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A closer look into the feasibility of future, large scale land reclamation

Author:
Michael de Lange

Supervisor:
Abukar Warsame

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Authors: Michael de Lange
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Abstract

Despite the fact that on average less children are being born and calming messages that the population issue has basically solved itself, the world population is continuously growing. Around mid century it is estimated that approximately 70 per cent of the world's population will be living in urban environments. This translates to an absolute increase of roughly 3.6 billion urban citizen today, to nearly 8 billion urban citizen by mid century. This unprecedented growth is going to have major impact on today's urban societies and administrative boundaries. Especially coastal cities will feel an increased pressure while the urbanization takes another upsurge.

The geographical limitations and scarcity of land in these coastal areas pushes the extension of administrative city boundaries sea inward, making land reclamation a popular tool for these governments. Nevertheless, this expected growth and the increased popularity of land reclamation seriously endangers the remaining natural wetlands. Alternative solutions of creating artificial "human made" land by reclaiming, could be a possible direct solution for modern urbanism. As a result of the unprecedented growth, natural resources are getting rapidly depleted and sustainability is being compromised. Over the total run of history, approximately 65 per cent of the world's wetlands have been in fractioned, polluted, destroyed, altered or lost by human activities.

This master's thesis consists out of a deep, qualitative, integrative and contextual literature review. The literature review is focused on population forecasts, urbanization and growth trends, followed by an analyses of various land reclamation cases around the world. Though, the research will include a quantitative data overview this research is a qualitative research. The collection of the quantitative data regarding urbanization and growth trends will be done by using the database of United Nations, World Bank and Gapminder.

Land reclamation, as a proposed solution, sets off a certain type of trade off mechanism. Large reclamation projects on one hand serve as great boosters for the economy and urban development, while on the other hand, these projects have severe implications on natural habitat from both marine and land species. Social benefits can both be realized through economic gains by land reclamation or social benefits from natural preservation. This implies land reclamation has basically two dimensions: a socioeconomic dimension and a socio-environmental dimension. A tradeoff between these two dimensions determine whether or not a land reclamation project for a specific geographical location could be economically, socially and environmentally feasible. With proper integrated and inter related governmental land planning processes, strong environmental considerations and increased public involvement, land reclamation could be sustainably feasible.

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A long educational process of reviewing, writing and consulting is coming to an end. Therefore, from this position, I would like to express my appreciation and grace to my supervisor Abukar Warsame, who has supported me through this entire process. The hours of consultation with Abukar that have led towards the completion of this master thesis were every time truly inspiring, educating and motivating. I also would like to thank my classmate Kert Kaljula, Risto Vahenurm and Firass Sjönoce for their everlasting support and meaningful conversations. And last but not least, I would like to thank my closest friends and family for their energy and thrust. It would not have been the learning experience as it was if it had not been for you. Thank you, thank you all so much!

A CLOSER LOOK INTO THE FEASIBILITY OF FUTURE, LARGE SCALE LAND RECLAMATION

Michael de Lange

midl@kth.se

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Master's thesis:

Master of Real Estate Development and Financial Services

Examiners: Hans Lind & Kerstin Annadotter

Supervisor: Abukar Warsame

School of Architecture and Built Environment

KTH Royal Institute of Technology

Stockholm, Sweden

ABSTRACT

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1. INTRODUCTION

This first introductory chapter is meant to give a brief description of the research topic central in this master thesis. This chapter also attempts to provide a rational background connecting historic demographic and socioeconomic events to today's modern urbanism. Going through this chapter should enable the reader to understand the main concerns and the research question that is being presented in this master's thesis. Together with this rational, this chapter will also describe the goals and objectives this master thesis is trying to accomplish. At the end of this chapter a theoretical framework will be provided to explain how the research has been conducted and how the remainder of this thesis has been structured.

1.1 Background

The Neolithic Revolution, followed by the Urban Revolution (10.000 – 5.000 BCE) mirrors the ancient transition in human sociology (Childe, 1950). This social transition represents the development of the pre-civilized, hunters and gatherers into cultivated farmers (Bender, 1978; see also Marlowe, 2005; Skoglund et al, 2002). In this transition, the hunters and gatheres replaced their shiffting migration patterns, into a stable, more permanent existence. Instead of the unstable hunting culture, agriculture and cultivation of animals became the new main source of living. This process, which relied on the domestication and herding of wild plants and animals, occurred independently in seven or eight parts in the world (Bellwood, 2005). It is believed that the rise of today's urban civilisation originates from the Neolithic Revolution, which tarted in Mesopotamia around 7500 BCE (Jacobs, 2012) and, which is believed to be the first justiviable source fundamental for urban growth. This advanced but still prematured form of cultivation of early societies made it possible for families to reproduce. The social transition was the beginning of an era which allowed for centralized living, production and trade (Bocquet, 2011). Aditionally, the new permanent societies provided room for human knowledge and technology to grow. The increased human capital and growth of resources led to physical and social infrastructural developments which, in turn, led to the growth of these earliest states.

Nowadays, approximately 12.000 years later, the concentration of opportunity and prosperity in today's modern urbanism unprecedented. Over the last decade, large amounts of studies have been conducted, investigating the mix and distribution of today's developed urban society (Bellwood, 2005; see also Bocquet, 2011; Angel et al, 2005). Interrelated factors, such as knowledge spillovers, technology, social- and physical infrastructure, are largely responsible for the population growth and the growth of urban settlements over the course of

history. Since the foundation of the earliest states, the world population has expanded exponentially, from a few million to a few billion.

The phenomenon of worldwide ubranization has become as stressing in its revolutionary implications for the history of civilization as were the earlier agricultural and industrial revolutions (Biswas & Uitto, 1999). Due to the latest industrial revolution, which took place between the 1950's and the 1990's, the relatively poor inhabitants from the rural areas, found their way into the central agglomerations (Piel, 1997; see also Ravalion et al, 2007); (Ravalion et al, 2007). Everywhere around the globe cities not only started to accumulate a higher number of inhabitants, but also started to significantly expand in land cover (Angel et al, 2005; see also Seto et al, 2002; Biello, 2012). The enormous growth of cities over the last couple of centuries has been evidently presented with modern technology, such as GIS, geographic information systems. With this unprecedented rate of modern urbanization, health hazards and the degradation of natural environment in and around urban agglomerations, have become serious issues on today's political agenda (WHO; UN HABITAT, 2010).

But despite these looming threatening for urban society and environmental health, in great detail explored and investigated by the World Health Organization (WHO; UN HABITAT, 2010), urban agglomerations have been and will be constantly growing. To blame are the obvious pulling characteristics and beneficiaries of life in an urban environment over living in the rural areas. According to the United Nations (United Nations, 2012), the World Health Organization (World Health Organization, 2014) and The World Bank (The World Bank, 2014) statistics, the urban population is expected to grow from 3.6 billion today, roughly half of the entire population, to nearly 7 billion by 2050. These growth expectations raises questions concerning livability, sustainability and future construction of urban settlements (Piel 1997; WHO, UN HABITAT, 2010).

In other words, what will be the future of urban development and urban planning in a century of further urbanization and growing cities? How much influx of new inhabitants can today's cities still absorb? And what is the population cap size of cities with the growing demand for real estate into the future? Some of these concerns relate themselves to the possible optimal size of urban aglomerations, while others concern themselves over the ideal urban society to live in. Implications of urban expansion on society and the magnitude of environmental degradation have become important issues on today's agenda of many governmental agencies. Various organizations have presented their concern that the inevitable demand for urban space will increase tensions for arable land and push boundaries of traditional city

planning. Arable land is getting scarce and with the expectations of urban population in the future, natural land resources are running out (WHO; UN HABITAT, 2010).

But, while running out of particular set of natural resources, the use of water is a common pool resource. While in essence, it has to be protected and nurtured for its continuous exploration, a fringe of units can be harvested for current of future human benefits and necessities (Ostrom, 1990). Alternative solutions of creating artificial "human made" land by reclaiming, could be a possible direct solution for modern urbanism. Is it possible mankind has to take some of its nomadic background back in pursuit of new lands in order to adjust to its current needs? And what social, environmental and economical implications does land reclamation bring along with it? These questions are all main concerns being put forward and discussed in this master's thesis.

1.2 Project thesis description

1.2.1 Goal setting and research questions

The overall objective of this master thesis is to develop an extensive literature overview on the topic of land reclamation. This thesis will provide a comprehensive literature review to investigate and answer the following research question:

Can land reclamation be an environmental, social and economical sustained feasible solution for urban growth into the 21st century?

This research has been developed out of two well known, counter responsive phenomena. On one side there is the rising population growth and fast paced urbanization asking for land appropriate for urban development and economic growth, while on the other hand, there are boundaries such as environmental preservation, land regulations and geographical limitations which heavily constraints the supply of arable land. Combining these two elements together illustrates the threat for the urban development into the 21st century: the natural land resources, suitable for urban development, are running out. While the two forces of growth and limitations are working against each other, the challenge remains to maintain and create high quality and well sustained urban agglomerations. The main challenge is to provide a high standard of living with all necessary amenities, while preventing urban growth to convert into urban poverty as well as to preserve the ecological functionality of the environment around us (Haas, 2013).

To support the main research question, various sub questions have been formulated. These sub questions are:

:

- *What are the growth expectations of the world population until the end of the 21st century, where is this growth going to taking place and how much of this growth is happening within an urban perspective?*
- *What are the consequences of this urban growth for existing coastal cities and agglomerations?*
- *What role could land reclamation have in solving these challenges for coastal cities and agglomerations?*
- *What are the possible implications of land reclamation and is land reclamation environmentally feasible?*
- *What are the possible implications on the urban society and is land reclamation socially feasible?*
- *What are the economic costs of large scale reclamation projects compared to existing development, is the use of land reclamation economically feasible?*

1.2.2 Significance

It can be said with fairly high confidence that the unprecedented increase of the urban population from the last half a century, will continue to grow even further into the 21st century. Even though the 21st century has only just begun, a lot can be said already about the expected world population growth and the threats it brings to people and landscape. The growing numbers of urban settlers demand for more residential, more commercial and more industrial real estate development (Haas, 2013). While the number of urban population is increasing the tendency would also be that the size of urban areas is increasing. In the context of this thesis this is only partially true. Yes, when urban population increases also the urban size should increase. This is the trend as humankind has been experiencing it, but this trend is coming to an end. Continues growth and continues development of urban areas have reached a point in where they get involved with government land policies, zoning, land regulation and environmental limitations. The already limited supply of arable land combined with aforementioned limitations, constraints the available land for urban expansion (Conway & Lathrop, 2005). According to Conway and Lathrop (2005), further urbanization and urban growth does not only threaten the quality of human health, but also the quality of the environment and landscape around us. In order for our generation and future generations to enjoy the same quality of live as we do, traditional urban planning and city planning is on the verge of a break through. Sustainable solutions regarding urban planning, city development

and urbanization are needed in order to sustain the quality of life with all its perks and benefits, now and for the years to come.

1.2.3 Methodology

This master's thesis consists out of a deep, qualitative, integrative and contextual literature review. The literature review is focused on population forecasts, urbanization and growth trends, followed by a careful analyses of various land reclamation cases around the world. Though, the research will include a quantitative data overview, focused on the statistics and numbers regarding the growth of the urban population, this research is a qualitative research. The latter qualitative part of this research consist of an extensive literature review to combine and analyze what has been written already in this subject. The amount of available literature directly written into the subject of land reclamation as a sustainable solution for urban growth is not over excessive, though, there are many studies that touch the subject of land reclamation, urban growth and rising urban hazards from other relevant perspectives. Because of the extensive literature used, this study relies heavily on the validity and reliability of secondary data.

The collection of the quantitative data regarding urbanization and growth trends will be done by using the database of United Nations, World Bank and Gapminder. These organizations have done their researches into the growth of the world population and have provided a compressive overview of the statistics. These organizations also hold information about the health hazards of growing cities in various reports. The main goal is to gain information about the current state of urban population, the growth until 2050 and the effect this growth has on the demand for land. This information is an essential part in this research paper because it will magnify the importance and the need of finding sustainable solutions for urban growth into the short future.

The chosen methods for collecting data from the abovementioned sources will provide a solid starting ground for investigating the growth effect of the urban environment on the demand for space and depletion of natural resources. While the qualitative study and the involvement of the case studies widens the perspective and investigates the relevance of the proposed questions of the significance of land reclamation, the quantitative data gathering gives possibilities for generalizations of the results. A generalization for this research and problem statement has to be made to fit the purpose of this study. Not all urban settlements will face the challenges presented in this proposal, therefore the conclusion whether land reclamation could be a sustainable solution for urban growth will be generalized to a threat due to urbanization in general.

Even though an entrepreneurial thesis such as this one is far from perfect (due to lack of literature and research in the field) there are various problems within this thesis which should be considered while reading the results:

- **The method used is not optimal for this research**
  It is possible that there might be better ways for collecting the data that the author is not aware of. From the literature study the conclusion was made though that the listed organization has the most extensive and reliable databases regarding this issue of urban hazards and demographic growth.
- **Analyzing the data**:
  Even though lot of time has been involved in selecting and analyzing the data, the data might found might be outdated and therefore not be as represent able. In that case the report would have to work with incorrect numbers and this will significantly affect the final result and impact of this research.
- **Width and depth of conducted research**
  The topic of land reclamation is fairly wide. The case studies discussed have been analyzed in a macro- and meso-level perspective. Each case study used would fill its own individual thesis if analyzed on a more detailed mirco-level. Therefore, the decision has been made out of time and knowledge constraints to conduct this research on macro- and meso-level.
- **Reliability of secondary data**
  This master thesis relies heavily on data extracted from secondary sources. Mainly due to the lack of primary data, linkages with the actual practical world are harder to be justified.

1.2.4 Framework of the thesis

This research is organized in five chapters. Chapter one has provided a brief introduction connection well known urban phenomena with the research question central in this thesis. Chapter one has also illustrated the scope, objective and the sub goals. Chapter two looks deeper into the historic demographic trends and the growth trends as they are expected in the further course into the 21st century. In chapter three a foursome case studies will be conducted to generate a world view perspective of the impact of this historic growth. Chapter three will have a close connection with the environmental, social and economical implications of land reclamation. In chapter four the results of the analysis will be presented together with a discussion of various topics that have come to light during the research. Chapter five will be solely devoted into defining a conclusion.

2. BACKGROUND

This chapter focuses on analyzing historic demographic events and dives into the relation between population growth, urbanization and the advance of modern urbanism. Understanding and visualizing the impact of population changes and growth trends on urban development and city growth are fundamental for the further review of this thesis.

2.1 From millions to billions

Presumably, the Neolithic and the Urban revolution brought a major socioeconomic change to the early human societies around 10.000 and 5.000 BCE (Childe, 1950). After having lived through many generations of hunters and gatherers since the emergence of the first *Homo Erectus* (Alexander, 1990), human society evolved into a more civilized and agricultural society. At the peak of these evolutional times, it is believed the world population had reached a total of five million inhabitants (United Nations, 1999; US Census, 2013). According to various contradicting studies, this five million grew out to a world that was inhibited by between 300-600 million up until the start of the 1st century, with an annual growth rate of approximately 0,05% per year (Worldometers, 2014). The revolutions, which replaced the nomadic life style of the homo sapiens into a permanent way of life, made it possible to grow crops, fertilize ground, reproduce and expand families. The new *permanent* way of living and the shift in the society, was also the beginning of an era that led to the rise of new settlements and of the world's first cities (Bocquet, 2011; Smith, 2009). According to various archaeologists also described as 'the earliest states'. Today, ruins and remains can be found, scattered over the world that remind us about the cultural shift in these earliest states. Mesoamerica, Andes, Egypt, Mesopotamia, Indus and China all have world famous examples that connect back to these ancient human societies.

Nowadays, ten thousands of years later, the total world population has increased tremendously. Since the start of the 1st century the population growth rate has had a steady increase, followed by a truly unprecedented growth rate over the last decades. This rapid population growth has resulted in interrelated concerns. Questions regarding environmental impact, social structure change, political-economical consequences and the way human societies have centralized their position in urban geography are the main concerns (Fan, 1999). As a result. city planners and urban developers now face the challenge of how to sustain economic and urban growth while minimizing the impact and preserving the environment. It might therefore also be no surprise that the topic of sustainable urban development has significantly increased in popularity during the recent decades (WHO; UN HABITAT, 2010).

2.1.1 Population growth between 19th and 21st century

Mainly due to the influence of the first and the second industrial revolutions, the 19th and 20th century experienced the largest modernization of technology ever recorder in human history (Buchana, 2012). The evolution of scientific and medical knowledge, establishment of more efficient transportation networks, streamlined interpersonal telecommunication and the development of better technology have all challenged the traditional monoocentric city planning models. According to Eberstadt (2010), political economist at the American Enterprise Institute, the development of the medical knowledge in particular has contributed significantly to the population growth over the last two centuries. In his book, space in a globalizing city, Marcuse (2006) compliments Eberstadt's statement by stating that the exceptional strengthening in communications and transport technology can also be held responsible for contributing to the rapid urban growth over recent years.

Industrial Revolutions: when the world population really took off

It was not until the start of the 19th century, around the year 1800, that the world surpassed its first one billion inhabitants. Even though fertility rates around this period in time were high, the child mortality was also high (Gapminder Foundation, 2009). Therefore, it had taken over 1800 years for the population to grow to its first one billion milestone. The Industrial revolutions, which occurred from mid 18th century to mid 19th century and from late 19th century to early 20th century, resulted in a major socioeconomic change (Smelser, 2013). According to well respected statistician and co-founder of Gapminder, Hans Rosling (2013), the first industrial revolution increased wages, realized a better provision of food and water and an increasing amount of health care. In other words, the industrial revolution made a better quality of life. This increase in quality of life increased the total world population to 2 billion by 1930, to 3 billion by 1960 and to 7 billion by 2012 (Worldometers, 2014)(see figure 1). Figure 2 illustrates the amount of years it took for the world to double its population in history. Additionally, figure 3 presents the compounded annual growth rate (CAGR). The largest growth spike occured from mid 20th century until the beginning of the 21st century.

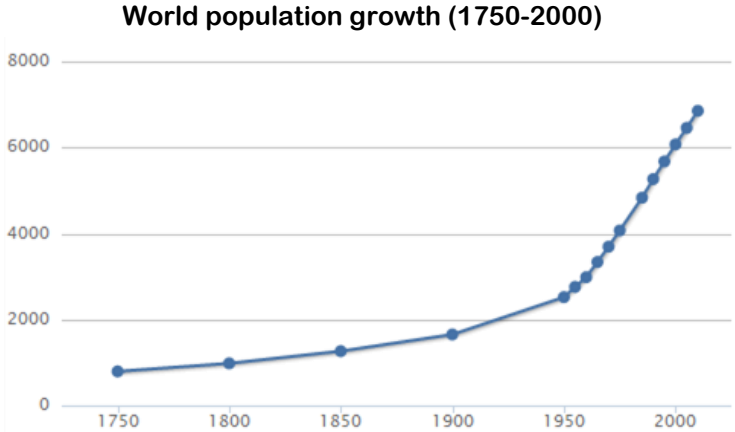

Figure 1: World population growth from 1750 – 2000 (in thousands)
Source: (Alberich, 2010)

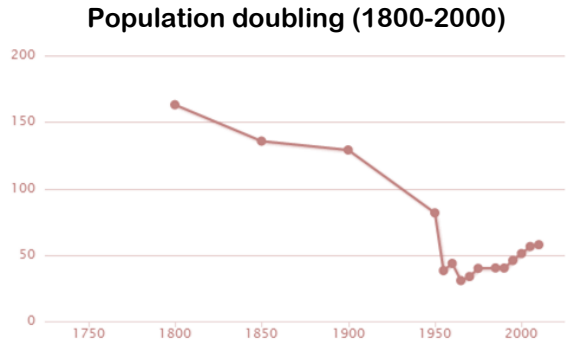

Figure 3: Population doubeling from 1750-2000
Source: (Alberich, 2010)

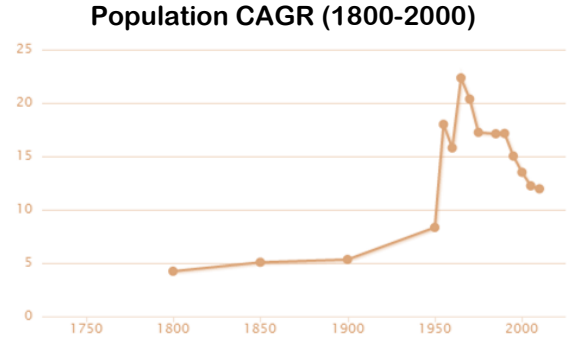

Figure 2: Compounded annual growth rate from 1800-2000
Source: (Alberich, 2010)

Nowadays, a new social balance has been restored: from big families with low life expectancy to small families with long life expectancy (Eberstadt, 2010). We no longer life in a devided world between East and West. According to Rosling (Gapminder Foundation, 2013a), this is all miss understood by preconveived ideas of world view. Also in less developed countries the average fertility rate has move to Western standards. To get an idea what implications these socioeconomic changes have on future population growth see figure 4. Figure 4 represents the forecasted total population growth based on statistics of United Nations (United Nations, 2004; 2013), the World Bank (The World Bank, 2014) and Gapminder (Gapminder Foundation, 2013b). The graph shows three possible growth trends.

