Planning for Sea Level Rise in Singapore

A study on how decision makers, planners and researchers are thinking and planning for future Sea Level Rise

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Abstract

World sea levels are rising because of increasing levels of greenhouse gases (GHGs) in the atmosphere. This report aims to describe and analyze how the small, low-lying and vulnerable country of Singapore is planning for sea level rise (SLR). The ministries, authorities, agencies, secretariats etc. that are working with SLR questions are identified and the most important environmental documents with or without SLR are also studied. University and government researchers as well as other government personnel are contacted and asked questions in relation to SLR. The interview process was difficult because some people have signed agreements with the government that restrict them from participating in any activities. Planning for SLR is discussed from different points of view and numbers of possible sea levels are also discussed. Mostly they follow IPCC projections and they often refer to the assessment report 4 (AR4) where SLR is estimated to 0.18-0.59 m by 2100. They rarely refer to IPCC’s assessment report 5 (AR5), since the research for Singapore’s environmental documents was conducted before the release of AR5. The IPCC levels are mean sea levels and it is argued by one governmental researcher who is part of the study that these levels are not sufficient for planning purposes as it is the sea level extremes that are important to plan for. Seasonal wind, tides, waves and other factors all interact to affect sea level extremes at any particular location. Singapore is located in a particularly complex region and is therefore a complex country to plan for. The report concludes that Singapore needs a better strategy to share information, and authorities need to show their results in relation to SLR, and pass on their knowledge. This will help the whole world to reduce their impact and together, make it possible to create a sustainable world, minimizing climate change effects on Earth.

Keywords

Sea level rise (SLR), climate change, Singapore, sustainability, sustainable development
Sammanfattning

Världen är på väg att förändras. Olika funktioner på jorden förändras i och med ett överutnyttjande av jordens resurser. Stora mängder växthusgaser släpps ut från mänskliga aktiviteter och mängden koldioxid i atmosfären ökar. Jordens temperatur stiger och som en följd av detta leder det till att isar smälter och havsnivån höjs. Denna rapport syftar till att beskriva hur Singapore, ett litet, lågt liggande land i en komplex region planerar för och tänker kring kommande havsnivåhöjningar. Processen har varit svår då många personer inte har haft tillåtelse att delta i några intervjuer (på grund av att de skrivit på avtal med regeringen) eller inte har kunnat delta på grund av andra orsaker. Planeringen diskuteras utifrån de forskare och regeringsanställda som jag har haft kontakt med och vars åsikter jag har kunnat ta del av. Dessutom diskuteras de mest intressanta miljödokumenten och de viktigaste myndigheterna som arbetar med frågor som rör klimatförändringar och havsnivåförändringar. IPCCs olika havsnivåer från både AR4 och AR5 tas upp, dock refererar de flesta miljörelaterade dokumenten till AR4 och en havsnivåhöjning på 0,18 till 0,59 m. AR4 var den senaste aktuella rapporten från IPCC då dessa skrevs. En regeringsanställd forskare menar på att IPCCs nivåer är medelnivåer och därför inte är optimala att använda i planeringssyften. Samma forskare menar istället att det är de extrema nivåerna som det bör planeras för. Eftersom Singapore ligger i en mycket komplex region blir denna planering också komplex att utföra. Slutligen behöver Singapore en bättre strategi för att dela med sig av sina kunskaper till resten av världen för att alla tillsammans ska kunna minska sina respektive påverkningar och skapa ett hållbart samhälle.

Nyckelord

Havsnivåhöjningar, klimatförändringar, Singapore, hållbarhet, hållbar utveckling
1. Introduction

Since the 1950s many observations of climate change have been made. Paleoclimatic reconstructions are available from hundreds of millions of years back in time and they show that today’s levels of greenhouse gases (GHGs) are unprecedented. Both the temperatures in the oceans and in the atmosphere tend to increase, the concentration of GHGs increases and sea level is rising. The rate of sea level rise (SLR) since the 19th century has been greater than the previous two millennia, and the mean sea level has risen by 0.19 meters over the period 1901 to 2010 (IPCC, 2013). As much as 20 percent of the human population lives in areas close to the coast (within 30 km from the sea), and the population doubles if you increase this range to 100 km. Low-lying islands and regions are some of the most vulnerable locations of the Earth with regard to SLR (Wei-Shiuen & Mendelsohn, 2005).

Singapore is a small low-lying country in south Asia with a valuable land area because of its high population density, and high degree of urbanization and industrialization (Wei-Shiuen & Mendelsohn, 2005). In Singapore’s 2012 National Climate Change Strategy, the deputy Prime Minister Teo Chee Hean claimed that the country especially needed “a deeper understanding of [its] vulnerabilities, and develop appropriate adaptation solutions to protect Singapore against the risks posed by climate change”, specifically due to its position as a low-lying country in a complex region.

![Figure 1. The low-lying Singapore with the valuable Central Business District (CBD) to the left which is close to the sea. Photo by author, 2014.](image)

The National Climate Change Strategy also clarifies what most scientists agree on: how severe the expected consequences from the climate change will be. The climate is changing and the world has to take action. There is no time to wait (NCCS, 2012).

If carbon emissions continue to increase, both global average temperatures and sea levels will rise. Singapore’s National Climate Change Strategy emphasizes that this will not only have an effect on Singapore’s businesses and economy, but also on its environment and its citizens’ social well-being. Therefore, Singaporeans are ready to do their part and reduce their emissions. Teo Chee Hean claims it will be challenging to do so due to Singapore’s small amount of alternative energy sources such as solar or wind power. Despite these obstacles, Singapore will try to develop low carbon technologies to reduce emissions (NCCS, 2012).

1.1. Singapore’s size compared to Sweden

Singapore is a small and densely populated island city-state in the south part of Asia with a land area of only 716.1 km² (2013) and a population of around 5.4 million people, which has increased by 1.6 % from the previous year. This gives Singapore the high population density of 7,540 persons/km² (Singapore Department of Statistics, 2013), compared to Sweden which
has a land area of 410,340 km² (2010) and had a population of 9.5 million people in 2012 (Trading Economics, 2013). The island Öland in Sweden is most comparable in land area, even though Öland has almost twice the size (1,342 km²) of Singapore (SwedenSite, 2005).

1.2. Purpose/intention
The purpose with this report is for me to get to know how a big Asian city, like Singapore, is working with SLR questions and how the country’s decision makers are planning for SLR. My intentions are to identify all relevant ministries, authorities and agencies in Singapore to further find out about what governing documents existing in Singapore and how planning for SLR is implemented in these. I also intend to find what sea levels are expected and what time perspective Singapore’s authorities plan for.

In the report I will define and discuss the expression sustainable development and use that as a background when analyzing more about sustainable cities. I believe sustainable cities are those cities that work with sustainability questions and sustainable development, as defined in this paper, and especially SLR-questions in this case, to prevent the city from being flooded by SLR.

Other questions raised in the report are whether Singapore is planning to continue building in areas near the coast. Do they have any other choice when the island is quite small (as brought up earlier Singapore is almost half the size of the Swedish island Öland) and a big part of the country is urbanized or designated for things which cannot be imported, such as the water supply. If they are continuing to build more in areas close to the coast it would be interesting to know more about the possibilities to build sea-walls to protect the country from being put under water as a result of SLR.

1.3. Research question/aim
From the purpose stated above, my main research question is to investigate how decision makers, planners and researchers in Singapore are planning for (or thinking about) future Sea Level Rise (SLR) in the country and how they will prevent the problems it will create. Another important part of the report is to investigate how this is displayed in Singapore’s guiding documents for SLR planning.

1.4. Relevance and background of the project
In light of what is mentioned above, planning for SLR in Singapore is an interesting subject for both Sweden and Singapore. Obviously the subject is important for Singapore as a big Asian city state in a coastal region. Singapore’s planning for SLR is relevant also since Sweden hopefully could learn something about how other countries are planning for SLR and working with these questions.

This project is undertaken as a Degree Project in Energy and Environment (15 hp) at KTH Royal Institute of Technology, with Jacob von Oelreich as supervisor. Jacob works at The Division of Environmental Strategies Research (fms), at KTH Royal Institute of Technology, in Stockholm, Sweden. During the research and the writing period I lived in Singapore as an
As a follow up to the report “Planning for future sea-level rise in Swedish municipalities”, this Degree Project will give input for how other countries in other regions are planning for SLR and it may be interesting to compare the documents, but that will be left for further research.

