning
HDI index (national)	0.666, rank 119th	UNDP	Possible indicator of local capacity
GNP/capita (probably national)	5 273.59 $US PPP	World Bank	Possible indicator of local capacity
Proportion of national population that is coastal	40% within 100km	Records, satellite, literature	To determine whether coastal adaptation is/will be high on the national agenda

Governance	Parlimentary republic/democracy	National and local records	Aid in determining adaptive capacity
Historical areas	ha, buildings	National, local and NGO records	A measure of benefits from protection
Environmental areas	33284 ha: mostly forest areas, one national heritage site and some nature reserves	National, local and NGO records	A measure of benefits from protection
Cultural areas	ha, type	National, local and NGO records	A measure of benefits from protection
Tourism areas	ha, type	National, local and NGO records	Economic measure of benefits from protection
Relationships to larger governmental entities	Eden District, Garden Route,	National and regional records	Measure of capacity to adapt
Relationships to international entities		National, local and NGO records	Measure of capacity to adapt
Minority status	19.4% living in poverty	National, local and NGO records	Measure of need to adapt: aid design of adaptation measures

Lemvig

Typology Elements	Indicators or metrics	Sources	Note
Lemvig			
A. Hazard and Susceptibility			
Settlement location	56.55 N 8.30E	Records, satellite, local data, GCMs	Link to CC forecasts, assistance agencies' programs
Coastal erosion	Presence of coastal erosion mitigation management; degree of historic and future coastal erosion	Satellite, records, literature, local knowledge	To determine if the settlement is located on/near erodible coasts
Located in tropical storm zone	-	From records and forecasts	Nature and frequency of impacts
Slopes and angles on or near the shore	Generally, quite flat	Satellite, records, literature	Suggest/determine adaptation methods
Inland Rainfall	Average rainfall for Denmark is 792mm/ year	Records or local knowledge, GCMs	Need for interior protection
Base Rock	Glacial deposits, tillite	Records	Determine physical impacts through salination
Köppen–Geiger climate classification system	Dfb	System, literature	Guide choice of adaptation methods
Inland rivers	LimFjord	Hydrologic data, literature	Determine whether there is a threat from simultaneous coastal and fluvial flooding
Isostatic rebound	0.15 – 0.20 cm/year for Denmark SL could be 0.2m lower as a result	DTU Space - National Space Institute	Add/subtract from SLR forecasts
Subsidence	1cm/yr in some areas (Thyboron)	From literature	Add to relative SLR forecasts

Local/regional mass density changes		From GCMs and literature	Adjust global or large region SLR data
Extent and likelihood of coastal and/or fluvial flooding	Increase of intensity of storms, 1-in-20 year floor occurred 5 times in 20 years	Records, local knowledge, GCMs	Assist in design of adaptation measures
Groundwater salination	Under threat from North Sea	Records, local knowledge, literature	Assist in design of adaptation measures
B. Exposure and Vulnerability			
	Indicators or metrics	**Sources**	**Rationale**
Population	20 293	Records, satellite, local knowledge	Size of adaptation challenge
Future Population Change	-4% from 2017 to 2021.	Western Cape Government Provincial Treasury (2015)	Whether greater or fewer adaptations needed
Infrastructure	Location of buildings, transport infrastructure, key assets	Records, literature	Ascertain the potential assets that are exposed
Historical coastal and/or fluvial flooding	No incidents since 2014	Records, local knowledge	Assist in design of adaptation measures
Available geographic/GIS data	Housing, population, elevation	Records, literature	Assist in planning
HDI index (national)	0.925, ranked 5th	UNDP	Possible indicator of local capacity
GNP/capita (probably national)	51 040 $US PPP	World Bank	Possible indicator of local capacity
Proportion of national population that is coastal	99 % population within 50km from the sea	Records, satellite, literature	To determine whether coastal adaptation is/will be high on the national agenda
Governance	Parliamentary representative democracy, constitutional monarchy and	National and local records	Aid in determining adaptive capacity

	decentralized unitary state		
Historical areas	ha, buildings	National, local and NGO records	A measure of benefits from protection
Environmental areas		National, local and NGO records	A measure of benefits from protection
Cultural areas	ha, type	National, local and NGO records	A measure of benefits from protection
Tourism areas	ha, type	National, local and NGO records	Economic measure of benefits from protection
Relationships to larger governmental entities	Part of central Denmark region	National and regional records	Measure of capacity to adapt
Relationships to international entities	EU Life funded project Coast to Coast	National, local and NGO records	Measure of capacity to adapt
Minority status		National, local and NGO records	Measure of need to adapt: aid design of adaptation measures