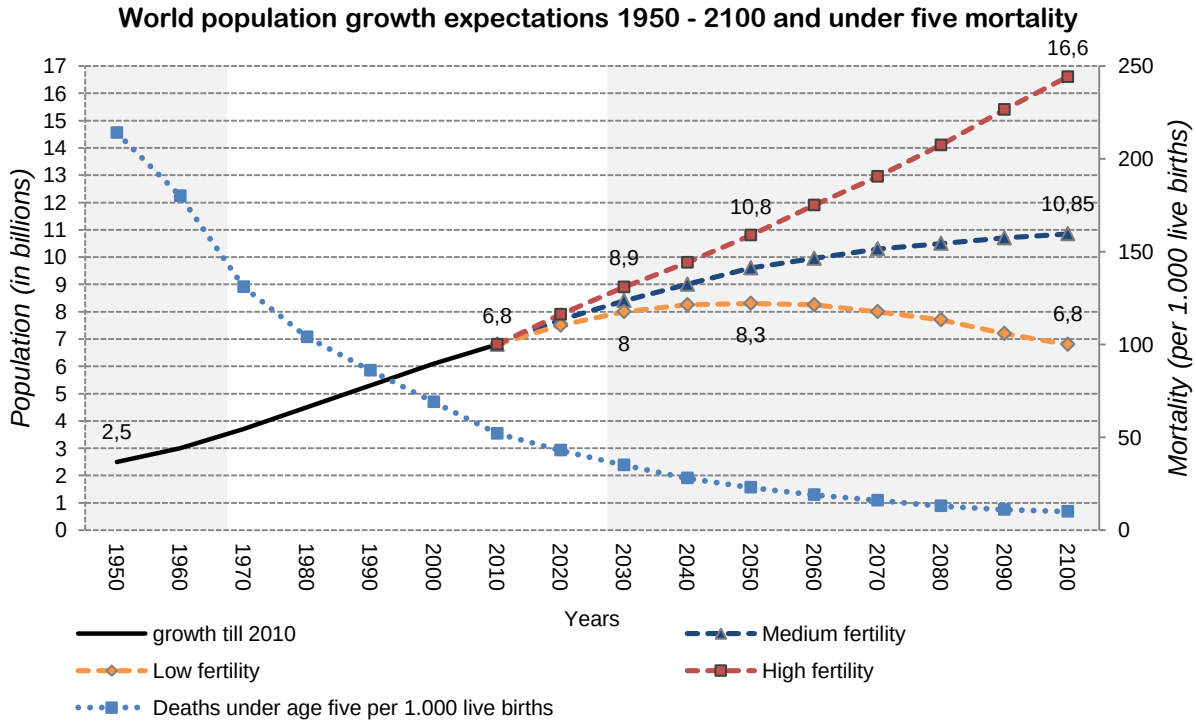

Figure 4: World population forecast until 2100 (including high, medium and low fertility growth expectations)
Source: (United Nations, 2004; 2013) (The World Bank, 2014)(Gapminder Foundation, 2013b), interpetation of the author

Tabel 1: World population growth trends between 2030, 2050 and 2100 (high, medium and low fertility)

WORLD POPULATION GROWTH TRENDS (2030-2100)				
Trend	**Fertility**	**2030 expectation**	**2050 expectation**	**2100 expectation**
▲ **Growth trend 1**	High Fertility	8.9 billion	10.8 billion	16.6 billion
▶ **Growth trend 2**	Medium Fertility	8.4 billion	9.6 billion	10.8 billion
▼ **Growth trend 3**	Low Fertility	8.0 billion	8.3 billion	6.8 billion

Source: extracted tabulated data from figure 4, interpretation of the author

An important aspect to keep in mind while interpreting these forecasts is that only a small change in the economy can significantly reduce the accuracy of the current interpolated data. Nevertheless, due to close analysis of previous growth trends and data collection with relative low errors, a confident estimation can be given for the population growth until the end of this century, giving a certain bandwidth between high and low fertility. It is safe to give a prediction of the population forecasts until 2030 and relatively safe to give a forecast until 2050 because the overwhelming majority of those who will inhabit the world in 20 to 40 years from now are already alive (Eberstadt, 2010). Also the general observation that the peak child has been reached adds to the probability of the forecasts.

Up until 2050 it is expected that the world population will grow, despite the peak child which is globally adopted (Rosling, 2013). According to the data presented in figure 4 and the extracted tabulated data in table 1, after 2050 there are two clear trends: a continuous steady increase or a slow decline of the entire population and a decreasing mortality rate among infants and children. These projections provide us a tool of future population growth and necessity of anticipating measures to facilitate this growth. Population growth into the future is inevitable, but knowing the exact location of this growth can help urban planners anticipate to future changes. It is clearly more important to know where exactly this growth is or is going to be taking place. While keeping the medium fertility trend in mind, growth expectations for the following geographical locations can be presented in table 2.

Tabel 2: World population balance from 2014 till 2100, where is the growth going to take place?

WORLD POPULATION BALANCE 2014 - 2100					
Geographical area	**2014**	**2030**	**2100**	**Growth percentage**	**Growth trend**
North and South America	1 billion	1 billion	1 billion	0 %	▶
Europe	1 billion	1 billion	1 billion	0 %	▶
Africa	1 billion	2 billion	4 billion	300%	▲
Asia Pacific	4 billion	5 billion	5 billion	25%	▲
World	7 billion	9 billion	11 billion	57%	

Source: data extracted from (Gapminder Foundation, 2013a), interpetation of the author.

Table two presents a rough estimation of the world balance as it is today, in 2030 and in 2100. According to these estimations less than a quarter of the world population will life in developed countries in North America, South America and Euopre. On the other hand, aproximatly half of the population will life in the Asia Pacific region and a rapid population growth is expected to take place in Africa. The developing part of the world will see a tremendous population increase during this century (see table 2). Plans of the United Nations and The World Bank to eliminate extreme poverty before 2030 puts an extra pressure on the urban sustainability issue (McArthur, 2013; Reuters, 2013). If the United Nations manages to accomplish this goal, the 1.3 billion people currently living in extreme poverty in developing Africa, will cause a major influx of individuals seeking a better life within the urban society.

2.1.2 Shifting of the urbanizing core and further urbanization into the 21st century

By taking a closer look at the development of the thirty worlds biggest agglomerations between 1950 and 2050 (United Nations, 2013c) detailed observations can be made. Up until 1950 the majority of urban growth had been taken place in the Global North. But from the second half of the 20th century an increasing share of urban growth amongst the 30 biggest urban agglomerations is taking place in the Global South. In other words, "the global South is now rising to dominate urban growth" (Watson, 2009). According to data presented in table 3 and observations made by Watson (2009), for the first time in history the majority of the world's largest cities were to be found in countries belonging to the global south. As can be seen from table 3, in 2050, over 75 per cent (23 out of 30) of the world's biggest agglomerations will be represtented by countries of the Global South. This emerging growth of the Global South is no surpise taking in consideration the previous paragraph, describing the world balance. Table 2 presented increasing growth percentages for Asia and Africa, while the population growth in Europe and the America's stagnates. This, assumingly, *steady state* of the Global North does not indicate that cities in these regions will not be growing in the future. There is a wide range of studies available which addresses that stagnating population growth does not necessarily translate into declining urbanization. While population growth continueus and urbanization is expected to take another upsurge in the upcoming decades, urban growth will also been seen in urban aglomerations within the global North (Healey, 2000; see also Angel et al, 2005; Eberstadt, 2010).

According to reports of World Health Organization in collaboration with the United Nations (WHO; UN HABITAT, 2010), since 2010, for the first time in human history the majority of the world population is living in urban areas. Various other statistical studies of the United Nations into the division of rural and urban population state that up until the 1950's, less than one third of the world population lived in urban areas. Over the last few decades this ratio

has been constantly growing from 40 per cent in the 1990's to 50 per cent in 2010 (United Nations, 2013d), see figure 5. With the continues growth of urban areas and the increasing share of urban population, it is expected that by 2050, almost 70 per cent of the entire world population will be living in urban areas (United Nations, 2013d; Demographia, 2014). The effect of this increasing share is tabulated in table 4. As a result, more and more mega cities with over 10 million inhabitants will be realized (Manomaiphibul, 2011). This transition to a predominantly urban world is irreversible and brings with it irreversible changes in the way we use land, water, energy and other resources (Biello, 2012). How we manage this rapid urbanization will be the key to sustainable urban modernism.

Tabel 3: Realized and expected urban growth in the world's 30 largest urban agglomerations, from 1950 till 2050

Rank	1950		1975				2000				2025				2050			
	City	Pop.	City	Pop.	trend	prev.	City	Pop.	trend	prev.	City	Pop.	trend	prev.	City	Pop.	trend	prev.
1	New York	12,34	Tokyo	26,61	▲	2	Tokyo	34,45	▶	1	Tokyo	38,66	▶	1	Delhi	59,01	▲	2
2	Tokyo	11,27	New York	15,88	▼	1	Mexico City	18,02	▲	3	Delhi	32,94	▲	6	Mumbai	47,00	▲	4
3	London	8,36	Mexico City	10,69	▲	16	New York	17,85	▼	2	Shanghai	28,40	▲	7	Lagos	44,67	▲	11
4	Paris	6,28	Osaka-Kobe	9,84	▲	10	São Paulo	17,10	▲	5	Mumbai	26,56	▲	5	Dhaka	44,05	▲	8
5	Moscow	5,36	São Paulo	9,61	▲	23	Mumbai	16,37	▲	14	Mexico City	24,58	▼	2	Shanghai	43,08	▼	3
6	Buenos Aires	5,10	Los Angeles	8,93	▲	11	Delhi	15,73	▲	22	New York	23,57	▼	3	Karachi	38,36	▲	10
7	Chicago	5,00	Buenos Aires	8,74	▼	6	Shanghai	13,96	▲	17	São Paulo	23,17	▼	4	Tokyo	36,77	▼	1
8	Calcutta	4,51	Paris	8,56	▼	4	Calcutta	13,06	▲	9	Dhaka	22,91	▲	13	Beijing	34,58	▲	9
9	Shanghai	4,30	Calcutta	7,89	▼	8	Buenos Aires	11,85	▼	7	Beijing	22,63	▲	15	Calcutta	33,36	▲	12
10	Osaka-Kobe	4,15	Moscow	7,62	▼	5	Los Angeles	11,81	▼	6	Karachi	20,19	▲	16	Kinshasa	32,73	▲	20
11	Los Angeles	4,05	Rio de Janeiro	7,56	▲	14	Osaka-Kobe	11,17	▼	4	Lagos	18,86	▲	28	Mexico City	32,47	▼	5
12	Berlin	3,34	London	7,55	▼	3	Rio de Janeiro	10,80	▼	11	Calcutta	18,71	▼	8	New York	29,78	▼	6
13	Philadelphia	3,13	Chicago	7,16	▼	7	Dhaka	10,28	▲	-	Manila	16,28	▲	18	Manila	29,52	▶	18
14	Rio de Janeiro	2,95	Mumbai	7,08	▲	17	Caïro	10,17	▲	16	Los Angeles	15,69	▼	10	São Paulo	28,42	▼	7
15	Saint Petersburg	2,90	Seoul	6,81	▲	-	Beijing	10,16	▲	19	Shenzhen	15,54	▲	-	Caïro	24,97	▲	19
16	Mexico City	2,88	Caïro	6,45	▲	20	Karachi	10,03	▲	25	Buenos Aires	15,52	▼	9	Bangalore	24,46	▲	23
17	Mumbai	2,86	Shanghai	5,63	▲	-	Moscow	10,00	▼	10	Guangzhou	15,47	▲	26	Shenzhen	24,16	▼	15
18	Detroit	2,77	Manila	5,00	▲	-	Manila	9,96	▶	18	Istanbul	14,90	▲	21	Guangzhou	23,94	▼	17
19	Boston	2,55	Beijing	4,83	▲	-	Seoul	9,92	▼	15	Caïro	14,74	▼	14	Chennai	23,64	▲	-
20	Caïro	2,49	Jakarta	4,81	▲	-	Paris	9,74	▼	8	Kinshasa	14,54	▲	-	Istanbul	21,83	▼	18
21	Tianjin	2,47	Philadelphia	4,47	▼	13	Istanbul	8,74	▲	-	Chongqing	13,63	▲	25	Jakarta	20,73	▲	24
22	Manchester	2,42	Delhi	4,43	▲	-	Jakarta	8,39	▼	20	Rio de Janeiro	13,62	▼	12	Los Angeles	20,22	▼	14
23	São Paulo	2,33	Saint Petersburg	4,33	▼	15	Chicago	8,33	▼	13	Bangalore	13,19	▲	-	Wuhan	19,78	▲	26
24	Birmingham	2,23	Tehran	4,27	▲	-	London	8,22	▼	12	Jakarta	12,82	▼	22	Buenos Aires	19,18	▼	16
25	Shenyang	2,15	Karachi	3,99	▲	-	Chongqing	7,44	▲	-	Chennai	12,81	▲	-	Tianjin	18,55	▲	30
26	Rome	1,88	Hong Kong	3,91	▲	-	Guangzhou	7,33	▲	-	Wuhan	12,73	▲	-	Chongqing	17,69	▼	21
27	Milano	1,88	Madrid	3,89	▼	-	Lima	7,29	▲	30	Moscow	12,58	▼	17	Rio de Janeiro	17,04	▼	22
28	San Francisco	1,86	Detroit	3,89	▼	18	Lagos	7,28	▲	-	Paris	12,16	▼	20	Paris	14,88	▶	28
29	Barcelona	1,81	Bangkok	3,84	▲	-	Tehran	6,88	▲	-	Osaka-Kobe	12,03	▼	11	Moscow	13,09	▼	27
30	Glasgow	1,76	Lima	3,70	▲	-	Hong Kong	6,78	▼	26	Tianjin	11,93	▲	-	Osaka-Kobe	12,15	▼	29

■ Global North agglomeration / ■ Global South agglomeration
▲Increased ranking since last interval / ▶ Same ranking since last interval / ▼decreased ranking since last interval

Sources: (Zeigler, Brunn, & Williams, 2003), (United Nations, 2013b), (United Nations, 2013c)

Interpreting figure 6, based on data presented in table 3, not only the world population has been constantly growing, also the share of people living within urban agglomerations has been growing, multiplying the effect of urban growth on the largest agglomerations exponentially (see figure 5). For example, where New York, as largest agglomeration based on population size in 1950, was the only city with over 12 million inhabitants, the number one rank in 2050, Delhi, will inhibit approximately 60 million inhabitants. On the lower end of the top 30 ranking system them same movement occurs. Where the rank 30 city in 1950,

Glasgow, had approximately two million inhabitants, by 2050 the rank 30 city, Osaka-Kobe, represents a city size of over 10 million, the same size of a rank one city in 1950.

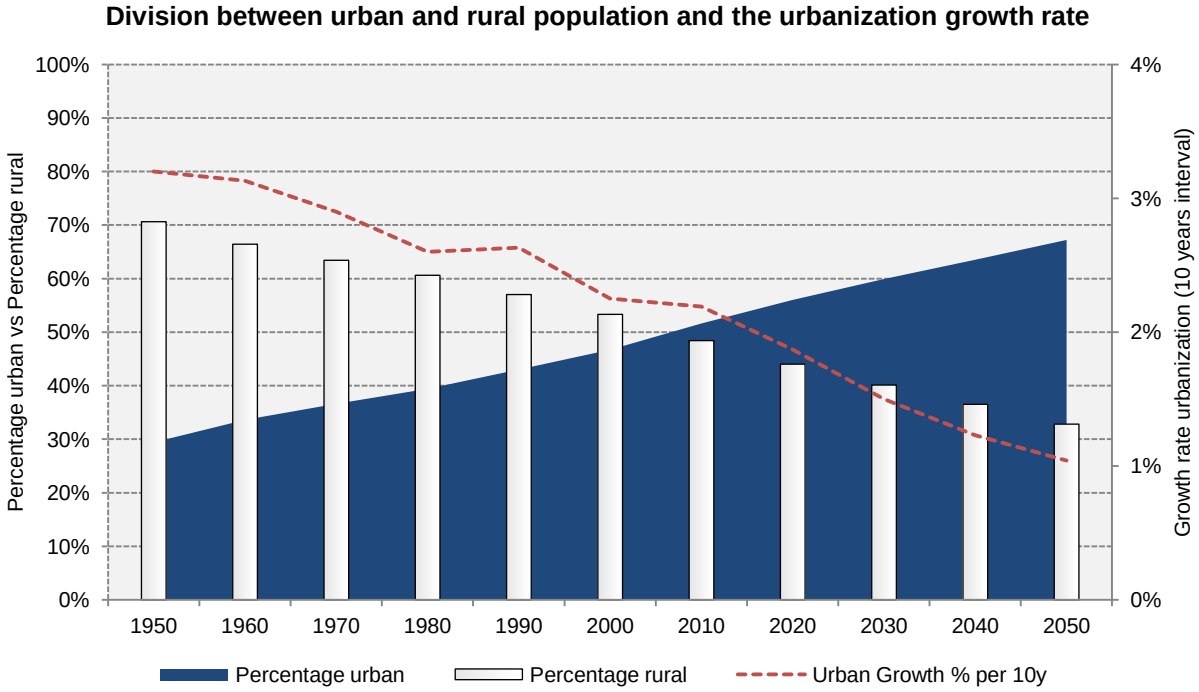

Figure 5: Growth and total share of urbanization from 1950 to 2050
Source: made by the author, data extracted from (United Nations, 2013a)

Tabel 4: Urban population as a share from the total world population, from 1950 till 2050

GROWTH URBAN POPULATION 1900 – 2050				
Year	**World population**	**Percentage urban**	**Urban population**	**Growth since last interval**
1900	1.6 billion	13%	0.2 billion	-
1950	2.5 billion	29%	0.7 billion	250%
2000	6.1 billion	47%	2.8 billion	300%
2030	9.0 billion	60%	5.4 billion	93%
2050	11.2 billion	67%	7.5 billion	39%
			Total urban population growth between 1900 - 2050	360%

In graph figure 6 a visual representation of the impact of this exponential growth is presented. Additionally, table 4 displays the growth of the total world population from 1950 till 2050 in relation to the growth of urban population. From the beginning of the 20th century until the end of the 20th century the total urban population has grown unprecedented. Currently, a slower growth rate of urbanization can be observed, mainly due to the peak child that has been reached. Nevertheless, the population growth and related urbanization rate still threatens the future sustainability concerns of modern urbanism. Especially the fact that this growth has taken place in a relatively short time period contributes to the concerns.

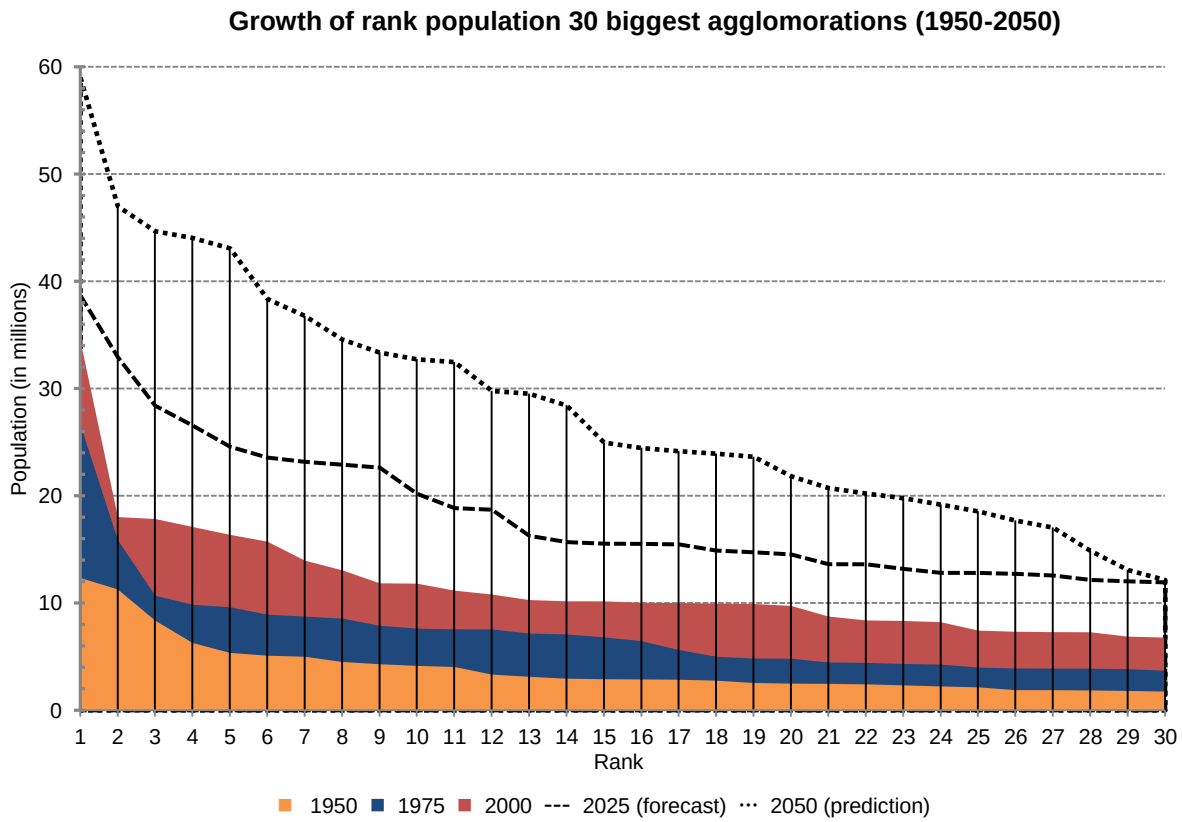

Figure 6: Population size of the 30 largest agglomerations from 1950 till 2050
Source: based on table 3 by (Zeigler, Brunn, & Williams, 2003), (United Nations, 2013b), (United Nations, 2013c)

2.2 Modernisation of traditional city planning

While population growth trend seems to be following a positive, but decreasing upwards slope[1], simultaniously the demand for housing, infrastructure and other ammenities tends to increase (Piel, 1997). According to Piel (1997) especially the developing countries will face major challanges providing quality accomodation and related city services such as hospitals, police, schools and other amenities for new urban dwellers. For the developed countries who are able to provide the basic ammenities another challange awaits: limited natural resources.