1.5. Methods

In this report several methods will be used. First, a literature study will be conducted. This study will focus on climate change worldwide, and global carbon emissions that change the world’s average temperature. This temperature change affects the glaciers and ice-sheets in the world, causing widespread melting. This and other factors in turn lead to SLR, which is a huge problem for coastal cities in the world.

The literature study is then followed by a study on Singapore. In the Singapore Study I will first find out more about Singapore and what is written about SLR and then make an electronic form (e-form) for decision makers, planners, researchers and others to fill in about SLR questions in Singapore. In the electronic form, the participants will be asked questions about their position and their possibility to change how Singapore is working with these questions. The questions will then continue to the expected levels and the time perspective. Participants will also be asked questions about risk assessments and for example lowest new reclamation levels.

The e-form turned out to be a challenging way to reach relevant persons in regard to SLR, however the questions were instead subsequently used as interview questions (see Appendix I) in different e-mail conversations. All questions were not answered by all contacted people but they have worked as a base. One of the aims of the study was to make interviews with some of the important persons in Singapore in relation to SLR. I have tried hard, but people do not want to, or are not allowed to participate in interview studies because of agreements with the government, therefore the study does not include personal interviews. However, e-mail based conversations or interviews have been made. In the reference list all e-mail conversations are listed as (e-mail) interviews. The plan was to ask them follow-up questions depending on their answers, but because of their “no possibility”, “not allowed to” or their “no time” this was unfortunately impossible. This type of interview method, where there are pre written questions but there is also space for other questions raised during the interview, is called the semi structured method (Kvale, 1996). The e-form was answered by two researchers and their answers will be discussed.

The results from the study, including the authorities and also the guiding documents available in Singapore, plus the e-mails from different authorities, will be analyzed in different ways. The analysis will connect to climate change, sustainability and sustainable development, which are parts of the theory from the Introduction.
2. Sea Level Rise

2.1. Climate change
In 2013, IPCC presented its Fifth Assessment Report (AR5) by Working Group I. In chapter 14 IPCC expresses global mean temperature projections as more certain than regional projections, as regional climate varies and depends heavily on its location. The global mean change is a summarization of many regional climate responses and it is therefore more complex. Some climate phenomena, such as storm tracks, monsoons and climate variability, can change in the future. If these change then regional climate will also change (Christensen, et al., 2013). In addition to coastal zones, ecosystem functions that help provide for water, and food will also be affected if human activities creating GHG emissions continue to increase (NCCS, 2012).

2.2. Temperature and Sea Level Rise
It is very certain that historical global mean sea level has been between 5 and 10 meters above today’s level. This happened when the temperature was at least up to 2 degrees warmer than pre-industrial temperatures (Church, et al., 2013). In the Fourth Assessment Report (AR4), IPCC provided a change in global mean sea level by the end of the twenty-first century at a range of 0.18-0.59 m. These numbers were in relation to the end of the twentieth century. They did not include potential future changes in the ice sheets in Greenland and Antarctica (IPCC, 2007). In the Fifth Assessment Report IPCC the predicted levels have changed to 0.26-0.82 m by 2100. Already in the mid-twenty-first century the levels are predicted to be between 0.17 m - 0.38 m calculated with respect to the reference period 1986–2005 (IPCC, 2013).

In 2009 the G8 leaders agreed on a goal of 2 degrees Celsius to measure the effects of climate change. Since the temperature has changed over time and in recent time has changed by 0.7 degrees the goal was set to 2 degrees. The 2 degree Celsius global warming goal can be reached if the emissions peak in 2020 and are reduced by half in 2050 (Reuters, 2009). Many studies have shown that no matter how much we reduce, due to time lags in the carbon cycle we will pass the 2 degree threshold (IPCC, 2013).

2.3. Climate-sensitive processes
Since the 1970s ice sheet losses from glaciers account for about 75 % of the observed sea level rise. The contribution to the observed rise in sea levels from Antarctica and Greenland has also increased. However, ice sheets and ice shelves not only the affect sea levels. All climate-sensitive geological processes and components, such as hydrological cycles in the atmosphere, ground water, interaction between the ocean and the atmosphere, and processes in the ocean such as circulation may also affect SLR (Church, et al., 2013).

2.4. Sustainability and sustainable development
Today and in the future, humanity will face a big challenge in becoming sustainable and developing sustainably (Gröndahl & Svanström, 2011). It is only during the last 40 years that the environment has become an important topic in international law. In the beginning, the creation of international environmental documents were connected to global conferences.
They were supposed to aspire and link every country’s endeavors as to show that each great effort requires others. Sustainable development, with its dual importance, development and environment, is typical of such efforts (Kates, et al., 2005). Based on this, questions arise about what sustainable actually is. Here I would like to present a few different statements or definitions regarding sustainability, which I have identified and which I believe are the most relevant.

2.4.1. Brundtland
My first definition is the one from the Brundtland Commission, which today is nearly universally accepted (Gröndahl & Svanström, 2011). In the report Our Common Future, Brundtland describes sustainability as (WCED, 1987):

“…development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

The report is often called the “Brundtland Commission” from the chairman of the commission, the former prime minister of Norway Gro Harlem Brundtland. In the report Brundtland discusses the meaning of the words environment and development (WCED, 1987).

“The environment does not exist as a sphere separate from human actions, ambitions, and needs, and attempts to defend it in isolation from human concerns have given the very word “environment” a connotation of naivety in some political circles. The word “development” has also been narrowed by some into a very limited focus, along the lines of “what poor nations should do to become richer,” and thus again is automatically dismissed by many in the international arena as being a concern of specialists, of those involved in questions of “development assistance.” But the “environment” is where we live; and “development” is what we all do in attempting to improve our lot within that abode. The two are inseparable.”

In the Brundtland Commission Report it is possible to find four different ethical principles with regards to sustainable development. The interdependence between humans and ecosystems, humans depending on each other, justice and equality between generations and last participation in decision makings. Overall these four principles contain aspects such as ecosystem services, livability, quality of life, democracy and being able to be a part of development (Gröndahl & Svanström, 2011).

The Brundtland Report is based on an anthropocentric point of view, where humans and their needs are the most important, in comparison with the economy-centric perspective that has for a long time been featured in society. The economy-centric point of view is where economics is the independent variable that controls ecological and social development. Others are more positive to the ecological (eco-centric) point of view where the value of nature remains even when the human being is not there anymore (Gröndahl & Svanström, 2011).

SLR will have an impact on many major important societal functions in the future. Adaptation needs a long-term perspective. Some studies have shown scenarios of SLR that could yield between 1-3 meters even in low-emission scenarios by 2300. In high-emission scenarios others found the sea level to rise 2-12 meters (von Oelreich, et al., 2013).
2.4.2. Three dimensions
In order to be able to discuss sustainable development it is good to have a few models. Most models usually contain three dimensions; the society, the economy and the environment or the ecology.

Sustainable development is something that includes all three dimensions at the same time. An illustration of this may be three overlapping circles, forming a sustainable “triangle” in the middle, see figure 2. This middle part, when all three dimensions are represented, is the goal and the place where sustainability or sustainable development is achieved (in this model) (Gröndahl & Svanström, 2011).

The Russian Doll model (figure 3) is, compared to the three overlapping circles, a model that values the three dimensions differently. The model can be understood as something between an eco-centric and an anthropocentric approach. Both models underline the need for an efficient use of resources but anthropocentricity focuses on humans and eco-centricity on nature (Manzi, et al., 2010).

SLR concerns uncertainties which must be handled by local governments and planners (von Oelreich, et al., 2013). Countries in the world, especially low-lying islands that are vulnerable to sea level changes, have to face these SLR-questions arising from climate change (environment) (NCCS, 2012). Wei-Shuinen and Mendelsohn discuss costs in their article The impact of Sea Level Rise in Singapore. The economical part of the SLR problem will be considerable. If you assume protection of land will be provided by sea walls and that they will mirror the SLR, cost will escalate over time. The authors, nevertheless, conclude that the benefit of protecting the land of the society outweighs the costs (Wei-Shuiren & Mendelsohn, 2005).

2.4.3. Indicators and measurements
Another way to define sustainable development is through measurement. In spite of sustainable development being an ambiguous concept, you can find appropriate indicators and measure them. Some global studies use country or regional data, for example; well-being index, ecological footprint, environment sustainability index and many other indexes. The variety of opinions affect the negotiations of what indicators are the most important. Often a large number of indicators are needed to show a vision of sustainability (Kates, et al., 2005).

Global mean sea level is a sensitive indicator of climate change (Gornitz, 1995) and in the IPCC reports (both the fourth and fifth assessment reports) SLR is indicated as a measurable factor with the number of SLR differing between 0.18-0.59 m (IPCC, 2007) and 0.26-0.82 m (IPCC, 2013) by the end of the twenty-first century.
Sustainable development is still a concept of malleability, it is open and can be adapted to fit different situations. However, the concept is still working and it enables participation both locally and globally, across sectors, governances, business and society. It can be shaped to fit the purpose of many kinds of activities (Kates, et al., 2005).

2.5. Reflections on sustainability and climate change

The global climate is not only set to change in the future, it is changing now. Global climate change can be understood as a change in the overall global mean climate, which is an amalgamation of all regional climate changes. This means if the regional parts of the climate are changing, so is the global. Since human activities creating greenhouse gases are continuing to increase, which will affect a big part of Earth functions, we have to react. This increase needs, in my opinion, to be stopped. Alternatives to burning fossil fuels are needed in order to create energy in more sustainable ways: ways that do not affect the Earth in negative ways.

The temperature has already increased and the sea level has been changing along with it. Historically, sea level has been five to ten meters above today’s level, which occurred when temperatures were 2 degrees higher than today. If the climate is changing and the aim is not to reach the 2 degree Celsius global warming goal (which is almost impossible with regards to IPCC Summary for Policymakers, SPM5) GHG emissions has to be reduced and the lifestyle habits has to change. Otherwise this will lead to an increase in sea levels to the same extent as the historical levels (5-10 meters above today’s level) when the temperature will get 2 degrees warmer than pre industrial.

Thanks to IPCC’s AR5 we now know glacier melt and ice sheet loss can explain 75% of observed sea level rise. The SLR levels in AR4 do not include the future changes in ice sheet losses in Greenland and Antarctica. This means the AR4 levels are not the best source when using them for planning purposes.

The challenge in the future (and today) is to reach sustainability regarding climate change and global warming. To adapt to sea level rise in a good way and reach sustainability we need to adopt a model. In my opinion the Russian Doll model (figure 3) is the best model in regard to SLR. The model focuses on the eco-centric point of view and therefore the environment is the most important part and based in the environment are then society and economy. Nevertheless, without a functioning environment we cannot have neither a functioning society, nor an economy. I have to admit I like the Brundtland definition too with the anthropocentric point of view, where the focus is on humans and future generations. But for me, to reach a sustainable future and healthy future generations this has to be based in a working and properly functioning environment.
3. Study – What does the situation look like in Singapore?

This third part of the report is focusing on what the situation in Singapore looks like. The chapter is supposed to give answers to my purpose and my research questions, which are concentrated on the planning for sea level rise in Singapore. The first two parts of the Singapore Study are focusing on what important environmental authorities and what guiding documents existing in Singapore, focusing on climate change and sea level rise. After these two introductory parts the reader is introduced to the results from the study to later on be able to answer the main research questions.

3.1. Introduction to Singapore’s main environmental governmental authorities

This part of the report introduces the reader to some of the most important environmental authorities, secretariats, committees, ministries and research institutions which exist in Singapore. Those are all connected to climate change questions in Singapore and will later on be discussed and analyzed.

3.1.1. NCCS – National Climate Change Secretariat, Prime Minister’s Office Singapore

From the beginning, NCCS was created to implement and develop the climate strategies and policies, both national and international and also to manage climate change questions. The secretariat was established 2010 under the Prime Minister. NCCS has four main responsibilities which are “facilitate efforts to mitigate carbon emissions in all sectors”, “help Singapore adapt to the effects of climate change”, “harness economic and green growth opportunities arising from climate change” and “encourage public awareness and action on climate change”. One mission of the NCCS is “to lead and coordinate Singapore's domestic...
and international policies, plans and actions on climate change to secure a sustainable living environment for future generations” (NCCS, 2013a).

3.1.2. IMCCC – Inter-Ministerial Committee on Climate Change
Since 2007, IMCCC deals with the coordination of the whole climate change strategies and policies in Singapore (MEWR, 2013a). This coordination includes all of the authorities, which work with climate change questions, and should ensure that Singapore is prepared for the varying impacts of climate change as they present themselves. The Chairman of IMCCC is the Deputy Prime Minister Mr Teo Chee Hean and the members are different ministers for Finance, Trade and Industry, National Development, Environment and Water Resources, Foreign Affairs, Law and Transport (NCCS, 2013b).

3.1.3. NEA – National Environmental Agency
NEA is the leading environmental, governmental organization in Singapore. NEA is responsible for the environment and to create a sustainable country. The agency develops programs and other initiatives, in partnership with the three P sectors (People, Public and Private). NEA’s stated aim is to give cause for every single Singaporean to take care of the environment. They intend to protect Singapore from pollution to maintain good public health. NEA also provides meteorological information when needed and works towards a sustainable development and a livable environment for present and future citizens (NEA, 2013a).

3.1.4. MEWR – Ministry of the Environment and Water Resources
MEWR is the governmental authority responsible for providing a high-quality living environment in Singapore. Their long term environmental goal is to reach environmental sustainability. They collaborate with the two other agencies, the National Environment Agency (NEA) and Singapore’s National Water Agency (PUB) in environmental questions, to reach sustainability via innovation and cooperation between sectors and also to manage the limited land resources (MEWR, 2013c).

3.1.5. URA – Urban Redevelopment Authority
URA works with different parts of the redevelopment of Singapore. One of their most interesting work regarding this report is the Planning for Long-Term Sustainability. They also work with promoting architectural, urban design and planning. URA aims to guide and shape design plans and also make public spaces into fun places. The authority is working with long term integrated approaches including balancing the need of a growing economy and at the same time working to provide a livable and sustainable environment for the society (URA, 2014a). In an answer of my email they underline that they “have checked and confirmed that URA does not have information related to the rising of sea level” (URA, 2014e).

3.1.6. TMSI – The Tropical Marine Science Institute
TMSI is a part of the National University of Singapore (NUS) with a vision “to be a centre of excellence for research and development in tropical marine science, regionally and internationally”. Their missions are to play leading roles in the tropical marine science research and education and to be a national resource center in this research (TMSI, 2009a). The institute collaborates with the academic as a part of NUS but also with the industrial sector and the government. They are not only working with tropical marine science but also environmental science and climate change (TMSI, 2009b). One contacted researcher writes “unfortunately I am not in a position to participate in your questionnaire survey. I had signed agreement with the Govt agencies not to participate in such activities” (Raju, 2014).
3.1.7. BCA – Building and Construction Authority
The BCA is an agency which is supposed to develop an "admirable" built environment within Singapore. They have a mission to shape a sustainable and friendly built environment with good quality. BCA works for greening the built environment in Singapore and enterprises sustainability in the environment (BCA, 2010).

3.1.8. MND – Ministry of National Development
The Ministry of National Development was established in 1959 and is one of the key government ministries responsible for the development of Singapore, land use and planning. MND are supposed to guide Singapore in those areas to maintain a quality and sustainable built environment (MND, 2014).

3.1.9. CCRS – Centre for Climate Research Singapore
The first center for tropical climate and weather research in the world was opened in March 2013 in Singapore. CCRS (Centre for Climate Research Singapore) was established under the Meteorological Service Singapore and aims to predict and understand weather and climate related questions related to Singapore. Dr Chris Gordon is the head of the team which consists of 25 staffs. "The scientific understanding of the dynamical and physical processes governing tropical climate and weather systems will naturally be the primary focus of CCRS. Improving our ability to predict extreme weather such as heavy rain, and project long-term climate change, is one of the key challenges for the Centre," says Dr Gordon (NEA, 2013c).