2.2.1 Declining densities and the need for more land

It is evident that increasing population sizes and further urbanization trends will set of an increased demand for natural resources c.q. greenfields c.q. arable land. *New* land is needed in order for a central government to facilitate enough accomodation for the influx of urban dwellers and to provide space for further economic growth. According to a World Bank study (Angel et al, 2005), with the high influx of urban dwellers the urban land cover is currently growing faster than ever. The World Bank's research explores and investigates the development of the actual built-up space of urban areas. The researchers make an

[1] at least up until 2030 according to previous presented tables and graphs

interesting observation that, on top of the increase of urban population and the natural sprawling of urban agglomerations, also the overall density per square meter has decreased over the past two centuries. With the decreasing density, each individual, on average will use more space per square meter of land per person. The decreased density of modern urbanism leads eventually to an aggravated, sprawling growth of cities. As a result, the total increasing land cover of urban agglomerations will consume more land, replace more forestation and convert more green fields into an urban, economic environment. Angel et al (2005) describe that this spatial movement has taken a notably rapid upturn in recent years.

Angel et al (2005) describe that the combination of subsequent urban population growth and the decreasing density, could greatly expand the urban land cover, far beyond the current administrative boundaries. This consuming trend can be seen in various cases all over the world and will be discussed in more detail in the next chapter. Angel et al (2005) also adds to the discussion that this sprawling effect is less obsolete in rapid growing urban areas. On average, the population living in developing countries, occupy less space per inhabitant than their developed counterparts. Nevertheless, in both developing and industrialized countries, average densities of cities have been declining quickly: at an annual rate of 1.7 per cent over the last decade in developing countries, and of 2.2 per cent in industrialized countries (Angel et al, 2005).

2.2.2 Modern urbanism and it rejuvenating impact on traditional land planning

Due to urbanization and socioeconomic changes, the traditional monoocentric city planning models are being challenged by the evolution of modern, 21st century city planning models (Lovering, 2009). Healey (2000) for example, anticipates to this change in her conceptualization from monocentric cities to multiplex cities. The well known central place theory of Christaller (1933) loses its implicational value in the modern day city planning. While the central place theory of Walter Christaller assumes the existence of one central place within the uniplex, the multiplex assumes various places with equal central values. The multiplex city for example, does not focus on a self contained CBD. Instead, it focuses on strong interrelated networks and high personal mobility (Healey, 2000). Zachary (2011), supports the conceptualisation of Healey (2000) by researching the urban hierarchy in cities in the United States in the 21st century. In his research he amplifies the effect of spatial urbanization and the importance of interrelated networks in today's urban planning (Zachary, 2011). Zachary (2011) describes a network-based hierarchy that reflects cities centrality within networks of interurban exchanges of people, goods and services. Healey and Neal both agree that this modernization has changed the way cities have been developing over the last decades. Additionally, the further development of urban modernism will have

significant impact on future city planning. Over the course of recent years, the increasing spatial movement patterns have become much more complex, causing the administrative boundaries of cities to become less meaningful (Watson, 2009). The “disappearance” of these administrative boundaries ask for innovative measures regarding land regulations and coordination of urban planning activities. A clear trend that moves away from government to governance is being observed. while modern urbanism is increasing in popularity, there is also criticism of those who oppose further development of modern urbanism. These opposing parties claim that modern urbanism is environmentally unsustainable.

2.3 Modern urbanism and the future of city development

To sum up: at one side there is the growing urban population and the need for urban expansion, while, on the other side, there are the social, political, environmental and economical constraints. On top of this, with the increasing land regulations land resources are running out. Alternative solutions to facilitate urban growth and economic development have to be found. While running out of arable land, the use of water as a natural resource is a common pool resource. While in essence, this resource has to be protected and nurtured for its continuous exploration, a fringe of units can be harvested (Ostrom, 1990). According to the US Geological Survey (2013), roughly 75 per cent of the world’s surface is water. Therefore, in comparison with arable land, there is an *abundance* of water as a natural resource. Opting to chose for urban expansion sea inwards, rather than realizing urban expansion by moving land inwards, might be an option to adopt in modern urbanism. Over the last few decades there has been an increasing amount of interest into land reclamation. With the increasing interest also the (ab)use of water as a buffer for urban development has been widely applied.

Land reclamation, conceptualization of the term

In order to understand what is meant by land reclamation, this paragraph is devoted to the conceptualization of the term. The concept of land reclamation originates from the verb “to reclaim”. According to the Oxford English dictionary “to reclaim” refers to the process of retrieving or recovering (something that was previously lost, given or paid) or to obtain the return of an object. Deeper analysis of the term exposes various contextual explanations and synonyms depending on the place in the world. In western European countries for example, land reclamation or to reclaim land is defined as the process of gaining land from the sea or coastal wetlands (OSPAR, 2008). While in the US and Canada, land reclamation refers to the restoration of disturbed lands to an improved state (Powter, 2002). Another definition comes from the North African and the Middle Eastern region of the world were authorities have both adopted the Western definition of land reclamation and added an extra feature of

referring to land reclamation as the process of converting desert areas to agricultural lands and rural settlements (Adriansen, 2009). Additionally there is the reclamation of various inland water bodies such as rivers, canals and lakes. The main difference between the various reclamation categories is the technology used. Mainland land reclamation uses substantial different technology compared to coastal land reclamation and vice versa. Even though the concept of land reclamation is around for centuries, there is not yet one unanimous uniform acknowledged definition.

Not only the definitions of land reclamation are widespread. Also the terms used to denote these definitions vary depending on the area in the world. Additional to the western related term of land reclamation, there is also a wide spread amount of literature of eastern part of the world referring to coastal reclamation and sea enclosing. For the continuation of the term within this thesis, land reclamation refers to the OSPAR definition: *the process of gaining land from the sea or coastal wetlands* (OSPAR, 2008)

3. CASE STUDIES

In the previous chapter a rational has been presented in which the issue of future land reclamation becomes relevant in today's urban society. This third chapter will focus on investigating and exploring the implications of land reclamation. By analyzing various land reclamation cases in different parts of the world an attempt is being made to open up the opportunity for a final judgement on future large scale land reclamation.

3.1 Land reclamation, a proposed solution.

3.1.1 An imbalanced relationship between the demand and the supply of land

Putting the urban growth trends, illustrated in the previous chapter, into a wider perspective provides a scenario in which urban agglomerations, specifically coastal cities, have the tendency to expand horizontally, rather than vertically (Angel, et al., 2005).At the same time, while the world population increases, the demand for space, hosting recreation, industry and city services increases (Piel, 1997). The distinctive correlation between city size as a power of population size is described in George. Kingsley Zipf's rank-size rule (Zipf, 1949). As discussed in the previous chapter, in today's modern world the spatial growth of urban agglomerations is being intensified by the increasing space demand per capita (Angel et al, 2005). Several cities in central China (McMahon, 2013) the United States (Ewing & Hamidi, 2014) serve as good examples were urban sprawl is the result of increasing space demand. While at one hand city governments promote urban growth through expanding their administrative boundaries, the limited supply of land and natural resources works as a growth constraint (Watson, 2009). Additionally, stringent land regulations in order to preserve natural green zones also hampers further urban growth and economic expansion. While on one side of the spectrum the demand for land increases (AD to AD' in figure 7) at the other side, the supply decreases (from A, to A' to A"). The shift in the aggregate demand and supply curve leads to an explosive growth of land prices per square meter (Mayer & Somerville, 2000; Ihlanfeldt, 2007).

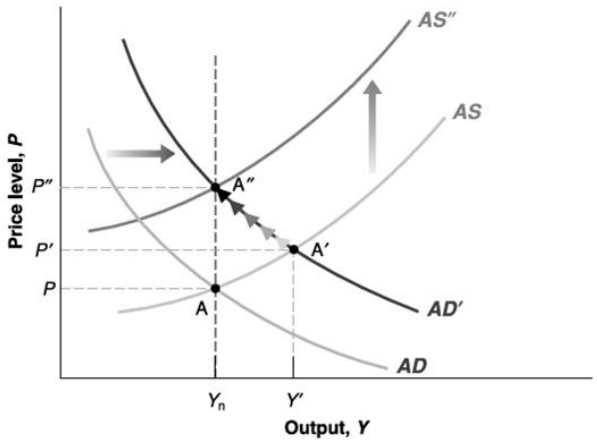

Figure 7: Urban land price evolution due to space limitations
Source: (Blanchard, Amighini, & Giavazzi, 2010)

In this paper land reclamation is being discussed as a possible solution for apparent imbalance between land demand and land supply. Several hundred cases, occurring between the early 19th century and today, can be presented were artificial man made land has mitigated this imbalanced relationship. Land reclamation have gained significant popularity over the last decades. Nevertheless, as far as for the author's knowledge, no studies have been conducted into the overall sustainable feasibility of land reclamation into the 21st century. He et al (2012) for example have studied the short term effects of soil change due to land reclamation on micro organic marine habitat. A small grasp out of the large amount of environmental studies are Wang et al (2010), who have studied the ecosystem service losses as a result of land reclamation and Sheppard et al (1992; 2010), Abuzinada et al (2008) and Bradshaw (2000) who have conducted several studies into the degradation of the environmental conditions implied by land reclamation. Also, but evidently less, research has been conducted into the socioeconomic implications of land reclamation.

3.1.2 Land reclamation: a popular tool for governments

After the industrial revolution in 1950 the world economy experienced a great socioeconomic upsurge. Due to the new and more efficient technology land reclamation became a smoothened process and gradually, the construction process became less and less costly. While natural land prices skyrocketed, an increased interest was being developed in the process of creating, relatively cheap, artificial land. A few examples of countries that have opted for land reclamation are Hong Kong (Mee Kam Ng, 1997; 2007), the Netherlands (de Mulder et al, 1994), Denmark (Pedersen, 2010) , Singapore (Tan & Hamid, 2014), the United Kingdom (OSPAR, 2008) and various states within the Persian Gulf peninsula (Zainal, 2009, et al 2012). Land reclamation, for the abovementioned examples, have served as a solution to facilitate land for economic growth and urban expansion.

Coastal areas often have to rely on alternative ways of land construction in order to realize a continuation of the economy. They are dependent on these alternative tools as, geographically, these areas usually do not have the infinite land resources. On the other hand, coastal areas do have a abundance of water surface supply from the sea. Nevertheless, coastal areas feel a continues pressure from urbanization and economic growth. As a result, coastal areas are forced to push their administrative boundaries further land inwards or sprawling along the coast line. During this sprawling process, an increasing amount of natural land resources is being consumed and converted to urban zones (Yu & Zhang, 2011), imposing negative effects on the surrounding environment.

Even though the topic of land reclamation has gained popularity over the last century, scepticism exists regarding its overall socioeconomic and eco-economic implications. The increase of studies into the socioeconomic and eco-economic impacts of land reclamation act as a source of evidence. Though, land reclamation has proven to be a “great” solution for the current demand and supply imbalance in fast growing cities all around the world. Important to notice though are the emphasises stressing that the word *great* is subjective. Various studies have both praised and refuted reclamation as a solution for the imbalance of land supply (Waterman et al, 1998; Jiu et al, 2001)

3.1.3 An integrated perspective

While the topic of land reclamation seems to gain popularity also the topic of urban sustainability is becoming a trending issue. According to the United Nations human settlements programme (United Nations, 2012) (see previous chapter) the total world population is expected to be approximately 9 billion people before the end of 2030 and approximately 11 billion before the end of 2050. This growth comes down to a rough 60 per cent population increase within the next 35 years. To add to the intensity of this growth, the world society is also become more urbanized. The current average share of 5 out of 10 people living in urban areas will, by 2050, have been increased to 7 out of 10. Port and coastal agglomerations, with their limited land resources, are foreseeing enormous space shortages to facilitate and accommodate this growth. Not only providing enough housing is a challenging issue, also the realization of the city’s amenities such as employment, education, recreation and transport will aggravated the already complicated planning process (Piel, 1997).

When urban growth occurs, the threat of social, political and environmental issues increases. For many governments and city planners in coastal cities, the ongoing self-perpetuating process of economic increase followed by a spike of population growth is a welcoming but at the same time stressing development (Kolman, 2011). This self-perpetuating process that Kolman describes in his paper about economical and social feasibility of land reclamation sheds light on the geographical limitations of urban expansion. Urban expansion along the coast often gets hampered by untraversable landscapes (Taubenböck et al, 2009). Due to the mixture of geographical limitations, economic pricing and social prestige, land reclamation becomes a potential solution to this problem. Though, in order for coastal cities to expand into the sea, specific technical and maritime requirements have to be fulfilled. Requirements that were, according to Taubenböck et al (2009), not always fulfilled or simply neglected over the last few decades.

3.2 Reclamation around the world: case studies

In this section of the thesis four different case studies will be analyzed. Each case study could essentially fill a separate thesis in itself, so for that reason and for the comprehensiveness of this research, the analysis will be done on a macro and meso level. The following four cases have been chosen due to their long history or magnitude of land reclamation:

- **Case 1:** The Netherlands – *the Flevopolder and the Maasvlakte.*
- **Case 2:** United States West Coast – *The San Francisco Bay area*.
- **Case 3:** The Persian Gulf – *Dubai, Bahrain and Qatar.*
- **Case 4:** South and East China Sea - *The Pearl River Delta.*

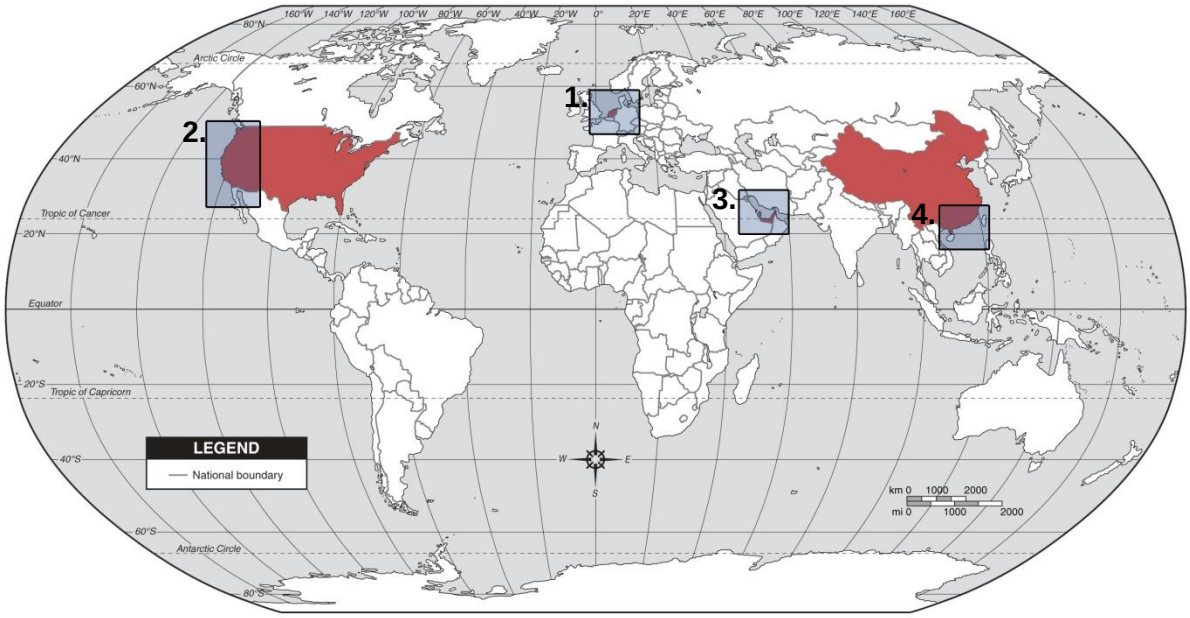

Figure 8: Overview of case study locations
Source: original map from http:///mapsof.net, modified by author

The first case that will be analyzed are two reclamation projects in the Netherlands: *the flevopolder and the Maasvlakte*. The second case being discussed is located in the United States. Though, the overall available literature on coastal land reclamation from the United States is limited, the San Francisco's Bay forms an exception. In the third case the focus shifts to the rapid emerging markets around the Persian Gulf. Countries such as Qatar, United Emirates and Bahrain have reclaimed large amounts of land over recent years, which makes this area particularly interesting to observe. The final case that is being discussed is land reclamation in the Pearl River Delta, one of the world's fastest growing economic zones in South East China and the world in general.

3.2.1 Economic development within the case areas

For the above mentioned case studies, economic growth has been a major factor contributing to the urban growth. In figure 10 an overview is presented of the actual GDP growth, in absolute numbers, of the general case study areas. By observing these two figures a few distinctions can be made. The first graph in figure 10 shows the growth of the developed countries. Within the developed world, including a large portion of the Global North , the GDP growth occurred from the mid 70's. The GDP in these two areas, North America and the European Union, has been growing ever since. Looking at the second graph in figure 10 shows another picture. In these areas, representing a majority of Global South countries, growth was also initiated in the mid 70's but only experienced a significant change from the early 90's. Over the last 15 years, the Middle East and South Asia have been experiencing a rapid economic growth.

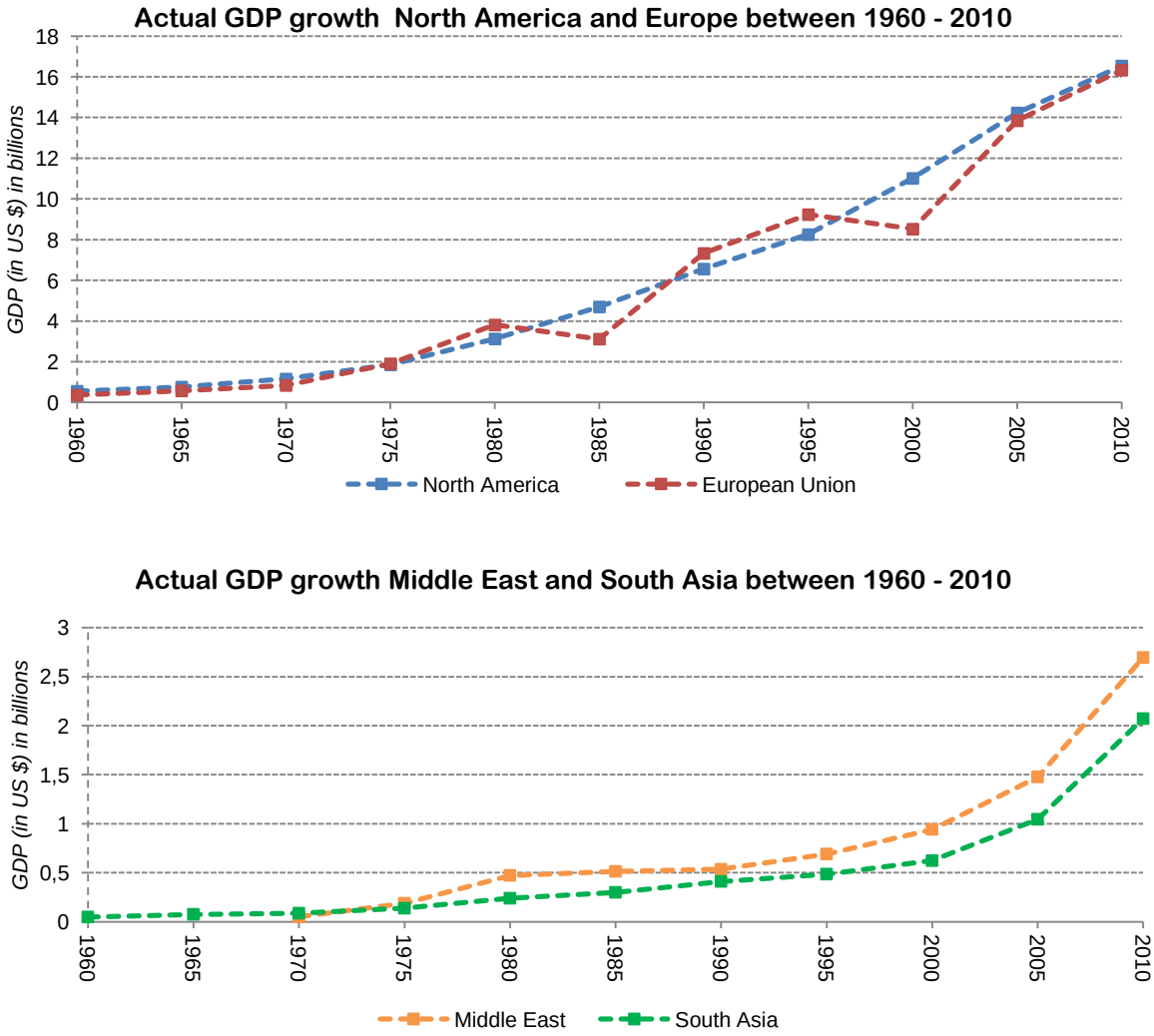

Figure 9: Overview of economic growth (GDP) in the general case study areas: North America, Europe, Middle East and South Asia
Souce: (United Nations, 2004; 2013) and (The World Bank, 2014)

3.2.2 Case 1 – The Netherlands: the Flevopolder and the Maasvlakte

Over the last decades a substantial increase of research into the topic of land reclamation in Europe can be observed (Healey & Hickey, 2002; Hoeksema, 2007). The importance of land reclamation for Europe is self spoken considering Europe's low laying geographical location and its second position on the ranking of highest population density continents. Considering all the water bodies in Europe, the largest amount of land has been reclaimed in the North Sea area (OSPAR, 2008). The United Kingdom, the Netherlands, Ireland and Denmark have all added opted for land reclamation to extend their national territory over the last century. Widespread literature and studies are available on these land reclamation projects, but only limited studies are available on the actual environmental effects on maritime habitats and species in European coastal zones. According to the OSPAR (2008), a convention between coastal European countries that cooperate to protect the west European watersheds, the majority of reclaimed land in the Euro zone is reclaimed for industrial or agricultural purposes.

Historic overview

The Dutch became pioneers in the modern day water engineering due to their long history of land consolidation and land subsidence by the North Sea (Hoeksema, 2007). Naturally, large parts of the Netherlands, about 60 per cent, lays below sea level. The decade long battle with the sea forced the Dutch into innovative, maritime solutions. In other words, the Dutch have become specialists in water engineering out of necessity.

The destructive force of the North Sea and the vulnerable, low laying position of the Netherlands became evident during a major flooding in 1916 and 1953. The flooding in 1953 which occurred due to a combination of extensive storms fallowed by a major dike break, flooded over 2000 square kilometres of land, had a death toll of over 1800 people and an approximate cost of half a billion euro's. To prevent such a disaster from ever happening again large reclamation and coastal defences were constructed along the whole coastline of the Netherlands. This specialism by necessity made the Dutch one of the first to conduct significantly large reclamation projects in order to protect the people. The Netherlands would not have had the shape as it has today without the significant influence of land reclamation. The Flevopolder and the Maasvlakte (see figure 9 and 10) are the most prominent land reclamation projects in the Netherlands.

The reclamation of the Zuiderzee and later on the sea water defences against the raging sea in the South-Holland province, was the birth of a specialized nation in dredging and reclamation activities. The Netherlands therefore developed the largest extent of land reclamation projects (OSPAR, 2008) within the Eurozone.

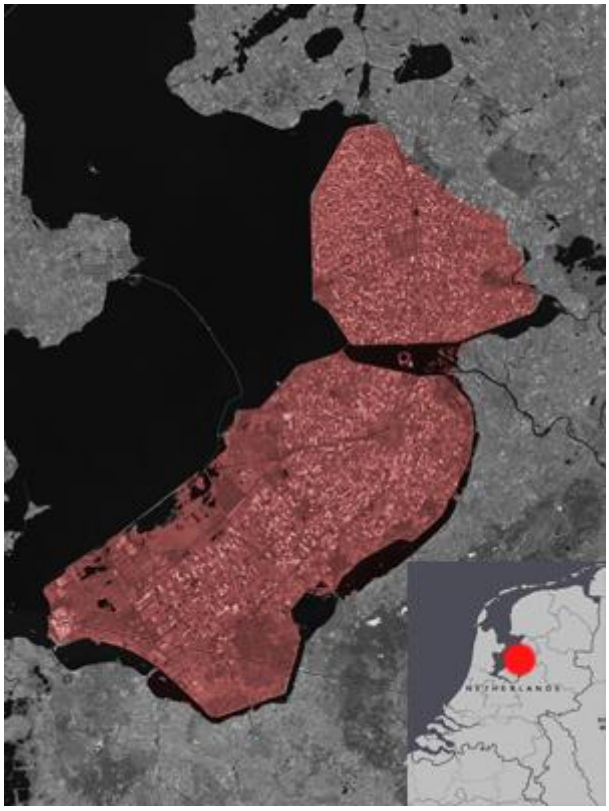

Figure 10: Case study 1.1 – the Flevopolder (in red, reclaimed area)
Souce: image retrieved from (Landsat, 2005) altered by the author

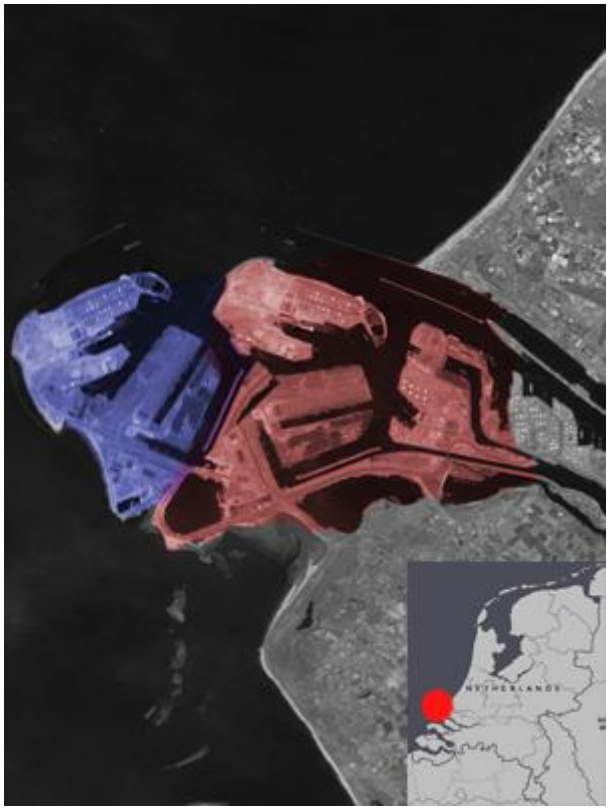

Figure 11: Case study 1.2 – the Maasvlakte 2 (in red, reclaimed area Maasvlakte 1. In blue Maasvlakte 2)
Source: image retrieved from (Landsat, 2005), altered by the author

The Flevopolder

Located between latitudes 52º35/N and 52º75N, and longitudes 5ºE and 6º/E, lays the Flevopolder (see figure 9). The entire Flevopolder has been reclaimed from the Zuiderzee in 1955. The construction of the Flevopolder was twofold: to mitigate the threat from the sea and to gain valuable land for agricultural purposes. The idea to reclaim land from the Zuiderzee was initiated in 1667, but only became technological feasible in 1886. The capital of the new Province later was named after the initiator of the proposal, Cornelis Lely (de Pater, 2011).

Initially, the proposed reclamation of the Flevopolder, did not receive a lot of public support. Only after the major flooding in 1916, the public opinion of the Netherlands shifted and the proposal received the public support it needed. With the plan approved, the work could not start before the Zuiderzee was entirely closed off from the North Sea's current. In 1932 a major tidal closure damn, connecting the province of North-Holland with Friesland, was developed. The tidal sea wall, called "the Afsluitdijk", had an estimated cost of 17 million euro's and stretched over 30 kilometers in length at the time it was finished (Bonte & Zwolsman, 2010). Main function of the tidal dam was to protect the area from flooding while

creating a transportation route between the two provinces of Noord Holland and Friesland. After the completion of the Afsluitdijk, the Zuiderzee was renamed to Ijselmeer, which was a more appropriate name for a sea that was converted into a lake. With the Afsluitdijk constructed, the development of the actual land reclamation could start.

At the beginning of the 20th century, there were intensive debates between the Dutch government and the public regarding the environmental feasibility of the proposed project. Support and opposition for this project was divided over several stakeholders (Bonte & Zwolsman, 2010). Obviously, the engineers in favour for the project were convinced by the possible economic benefits, while the biologist were mainly concerned about the loss of natural habitat and landscape (de Jongh, 2013). Initially, the public supported the biologist's opinion, opposing the proposal of Cornelis Lely. The biologists mainly found support from the local fisherman, who were foreseeing a loss of revenues and thus were against the reclamation project. Basically, the public did not see why a beautiful, natural rich coastal area as the Zuiderzee should be replaced by land for agricultural purposes. Finally, this economic gain of the new transportation route and the to be gained agriculture land, outweighed the objection from the public (Hoeksema, 2007). The acceptance and support for the construction became smooth after the flooding in 1916. In 1918, Cornelis Lely was able to submit and pass his proposal for the project. After this shift in public support the government realized that social support was important for the success of the project. The entire project area was constructed for approximately 90 million euro's but the economic gain after construction was much higher compared to the initial cost (de Pater, 2011).

One of the major direct implications of this project and the construction of the tidal dam is a loss of habitat and various salt water species (Zwart, 2008). According to the studies of Zwart, in cooperation with a project assessment group, salt water levels of the Zuiderzee water body have changed to sweet water levels. This change in water quality has inflicted decrease of soil quality and mutilated various salt water plants and species of fish (Zwart, 2008). It has been said that, at the cost of land reclamation, a decreased magnitude of wild life can now be observed in the area. Though quantitative studies confirming these observations are, to the knowledge of the author, nonexistent or very limited. On the contrary, sweet water has replaced the salt water in the region, which could explain this phenomena of disappearing wild life. Salt water has been converted to sweet water and various new water species are now present in the Ijselmeer (Hoeksema, 2007).

The Maasvlakte and Maasvlakte 2

The second major and largest land reclamation project in the Netherlands and Europe is the Maasvlakte, located between latitudes 51º90/N and 52º/N and longitudes 4ºE and 4º25/E. The Maasvlakte is on a discharge location of the river delta of the Maas and has a total size of 20 square kilometres. The Maasvlakte is an expansion of the Rotterdam mainport. Due to the influence of the in the 17th century founded United East India Company (VOC) and the two centuries of extensive trade, the harbour of Rotterdam became a well known multinational transportation hub. Reason for the construction of the Maasvlakte and converting this part of the North Sea into industrial and harbour area was the increasing demand for docking space from international trade and increasing pressure on the existing Europoort in Rotterdam. To avoid clotting of the river Maas with further inward port expansions, the municipality of Rotterdam decided in 1970's to reclaim a part of the North Sea and to rezone it into an industrial and harbour zone (Port of Rotterdam, 2011).

Environmental Impact Assessment of the Maasvlakte 2

Large amounts of natural resources was needed for the construction of the Maasvlakte 2. Approximately 450 million tons of raw material (clay, sand and stones) of which almost 300 cubic meters of sand were extracted from borrowing areas just several kilometres from the project site into the North Sea. The choice of extraction site has been analysed into great detail to minimise the costs and the impact on the direct natural environment. Large trailing suction hopper dredgers (TSHD's) were then used to extract and dump the needed sand on the sea bottom at the project location (Port of Rotterdam, 2007; Heinis et al, 2013). The environmental impacts of the sand extraction from the North Sea and the dumping of the material of the coast close to the Voordelta, a by European law protected environment for European birds and habitats (Natura 2000), have been documented in various studies and EIA (Berkenbosch, 2007; see also Vertegaal et al 2007; Grontmij, 2008). The EIA by Berkenbosch (2007), commissioned by the Port of Rotterdam was carried out in two time periods. Two periods were chosen in order to investigate the full implication of the reclamation works on the natural habitat and maritime wildlife. An overview of the implications mentioned in the report is shown in table 4. According to the EIA's the most environmental and economic friendly option has been chosen for the sand extraction.

According to the EIA's in commission of the Port of Rotterdam and the overview presented in table 4, the reclamation works of the Maasvlakte 2 has had adverse effects on the direct natural environment. To compensate for this environmental loss, the Port of Rotterdam has initiated the construction of a 750 hectares wildlife and natural reservation, with elevated nature values of 10 per cent (OSPAR, 2008; Homes et al, 2009).

Tabel 4: Environmental Impact Assessement for the Maasvlakte 2

ENVIRONMENTAL IMPACT ASSESSEMENT	
CONSTRUCTION PHASE	
Description	**Effects**
Sand extraction and construction works (noise levels) may frighten of species	*Temporary*
290m^3 sand extraction from North Sea causing impairment of seabed life	*Temporary*
Reduction of 0-6.4 per cent of various bird species due to increased level of silt concentration caused by extraction and dumping activities. Higher level of silt concentration slows growth of algae and shellfish.	*Permanent*
Shore line retention in project area	*Permanent*
Fuel consumption will reduce air quality permanently	*Permanent*
Loss of catchment area of small fish	*Permanent*
OPERATIONAL PHASE	
Description	**Effects**
Completion of the Maasvlakte 2 will cause a loss of the protected habitat type of sandbank	*Permanent*
3,1 per cen loss of the potential forage area of the Black Sea duck.	*Permanent*
Reduction of approximate 5,9 per cent of the living and foraging area of the common term	*Permanent*
Reduction of approximate 3,7 per cent of the Sandwich term due to the reduction of living and foraging area of the common term.	*Permanent*
Re-equilibration of silt concentration on the north and south side of the reclaimed area. The new equilibrium in the sediment can result in a change in habitat of various (benthic) sea organisms.	*Permanent*
Surrounding waters have become shallower due to loss of water in flow by reclaimed area	*Permanent*
Reduction in water quality caused by increased amount of traffic in the coastal zone.	*Permanent*

Source: Data taken from (Berkenbosch, 2007), table constructed by author

As presented in table 4 and documented in various studies, the construction of the Maasvlakte and the Maasvlakte 2 has had a significant impact on the physical appearance and environment of the Dutch coastline. The North Sea's depth and the relatively high turbidity, caused by a succession of poorly consolidated to unconsolidated sediments (de Mulder et al, 1994), there is no vegetation on the seabed in the reclamation area. The seabed is only being inhabited by several benthic organisms which serve as food for certain species of fish. As pointed out by research (van Kruchten, 2009) aggravating the natural succession of fine sediments and silt by sand mining from borrow areas and sand dumping in the reclamation area, leads to a significant reduction of water quality. Increased turbidity due to reclamation works subsequently lead to a further decrease of the light intensity in the water of the Voordelta. The decrease has affected the direct living environment of different microorganism. Aggravating the turbidity of the sea water decreases the number of benthic

organisms, which in turn reduce the amount of food for fish species, fish-eating birds and mammals in the project area and the protected area of the Voordelta (Berkenbosch, 2007)

The last environmental implication which should be highlighted is the possible disturbance of sea life impaired by noise, above and below water level. Noise impairment below surface level is mainly caused by the operations of TSHD's and transportation vessels. Noise impairment above surface level is caused by fleets, ships and reclamation installations. The EIA by Berkenbosch (2007) and a more recent study carried out by Heinis (2013) both conclude that there are no permanent implications of noise levels in the case of Maasvlakte 2. The authors refute the noise argument with the statement that mammals and porpoises have variable living areas as they are continuously replacing themselves in order to find food. The research also concludes that the noise implication for fish did not exceed the threshold shift and did not have additional implications on residential areas nor regions at sea.

Social support and public hearing

Besides the self-evident environmental impacts also the societal issues played a significant role in the decision making process of the expansion of the Mainport Rotterdam. For the construction of the Maasvlakte 2 and contrary to the construction of the Flevopolder, a classical decision-making process was adopted (Hommes et al, 2009). In a nutshell, a classical decision-making process indicates that decisions are made rationally based on scientific and real time objective factual knowledge. Professor Hawkesworth (1988) describes this classical decision making process as the gathering of information based on the reality of today and the separation of subjective and normative sights, theories and prejudices (Hawkesworth, 1988). In order for the Dutch government and the Port of Rotterdam to make objective and rational decisions, involvement with the public and hearing of the public opinion was needed. The public was able to file objections and complaints towards the proposed plan, several policy decisions and ongoing processes. The Council of State judged various objections, including an objection filed by the Dutch Fish Product Board regarding insufficient environmental investigation and a loss of revenues, valid. The research done by Hommes (2009) concluded that the proposed land reclamation of the Maasvlakte 2 had clear socio-economic implications on the fishing industry.

3.2.3 Case study 2: The United States - The San Francisco Bay

The second case discussed in this thesis in the San Francisco Bay (see figure 11). The entire San Francisco Bay Delta estuary covers between 150.000 and 190.000 square kilometres of watershed area (depending on which areas are included) (US EPA, 2011; 2014). The San Francisco Bay, with its nearly 12.000 square kilometres in land cover, covers

approximately 7 per cent of the entire delta estuary and is located between latitudes 37º56/N and 37º83/N and longitudes 122º10/E and 122º0/E.

Gold rush, urbanization and decline of the Bay

Population growth within the San Francisco Bay started around mid 19th century, initiated by the discovery of gold in the area. The exploration of gold by James W. Marshall made the State of California popular: over 300.000 people moved to the Bay area to benefit in the gold exploration, which later was named, the Gold Rush (Holiday & Swain, 2002). Now, some 150 years later, the Bay area is surrounded by large urban settlements which have agglomerated together over the years. Despite the relatively slow population growth rate, the Bay area has been an attractive economic zone with a strong concentration of innovative and high productive technology companies (Bay Area Council Economic Institute, 2012). The San Francisco Bay area now has an estimated population of over 7 million (US Census, 2011a; 2011b).

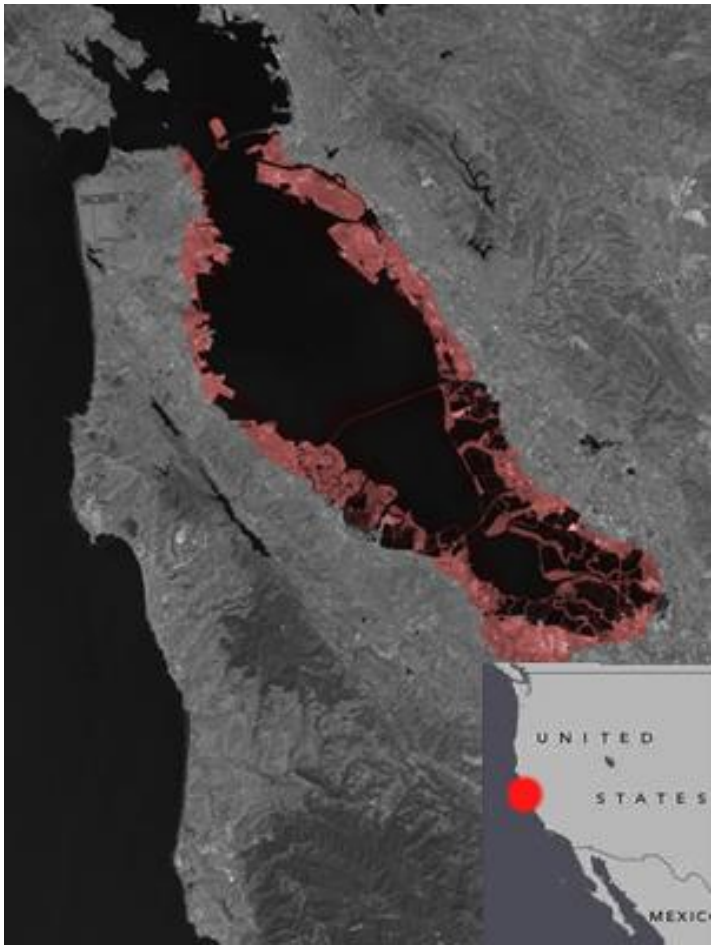

Figure 12: Case study 2: San Francisco Bay (in red, unaccurate area of land reclamation and shore line modification
Source: image retrieved from (Landsat, 2005), altered by the author

The population growth since the start of the Gold Rush has simultaneously led to a steep decrease of the San Francisco central Bay water area. What during the Gold Rush was known as rough 2100 square kilometre of open water space has now been decreased, due to space demand for industry and urban growth, to approximately 1400 square kilometres (Travis, 2007)(see figure 12). According to the executive director of the Bay Conservation and Development Commission and other studies (Baumann, 2001) another rough 850 square kilometres of open water space is being threatened directly for further economic expansion.

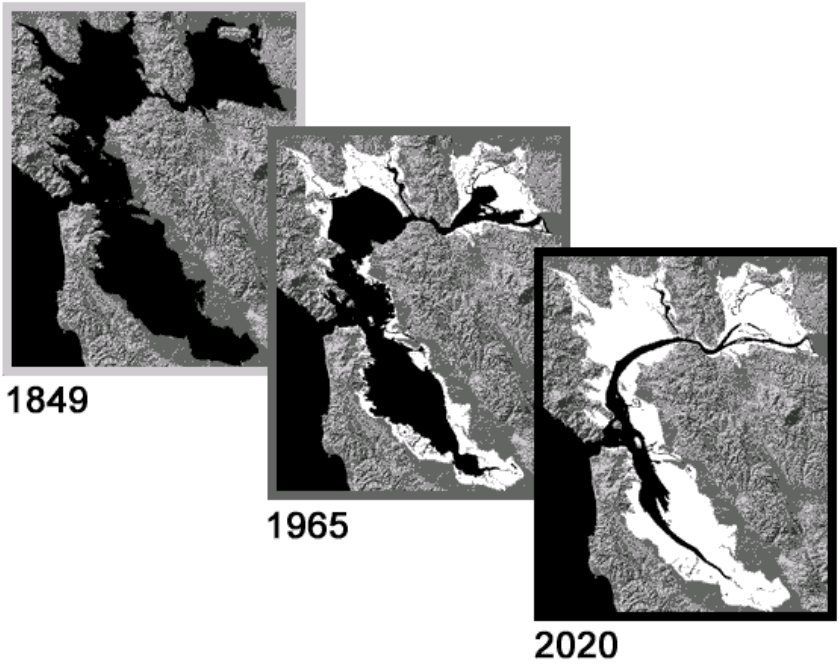

Figure 13: Urbanization and intensified reclamation process in San Francisco Bay area
Source: (Travis, 2007), retrieved from http://www.bcdc.ca.gov/history.shtml

One of the major problems, which has contributed to the decline of the San Francisco Bay is the natural sedimentation (Baumann, 2001). According to Baumann (2001), the natural sedimentation process and the decline of San Francisco's water body has been aggravated due to artificial shoreline modification for agricultural development, industrial growth and rapid urbanization. Another study conducted by Schoellhamer et al (2013) confirms Baumann's observation. To quote the first initial line of their paper:

> "*the general progression of human land use is an initial disturbance (e.g., deforestation, mining, agricultural expansion, overgrazing, and urbanization) that creates a sediment pulse to an estuary followed by dams that reduce sediment supply*" (Shoellhamer et al, 2013).