3.2. Reports, plans, strategies, policies and other important documents related to Singapore and Climate Change.

3.2.1. Singapore Green Plan
The Singapore Green Plan was first handed out in 1992 and was Singapore’s first environmental policy script, called an environmental blueprint. The aim of the Green Plan was to ensure economic development and to meet the needs of today’s generation without compromising the need of the future generations. A review of Singapore Green Plan 2012 (SGP 2012) was made seven years later and launched in 2002 to update the SGP 2012 with new ideas and concerns which had emerged over time. Another edition of the report was launched in 2006 to keep the SGP 2012 up to date and force it towards environmental sustainability (MEWR, 2013b).

3.2.2. Sustainable Singapore Blueprint
To achieve a sustainable Singapore in the future a new developed edition of the SGD 2012, a new script: the Sustainable Singapore Blueprint (SSB) was launched in 2009. The real title of the blueprint is A Lively and Livable Singapore: Strategies for Sustainable Growth but is normally called the Sustainable Singapore Blueprint. The new SSB was developed since most of the aims and goals in the SGP 2012 were already met. SSB serves as a guide for sustainable development strategies until 2030 (MEWR, 2013b). Five years after the release in 2014 the report will be reviewed and updated (MEWR, 2014).

3.2.3. National Climate Change Strategy
The Climate Change & Singapore: Challenges. Opportunities. Partnerships. National Climate Change Strategy 2012 document (normally called National Climate Change Strategy) is published by the NCCS. Questions and problems brought up in this report are for example
about what climate change is and why it matters. Another important part is the impact of climate change on Singapore, both now and in the future. In addition to the questions above, the document seeks to bring out initiatives and strategies to prepare for the climate change challenges. (NCCS, 2012).

3.2.4. **The overall planning process with Concept and Master Plans**

The overall planning in Singapore consists of two important documents, the *Concept Plan* and the statutory *Master Plan*. The Concept Plan guides Singapore in its development, land-use and transportation over the next 40-50 years. The plan is supposed to ensure Singapore’s long-term population and growth and also provide a livable environment. The Master Plan is more detailed and only guides Singapore over 10-15 years. It is aimed to convert the long-term strategies from the Concept Plan into more detailed plans (URA, 2014c).

3.2.4.1. **Actual Concept Plan**

The actual Concept Plan was reviewed and carried out in 2011. The review was made in the National Population & Talented Division (NPTD). A discussion about a sustainable population for Singapore released the Population White Paper in 2013. In the same time as the Population White Paper was released the MND’s Land Use Plan was published to complement it. The Concept Plan from 2011 is not readable on the URA website, but the MND’s Land Use Plan can be read. The strategies from this MND plan will be transferred to the next review of the Master Plan. In the Concept Plan they do not mention SLR (URA, 2013).

3.2.4.2. **Actual Master Plan**

The actual Master Plan in Singapore is from 2008, but it has recently been reviewed to the Draft Master Plan 2013. The Master Plan from 2008 contains a map of the country with a legend which explains the future land use. The Map is to be read with the Master Plan Written Statement and in the statements the expression SLR is not mentioned (URA, 2008).

3.3. **The process – governmental structure and contracts**

Mr. Shuy Eng Ban, a lecturer at the Nanyang Technological University told me in a small discussion about Sea Level Rise that most studies on SLR are confidential. He gave me three names working with these studies, two were working on the BCA and one on TMSI (Ban, 2014). The man from TMSI, Mr. Durairaju Kumaran Raju, was very happy to hear about my research on SLR and its impact on Singapore. Unfortunately he told me he is in a situation not being able to participate in other research since he had signed an agreement with the Singapore Government not to participate in activities like that. He will therefore not answer any of my questions for the same reason. Raju told me to instead approach Mr. Dan Friess who works at the Geography Department at the National University of Singapore (Raju, 2014). Dan Friess has unfortunately not answered my email. Shuy Eng Ban also told me the name of the company Surbana which is undertaking an adaption study in regard to SLR, which has just started. The company has not replied to my e-mails (Ban, 2014).

In the beginning of December 2013, I was in contact with a female researcher, who wants to be anonymous, at NTU because her profile on the school website was telling she had some knowledge in the specific subject. She had no interests in helping me and thought she had different experiences from what is needed and that this research was outside of her expertise. She told me to contact TMSI with the thought they would know more about adaption due to

General emails have also been sent to URA, NEA and to NCCS after recommendation from URA. URA elucidates the authority does not have any information related to rising sea levels. Instead the authority suggests accessing the NCCS’s web portal as this may have relevant information (URA, 2014b). After sending more emails to the URA with the concerns about climate change and the impacts of rising sea levels in Singapore, I got a confirming answer about what I have managed to get to know. The email focuses on the connection between agencies like IMCCC and the Resilience Working Group (RWG) which includes URA. URA also confirms Singapore as a low-lying vulnerable country where SLR is a threat. The Authority also writes about the new reclamation levels which are brought up in the report, which also confirms the importance of this question.

NCCS, BCA and NEA have all written replies to my emails that the answers to my questions (the ones from the e-form) will be forwarded to me from one authority. The answer will therefore be coordinated and likely contain the same information as provided on all the different websites. Mr. Ji Min Sheng, a manager of infrastructure on The Ministry of National Development conducted an answer on my queries (for the RWG Secretariat).

The female researcher (1) from NTU, who wants to be anonymous and one male researcher (2) from the governmental National Environment Agency (from a contact with CCRS), who also wants to be anonymous completed the e-form. Their opinions will be discussed further down.

### 3.4. Sea Level Rise in important governmental documents

Sea level rise is raised as a problem in some of the important documents which exist in Singapore. In the National Climate Change Strategy by NCCS, SLR is already mentioned in the overview. It is pointed out that rises in sea level and temperature changes have already been observed for Singapore. SLR is brought up as one part of the complex, weather related system, climate change. Some of the variables brought up as affecting factors of climate change are the atmospheric temperature, the humidity, the wind, the surface and the sea level. The National Climate Change Strategy document refers to the IPCC’s Fourth Assessment report (at the time when the document was written, the Fourth Assessment Report was the latest IPCC report) to state climate change as “statistically observable variations in the state of the climate that persist for an extended period (usually decades or longer)”. The document also mentions that “this can manifest as an incidence of heat waves, heavy rainfall and extremely high sea levels” (NCCS, 2012).

To answer one of the most important questions (one of the few from the National Climate Change Strategy overview) about why climate change matters, the National Climate Change Strategy document states that the Earth’s climate is powerful and influences other physical, biological and ecological systems on the Earth. Once again the document refers to the IPCC’s AR4 and states sea level rise as a problem today and in the future. It is also established because of the accumulation of the GHGs in the atmosphere since 19th century, that the sea level could possibly continue to increase for centuries. According to the IPCC’s AR4 it is stated the world temperature possibly could rise by 1.1°C – 6.4°C during this century and the sea level could rise by 0.18m – 0.59m. For Southern Asia the projections are within a smaller range,
where the temperature could rise by 1.7°C – 4.4°C. However, with this temperature rise in Asia the sea level will still be the same as for the whole world (NCCS, 2012).

Figure 6. Key Findings of the Singapore Climate Change Study’s (V Study) first phase (2009) and the IPCC AR4 from the National Climate Change Strategy document (NCCS, 2012).

<table>
<thead>
<tr>
<th>Climate Change Projections (in 2100 relative to present)</th>
<th>IPCC AR4 Projections</th>
<th>Singapore Climate Change Study Findings (V Study)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Average Temperature (°C)</td>
<td>+1.7 – +4.4 (A1B Scenario, SE Asia)</td>
<td>+2.7 – +4.2 (A1B Scenario)</td>
</tr>
<tr>
<td>Change in Mean Sea Level (m)</td>
<td>+0.18 – +0.59 (A1B Scenario, SE Asia)</td>
<td>+0.24 – +0.65 (3 IPCC Scenarios)</td>
</tr>
</tbody>
</table>

In the National Climate Change Strategy document it is mentioned the numbers (in figure 6) should be updated when there is more information, such as when the Fifth Assessment Report by IPCC is available (NCCS, 2012). AR5 is since 2013 available (IPCC, 2013).

Singapore’s first vulnerability study (V Study) was commissioned by NEA in 2007 (NEA, 2011). This study is also called Singapore’s 1st Climate Change Study (Researcher 2, 2014). The first part of the study was led by TMSI and completed in 2009. The aim of the first part of the V Study was mainly to predict the effects of climate change which includes sea level change. The study also concluded an average daily temperature increase of 2.7°C - 4.2°C and a mean sea level rise between 0.24m to 0.65m by 2100. Those numbers are consistent with IPCC’s AR4 numbers which are both included in figure 6 (NEA, 2011).