Several studies (Nichols et al, 1986; see also Baumann, 2001; Barnard et al, 2013; Shoellhamer et al, 2013) argue that the gold mining during the mid 19th century is the main explanation for this disturbance within the San Francisco Bay. Washed sedimentation from excavation works further upstream have deposited much sand, clay and other natural minerals on the sea bed of the San Francisco Bay. As a result, various upstream rivers were fortified to mitigate the erosion and sedimentation transport into the Bay (USFWS, 2004). Nevertheless, sedimentation has lead to shallow shore lines within the Bay. Currently, around 600 square kilometres of this shallow water could possibly be reclaimed quickly for further economic and urban expansion (Baumann, 2001), transforming the ever so rich Bay into nothing more than a river. The urbanization process of San Francisco and the decline of the Bay's water surface is presented in figure 12.

Environmentalist vs government policies

Due to diking and reclamation works a clear environmental and ecologic loss of wildlife can be observed. Reclamation in San Francisco Bay caused a 80 per cent decline of its marsh lands (Grenell, 1990), destructed 90 per cent of its shore wetlands and disrupted over 40 per cent of its aquatic and maritime ecosystem (US EPA, 2011). Furthermore it threatens extension of over 20 protected wild life species and alters natural habitat of millions of migratory birds (US EPA, 2014a). Additionally, soil contamination of reclaimed agricultural land has decrease water quality due to sedimentation of toxic pesticides (Anderson et al, 2007; Conner et al, 2007).

These abovementioned environmental implications are the result of governments non-regulatory policies. It is believed that besides large population growth, these non-regulatory policies have contributed to the rapid decline of open water bodies within the San Francisco Bay area. Since the 1960's, around 30 activist groups, supporting the environmental preservation of the Bay, have made their voice heard (Grenell, 1990). The largest of these groups are the San Francisco Bay Conservation and Development Commission (BCDC, 2007), the United States Army corps of Engineers (US ACE, 2014) and the regional water quality control boards (US EPA, 2014b). These groups, together with the San Francisco Port Authority (SFPA) (Garcia, 2007), focus mainly on raising public influence and natural preservation within the governmental planning process (Monroe, 1990). Governmental authorities therefore are currently being restricted and highly regulated in their city planning as the SFPA holds jurisdiction, with support of the environmental agencies (Metha, 2002), over San Francisco's shorelines (Garcia, 2007). The preservation of the iconic San Francisco Bay is now being protected by an increasing amount of professional and non-professional public organizations.

3.2.4 Case study 3: The Persian Gulf area – Dubai, Bahrain and Qatar

The third case discussed in this thesis is the Persian Gulf area, more specifically: Dubai, Bahrain and Qatar (see figure 13 and 14). Since the early 70's there has been a growing interest in off shore reclamation projects in the Persian Gulf. Simultaneously, there has been a significant growth of literature into the environmental implications of land reclamation into the Gulf area (Burt, 2013).

The hyper-arid climate, the shallow waters, the wealth and the rapid growing economy have been the main drivers of the Gulf's attractiveness (Sheppard, et al., 2010). But apart from the increasing interest in off shore coastal development, the states surrounding the Persian Gulf are also well known for their oil resources and interrelated socioeconomic growth (Nassar et al, 2014). The wealth and social development around the Persian Gulf have taken a quick development over the last two decades. The prosperity of states neighbouring the Persian Gulf and the exploding reclamation works into the Gulf have led to raising concerns regarding the sustainability of the Gulf's waters and natural habitat (Price, 1993; see also Zainal, 2009; Burt et al, 2009; Sheppard et al, 2010). In this section of the thesis the socioeconomic and the eco-economic implications will be investigated to serve as a judgement for future large scale reclamation. The pace and size of reclamation projects in Dubai, Qatar and Bahrain are unprecedented and therefore could provide needed inputs for the holistic judgement this thesis is aiming for.

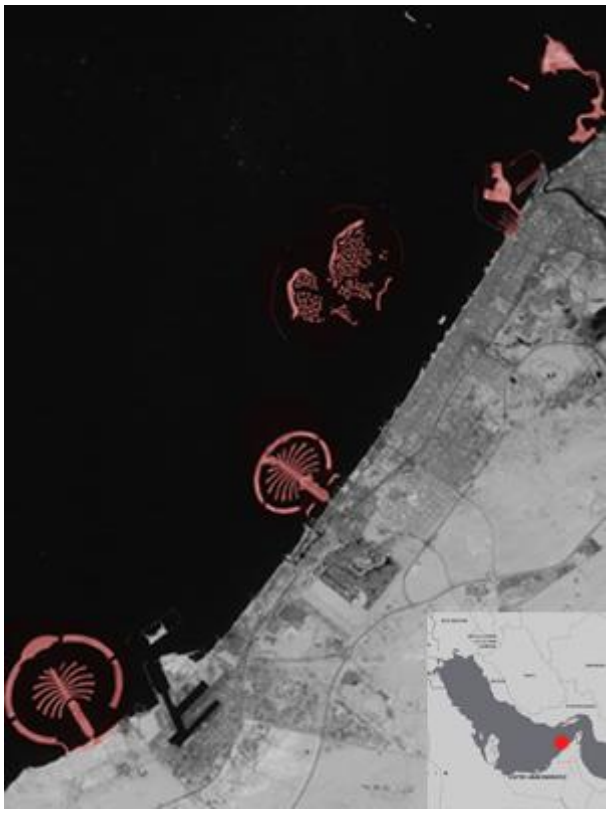

Figure 14: Case study 3.1: Duabi (in red, from down to up: Palm Jebel Ali, Palm Jumeirah, the World, Port Rashid and Deira Islands
Source: image retrieved from (Landsat, 2005), altered by the author

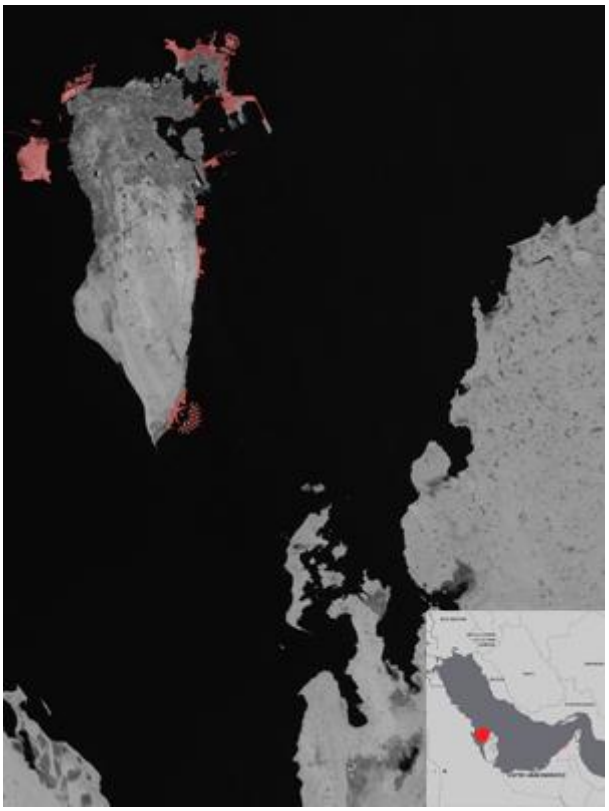

Figure 15: Case study 3.2 - Geographical location of Kingdom of Bahrain (reclaimed island indicated with red) towards Qatar (mainland)
Source: image retrieved from (Landsat, 2005), altered by the author

Project case description: Dubai

The largest and most prominent real estate developments of the Middle East are taking and have been taking place in the United Arab Emirates. Over the last few decades Dubai, the second largest emirate after Abu Dhabi, has been growing rapidly. What once was known as a scarcely populated desert land, has grown out to a multibillionaire transportation hub, financial business centre and resort for tourist from all over the world. From its historic economic perspective, at the beginning of the 19th century, Dubai has been an important trading transit point for the exchange of goods with neighbouring countries and Asia. With the emerging of the oil market in the early 70's Dubai ranks now among the of the world's largest transportation hubs (Pacione, 2005; Nassar et al, 2014). A demonstration to amplify the magnitude of the growth in Dubai over the last few decades, can be found in various denoting that on the peak of Dubai's development in 2005, 25 per cent of the total of construction cranes in the world were operating in Dubai (Badouri, 2007). With the revenues generated by oil trade, the Dubai government invested in capital and infrastructural developments, including expansion and modernization of the ports and an international airport (Pacione, 2005).

In order to sustain Dubai's economic growth into the future, independent of oil trade, the Dubai government initiated attractive incentives for foreign businesses to invest in Dubai (Fakhro, 2013). Incentives such as zero per cent corporate tax rate and ownership of Dubai Real Estate attracted large amounts of foreign investors to boost the economy. From the early 70's the government also started with coast line expansions and reclamation projects. The first project along the 65 kilometres long shoreline of Dubai was the reclamation of port Rashid. Even though this first reclamation project was relatively small compared to the latter developments that followed, port Rashid has always been an important transit point for international trade. Increasing demand for international trade initiated the reclamation of a second harbour further south along the coast line: Jebel Ali, recognized as the world largest inland harbour in the world (Pacione, 2005). The first initial land reclamation of the famous Palm Island was initiated in 1992, after which Palm Jebel Ali and the World Islands quickly followed. Currently there are still reclamation works along the Dubai coastline at the far north (the Deira Islands) and the far south (Dubai Waterfront).

Urban growth, tourism and more reclamation works

The rapid growth and pace of urban development has not gone by unnoticed for economists, environmentalists and urban planners, who have now turned their focus on monitoring the developments in Dubai and neighbouring states. However there is only limited publicly accessible information on the expansion of Dubai, likely due to "governmental restrictions on data that does exist" (Nassar et al, 2014). Nevertheless, valuable information regarding the development of Dubai is documented in studies of various researchers referred to in this thesis. According to a recent study carried out by Nassar et al (2014), in which they used and assessed satellite remote sensing data to quantify Dubai's growth, Dubai has expanded almost 600 square kilometres in less the 40 years. This quantitative growth equals over 10 per cent annual growth in urban land cover (Nassar et al, 2014). The study then continuous by comparing this urban growth rate against the urban growth of Guangzhou City in China which had an annual compounded growth of almost 8 per cent over roughly 25 years (Ma & Xu, 2010). These unprecedented growth numbers can be explained by the declining population density (Angel, et al., 2005) due to spatial, horizontal city growth. One factor, motivating urban sprawl in Dubai which contradicts with the other cases discussed in this thesis, is the large supply of vacant desert lands in the emirates available for urban expansion. Nevertheless, expansion of the coastal areas is preferred due to its high economic value compared to inland development.

Nassar et all (2014) also analyzed the relation between the coastal development and reclamation projects. They studies the direct connection between the increase of water bodies and vegetation that occurred simultaneously with Dubai's urban growth. According to their analysis and assessment the total amount of vegetation and water bodies expanded from less than 5 square kilometres in 1970 to a vast 60 square kilometres by 2012. Nassar et all (2014) explained this expansion of vegetation and water by an incentive supported by the Dubai government to increase the liveability of the desert city (Al Marashi & Bhinder, 2008). The authors of the assessment also stress their concern that such huge changes in land cover and vegetation will have adverse effects on environment and coastal eco systems. Their statement gets supported by the argument that such areas of vegetation require large supplies of energy to be maintained. Additionally, up until now, Dubai has converted approximately 70 square kilometres of marine environment into urban areas and islands where, four islands are still under development (Nassar et al, 2014). Treats for marine and coastal environment are present. On the other side, the authors also argue that the increase of land cover will stimulate biodiversity. In this further part of the thesis a deeper investigation into the environmental and ecological implications will be conducted.

The main developer and initiator of the redevelopment of the Dubai coastline is Nakheel properties, the real estate body of the state conglomerate Dubai World (Fakhro, 2013) (Nakheel PJSC, 2014). All together, Since the early 90's Nakheel properties has transformed the traditional Dubai coastline into a giant spectacle of non-traditional land reclamation projects. Among the projects are the large scale reclamation works of Palm Jebel Ali, The World Islands and the Palm Deira. But also the lesser known projects such as the Dubai Waterfront and the Dubai Promenade are a gathering of Dubai's luxury attitude and entrepreneurship in land reclamation. The Palm Jebel Ali, which is located along the far south end of the Dubai coastline, is over twelve square kilometres in size and provides home to quarter of a million residents (Nakheel PJSC, 2011a; Fakhro, 2013). The Northern reclamation projects, the World Islands and the Palm Deira, are as fascinating and complex as the other projects. The World Islands form a cluster of 300 artificial islands, spread over 63 square kilometres, who together resemble the shape of the world. The most recent project, Palm Deirah, is currently still under construction and, once finished, will replace roughly 64 square kilometres of sea into artificial manmade land.

The land reclamation works in Dubai have increased the total amount of beach front by over 1400 per cent since the start of the reclamation works in 1993. This is an annual compounded increase of reclaimed land of 14 per cent each year over the last twenty years. Within this timeframe, the Dubai government has extended its original 65 kilometres long

coast line by over a thousand kilometres of manmade artificial beaches and boulevards (Abai-Diba, 2009). In total, the reclamation works have converted 70 square kilometres of untouched sea habitat into sandbanks, land, luxurious real estate and leisure. The series of land reclamation works were needed to ensure the continuation of Dubai's economy into the future. As the Dubai government understood that the supply of oil will run out within the next two decades (Fakhro, 2013). According to various studies, such unprecedented large scale and high paced reclamation works within a relative small time frame, may have drastic adverse implications on marine live in Persian Gulf (Fakhro, 2013; see also Burt et al, 2009; Sheppard et al, 2010). Because analysis for the entire Dubai coastline provides enough information for a separate research thesis, only the Palm Jumeirah will be included in the further case study within this thesis.

Dubai's iconic land reclamation: the Palm Jumeirah

Palm Jumeirah is located between latitudes 24º90/N and 25º20/N and longitudes 55º10/E and 55º50/E. The plan for the Palm Jumeirah was envisioned during the early 90's but construction only began in 2001, initiated by Nakheel Properties commissioned by the Dubai government The proposed concept of the world famous palm Jumeirah was extraordinary and non-traditional. The palm Jumeirah, with its palm shaped islands, have become an iconic landmark of Dubai. The entire proposed project by the Dubai property developer Nakheel covered over 600 hectares and once it was finished, added 75 kilometres to Dubai's shoreline (Gahir et al, 2006; Nakheel PJSC, 2014).

Land reclamation with such a level of complexity and size as the Palm Jumeirah, had never been done before. Therefore, the construction of the Palm Islands required advanced expertise and understanding of water engineering. This expertise and understanding was found among the Dutch, who have a long history with the natural forces of the sea. A Dutch and Belgian company were hired to consult in the further planning and development of this project (Bassett, 2005). To add to the uniqueness of the entire project, the Palm Jumeirah had to be completed within five years, of which two years were dedicated to the reclamation process and the remaining three years for the construction of commercial, residential and leisure real estate[2]. Even though for the construction of the Palm Islands undefined complications were to be expected, due to its complexity and timeframe, the Dubai government insisted construction would begin in 2001.

Before the actual reclamation of the palm could start, an 11 kilometre long breakwater had to be constructed. The breakwater encircled the entire project area, leaving, initially, two small

[2] Mega structures, "Impossible Island: Dubai Palm Island", 2005 (https://www.youtube.com/watch?v=0BXGh0EYJtE)

discharge locations at the base of the palm. After the actual completion of the break water, the initial design was altered to a design with four discharge locations to improve the influx of fresh sea water and to reduce to accumulation of algae (Bassett, 2005). The breakwater consists of a mixture of big chunks of rock filled with sand. The purpose of the breakwater is to protect the reclamation process and sedimentation of material from heavy tidal waves and beach erosion, which occurs naturally along the coast lines (Fakhro, 2013).

In total, 94 million cubic meters of sand and 5.5 million cubic meters of rocks and boulders were needed for the construction of the Palm Jumeirah. Large dredgers were used to excavate sand from various borrowing sites roughly 12 kilometres away from the project. A single dredger would take about three hours to complete a full process of excavation, transport and dumping on the project site location. Rocks and boulders were excavated from inland locations and transported by truck. The rocks would take approximately 24 hours to be transported (Bassett, 2005). A study conducted for off shore reclamation works in Egypt resulted the following socioeconomic and eco-economic comparison between onshore and off shore excavation:

MINICASE: ONSHORE VS OFFSHORE RESOURCES

An offshore project has roughly two options for the gathering of the resources needed. First there is the option for resource excavation and transportation via trucks and trailers. Secondly, there is the option for large trailing suction hopper dredgers that excavate sand from various sea bed locations. A simple equation is conducted in the study regarding environmental impacts of dredging and land reclamation for the Abu Qir Bay in Egypt (Yasser, 2012), fragments shown below.

Referring to the reclamation works for the Abu Air Bay in Egypt:

> *"... each truck can transfer about 30 cubic meters of fill material in one trip. Approximately 20.000 to 30.000 trips are needed, over approximately 12-18 months to fill the project..."* (Yasser, 2012)

For the Palm Jumeirah, which is far larger than the reclamation case in Egypt, the amount of trips needed would extend over more than three million trips and would last 150 years to complete.

Referring to the reclamation works for the Abu Air Bay in Egypt:

> *"... On the other hand, a modern dredger can take up a total sand capacity of approximately 4000 cubic meters of sand and would make the trip from excavation site to project site in approximately three hours. This mean that each day, around 24.000 cubic meters of sand can be dredged, transported and dumped at the project site."* (Yasser, 2012)

Taken the mini case as a comparison and using the provided data as an assumption, around 4000 trips are needed to complete the entire excavation and dumping process on the Palm Jumeirah. These 4000 trips equals around 1,25 years of three daily trips of three dredgers to fulfil the needed demand. Even though the mini case might only be suitable for a rough estimate, the actual duration of reclamation of the palm lasted around two years, around nine months longer than assumed with this mini case comparison. Though, in the mini case, no external factors such as storms and financial problems are included.

Even though the Persian Gulf is surrounded by vast amounts of dessert sand, this sand is not appropriate for land reclamation. The desert sands cannot be used due to its fine texture by constant erosion to the wind. Instead, the sand had to be taken from various borrowing areas roughly 12 kilometres away from the project area. Clearly, in the case of Dubai there were no alternative options of the collection of resources needed. According to the results of Yasser (2012) off shore excavation has "*revealed significant impacts on marine ecology, sea floor, shoreline erosion and sea water quality", while on the other hand onshore excavation has "revealed minor impacts on terrestrial ecology, moderate impacts on human environment, air and land climate, surface and ground water*". Based on the results of the comparison between off shore and on shore excavation (Yasser, 2012), it can be said that the off shore option "exceeds" the implications of on shore excavation, though, the difference is only "a small increment". A clear trade off between socioeconomic and eco-economic transpires.

Another social implication that threatens the social feasibility of the palm Jumeirah is the treat of liquefaction. Liquefaction refers to the process of which solid material converts into a fluid like mass. This phenomena is a serious treat for the social environment as it can causes serious socioeconomic damage during an earthquake (Alden, 2011). Dubai is located near the intersection of the Arabian, Eurasian and the Indian continental plates which significantly increases the treat of liquefaction of current and future reclamation projects.

Large scale reclamation in Dubai and environmental concerns

Nowadays, an increasing number of environmentalists are stressing their concerns regarding the possible large scale environmental implications on marine environment in the Persian Gulf. These environmentalist argue that land reclamations into the Persian Gulf leads to a loss of natural habitat in coral reefs (Purkis & Riegl, 2005). In a response to these concerns the main developer in Dubai, Nakheel, said the following (Fakhro, 2013):

> "*The land reclamation works exists harmoniously with the diverse, surrounding marine life that inhabits its waters. Based on an EIA, the quality of seawater surrounding the islands was superior to that tested along the shoreline of Dubai. Along the breakwaters, there exists today more than 30 species of flora and fauna. As a result, colonies of pearl oysters and other molluscs' are beginning to proliferate. Various sea life, such as coral anemones and sea squirts, thrive along and in between the breakwaters surrounding the islands, accepting it as part of their natural environment. The shoreline areas comprise diverse marine life such as sea cucumbers, oysters, sponges, plankton, butterfly fish and jellyfish*". (Nakheel PJSC, 2011b)

Additionally, Fakhro (2013), supplements this abovementioned statement from officials of Nakheel by another statement made by the property developer of Dubai. Nakheel continued its statement by saying that after the construction of the Palm Jameirah it is expected that:

> "*...the artificial manmade lands are to enhance the local wildlife population, create new habitats for fish and other local wildlife and ultimately provide massive environmental benefits*." (Fakhro, 2013)

Though, surprisingly, this statement by Nakheel gets partly supported by a recent research (Burt et al, 2009) into the phenomena of replacing natural coral reefs in Dubai by artificial, manmade reefs. The research confirms that the construction of the eleven kilometres long breakwater did indeed create new habitats for fish and other local wildlife. Though, the species found at the location several years after construction are different compared to the species that originally used that areas as their natural habitat. The researchers conclude that "breakwaters should not be thought of as replacements for natural habitats in Dubai" (Burt et al, 2009). Fakhro (2013) also then formulates his counter argument, adding to the subjective viewpoint of the real estate developer, referring to a study conducted by Sheppard et al (2010). Sheppard refutes Nakheel's response, in his paper focused on "examining the substantial changes that have taken place in marine habitats and resources of the Gulf over the past decade" (Sheppard, et al., 2010), by saying that:

> "*...most scientists working in the Gulf agree that the most significant and important threat to the sustainability of the Gulf ecosystem comes from the massive extent of coastal habitat modification by dredging and converting shallow, productive marine areas into land*".