Between 1948 and 2011 the mean surface temperature in Singapore has risen from 26.8°C to 27.6°C and the sea levels in the Singapore Strait over the last 15 years have risen by 3mm per year. It is also declared that future changes are expected (NCCS, 2012). Other climate change challenges and problems are also brought up in the National Climate Change Strategy document where SLR is just one of the problems they focus on.

Long term global mean sea levels (MSL) have been estimated by some researchers and the global trend during 1901-2009 was found at the highest rate in recent time. The MSL is rising by 1.7 ± 0.2mm per year. The average MSL in the Singapore Strait is 2.9 ± 0.6mm during 1984-2011 and has been higher in the more recent years. Between 1984 and 2009 the SLR average per year in the Singapore Strait was 2.1± 0.6mm and between 1993 and 2009 was the SLR 3.4 ± 1.3mm. The global average for the same periods of time was 2.4 ± 0.4 and 2.8 ± 0.8mm per year which when compared with the SLR numbers for Singapore Strait meaning the Singapore Strait has accelerated faster than the global average SLR (Tkalić, et al., 2012).
3.4.1. Past and future reclamation levels

Raffles established the Singapore territory in 1819. Since then they have been doing land reclamation. The first materials for the construction came from hills on the island and were concentrated on areas that were often flooded by high tides. Between 1919 and 1923, land reclamation increased for military purposes, public utilities and also for coastal protections. At this time land reclamation was also necessary to make possible building transportation as roads and railways (Glaser, 1991).

When the need for hundreds of hectares of land for industrialization, transportation and housing became necessary, land reclamation was seen as a natural solution. Islands were formed from the sea to meet the need. Mostly off-shore islands have been formed to meet industrialization needs like petrochemical industry islands. Other islands, by land reclamation, have increased their size from 15 to 150 ha (Glaser, 1991). In 2008 Singapore’s land area had increased by 17 % through land reclamation and in figure 7, above, it is possible to see how the coastline has changed over the years (Wildsingapore, 2008).

3.4.2. New Reclamation Levels

Most of Singapore’s land area is less than 15m above sea level and the city is one of the most density populated in the world. Furthermore, 30 % of Singapore’s land area is below 5m above sea level. Singapore is working with enhancing resilience and coastal erosion problems which arise from the problem of rising sea levels, claims NCCS in the National Climate Change Strategy (NCCS, 2012). URA in an email also confirms that sea level rise poses a threat to the low-lying island of Singapore. Work has already started to enhance resilience against coastal erosion and inundation which can be associated with SLR (URA, 2014d). However, already 70% to 80% of Singapore’s coastline consists of paved surfaces. The reclamation levels for newly reclaimed land have since 2011 been raised with 1m because of rising sea levels. The previous level was set to 1.25 m above the highest tide level, which has been observed before the year of 1991. Infrastructure adaptation will also be made to minimize the flooding risks due to SLR. The raise of the reclamation levels for newly reclaimed land is made to ensure all new land is safe in view of future increases in the sea.
level (NCCS, 2012). URA also confirms the raising of the reclamation level from 1.25m to 2.25m to safeguard the country against long-term sea level rise (URA, 2014d).

Biodiversity loss is also problematic in the face of SLR. Biodiversity in the mangroves will be affected because species living there cannot evacuate inland. SLR also influences the corals which require sunlight and those will get less when the sea level is rising (NCCS, 2012).

3.4.3. News Releases about AR5
A more up to date authority is NEA which writes about news releases on its website. One topic on this page is *IPCC’S Latest Findings Suggest Future Increases in Global Sea-Level Rise and More Extreme Rainfall in the Region*. These findings are a result of the release of the IPCC’s Fifth Assessment Report “Summary for Policymakers” (SPM) by working group I. It is written on the NEA web page that AR5 has updated the analysis of climate change and likewise the projections of the future. They establish the findings to be consistent with those from the AR4. If the years between 1986 and 2005 are used as a reference period, the analysis from SPM (AR5) is that the sea level could rise between 0.26m and 0.82m until the period between 2081 and 2100. Those projections depend mostly on the GHG concentration in the atmosphere. If the worst case scenario occurs the sea level could rise by 0.52m-0.98m until the year 2100. (NEA, 2013b)

The news-text also claims it could take a millennium or longer to completely melt the Greenland Ice Sheet but if this happens, the sea level could rise up to 7m compared to current level. Nevertheless, this is a long-term expectation which needs more research to refine the projection. A new Singapore Climate Change Study (as Singapore’s 2nd National Climate Change Study) will be carried out to update it with the knowledge released in the latest IPCC Fifth Assessment Report (NEA, 2013b).

Figure 9. The Sea Level Projections from IPCC’s Fifth Assessment Report, “Summary for Policymakers” conducted through NEA’s web page about News Releases.

<table>
<thead>
<tr>
<th>Sea Level Projections of the period 2081 – 2100 from NEA (and IPCC AR5) relative to 1986 – 2005</th>
<th>SPM Scenario</th>
<th>Aggressive Climate Change Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Sea Level (m)</td>
<td>+0.26 – +0.82</td>
<td>+0.52 – +0.98</td>
</tr>
<tr>
<td>Change in Temperature (°C)</td>
<td>+0.3 – +1.7</td>
<td>+2.6 – +4.8</td>
</tr>
</tbody>
</table>
The National Climate Change Strategy mentions SLR but it is not the only script which does. The Sustainable Singapore Blueprint focuses however on sustainable development through long-term planning, cost approach, flexibility and land use planning. Furthermore, in the script, sea level changes are brought up as a problem but not as detailed as in the National Climate Change Strategy. The SSB mentions SLR twice as a problem caused by climate change. The development around the world has influenced the global environment as a result of the human activities. It is written that to secure a long-term future action is needed from countries around the world, Singapore included (MEWR, 2009).

3.5. Answers to questions by researchers and authorities

3.5.1. Coordination between Governance Authorities

After sending emails to different governance authorities and ministries, replies have also been received. NCCS, NEA and BCA replied in different ways that their agencies are still looking at the request (the questions from the e-form). NCCS mentioned the answer will be forwarded when they receive it (NCCS, 2014). NEA is still checking with other agencies and NCCS told them the Ministry of National Development will reply to the queries (Chia, 2014). The coordination between authorities and ministries is also confirmed by BCA (by Chai Teck Ho), which writes that information will be obtained from several different governmental agencies and ministries in order to create a reply to my queries (Ho, 2014).

Mr Ji Min Sheng, a manager of infrastructure at The Ministry of National Development conducted a consolidated answer to my queries for the RWG Secretariat. They mean that the process of answering my emails is more effective and facilitate when the authorities are working together. Ji Min Shen refers to my emails which I have sent to both NCCS, BCA and NEA and told me that “we have worked together to prepare a consolidated response” to “facilitate the process” (Ji, 2014).

Ji Min Sheng confirms the vulnerability of the small, low-lying island city state of 716km², and with a population on 5.4 million the country is one of the most densely populated in the world, situated in the tropics. “Singapore is naturally vulnerable to the impacts of climate change” and the country “already feels some effects of climate change” and because of those effects they think “it is important for Singapore to prepare for and adapt early to climate change” (Ji, 2014).

Ji Min Sheng also (in the answer) focuses on the importance of IMCC and he is explaining what this committee on climate change works for. “The Inter-Ministerial Committee on Climate Change (IMCCC) was established in 2007 to enhance Whole-of-Government coordination on climate change policies. The Resilience Working Group (RWG), an inter-agency platform under the IMCCC, assesses Singapore’s vulnerability to the effects of climate change and recommends long term plans that ensure the nation’s adaptation to future environmental changes, based on a risk management approach”. They also refer to the Singapore’s National Climate Change Strategy 2012 as an important environmental strategy for the country (Ji, 2014).

Ji Min Sheng covers the 1st National Climate Change Study (2007 – 2013), which has examined long term effects of climate change on Singapore. He mentions that the “findings showed that the mean sea level around Singapore could rise by 0.24m to 0.65m (not
inclusive of ice sheet melt) in 2100." He also underlines that “this is comparable to the findings in the Fourth Assessment Report (AR4) and Fifth Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC)".