Even though it is not explicitly mentioned in the context, Sheppard (2010) refers in his statement to the falsified comparison between the construction phase and operational phase

and the possible bias of various stakeholders. Comparing these two phases as identical is similar to 'comparing apples with pears', which today is still denoted as a biased comparison. Nevertheless, Sheppard's statement finds support from the director of the World Wide Fund, Fredric Launay, in Dubai. Launay argues that large scale reclamation works in Dubai, including the Palm Jumeirah, has moved beyond the point of no return: meaning that the rapid reclamation works and increased salinity [3] (Schiedek et al, 2007) have had adverse, unchangeable effects on the maritime habitat in the Persian Gulf. Another study form the United Nations University confirms that the large scale reclamation works of the Palm Islands have permanently altered sea currents, tidal waves and an increased percentage of beach erosion and sedimentation patterns (Fakhro, 2013). Launay explains his statement by saying that the large magnitude of sand excavation and dumping works have not only destroyed the only known coral reef off the shores in Dubai, but also the natural habitat of various water species.

Another study conducted into the environmental implications concludes that the ambitious, unprecedented and time restricted reclamation works in Dubai have ruled out the option of maintaining and preserving the natural habitat, leaving only the option of mitigation and remediation in the future (Stensgaard, 2004).

Qatar and Bahrain: from land reclamation to cross boundary tensions

In the middle of the Persian Gulf, between Qatar and Saudi Arabia, lays an archipelago of approximately 40 islands, of which the main island is the Kingdom of Bahrain (Zainal, et al., 2012). The entire Kingdom of Bahrain is located between latitudes 27º10/N and 25º22/N and longitudes 51º07/E and 50º16/E. About 40 kilometres out of Bahrain lays the independent Arab emirate Qatar. With its roughly 11.500 square kilometres of land cover, Qatar is about 15 times bigger than Bahrain. Qatar also has a population of approximately 2 million, compared to 1.3 million in Bahrain. These numbers are based on statistics of 2012. According to studies, due to its geographical location, the Kingdom of Bahrain has to cope with a limited supply of natural land in relation to the population growth and economic development (Zainal, et al., 2012). To compensate for the limited supply of land, Bahrain has opted for the construction of large amounts of land reclamation. Over the last 50 years, Bahrain has increased its total territorial land mass with 13,6 per cent. The environmental implications of this land expansion in Bahrain has widely been qualitatively documented (Madany et al, 1987; see also Sheppard et al, 1992; Fadlallah et al, 1995; Al-Madany & Al-Sayed, 2001; Alkuzai et al, 2009; Loughland & Zainal, 2009; Zainal et al, 2012) and is

[3] Land reclamation activities in the Gulf are contributors to the increased salinity in the Persian Gulf. Though, apart from reclamation activities, global warming is also a large contributor to the increased pollution.

summarised in table 5. Even though table 5 only provides a rough indication of the losses, according to Zainal et al (2012) the total cumulative loss of the major maritime habitats, due to dredging in Bahrain, was roughly 160 square kilometres. A total estimated loss of 49 million US dollars.

Tabel 5: Environmental Impact Assessment of land reclamation in Bahrain

ENVIRONMENTAL IMPACT ASSESSEMENT BAHRAIN			
Affected habitats	**Total coverage**	**% loss**	**loss**
Algal dominated	2.27	-	-
Coarse sands	2.86	-	-
Deep water gravels	82.18	22%	18,08
Medium to fine sands	45.05	12%	5.41
Mixed sands/seagrass/algae	128.38	34%	43.65
Rock with soft veneer	15.04	11 %	1.65
Rock/sand with coal/algae/seagrass	9.79	44%	4.31
Seagrass	88.93	23,5%	20.9
Shallow water muds	2.71	-	-
Total	**377.21**		93,99

Source: data acquired from Zainal et al (2012)

A major implication of the loss of marine habitat is the disappearance of various marine organisms, of wish the revenues of local fisheries relied. According to findings in a report by the United Nations Development Programme roughly 80 per cent of Bahrain's coastline has been subjected to land reclamation (Fuller, 2006), resulting in a loss of a fertile coral reef between Qatar and Bahrain.

The loss of maritime habitat has severely induced Bahrain's fishing industry. Large scale reclamation works have caused the disappearance of marine habitat and a decrease of 90 per cent of the fishing export of Bahrain (United Nations, 2008). The treat of overfishing lead to a decline of allowed landings for fishing. Many Bahrain fisherman therefore wade into Qatar territorial waters (Fakhro, 2013), raising the treat of interrelated political problems. According to a fairly recent news broadcast by Gulf Daily News (Torr, 2010), Qatar arrested over 140 Bahrain fisherman and took possession over 260 fishing vessels in 2010. In total, hundreds of Bahrain fisherman were arrested and prosecuted due to illegal trespassing and fishing in Qatar waters. A protest against land reclamation and a call for more stringent regulations of dredging and reclamation was the result. Though land reclamation has obvious environmental implications, the cases in the middle east present clearly the treat of social disruption and political treats. A similar case of heaved political discussion between states can be found in reclamation works between Singapore, Malaysia and Indonesia. Large land scarcity in Singapore has led to major reclamation works into the Singapore strait: since the

1960's, a rough 20 per cent of Singapore's land cover has been reclaimed (Reuters, 2012). As a result a political conflict followed when Malasyia protested, accusing Singapore's reclamation works for trans-boundary environmental impacts. Additionally Indonesia raised an export ban of sand to Singapore as they believed Singapore prioritized socioeconomic gains over environmental protection and preservation (Choong, 2006).

3.2.5 Case study 4: South and East Chinese Sea – the Pearl River Delta

Recently, South East Asia has been experiencing one of the largest population growths in history. According to well respected report series of the United Nations, referred to in chapter two, this growth is expected to continue further into the 21st century. Therefore, the increasing popularity of land reclamation in South East Asia has been inevitable. According to a recent article in the China Daily (Wai, 2014), land reclamation has been and will remain a popular tool for Asian governments to mitigate the space issues. As the demand for living space and vacant land continues to grow and natural resources are running out, alternative solutions have to be found (Wang et al, 2014).

Urban expansion along the South and East China Sea

Geographically, China is the world's fourth largest nation, after Russia, Canada and the United states. The total land mass of China covers over 9.500 million square kilometres and is inhibited by over 1.3 billion people, almost 20 per cent of the entire current population. China also has vast amounts of untraversable mountainous and rugged terrain, which covers almost 60 per cent of the country. Due to the country's landscape a high concentration of the population can be found along the eastern coast line to the East China Sea and the West China Sea. Where, in Chinese history, the population would still be centred around popular areas for trade along the Yangtze river, nowadays nearly half of the Chinese population can be found in the fast growing coastal zones (Wang, Liu, & Su, 2014)

China's coastal zone is not only one of the largest emerging economies, it also ranks top in the world's fastest sprawling society and urbanization (Ge & Jun-yan, 2011). The rapid growth of the China's coastal cities over the last decades have caused a major shortage of cultivated land. The nation's rough landscape makes land reclamation a necessity to buffer between the conflict of growing population and diminishing land resources (Ge & Jun-yan, 2011). In the absence of strict control on land reclamation in the past, the local governments have resorted reclamation to provide replacement of those arable land expropriated for urban development and industrial construction (Liu et al, 2012).

China, and South East Asia in general, have a long history of land reclamation. Since mid 20th century and since the establishment of the PRC (People's Republic China) in 1949, it is

estimated that China alone has reclaimed approximately 13.500 square kilometres of land along its coastal line (Fu et al, 2010), roughly 240 square kilometres per year on average (Qian, 2012). The People's republic of China, the governing body of china, has reclaimed a total of 12.000 square kilometres (China Daily, 2008) (nearly 90%) of all the land reclamation to facilitate for the economic growth. Even though land reclamation was popular for agricultural purposes during the mid century, the demand for land reclamation to accommodate the urban growth did not start until the early 1980's (Wang et al, 2014), after the implementation of the economic reform in China.

Project case description: the Pearl River Delta

China's leading and fastest growing economic zone is the Pearl River Delta (Enright et al, 2010). The Pearl River Delta is located in the Guangdong Province in South China, between latitudes 21º40/N and 23 ºN, and longitudes 112ºE and 113º20/E (see figure 15). The Pearl River Delta is a major transportation and manufacturing hub and covers over 8000 square kilometres of land (Zhou & Cai, 2010) and 450.000 square kilometres including the wetlands and drainage basin into the South China Sea. With cities such as Guangzhou, Shenzhen, Jiangmen and the special administrative regions of Macau and Hong Kong in its close proximity, the PRD has set off a rapid economic growth since the economic reform in 1979.

According to research conducted by the Hong Kong Trade Development Council (HKTDC, 2014) in 2012 the PRD accounted for 9,3 per cent of China's total GDP and almost 30 per cent of China's total export. The region has had a steady GDP growth of 11 per cent to 20 per cent over the last decades. Constant economic growth has transformed the area from cheap labour "factory" to an excellent, fast-paced manufacturing hot spot (Zhou & Cai, 2010). The total metro area spreads out over nearly 60.000 square kilometres and is home to an excess population of approximately 55 to 60 million people (Enright et al, 2010), roughly 4 per cent of the entire Chinese population. By the end of 2030 an population of 70 million within the Pearl River Delta is to be expected. This is equal to a total growth of over 16 per cent in 10 years. The Pearl River itself ranks among one of the largest rivers. China's recent growth raises pressure on natural environment in order to facilitate the space demand for growth.

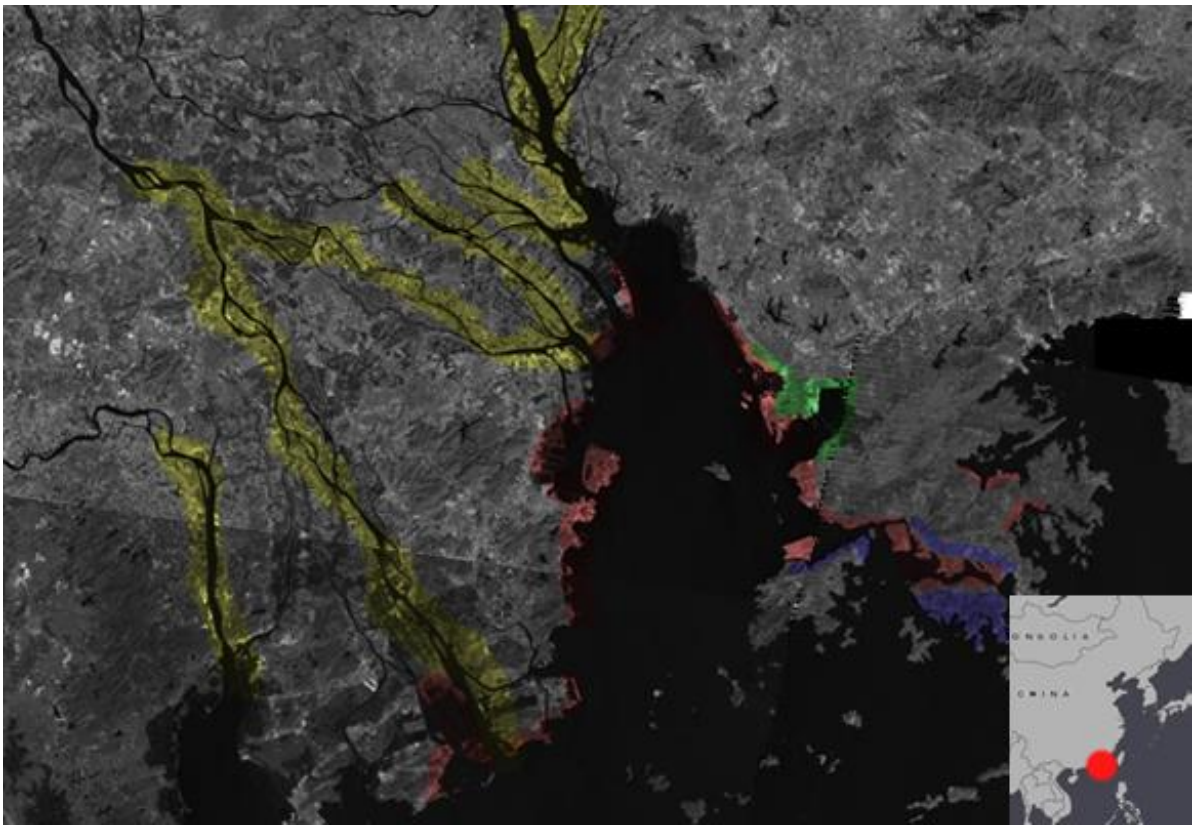

Figure 16: Case study 4:the Pearl River Delta (in red, areas of land reclamation in discharge locations, in purple land reclamations in Hong Kong, in green land reclamation in Shenzhen and in yellow the original Pearl River Delta rivers.
Source: image retrieved from (Landsat, 2005), altered by the author

But the PRD was not always known for its driving economic force and transportation turn over. The PRD has a long history of land reclamation which eventually created the PRD as it is today. In order to understand the continues growth of the PRD and the role land reclamation has played in the growth of this economic zone, it is important to look at the history of the delta and how the delta emerged to this manufacturing hot spot.

During the Neolithic times (5000 BCE) a vast majority of the PRD did not exist. Due to the high sea water level around this time period large parts of the PRD were submerged under the South China Sea (Weng, 2007). Only since the early beginning of the Common Era the sea subtracted itself and vast amounts of wet lands emerged from the sea (Li et al, 1991). The subtractions of the sea and the appearance of the wetlands made it possible for people to settle in this watershed river delta. Because of the areas previous occupation by the sea the majority of land within the delta were waterlogged areas[4]. In order to fertilize the ground and to make it suitable for living, early civilisations dumped large amounts of sand and loam on the waterlogged areas (Weng, 2007). By this primitive method of land reclamation around 1200 BCE the total land cover within the delta expanded.

[4] when the ground is completely saturated with water

Because of the delta's previous occupation by the sea and the connection with the Pearl river's discharge into the South China Sea, water engineering and landscape management were a necessity (Weng Q. , 2000). The conversion from wetlands to agriculture soon yielded fertile lands for agriculture and the population in the area started to grow. As water management was important, the agricultural development in the river delta grew simultaneously with dike building technology (Weng, 2007). In case a flooding would occur, alternative lands were easy to find in the still sparsely populated delta (Weng, 2007). Though, as the population increased, the available arable lands became scarce quickly, making today's urban areas vulnerable for natural forces. The population boom starting from the Common Era required more embankments of the lower wetlands for cultivation. An era of building dikes and embarking land in order to gain arable land had started.

Important to note is that around this time period the farmers were not yet aware of the implications their large scale reclamation might have on the environment. Though, already these early reclamation methods had severe implications on the environment. Erosion and sedimentation were the biggest factors changing land cover in the river delta. As the sea subtracted from the land more dikes were being constructed as areas were filled with sand and loam. The accumulation of silt in the narrower rivers affected the water quality.

With the population growth set in motion, a vicious circle was created: with each dike built more land became available, expanding the land cover sea wards (Department of Geography, Zhongshan University, 1988). Narrower rivers were the result of major dike building which led to an increased flow speed of the rivers in the delta. Instead of sedimentation in the rivers, the strong flows initially improved the silt discharge and sped up sedimentation process. More land emerged naturally at the discharge locations, increasing the land cover more and more into the sea. As the amounts of floods increased, also the amount of dikes constructed increased significantly, leading to shallower rivers due to sedimentation within the river delta. Slowly also the land in the river delta started to elevate above the water level.

From the Common Era till now the entire river delta has been transformed from an aqueous environment to a highly human made terrestrial environment. From the 17th century till half of the 19th century, mainly steered by political powers and greed of landlords for profit, large amounts of lands were non regulatory reclaimed. After the land was reclaimed, the reformed landscape led to change in soil conditions which improved farming conditions. The improved farming conditions resulted in a double economization and double incentive for land reclamation. The absence of specific strict laws and regulations on land reclamation and the negligence of both land lords and government parties towards environmental implications,

exploded the number of reclaimed areas within the river delta (Weng, 2007). Even though the Chinese government at some point raised a ban by increasing fear of silting up rivers and delta proper, the ban was later on dismissed by progressive demand and the potential economic benefit.

Another implication of the extensive reclamation works in the Pearl River was an altering of the delta's aquatic ecosystem. Additionally, the increased land in the river delta and the delta proper have raised the water level in for example the harbour of Guangzhou (Chen et al, 2005), threatening higher flooding percentages. The waterlogged areas can lead to a reduction in bearing capacity of the newly constructed land. According to Xu (2002) these changes in drainage network and hydraulic conditions present a great threat to flood prevention, water logging discharge, irrigation, and coastal ecosystems

Limitations on land supply and growth constraints

Due to its reclamation history and geographical position, the cities within the pearl delta have grown out into strong economical developed cities. According to chapter's 2 analysis, further expansion and urban growth in the Asian region is expected in the nearby future. Though, the PRD is enclosed by hill sides on the north, west and south side (Weng, 2007) which makes further urban expansion to stimulate economic growth a problematic issue. The higher estuaries of the river delta became quickly occupied as the economy was booming. Continues development has made arable land a limited and expensive resource in the area. Due to the lack of arable land a vast amount of reclamation projects has been already carried out. Officials say that because of the intensified reclamation in the Shekou Peninsula (Litang & Jiu, 2010), started after economic reforms in the late 70's, 80 per cent of Shenzhen's 270 kilometre long natural coastal line has disappeared (Tam, 2010).

Non participating and non regulated government policies

A connection to the reclamation activities in the PRD can be found in the rapid development of Hong Kong. Hong Kong is located east of the Pearl River Delta discharge area between latitudes 21º90/N and 22º50N, and longitudes 113º30/E and 114º35/E (see figure 16). Hong Kong's covers over nearly 3000 square kilometres. 40 per cent of the total size is land, of which roughly 6 percent (70 square kilometres) is reclaimed (Civil Engineering and Development Department, 2014).

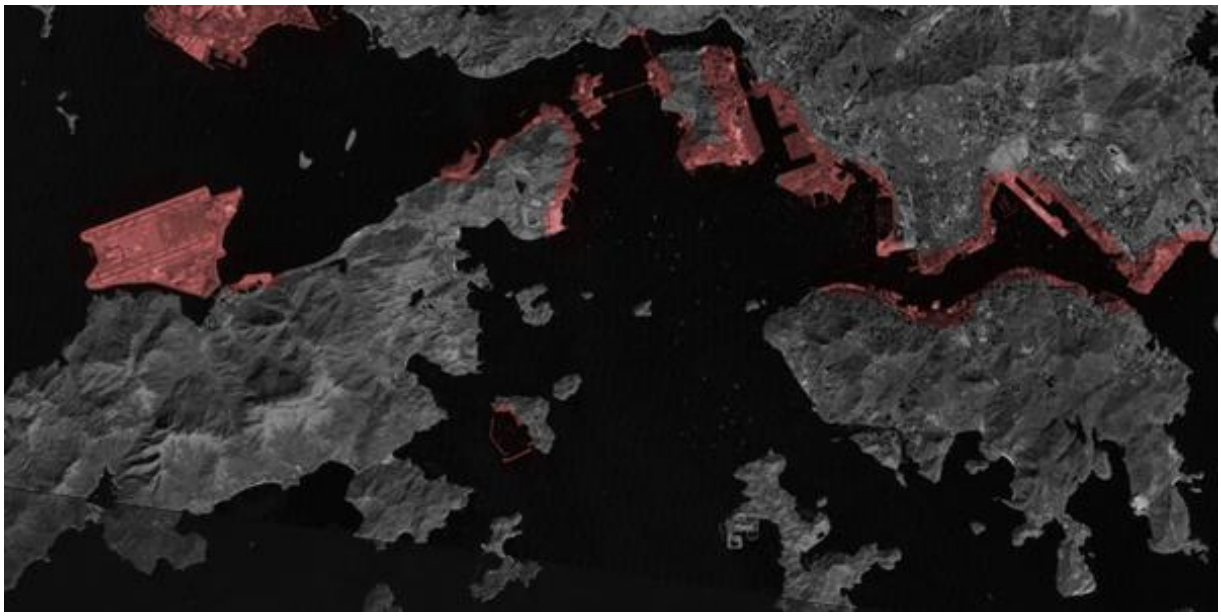

Figure 17: Case study 4:the Pearl River Delta – a closer look in reclamation works in Hong Kong (in red, areas affected by land reclamation. Far right: Hong Kong Island and Kowloon Island. Far left: Chep Lap Kok airport
Source: image retrieved from (Landsat, 2005), altered by the author

Luo et al (2007) state that sand excavation from the Pearl River Delta occurred "subsequently" during the late 80's and 90's to provide natural resources for Hong Kong's city development plan. Due to the lack of control on excavation, a majority of the dredgers operating in the PRD were carried out illegally by private owned firms (Luo et al, 2007). This statement implies that large amounts of natural resources transported for the further Hong Kong's city expansion were acquired illegally under the supervision of the People's Republic of China and the Hong Kong Administrative region. Concerns and regulations regarding the illegal activities and the environmental consequences did not start until 20 years after the excavation works. Even though after implementation of new regulations, the excavation works in some parts of the delta declined, a vast amount of illegal dredging still occurs today (Zhang & Yue, 2007).

Hong Kong's reclamation peak started from the late 60's and lasted until the beginning of the 21st century (graph x). Even though the steep population growth in Hong Kong did not start until the announcement of the People's Republic of China in 1949, early reclamation works in central Wan Chai, Causeway Bay and the Victoria Harbour were initiated mid 19th century (Planning Department Hong Kong, 2008; Kam Ng, 2008) (Figure 17 and 18). Due to Hong Kong's geographical location, the natural supply of land is very limited. Additionally, 40 per cent of Hong Kong's available land is zoned for "country parks" and "natural conservation zones" (Planning Department Hong Kong, 2011) which implied major restrictions on urban development. Land reclamation therefore became a popular tool to provide space and land to sustain economic and urban expansion (Kam Ng & Cook, 1997)

The first reclamation works took place along both sides of Kowloon Island and Hong Kong Island between 1840 and 1850. For a long time the soil purpose of Hong Kong was “to make money” (Rabuska, 1979). Therefore, private sectors in Hong Kong have worked closely together with land lords and the government to facilitate land for business development. As a result of reclamation works and higher demand for real estate, prices for commercial purposes skyrocketed and Hong Kong slowly started to develop as a financial centre. Over the last half a century the population of Hong Kong has grown out from approximately 2 million in 1950 (United Nations, 2002) till over 7 million by 2013 (The World Bank, 2014). Land reclamation gained more and more popularity as population of Hong Kong increased. Partly due to the contribution of the private sector and partly due the apparent “reluctance” and “inability” of the Hong Kong government (Bristow, 1984), land reclamation really took off from the late 1950’s (see figure 17). Between the 1950’s and the start of the 21st century major urban development took place along the entire skyline of Hong Kong, into the New Territories. In the New Territories, outside of the CBD, large satellite towns were constructed on reclaimed land between the 1950’s and the 1970’s (see figure 18)(Building and Lands department, 1988; Jiu et al, 2001).

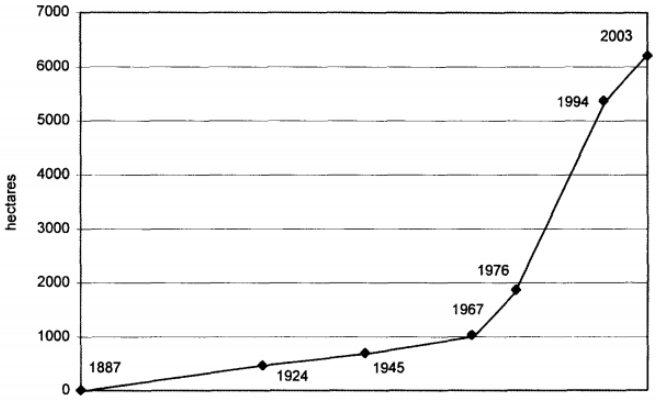

Figure 19: start of the reclamation boom in Hong Kong until 2003
Source: (Kam Ng,, 2005) (Planning Department Hong Kong, 1996)

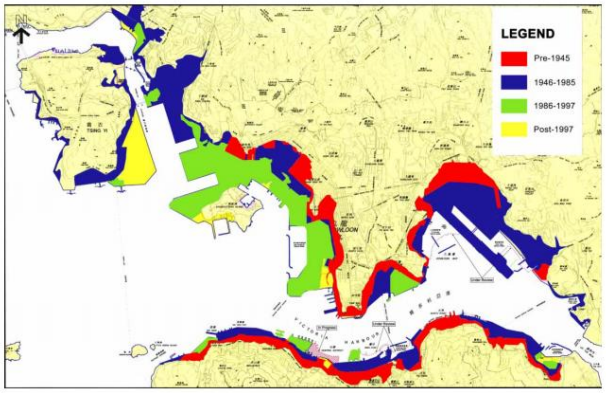

Figure 18: reclamation sites over the last few decades in Hong Kong
Source: (Kam Ng,, 2005)

Jiu et al (2001) stresses that while land reclamation serves as a great economic booster, it also increases the value of land. On the other hand, it also imposes serious implications to difficulties in water engineering (Waterman et al, 1998), disruption of local environment and ecologic implications (Tam, et al., 2013). For example, the reclamation works of the international airport Chek Lap Kok have had permanent effects on the natural habitat of nearly 20 major species of fish (Tam, et al., 2013), it has caused a steady decline of the amount of dolphins spotted in the area (Jefferson et al, 2009) and it has led to a decline of

the natural mangrove forests at Lantau Island (Tam & Wong, 2002). Additionally, the continues growth and demand for land within the Victoria Harbour threatens the disappearance of the harbour (Hong Kong Institute of Planners, 1995). (Wai, 2014) argues that while possibilities for land reclamation within CBD becomes rare, remote areas in Western Hong Kong still provide plenty of space. Additionally, even though Tsang is being opposed by environmentalists who prioritise environmental preservation over socioeconomic benefits, Tsang supports his statement by explaining that reclamation is needed to sustain Hong Kong's economy and to provide residence to the, still, growing population (Wai, 2014).

There is excess literature on environmental impacts assessments in Hong Kong. A limited amount of this literature has been targeted to investigate the impact of large scale land reclamation on ground water levels (Jiao, 2000; see also Jiu et al, 2001; Chen & Jiao, 2007; Litang & Jiu, 2010). These studies conclude that the reclamation into the sea increases ground water level, which affects the structural vulnerability and the stability of slopes. The structural vulnerability is translated into an decreased bearing capacity for construction due to a higher saturation of land, as discussed earlier in this chapter. The higher percentage of water may cause structural erosion and damage to floor plans (Jiu et al, 2001). In figure 19 a schematic representation of coastal land reclamation is presented. The newly reclaimed, lower laying piece of land elevates the ground water level, due to hydraulic conductivity. The structural vulnerability and erosion of real estate becomes a severe threat to the urban society.

Jiu et al (2001) conclude in their paper that while the increase of ground water level may be self spoken in the reclaimed part of land, the natural or previous reclaimed land might be ignored. Not only does land reclamation impact the ground water level, it also alters the ground water flow system, which has negative implications on flow pattern and sea water discharge locations (Litang & Jiu, 2010). A supplementing study into the fortification of reclaimed land at the Changi land reclamation project in Singapore, suggest that acceleration of land consolidation could possibly solve this structural vulnerability (Arulraja et al, 2007). Though, clear mentioning of this consolidation process in other reclamation projects is missing. Therefore, this might suggest, the accelerated consolidation is not yet widely applied and thus remains a serious socioeconomic and environmental implication.

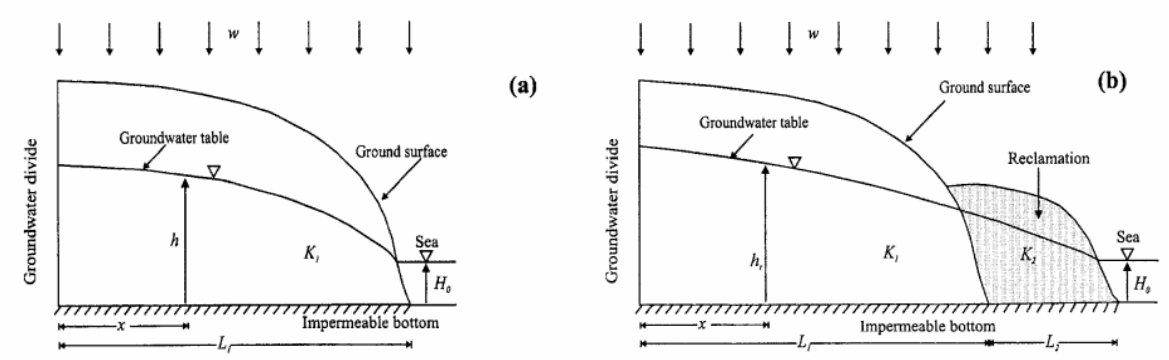

Figure 20: ground water in an unconfined aquifer system in a hillside near the coast (a) before reclamation and (b) after reclamation
Source: (Jiu, Subhas, & Hailong, 2001)

An additional, significant important factor influencing large scale reclamation works now and in the future, is soil contamination. The decades of uncontrolled disposal of sewage and industry in Hong Kong have led to populated waters. According to a recent study conducted by Dawes (2010), large portions of the Hong Kong sea bed are contaminated with toxic material and organic pollutants. The rapid economic and urban growth since the mid 20th century are two of the main contributors to this pollution. The Hong Kong Environmental Protection Department (EPD) (2013) admits that approximately 15 per cent of Hong Kong's territorial waters are categorized within the 'bad' or 'very bad' classification. The pollution can be a serious threat to urban society and the feasibility of land reclamation in Hong Kong into the future.

Despite the presence of several public concerns and the clear negative impacts on the environment, the government of Hong Kong remains a strong proponent of land reclamation. Arguments of the government in favour of land reclamation are twofold (Kam Ng & Cook, 1997): firstly, a further expansion of the city's business and finance sector and secondly an increase of residential zoning to accommodate the growing population. The earlier described statements of Financial Secretary John Tsang confirms these arguments (Wai, 2014). The private sector argues against economic expansion as they foresee decreasing land prices. Additionally. the public is sceptic about the government aspirations as the concern themselves over further possible environmental implications in Hong Kong (Kam Ng & Cook, 1997). Even though public voice is getting stronger and stronger, the inefficient organization and often non-participating monopoly of the governing system (Amirahmadi, 1999; Kam Ng, 2008) has led to prioritization of economic benefit at the cost of environmental loss (Zhou & Cai, 2010) and public involvement.

Overall, uncontrolled sand excavation from the PRD has left an impact on the natural and marine habitat as well as in the delta as in various dumping sites in the entire PRD economic zone. But despite negative effects, the dredging works also contributed positively to the local economy. Luo et all (2007) conclude in their paper, focused on investigating the effects of sand excavation on the PRD, that the dredging have caused an increase of soil instability, “brakish-water intrusion” and coastal beach erosion (China Daily Mail, 2005; Tam F, 2010). Also, dredging activities have led to water contamination and disturbance of local habitat (Liu et al, 2012). Though, the positive socioeconomic benefits are decreased threat of flooding, improved navigating conditions and more water influx in growing urban areas (Luo et al, 2007).

4. RESULTS AND DISCUSSION

In this chapter the results of the population forecasts and the case studies, analysed in the previous two chapters, will be presented. This chapter is structured as follows: first, the results of each of the four cases are presented individually and tabulated in a 5 scale plus and minis rating, where minus indicates low or extra low feasibility and plus indicates high or extra high feasibility. After presentation of the results an integrated and interconnected interpretation and discussion section will bring the results into a boarder, worldwide perspective. The goal of this chapter is to explore relations and/or similarities between the case studies, which will contribute to the generalisation of the final conclusion.

4.1 Results of case study 1: the Flevopolder and the Maasvlakte

4.1.1 Economic feasibility

No significant data has been found within the studied literature which indicate land reclamation in the Netherlands is economically not feasible. On the contrary, also no specific data has been found indicate the opposite.

Nevertheless, taking in consideration the case analysis, an assumption regarding the economic feasibility in the Netherlands can be made. Both the Flevopolder and the Maasvlakte resulted in positive economic gains. The Flevopolder has been transformed into a nature rich area and is home to small and medium sized settlements. In case of the Maasvlakte project, this land reclamation project has contributed to a growth of Rotterdam's function as a world port city. Considering these two projects a rational assumption can be made that the economic benefits imposed as a result of these reclamation projects outweigh the initial construction cost, thus making reclamation works in the Netherlands relatively economically feasible.

4.1.2 Environmental feasibility

According to the International Association of Impact Assessment (IAIA), an EIA is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken and commitments are made (IAIA, 1999). Within the Dutch legislation, the regulation for EIA were threefold: first, the EIA brought environmental issues and concerns into the decision making process. Secondly, environmental impact assessments could be used in an early stage prior to the start of a construction project in order to simplify decision making processes and last

but not least, EIA's could be used to raise environmental awareness among the construction sector (VROM, 1987; Stolp, 2006).

Conduction of EIA's were not mandatory in Dutch reclamation works until the introduction of the regulation in 1960 (VROM, 1987; Stolp, 2006). Therefore, only limited studies of environmental implications of construction works in the Flevopolder exists. In contrary, due to commencing of the EIA regulation in the Netherlands, wide spread literature on environmental implications for the Maasvlakte is available.

As stated in the EIA for the Maasvlakte 2 (Berkenbosch, 2007): "*First it must be established that the project will serve a major public interest and that no alternative exists. If this is the case, everything reasonably possible must be done to reduce or at least mitigate the significant negative effects. For the impairment still remaining – referred to as unavoidable "significant" effects – it is mandatory to take compensatory measures so as ensure the cohesion of natural reservations.*" This fragment, taken from the EIA for the Maasvlakte 2 adds a social dimension to the environmental dimension. Also, according to this fragment, everything possible has to be done to preserve the environment. In case of possible disturbance of natural habitat additional measures have to be taken.

A characteristic of the North Sea that makes a significant difference within the environmental feasibility is the natural high consolidation and uncompleted sedimentation within the North Sea. This uncompleted sedimentation leads to an increased turbidity of the North Sea. As a result, there are only a small group of maritime species affected by reclamation works in the North Sea, keeping the environmental implications to a minimum.

All of these aspects together indicate an above average environmental feasibility for future large scale land reclamation in the Netherlands.

4.1.3 Social feasibility

From historic perspective, land reclamation projects in the Netherlands have received negative feedback from the society. The reclamation of the Flevopolder presents a clear example were the public favoured environmental preservation over any socioeconomic gains. Additionally, the involvement of the public by the government was minimal. It was only until after the acceptance of the proposed project the Dutch government realized the significant importance of social support. In the end, it took a major flooding for the public opinion to shift towards an acceptance of the proposed reclamation.

Nowadays public involvement is being taken in well within the Dutch planning system. During the planning phase of the Maasvlakte 2 the Dutch Government and the Port of Rotterdam

decided to chose for a classical decision-making structure, as discussed in section 3.2.1. As a result, this public involvement has led to significant change in complexity within the planning processes. Where during the construction of the Flevopolder the public was initially not much involved, the public and environmental organizations had gained influence in the planning process during the construction of the Maasvlakte and Maasvlakte 2. The involvement of the public was further enhanced by the commencing of the environmental impact assessment regulation introduced in the late 1980's. Due to mutual respect from both government side towards the public and vice versa, the Netherlands have established large social support and therefore receive a high social feasibility.

The following table summarizes the aforementioned results in one comprehensive overview.

Tabel 6: sustainable feasibility overview case study 1: the Netherlands – the Flevopolder and Maasvlakte

FEASIBILITY RESULTS CASE 1					
Test area	**Rating**				
	--	**-**	**-/+**	**+**	**++**
Economical Feasibility				✓	
Environmental Feasibility				✓	
Social Feasibility					✓

4.2 Results case study 2: United States – San Francisco Bay

4.2.1 Economical feasibility

No clear evidence which implies that land reclamation in San Francisco is economical not feasible has been found or been explored. Instead, an assumption for the economical feasibility, based on the information found within the case study will be given.

As described in the case analysis, San Francisco is an important economic zone. San Francisco Bay area has a relatively high concentration of productive technology firms (Bay Area Council Economic Institute, 2012). Also taking the historic growth of the Bay area in consideration, this leads to assume that San Francisco has a strong demand for housing and city services. The presence of high technology firms and the high demand for land for urban development would assume a high economical feasibility. Additionally, the shallow Bay makes land reclamation an affordable investment. Though, this assumption is based on historic events and further research is needed to prove this assumption. Nevertheless, for the holistic approach and final verdict of this thesis the assumption will be made that San Francisco has a relatively high economic feasibility.

4.2.2 Environmental feasibility

Previous reclamation works within the San Francisco Bay area has lead to significant decline of natural land and marine habitat. Based on the case analysis, non-regulatory policies of the San Francisco government has led to an overall 90 per cent decrease of wetlands and nearly 40 per cent degradation of the Bay's maritime environment.

The San Francisco Bay is currently being threatened to shrink from what once was known as a great open water body, to northing more than a small river. As pointed out by Bauman (2001) this threat is twofold: firstly, there is the direct threat of natural sedimentation of the Bay and secondly there is the growing demand for land to facilitate urban and economic growth, which puts pressure on the shallow water areas within the Bay, also pointed out by Shoellhamer et al (2013). The major decrease of water body which has occurred since the mid 20th century makes further land reclamation environmentally not feasible. Land reclamation within the Bay could only be done with one major consequence: disappearance of the Bay entirely. This major consequence indicates a low environmental feasibility.

4.2.3 Social feasibility

Since the 1960's there has been a rapid growth of public influence within the planning processes in San Francisco. Nowadays approximately 30 organizations focus on preserving the San Francisco Bay. Additionally, the legal jurisdiction between land and sea policies have been split. As described in the case analysis, the main land policies are being driven by the San Francisco government, while the planning and jurisdiction of the entire shore line falls under the San Francisco Port Authority (SFPA). The SFPA is being supported by the public and environmental organizations. Together the SFPA, the public and the environmentalist form an organization that prioritizes natural preservation of the Bay over socioeconomic gains. Based on the result of the case analysis, it seems that the public values social benefits gained from environmental preservation more than socioeconomic gains, gained from further reclamation of the Bay, thus making land reclamation socially not very feasible.

The following table summarizes the case study of the San Francisco Bay according to the aforementioned discussion of the analysis and results.

Tabel 7: sustainable feasibility overview case study 2: The United States – the San Francisco Bay

FEASIBILITY RESULTS CASE 2					
Test area	**Rating**				
	--	**-**	**-/+**	**+**	**++**
Economical Feasibility				✓	
Environmental Feasibility	✓				
Social Feasibility		✓			

4.3 Results case study 3: Persian Gulf – Dubai, Bahrain and Qatar

4.3.1 Economical feasibility

The Persian Gulf has experienced a rapid socioeconomic growth over the last few decades. The exploration of oil has led to an unprecedented growth and wealth of the dessert nations surrounding the gulf. Additionally, due to its socioeconomic gains, rapid innovative urban development projects and the geographical location Dubai, Bahrain and Qatar have become a popular destination for tourists. The large revenues gained from oil trade and the new strategy focused on tourism, luxury and leisure makes the abovementioned states monetary invulnerable. Oversupply of arable desert lands, secure money supply and growth aspirations of the states as a whole provide space for future urban development. Economically, an urban development plan within the Persian Gulf, especially in Dubai, Bahrain and Qatar are feasible.

4.3.2 Environmental feasibility

Based on the literature discussed in the previous chapter, the Persian Gulf has experienced a significant decline in natural and marine habitat. In this case a clear correlation can be observed between socioeconomic gains at the cost of environmental loss. Ambitions urban expansion plans are being initiated to facilitate the rapid growing economy within these dessert nations and the previously untouched maritime habitat is experiencing rapid modifications. Despite statements of the lead project developer, saying that reclamation works within the Gulf stimulates natural marine habitat, a vast amount of studies oppose these statements.

Major reclamation works in Dubai have added over thousand kilometers of beachfronts to Dubai's coastline. Due to space limitations, also Bahrain has expanded its total territorial land mass with nearly 14 per cent. These major land expansions and the pace of which these developments have been carried out, have had irreversible environmental implications. According to the case analysis and referring to a study conducted by Schiedek et al (2007), land reclamation works in the Persian Gulf have led to a point of no return. Large coastal developments have permanently altered the marine habitat in the Persian Gulf, pushing negative effect on the diversity and sea quality of the Gulf as a whole. This degradation imposes serious environmental loss. A state of mitigation and remediation of the Gulf has been reached, implying a low environmental feasibility for future land reclamations within the Persian Gulf.

4.3.3 Social feasibility

While in the other cases a clear condemnation of certain parts of the public towards reclamation can be observed, the case in Dubai, Bahrain and Qatar opens a whole new perspective. Contrary to the other cases discussed in this thesis, the cases of Dubai, Bahrain and Qatar show none to only very limited literature addressing the social aspects of land reclamation in the Persian Gulf area. The lack of literature on environmental issues implies an overall negligence of Arabian society to environmental preservation. While this statement is hard to believe, evidence to proof the opposite has to be still presented. As far as to the author's knowledge, this literature is currently not available, opening up a topic for further research.

One of the very limited social issues found within the Persian Gulf., presents a dispute between Bahrain and Qatar. As discussed in the case analysis, this dispute led to heaved political tensions between the two states. This implies that effects of land reclamation goes beyond domestic borders. Another case between Singapore and Malaysia confirms these inter-boundary negative effects. As presented in the Bahrain and Qatar case, this inter-boundary effects is not only limited to political confrontations. Moreover, these political confrontations affect the social cohesion and support for land reclamation significantly. Nevertheless, the abundance of studies into the Persian Gulf and the missing confirmation of social condemnation leads to assume land reclamation in the Persian Gulf is relatively social feasible. Though, further research into this topic is recommended.