Since the island is low-lying, much effort to enhance resilience against coastal erosion and inundation due to SLR have already started. “Coastal protection structures, such as sea walls and stone embankments, are implemented at various locations around Singapore. The Building and Construction Authority (BCA), as part of the RWG, will continue to review and assess the feasibility of the options available, and take reasonable and cost-effective measures to protect Singapore’s coastline against climate change” writes Ji Min Sheng. The authority also explains that in 2011, through a revision of the Code of Practice on Surface Water Drainage the “minimum reclamation level was raised by another 1m, thus providing additional safeguard against sea level rise. On top of this, minimum platform level for buildings and minimum crest level for entrances to underground facilities, such as basement car parks and underground train stations, are stipulated in the Code of Practice to provide additional flood protection for developments” (Ji, 2014).

He also mentions that they “are mindful that specific adaptation measures will need to be reviewed and adjusted as we acquire new knowledge, information and data on the effects of climate change through climate science scholarship and study”. With the new release of IPCC’s AR5 it is necessary to update their knowledge and resilience plans, which are carried out through Singapore’s 2nd National Climate Change Study. These projects “will help the Singapore Government better understand the local impacts of climate change and the results will eventually strengthen Singapore’s climate resilience and adaptation plans” (Ji, 2014).

3.5.2. Electronic form
An electronic form has been conducted through the emails sent to all the persons and authorities. Not many have chosen to answer, neither the emails nor the form. The same questions (interview question conducted in the end of the report) have also been used as queries which have been emailed to those who answered they were not allowed to fill in a form (because of some agreement with the government).

One female researcher (1) from NTU has filled in the form. She mentions the government’s interest in the scientific research they are working with on SLR and she believes the government takes the information seriously in the decisions for planning. She mentions possible levels of 0.3-0.8 m in rise of sea levels until 2100, and also refers to the levels in the IPCC report (Researcher 1, 2014). These levels are not far from SPM AR5’s levels of +0.26m - +0.82m. To improve the planning she also thinks it is needed to obtain more information about sea level rise and what impact it will have on Singapore.

A male researcher (2) of the National Environment Agency (who answered instead of Dr Chris Gordon from CCRS, who probably forwarded my request) explains that the governmental agencies are currently conducting sea level assessment studies in conjunction with other institutions and universities (NUS, Hadley Centre, CSIRO, and NOCL) and the conclusion of these studies will be used for planning purposes. On the question about what sea levels that are mentioned until the year 2100 he explains by saying that the “estimation of the range and probability distribution of future sea levels, under different RCP scenarios, is part of the currently on-going studies”. He also underlines that “the estimated sea-level range
and probabilities will be used”. He does not mention any levels but does however refer to the fact that the studies are not yet complete but will “be concluded within this two years”. Therefore, he is not able to tell which sea levels are mentioned (in year 2100) in the guiding documents of Singapore. He also explains that “sea level changes in different ocean basins can, and do differ from global sea level changes. The mean sea level is not sufficient for planning purposes as it is sea level extremes that are important. Seasonal wind, tides, waves, etc. all interact to affect sea level extremes at any particular location.” He elucidates here that the mean sea level is not to be sufficient for planning purposes, instead stressing sea level extremes as the most important. He mentions that “seasonal wind, tides, waves and other factors all interact to affect sea level extremes at any particular location”. In this case, Singapore is located at a particularly complex region and therefore difficult to plan for (Researcher 2, 2014).

One question mentions in what specific guiding documents the levels which should be used in planning purposes can be found. The researcher (2) here states that this is pending of the results of the sea level rise studies. Therefore it is not yet decided in what specific guiding document the new sea levels will be found. On what grounds and what specific sea levels will be “synthesized by expert judgments” and “a range of ocean models covering different processes and scales will be used to estimate the range and probability distribution of future sea levels”. The “RCP emission scenarios form the basis of the study” and therefore he does not believe the chosen levels will rely on another specific and reliable report as for example the IPCC assessment reports. He also underlines that “sea level changes will follow from the results of regional downscaling” (Researcher 2, 2014).

When asked about what time perspective is used in the planning for SLR the NEA researcher explained that different agencies require different time perspectives for their specific planning purposes, which means the range varies from 20-30 years up to more than 100 years depending on the infrastructure in question. He also mentions the currently on-going (2nd) study on climate change, which will update the results of the previous (1st) study to the fact that makes Singapore’s planning different after 2011, this will be ready in about two years (Researcher 2, 2014).

He is also clear with the fact that they “do not perform risk assessment” and can therefore not give any answers on the questions about the raised minimum reclamation level for newly reclaimed land (Researcher 2, 2014).
4. Analysis

4.1. Governance Structure and Sharing of information

As has been illustrated from this study, Singapore can be seen as governed in a top-down manner. This becomes clear when authorities, research institutions and others working for the government are asked questions about sea level rise and cannot tell anything about either their work or what Singapore believes or is planning for with regard to SLR. It is clear, if you presuppose the numbers of the IPCC AR5 will occur, that SLR will be a problem for Singapore in the future as a part of climate change. Climate change is a global problem and furthermore something the whole world has to work against.

The Government in Singapore contains of a big number of ministries, authorities, committees and agencies. The report deals with some of the environmental ministries, authorities, committees and agencies but also secretariat and research institutions from the universities NTU and NUS. I have had contact with many people from different parts of the government in different authorities etc. and other workplaces as e.g. universities. As mentioned above, some of the people contacted were not able to answer my questions in regard to SLR because the government makes them sign contracts or agreements. Those agreements mean the researchers are not able to participate in other research activities (at least not this research) and therefore they were not permitted to answer my questions about SLR and its impact on Singapore.

Despite the lack of responses, one of the researchers contacted was really satisfied to hear about my research on SLR and its impact on Singapore. But unfortunately this researcher was then in the position not to participate or answer any questions. Instead this researcher gave me other names to contact; unfortunately this other researcher from a university department did not answer either. I think it is regretful that researchers involved in on-going research projects are not allowed to share anything about their specific knowledge.

Sharing information is apparently not something the Singapore Government is interested in. I have in many ways had contact with persons speaking about projects on SLR and the confidentiality of those projects. I am wondering why the material is confidential and why some researchers have signed these agreements. What do they want to hide and from whom? Is it to not scare the population of Singapore? Have they noticed extreme changes in the regional sea level that will affect the country more than what the IPCC AR4 and AR5 have predicted for global and south Asian predictions?

The researcher (2) from NEA, obviously in a position to participate, told me the on-going research projects (the second Singapore study on climate change) will be completed in two years’ time. It is then interesting to see if they are willing to share the information at that point. The confidentiality and their non-sharing agreements make the global climate change challenge harder to work against. It should, in my opinion, be more of sharing information to reach the climate change and sustainability goals together.

To reach sustainable cities and prevent the problems raised from climate change, I think it is a “must” to start to connect and interact in between countries. It would in the future be an important part of reaching those goals. If every country keeps their own work and planning to themselves then it is not likely that there will be an optimal development of sustainable solutions. The deputy Prime Minister Teo Chee Hean emphasizes, in the National Climate
Change Study, the significance of the world to take action now, because there is no time to wait. He refers to climate change and expected consequences from climate change, and underlines that the climate is changing now. He has a point, but regards to this statement Singapore could contribute more to solve those problems by start to interact and share information. However, this report is only discussing SLR, sustainability and climate change. Similar conclusions from other specific subjects connected to climate change can therefore not be made in this report.

However, the researcher’s satisfaction with my interest in SLR questions and the SLR impact of Singapore could be used in a better way. If there was no agreement between some researchers and the government they could make more students interested in this subject by telling more about their work.

4.2. When and how much is SLR mentioned in the important guiding documents and what are they planning for?

4.2.1. Guiding documents

The National Climate Change Strategy document published by NCCS, is according to me one of the most important environmental documents, which treats climate change extensively and sea level rises to a smaller extent. The document refers to IPCC’s future projections on both the rising of the temperature and the rise of sea level. The NCCS document is from 2012 and has therefore not the latest IPCC projections (AR5) included, but is instead based on the Fourth Assessment Report.

SLR is already in the overview mentioned as one part of the big and complex climate change challenge, and in my opinion this should mean that Singapore evaluates the problem as important and wants to show the citizens that they are working with the SLR questions. The National Climate Change Strategy is one of the easiest studies or documents to find when looking for climate change policies or studies regards to Singapore. If you google “climate change Singapore” the NCCS web page is the first result appearing and in their publications list you find the National Climate Change Strategy 2012 document. This probably means that many Singaporeans who are concerned about environmental- and climate change also have found and read the strategy.

The NCCS document uses the same levels of temperature rise as the IPCC AR4 report, 1.1°C – 6.4°C and the smaller width for south Asia 1.7°C – 4.4°C. This either mean they have the same conclusions as IPCC or that they uses the IPCC sea levels in their research. When talking about changes in sea level, the NCCS document also follows the projections in AR4, with a rise of 0.18m to 0.59m until the end of the century. They also point out the rise in sea levels between 1984 to 2011 as 3mm per year in the Singapore Strait and the change in mean surface temperatures for Singapore as things to take into consideration in regard to climate change. The latest numbers (3mm per year) is then probably a simplification of the levels in the report Sea level trend and variability in the Singapore Strait. Tkalich, et al. concludes from their numbers in SLR that the sea level changing rate has accelerated more recently and that the levels in the Singapore Strait also have accelerated more than the global average. From this you can conclude that Singapore is a vulnerable country due to sea level rises, because of its position as a low-lying country. If the SLR acceleration continues then they have to work harder to prevent the sea level rise to put parts of the country under water.
4.2.2. Land reclamation
Most probably Singapore’s land area will not be put under water in the near future. If associating to their reclamation strategies they will probably continue to increase their size. As long as the time since Raffles established the territory in Singapore 1819, the country has been working with land reclamation to make areas in the small country potential building places. More recently, Singapore has increased the land reclamation (see figure 7) and in 2008 the reclaimed land area was 17% of the country. The area of Singapore is therefore increasing instead of decreasing which would be more normal when the sea level rises. If the sea level will accelerate in its rise Singapore then has to reclaim more land from the sea and this costs money, especially when reclaiming in deeper sea but also because of other reasons. This to make sure the SLR not minimizing the area of the country. If they continue with the reclamation then it should not be a problem in my opinion to continue to build and construct buildings close to the sea.

70 % – 80 % of Singapore’s coastline already consists of paved surfaces. An increase to this extent could mean that more coastline gets paved which will affect the ecosystems and both marine and land living organisms. As brought up earlier mangrove cannot evacuate inland and so cannot other species either. An increase in the paved surface coastline could affect the living life and the new circumstances would probably make the living life not surviving. No normal coastline means deeper sea from land and out and beaches and shallower places can be hard for the organisms to find. Maybe some organisms need the shallow water in the same extent as the corals, which require sunlight.

However, paved surfaces are better protection for the county when the sea level is rising. Due to Singapore land reclamation strategies the paved surfaces will probably increase when the reclaimed land is increasing. Singapore has still 20 % to 30 % unpaved coastline, and still some beaches. With increasing risks for sea level rise and increased paved surfaces the beach- and unpaved areas also must decrease. This means that the country has to use a large amount of money for land reclamation sites and maybe in the same time lose money due to fewer tourists on Sentosa beaches.

4.2.3. Planning for SLR
The male researcher (2) from NEA explains that Singapore is located in a complex region which makes it hard to plan for. He elucidates it is the extreme levels that it is important and therefore it is those levels that they have to plan for. The mean sea level is in this case not sufficient for planning purposes. This means that planning should follow the extremes, but does it? What is then the extreme level? In the important guiding documents of Singapore similar sea levels as those from AR4 are mentioned. Since those levels (SLR) are not the extreme ones they may be inferior in planning purposes. The IPCC AR4 levels are a range between 0.18m and 0.59m until 2100, but this is unfortunately not the extremes, it is just mean sea level rise. However, how do we know what extreme levels will occur and how do you plan for them?

When they, in the National Climate Change Strategy document, are talking about new reclamation levels from 2011 it is one of the few examples when more extreme levels are mentioned. In this case the new reclamation level for newly reclaimed land has been raised in 2011. The old level was put at 1.25 m over the highest observed tide level and the new was raised by one meter in 2011 to prevent flood risks due to SLR. Furthermore, since this new reclamation level for newly reclaimed land has been introduced means the Singapore government are planning for higher sea levels. They also, because of the recent change in the
reclamation level for newly reclaimed land, think differently now in comparison to 1991 when
the first guidelines were introduced. The other possible option about their change in
reclamation levels due to SLR is that the sea rose more than expected between 1991 and
2011 and they therefore thought the raise of the level was necessary to protect the country. I
think it is good that they have changed the levels, and have them far above highest tide level
(+2.25m). Since Singapore is located in a complex region it is hard to know which levels that
can affect the country, not only a rise in mean sea level but the extreme sea levels in between.

The most important document when looking for SLR questions and the planning for SLR is
from this point the NCCS document National Climate Change Strategy where SLR is discussed
and where possible numbers of main sea levels are mentioned. When looking at other
documents it is not as good as in this document. The Sustainable Singapore Blueprint does
mention SLR, twice, but from my point of view this is not enough to show what they are planning
for. In SSB, SLR is just brought up as a problem arising from climate change. If the Sustainable
Singapore Blueprint are discussing and bringing up facts and other things to make Singapore
a sustainable city and country why is not SLR a bigger part of it? SLR is a big part of climate
change and is therefore an important part that needs to be worked on to be able to reach a
sustainable society, city or county. SLR is mentioned in the sustainability document, but could
probably have been more discussed.

In other documents like the Concept and Master Plans SLR is not even mentioned. On the
URA website, where those documents were found, they explain the concept plan to be the
document that are guiding Singapore with long-term strategies and the master plan to convert
the long-term strategies into more detailed plans and then guide in shorter periods of time.
Guiding documents, as the Concept and Master Plans, should contain planning for the country
in a long time perspective. When it is obvious the government recently has changed the
reclamation levels for newly reclaimed land I think it is strange that SLR is not even mentioned
in any of these plans. However, the plans mostly consist of an interactive map and then some
written statements. To be clear, SLR is not mentioned in the written statements, but not even
visible on the map as something that is included in the planning for the coming years.

The authority URA is also writing on their web page that they are working with planning for
long-term sustainability to achieve a livable, sustainable environment for the society. The
question that can be asked is then if they are doing this for SLR? When asking URA on why
no information about SLR could be found in the planning documents (Concept and Master
Plans) they just answered they do not have any information related to SLR. After sending
another email to them they once again replied but this time they were more detailed in their
answer. The answer contained mostly confirmations of things that I already had managed to
get information about, but this then confirms the importance of the new reclamation levels for
newly reclaimed land.

Singapore’s first Vulnerability Study (V Study) is in the National Climate Change Strategy
called Singapore Climate Change Study, but from the study findings I conclude they refer to
the same V Study. I have not looked at the V Study itself, but findings from NEA that addressing
this study, because it is a report that cannot be found directly on the authority website but have
to be requested from the NEA and other relevant authorities. This has not been successful.
Knowing there are studies, confidential or not, however, give me some hope. Singapore are
working with sea level rise questions both through Singapore’s first vulnerable study (V Study)
and through the studies which are formulated now (Singapore’s 2nd National Climate Change
Study). Singapore’s 2nd National Climate Change Study will be carried out to update the first
study with numbers from IPCC’s AR5, instead of AR4. Although it is good that the new study is on the way to be updated and give new input to how climate change is affecting Singapore.

4.3. Thoughts, contacts and structure
Because of the governmental structure with a large number of agencies, authorities, ministries etc., a part of this work has meant identifying those and also identifying the important environmental documents guiding Singapore in their planning. From the beginning of the project I did not know anything about Singapore, its governmental structure or any persons working with SLR. On this basis I started asking questions to lecturers at NTU and from that I have reached some of the persons whom I have been in contact with. A number of people have not answered my emails, not even by telling me they were short of time or of other reasons were not able to give me any answers on my questions.