The following table summarizes the Persian Gulf area case study according to the aforementioned discussion of the analysis and results.

Tabel 8: sustainable feasibility overview case study 3: the Persian Gulf – Dubai, Bahrain and Qatar

FEASIBILITY RESULTS CASE 3					
Test area	**Rating**				
	--	**-**	**-/+**	**+**	**++**
Economical Feasibility					✓
Environmental Feasibility		✓			
Social Feasibility				✓	

4.4 Results case study 4: South and East China Sea – Pearl River Delta

4.4.1 Economical feasibility

Based on various sources discussed in the previous chapter, in the area along the south and east China Sea land reclamation has been adopted as a popular tool for governments to facilitate land for urban and economic growth. Several examples, initiated over the last

decades, can be summed up representing this increase of popularity along the south and east China Sea. Additionally, the significant growth of news paper articles related to environmental and social implications of land reclamation indicate an increase in popularity (China Daily Mail, 2005; see also China Daily, 2008; Wai, 2014). A vast majority of reclamation works in South East China has been and is being conducted in the Pearl River Delta. Reclamation in this area has become increasingly popular due to limitations in arable land supply. According to financial secretary John Tsang (Wai, 2014) land reclamation is an economical feasible option within Asian perspective as it provides the necessities to stimulate further urban expansion and economic growth.

Referring to the case analysis, the Pearl River Delta can be presented as an example where large land reclamation projects have been constructed. The Pearl River Delta region has experienced great socioeconomic growth. Therefore, demand for land is relatively high. On the other hand, urban expansion since the second half of the 20th century has had a decreasing effect on the supply of arable land within this region. Urban development has not come to a stage where they meet the physical limitations of land supply. The limited amount of space available and excess demand, causes friction which drives up land values. Mainly due to increased land values, land reclamation is a profitable and economical feasible tool for governments in south east Asia. The Pearl River Delta serves as a great example where socioeconomic benefits have been realized due to large scale reclamation projects. Due to economic benifts gained through land reclamation, The Pearl River Delta has transformed from a labour “factory” to an excellent, fast-paced manufacturing hot spot (Zhou & Cai, 2010).

4.4.2 Environmental feasibility

For several decades, South East Asia allowed for large, non regulated land reclamation along its coastal beachfronts. In the absence of appropriate land regulations, land reclamation has been carried out with a minimal attention for environmental preservation (Liu et al, 2012). Where land reclamation first served for agricultural purposes, from the 1980’s there has been an increasing share of land reclamation to fill the demand for urban expansion and stimulation for local economies.

As discussed in the case analysis, the long history of land reclamation within the Pearl River Delta has had severe implications on the natural environment. It is believed that already during the 1st century, land reclamation in the early societies caused an higher accumulation of silt, which significantly decreased the water quality of the river delta. Continues population growth within the region has continuously extended boundaries and changed perspectives of environmental preservation. The industrialisation and productivity increase of agriculture, led

to a steep increase of land reclaimed within the Pearl River region. Concerns raised regarding the environmental implications and further silting of rivers were dismissed. Instead, land reclamation was motivated to support its socioeconomic benefits and to become a drive for economic growth.

The centuries of extensive land reclamation and the rebirth of reclamation in modern times threatens historic shorelines. Years of illegal, overuse and abuse of sand excavation in the delta have led to severe degradation of marine habitat and has imposed ecological consequences. Dredging and reclamation works have permanently altered the living environment of various types of fish and fish-eating birds. Contaminated sea beds, caused by uncontrolled sewage disposal and intensified industry in the Pearl River Delta, has become a serious threat for future dredging and excavation works. Overall, the environmental feasibility is estimated to be less than average.

4.4.3 Social feasibility

As described in the case analysis and as mentioned in the previous paragraphs, South East Asian government for a long time, has allowed non regulated reclamation works by the private sector. Bristow (1984) refers to the government's reluctance and inability as the main causes for these non regulated reclamation works. Additionally, the communistic background of south east Asia has allowed only limited participation of the public. Modern reclamation proposals only receive minimal social support. Over the last decade the non-participation status of the government has slightly improved, but still, not cohesive social support is being realized.

Recent proposed reclamation projects have received a major condemnation of the public. In an attempt to increase the social feasibility, the Chinese government is giving in to its non-participatory status and allows for modifications imposed by the public. Nevertheless, the magnitude of reclamation projects and alterations of the south east China coastlines have resulted in major dissent of the Chinese public. Where the public praised land reclamation as a socioeconomic benefit in the Chinese history, today the public prioritises environmental preservation over these socioeconomic gains. In Hong Kong, many fear that continuous economic growth and urban expansion may lead to the disappearance of the Victoria Harbour. Also, with recent studies stating that land reclamation may cause structural vulnerability to existing residential blocks due to increased ground water levels does not have positive implications on the social feasibility. Though, the correlation between the implication of structural invulnerability as social distress has not been statistically proven.

Tabel 9: sustainable feasibility overview case study 4: South and East China Sea – the Pearl River Delta

FEASIBILITY RESULTS CASE 4					
Test area	**Rating**				
	--	**-**	**-/+**	**+**	**++**
Economical Feasibility					✓
Environmental Feasibility		✓			
Social Feasibility	✓				

4.4 The sustainable resilience framework

4.4.1 Land reclamation: the broad perspective

With the described case studies it has become evident that in the 21st century, the possibility for urban growth does not depend anymore on the limited supply of land which has been naturally provided. Modern developed technology and human knowledge makes it possible to gain land at the marginal cost of losing the reclaimed area in water space and marine habitat. These losses can often and are being often justified by socioeconomic benefits. According to the analyzes of the different case studies, often reclamation is being opted as a necessary tool or due to the lack of alternatives. It has become clear land reclamation is being carried out when land space problems occurs. Therefore, justification for land reclamation can be rational.

In an attempt to bring the implications of the four individual case studies in a broader, worldwide perspective, a radar diagram has been produced in figure 20 (see next page). This radar diagram presents the inter-related feasibility of future land reclamation within an integrated perspective. Observing figure 20 presents clear high economical feasibility, an average social feasibility and a low environmental feasibility.

It is important to investigate what these results, presented in figure 20 are actually implying. In general, relative little knowledge has so far been generated to fully understand the overall implications of land reclamation on the economy, society and environment. The accumulative negative effects, caused by land reclamation may not be immediately visible. It is therefore important to realize that surface water bodies are sensitive to the impacts of land use practices in water-rich environments. Therefore, land use management has to ensure that these potential impacts are considered in governmental land use policies (Du et al, 2010). Especially with the expected population growth and the scarcity of natural resources, the topic of sustainable land reclamation becomes very relevant.

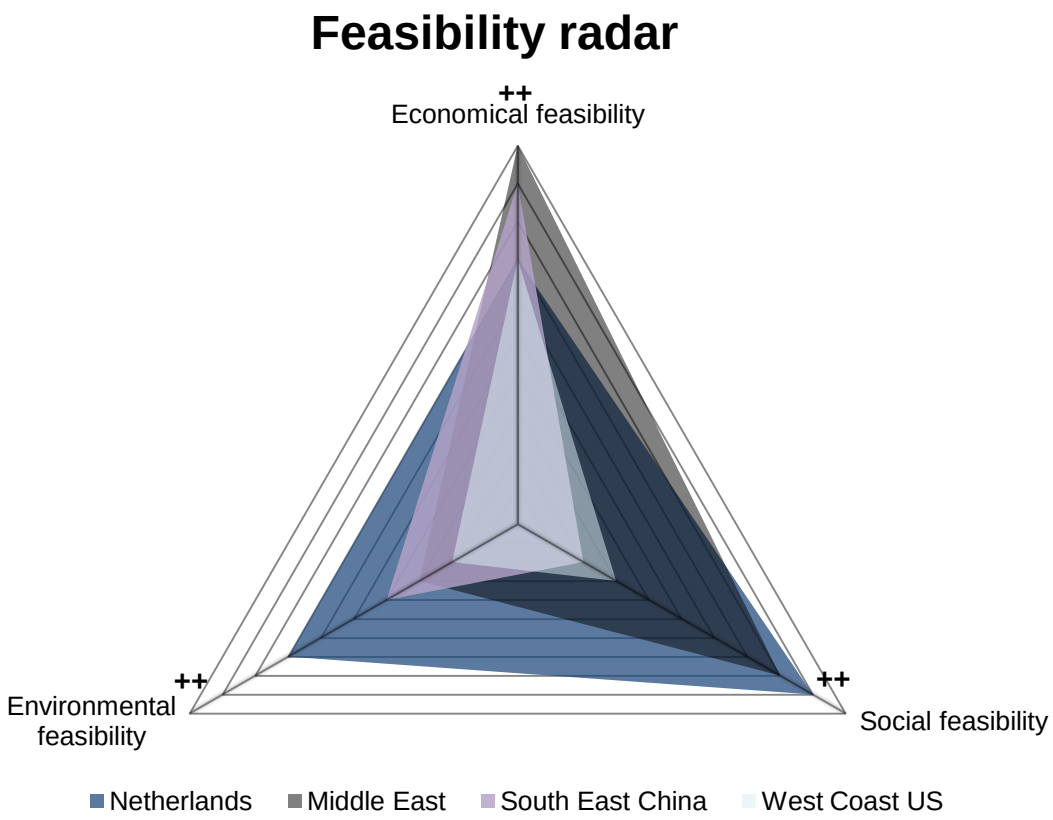

Figure 21: the feasibility radar

The rapid evolving and growing magnitude of urban areas everywhere around the globe, demand for further reaching and anticipating planning mechanisms. Based on the results from the case studies, money and finances will not be the problem. Modern technology and human knowledge has transformed land reclamation from a costly tool to a affordable, highly efficient economical solution. As stated earlier by Kolman (2011), the secretary general of the International Association of Dredging Companies and as stated by Groothuizen (2008) land reclamation “pays off” economically. It is estimated a square meter for artificial manmade land ranges around the 500 Euro’s, all in costs. While a large reclamation project could become a costly investment, with the current demand for land and the anticipated population growth, profits are most likely expected, making land reclamation economically feasible.

While the economic aspect of land reclamation seems not to be a problem, social and environmental implications leave room for a more extensive discussion. Based on figure 20, and taking in consideration the cases discussed, social feasibility seems to be very divided. The Netherlands and the Middle East seem to have a relatively high social feasibility, while San Francisco and South East China have a low social feasibility. In table 10 a relationship can be observed indicating that social feasibility depends highly on the environmental

awareness and public participation in the specific case area. This table indicates that social feasibility of land reclamation depends highly on governmental policies, already imposed negative effects on the physical environment the and overall environmental awareness of the public. Within the four case studies observed in this thesis, social feasibility tends to be high when public participation and environmental awareness are high. And on the contrary, social feasibility tends to be low when public involvement and environmental awareness are low. Government oppression and further government of states therefore also have a significant influence on the feasibility studies. Environmental awareness does not translate directly into environmental feasibility. The allowed public's involvement by governmental policies in the decision making process and the reclamation history also has an important role in determining role whether or not future reclamation is social and environmentally feasible.

It is important to remember that these case studies may serve as the basis for a generalization in order to create an overall perspective for worldwide sustainable land reclamation. Every land reclamation is unique and various local environmental, political and social aspects play a significant role in the final feasibility judgment.

Tabel 10: correlation between environmental awareness and socio-environmental feasibility

PUBLIC PARTICIPATION AND ENVIRONMENTAL FEASIBILITY				
	Environmental Awareness	**Public participation**	**Social feasibility**	**Environmental feasibility**
Case 1: Flevopolder and Maasvlakte	++	++	++	++
Case 2: West Coast Unites States: San Francisco Bay	++	-*	-	--
Case 3: Persian Gulf: Dubai, Bahrain, Qatar	--	--	+	-
Case 4: South East China: Pearl River Delta	+	--	--	-

** Public participation in San Francisco Bay was low until the beginning of the 1960s. Leaving negative effects on today's social feasibility*

4.4.2 To a sustainable resilience land reclamation framework

Various researchers (Pauly 1995; Sheppard, 1995; 2010) refer to the justification of land reclamation as suffering from the '*shifting baseline syndrome*'. The baseline syndrome occurs when environmental impact assessments, from origin, are based on a "little more than an already severely degraded marine ecosystem". Various non regulated human activities, including land reclamation, have caused severe degradation of marine life and watershed areas. The shifting baseline syndrome results in a subjective EIA and a falsified, irrational

decision making process, aggravating negative implications on environmental, social and economical feasibility.

Throughout the case studies and the latter part of this thesis it has become clear that land reclamation sets off a certain type of trade off mechanism (see figure 21). Large reclamation projects on one hand serve as great boosters for the economy and urban development, while on the other hand, these projects have severe implications on natural habitat from both marine and land species. Social benefits can both be realized through economic gains by land reclamation or social benefits from natural preservation. This implies land reclamation has basically two dimensions: a socioeconomic dimension and a socio-environmental dimension. A tradeoff between these two dimensions determine whether or not a land reclamation project for a specific geographical location could be economically, socially and environmentally feasible. With proper integrated and inter related governmental land planning processes, strong environmental considerations and increased public involvement, land reclamation could be sustainably feasible.

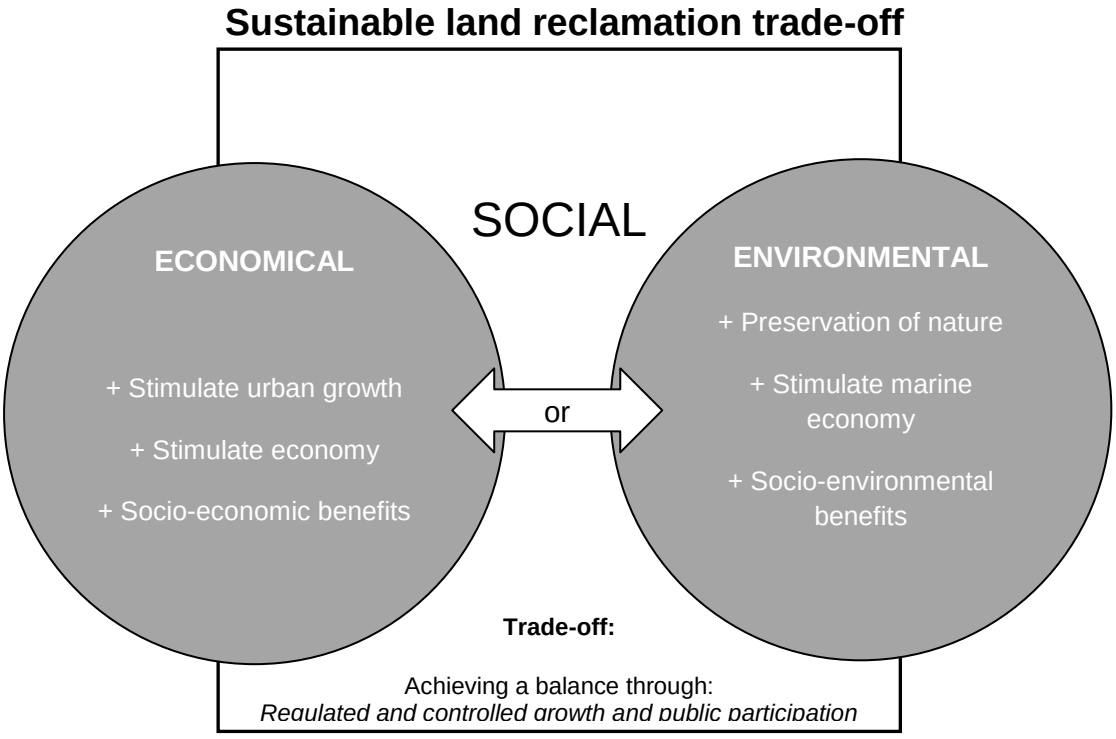

Figure 22: Socio-economic and socio-environmental trade off

5. CONCLUSION

This master's thesis has been trying to determine whether or not land reclamation could become a feasible solution for the growing urban society and the scarcity of developable land. Statistical growth patterns and various comparative case studies were conducted to investigate this central aim. In this chapter an answer will be formulated on the sub questions formulated at the beginning of this thesis.

5.1 Population growth and its implications

Despite the fact that on average less children are being born and calming messages that the population issue has basically solved itself, the world population is continuously growing. It is expected that until 2030 the world population will expand its current 7.2 billion inhabitants to 8.4 billion. Before the half of the 21 century it is expected the we will see another 2.8 billion people being added to the total population. Overall, this comes down to a rough 55 per cent population increase within the next 40 years, based on today's numbers and estimates of the United Nations, The World Bank and the Gapminder foundation.

The majority of this growth is expected to take place in the developing world and additionally an worldwide urbanization increase of roughly 20 per cent is expected. Around mid century it is estimated that approximately 70 per cent of the world's population will be living in urban environments. This translates to an absolute increase of roughly 3.6 billion urban citizen today, to nearly 8 billion urban citizen by mid century. This increase is truly unprecedented and will raise major challenges for future urban city planning. Especially coastal areas, which traditionally hold around 50 per cent of the total population face major challenges. The geographical limitations and scarcity of land in these coastal areas pushes the extension of administrative city boundaries sea inward, making land reclamation a popular tool for these governments. Nevertheless, this expected growth and the increased popularity of land reclamation seriously endangers the remaining natural wetlands.

5.2 Land reclamation and its implications

With the growing, anticipated world population and the scarcity of land resources in coastal urban areas, conduction of large scale reclamation in the future seems to be inevitable. Simultaneously, the task to preserve and nurture the marine and natural environment is becoming severely endangered. As discussed in the case studies, the environmental loss, in turn, can have adverse social, political and economical implications. The global urban modernization, imposed by today's modern technology, asks for further reaching, more controlled and innovative planning mechanisms. There is a desperate cry for planning mechanism that could solve the looming threat of worldwide environmental loss.

While financial resources to fund reclamation projects seem not to be the problem, there a plenty of objections of those who once praised urban modernism. These parties find support in their objections from the public and environmental agencies. The objections state that, amongst other things, urban modernism is environmentally unsustainable. Due to its negative environmental implications, land reclamation receives large amounts of negative social support. Nevertheless, modern urbanization today is directly linked to innovative new master planning. These master planning processes show a clear trend were governments move from “government” to “governance”, allowing for influential input for the society.

Mainly due to the absence of appropriate coordination and planning in historic reclamation projects, population growth has led to an overuse and abuse of natural resources. Additionally, the urbanization growth often outpaces the government’s ability to consider environmental implications thoroughly. As a result, natural resources are getting rapidly depleted and sustainability is being compromised. Over the total run of history, approximately 65 per cent of the world’s wetlands have been in fractioned, polluted, destroyed, altered or lost by human activities. While the population magnitude living in coastal areas is currently reaching over 50 per cent and economies are desperately looking for space to sustain economic development, more and more wetlands are expected to meet the same fate of being converted for urban development or economic, industrial gains. The lack of proper urban and regional planning will have far-reaching the consequences effects on land use, climate change and the world’s economy at large. Urbanization and future land reclamation provides opportunities at one side but it also enables a lot of threats on the other. A trade-off mechanism between socioeconomic and socio-environmental benefits seems to be present within today’s reclamation proposals.

Though, over the years a clear dived has been developed separating those who praise land reclamation and those who oppose it. With today’s modern urbanism and the rise of governance this decades long confrontation is coming to an end. Economically land reclamation has been feasible for decades. The developments within the political and governmental are now also opening up perspectives for social and environmental feasibility. Land reclamation, if properly managed and gradually applied, could become a valuable solution to solve the urban related space demand issues, now and further into the 21st century.

5.3 Political recommendations

Nowadays, the tradeoff between socioeconomic gains at one side and the socio-environmental preservation at the other, is becoming more and more important. Over the last few decades, governmental policies have preferred socioeconomic gains at the cost of

environmental loss. Therefore governmental agencies and political organizations, in particular around coastal urbanizing areas, play an important role in today's sustainability question. As seen from the case studies, the political policies and aspirations of the government have a significant impact on the feasibility of large scale land reclamation. In order to sustain economic growth and to preserve the fragile environment with land reclamation, integrated collaboration between stakeholders, initiated by the government is needed. Governments, especially in coastal areas, have to establish a balance through regulating and controlling urban growth. Together with increased public participation and involvement with various other stakeholders (investors, constructors, non-governmental agencies, environmental organizations, professionals and etc), a starting ground could be established were knowledge spillovers occur and stakeholders work towards realizing mutual interests. The government, with its urban planning authority and legislative power, should be the lead stakeholder to initiate and to control sustainable land reclamation into the future.

5.4 Further research

This study has made an attempt to put large scale land reclamation into a sustainable feasible perspective. Even though the conclusion of this study has shown a sustainable feasibility of large scale land reclamation, further research into this area is recommended. The magnitude of this research area is large and has to cover several dimensions. Some dimensions have not been covered in this research but could have a significant impact on the social feasibility. Climate change and the rising sea water level for example, forms a direct threat to coastal urbanization and land reclamation projects. Further research is needed into the relation between climate change and the threat for coastal urbanization. Additionally, in this study, *only* four case studies have been used. Further research into a various other land reclamation sites is recommended in order to establish a wider holistic feasibility perspective. And final, this research is based on intensive literature review, therefore it is recommended to connect the theory to the *real world*. Establishing the connection between theory and practice, by conducting interviews with a majority of stakeholders, could provide new useful information that could significantly increase the relevance of this topic.

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