When I finally got some answers, then the people were not able to answer me and tell me anything about SLR. After re-contacting a female researcher (1) on NTU I got some good tips of others working with these questions. Some authorities (NCCS, BCA and NEA) also answered, however, not with an answer on my queries but with a message about that a consolidated answer from a number of authorities should be created and forwarded to me, since I had contacted a few. The consolidated answer from those authorities came to me from Mr Ji Min Sheng and I will therefore refer to him or to the consolidated answer when I am discussing it further down. NEA as an agency answered with the consolidated answer, but when I contacted CCRS I got an answer from a male researcher on NEA, linked to CCRS. The researcher from NEA was at least not under an agreement with the government preventing him to answer, but he wanted to be anonymous. Others, like Pavel Tkalic from TMSI answered by sending me an article which he thought could answer my questions. On this basis, I conclude that different authorities, ministries, agencies and research institutions have different rules to follow, and also different strategies to meet requests from students.

I think it is interesting when asking a number of different authorities, ministries and agencies about their specific perspectives on SLR, and how they as a governmental authority, ministry etc. are working with SLR questions and that each authority cannot answer themselves. Singapore has then a unified approach to how each authority is working with these questions. Or have they? Why cannot each authority show their SLR work, and how this question is implemented in their work? Why does URA say SLR is not a part of the Master or the Concept Plan which are the bigger plans for the Singapore future? Since reclamation has been important in the history of Singapore for a long period of time, it will probably be the same in the future which has an influence on how SLR is affecting Singapore. If reclamation is a part of future planning, it should be mentioned in those plans.

The consolidated answer did not entirely answer the questions and was confirming facts that can be read in the guiding documents or on the governmental authorities’ web pages. Like other emails I have received, Mr. Ji Min Sheng starts to explain the vulnerability of the small and highly densely populated island situated in the tropics. He also mentions that Singapore already is feeling some effects of climate change. He elucidates that it is because of this Singapore thinks early adaption is important. Then I think about what would have happened if Singapore not yet had felt some effects of climate change, would the early adapting then not be important? Or if just other countries around the world had been affected, would Singapore then not do any research in this specific area? These are of course questions which I am not able to answer from the results I have in this study. The only thing I know is that more questions
are raised and the topic can be investigated more viewed from other points of views. In the consolidated answer, Ji Min Sheng also refers to the importance of the IMCCC and the RWG (which is under IMCCC) work and to the most important Strategy, The National Climate Change Strategy 2012.

It is interesting that they refer to the 1st National Climate Change Study which he underlines examines long term effects of climate change of Singapore. This Study is then one of the most important studies in regard to climate change work and probably works as a base of information for the reports that are brought up in this project. The National Climate Change Study, as said before cannot be found but have to be requested, which has unfortunately not been successful. This study has like IPCC’s AR4 found out possible SLR levels in Singapore until 2100. They found out the sea level could possibly rise 0.24m to 0.65m (not inclusive of ice sheet melt) in 2100. It is good they have the same projections as AR4, but as he mentions these levels are not inclusive of ice sheet melt and will therefore be changed with AR5 and the 2nd National Climate Change Study. I think it is important to remember the results of the Tkalich et al. (2012) study on Sea level Rise in the Singapore Strait where accelerating levels have been observed in the later years. Do the accelerating levels depend on the ice melt or on other factors due to the complex region? We do not know what will happen in the future, if the sea level will increase to rise faster or not. However, we know it will affect countries in vulnerable places.

Nevertheless, Ji Min Sheng underlines the importance of the raise of the reclamation level of newly reclaimed land, something that I really think is important too. Another thing he mentions it the importance of early adaption, but also to be mindful that specific adaption will need to be reviewed and adjusted when new knowledge (e.g. through Singapore’s 2nd National Climate Change Study) is available. Ji Min Sheng has here an essential point, because without reviewing the specific adaption we might be working against the wrong things.

The male researcher from NEA focuses on the governmental agencies that currently are conducting sea level assessment studies (Singapore’s 2nd National Climate Change Study). He underlines those studies are meant for planning purposes. The studies contain future sea levels, but he cannot tell me anything about what levels just that they are working with different scenarios. I think the most important and interesting part of his answer to my questions is the explanation about the extreme levels.

I have also reacted to that some parts of the answers to my questions they have sent me on email almost is like they are pre written. The paragraphs do often not answer a specific question but instead explain the situation from a whole perspective, not part by part and question by question which was what I asked for. I think this is interesting because either does this mean they get a lot of questions about climate change or sea level rise and have something pre written which makes the process smoother or they do not get any questions about the subject. I believe the second statement is the truth with regard to their explanations about who should be giving me an answer and who should not. The consolidated email is also evidence to this extent.

4.3. Final reflections

In light of the above discussion, it can be concluded that Singapore is a vulnerable country with regards to climate change and SLR. Singapore is a low-lying country and is situated in a complex region, which also many people mention in their answers on my queries. From what I have managed to understand, the documents National Climate Change Strategy and Singapore’s 1st National Climate Change Study are the most important documents for the
planning purposes with regards to SLR. In addition to these documents, there are many other types of documents, but these are not important to the same extent. In the future (probably within two years) the 2nd study on climate change will also be conducted and part of the most important documents for planning purposes. What should be mentioned is then that the mean sea level is insufficient for planning purposes, which the male researcher (2) from NEA underlined. The important ministries, authorities and agencies are listed in the beginning of chapter 3, but based on this the most important, in my opinion are, IMCCC, NCCS, CCRS, NEA and The Ministry of National Development. The levels that both the Singapore Studies and IPCC have developed and the levels that they are planning for are almost the same as those in the Fourth Assessment Report from IPCC. The mean sea level could possibly rise between +0.24m and +0.65m (in regard to the V Study) until 2100. The AR4 numbers are here +0.18m to +0.59m, which can be compared to the V Study levels. During the same period of time the temperature could rise by between +2.7°C to +4.2°C (V Study) and +1.7°C to +4.4°C (IPCC AR4), which also are comparable. The most important comment in regard to planning is the one about not making the planning just from mean sea level rises but plan for extreme levels. Seasonal wind, tides, waves and other factors all interact to affect sea level extremes at any particular location. In this case, Singapore is located at a particularly complex region and is therefore a complex country to plan for.

The problems which arise from SLR have until now been prevented by land reclamation, a method that until today has made Singapore’s land area 17% bigger. A number of authorities and researcher underline the importance of a raise of the reclamation levels for newly reclaimed land. This means this is one of their important adaptation methods. In the foreword of the National Climate Change Strategy the deputy minister otherwise stresses the importance of Singapore also contributing to reduce their part of GHG emissions as something important to minimize the risks of climate change and SLR.

Lastly, Singapore has to improve their behavior regarding sharing of knowledge and information, which is apparent to help the whole world reduce their impact and together make a sustainable word and minimize the climate change effects on Earth.

4.4. Further issues and research
From this information and on the basis of the above discussion it would be interesting to continue the research on these specific areas in two years’ time. In 2016, Singapore’s 2nd Climate Change Study should be completed and more information could possibly be found. Another interesting thing would be to compare the results from this study which other similar studies from other countries’ work on SLR.
5. References


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Appendix I - Interview Questions (electronic form)

- What Is Your Name?
- What is your email address and/or phone number?
- Do you agree to your name being used with your opinions in the following report?

- What is your position?
- Where are you working?
- In your position, to what extent do you have the power to influence and change how Singapore is working with planning for Sea Level Rise?

- What Sea Levels are mentioned (in year 2100 or/and possibly later) in the guiding documents for Sea Level Rise in Singapore?
- In what specific guiding documents (original source) can these levels be found?
- What agencies (and persons) in Singapore have the main responsibility regarding sea level rise questions?

- What time perspective is used in the planning for Sea Level Rise in Singapore?
- How (on what grounds) and why are these levels chosen?
- Do the levels and times rely on a specific (reliable) report?
- What percentages of Singapore land will be affected due to the rising sea levels? Land loss? Just partly affected?

- Are there any social key functions that are more vulnerable to rises in sea levels? If so, what are these?
- Do you think more knowledge and/or information is needed to make the planning for Sea Level Rise better? If so, who should then be responsible to obtain this knowledge, the government, the universities, another agency or something else?

- What is the lowest allowed (crest) level for new buildings in Singapore?
- In year 2011, the minimum reclamation level for newly reclaimed land changed. What was that level before 2011 and what is it today (after 2011)? Why was this change made?
- What actually makes Singapore’s planning different after 2011?
- How has the policy regarding the rise of sea levels changed over time?

- Do you have something to add?
- Can you imagine being further interviewed about sea level questions?

- As a last question, which key persons within sea level rise, are there in Singapore?