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Development and Management of Offshore Islands

Sustainable Water Supply and Sewage Treatment

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The development and management of offshore islands are discussed in this thesis. The island involved are Vallisaari and Kuninkaansaari in Helsinki, Finland. The thesis itself is introducing from different perspectives to find the most suitable feasible and reliable methods to develop the islands with its own natural preserve. In addition, it contains a case study of comparing island tourism with Maldives.

From a general understanding of history, an economic and environmental analysis, this thesis is aiming for implementing the clean tech on the islands, create an innovative smart and clean concept that strengthens the image of Helsinki as a leading smart & clean city. The research is based on literature reviews from different fields, reports and online sources. This thesis has been conducted on the basis of information on a given tourist peak flow, and the conclusion and recommendation are theoretical and still quite preliminary. The potentials of the clean tech market are huge.

Keywords	EPI, Water from air, bio-waste, public service

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Preface

This individual project work has been compiled as the final thesis for the Bachelor's degree in Environmental Engineering offered by Helsinki Metropolia University of Applied Sciences, Finland. The author of this study shall use the study to demonstrate the learning results of the four-year EE program.

This individual project work has been prepared for Helsinki Metropolia University of Applied Sciences and the objective of the study is to offer to the Competitiveness Development Unit of the City of Helsinki, a competition for clean innovations leading Helsinki to a new age.

This work gave me a brand new perspective to evaluate my knowledge and know-how with my major in Environmental Engineering. It also tested and trained my ability to withstand massive new information and difficulties in processing them. This work benefited me in academic skills and also at the same time managed to develop several skills. I learnt time management, searching gathering and organizing information, and also got the opportunity to speak to the real experts that enlightened me in a broader field. I also realized my weaknesses and how limited my knowledge was. I would say that the most rewarding achievement through my study years so far is the completion of my Bachelor's thesis.

I would like to thank all the lecturers of EE program, who contributed to increasing my knowledge and interest in the field of engineering studies. My special thanks goes to my supervisor, Mr. Kaj Lindedahl, and Mr. Valtteri Lankiniemi from Sweco Ympäristö Oy. They were very generous with their time and knowledge and assisted me throughout this work. Finally, I would like to take this opportunity to express my gratitude towards my team who is also working on the competition with their priceless support and assistance.

I would like to acknowledge Metropolia UAS for giving me the opportunity to study in Helsinki with a pleasant atmosphere and facilities. I also want to thank to Sweco Ympäristö Oy for offering help and support in order to be able to finish it.

1 Introduction

This individual project work proposal has been written in order to identify the challenges and to suggest solutions to the problems present on the Islands of Vallisaari and Kuninkaansaari. Furthermore, the objective of this study is to find out whether providing leading clean technologies on the islands would boost the local tourism and therefore create business opportunities for Finnish companies. The main problem of the study is that the islands have been isolated from other archipelagos for military use for some years. The ambition is to turn them into a tourist site and specifically a platform for showcasing Finnish know-how in development of clean technologies and this solution, however is very challenging but at the same time an interesting way of utilizing limited resources for a good cause.

The purpose of this study is to identify the issues on 3 main themes of the whole competition and to present conclusions and recommendations on how to solve these issues. At the same time the conclusions and recommendations must result in a minimum carbon footprint and be environmental friendly. The objective is to enable the emergence of clean technologies as a subsector of the tourism on these islands and help the Finnish companies to provide their services in order to create job opportunities.

This study has used secondary research in order to find the most appropriate solutions to the detected problems and prepare a reliable study for the readers. The study has been structured so that it offers topic-related and the following information in the order of:

1. Introduction to the problems
2. Case study
3. Presentation of the different solutions found in the research process
4. Final conclusions and recommendations in order to solve the detected problems

1.1 Objectives, Scope and Methodology

The objective of this research is to find out the most feasible clean technology solutions for the islands. The market potentials for Finnish companies to establish themselves on the islands with providing their services to the public, potential customer groups engaged with tourism industry were investigated.

The positive and negative impacts of tourism are described in the thesis with the emphasis on environmental impacts, which are the most relevant considering the theme of clean technology. Furthermore, one developed tourist destination country was chosen as a case study in order to outline different cultures and environments issues. The Maldives was selected because they have a solid popularity as a tourist attraction, but at the same time represent totally different cultural and economic backgrounds compared to Finland, as well as differing tourism attractions and natural environments.

The information for this research was obtained from topic-related by literature reviews on tourism, management, water related reports and materials provided by the City of Helsinki.

2 History and Background

Vallisaari and Kuninkaansaari islands are situated a short distance off the coast of Helsinki, next to the Suomenlinna Fortress. These islands are surrounded by the Baltic Sea and Vallisaari has served the Finnish military as an arms depot. These islands provides military activities dating back hundreds of years. These two islands holds the richest heritage of Finnish history.

The Swedish Reign

In the middle ages, dating back to the 16th century, Vallisaari was known as Lampisaari (Pond Island) by its old name. Until the middle of that century, in 1550s Helsinki was then found. It is possible that the early fortification happened during the foundation of Helsinki. However, the earliest recorded information on the fortifications were in the 17th century, at that time the island acquired its present name, Vallisaari (Embankment Island).

By the middle of 17th century, the decision of constructing a massive sea fortress offshore to Helsinki was taken, construction began in 1748. On a neighboring island, which by today's name is known as Suomenlinna, a powerful fortress was built, known by the name in Finnish as "Viapori" and referred to as the "Gibraltar of Finland". [1]

While a small fortress was built on Vallisaari, the island remained otherwise in its natural state, with the cattle grazing in Vallisaari, the island served as a supply point for Vallisaari. The trees on the island were used as firewood.

In the 18th century, Vallisaari became a base for pilots. The pilots lived in their cabins at the north-western tip of the island, next to the Kustaanmiekka strait (between Suomenlinna and Vallisaari).

The Russian Reign

In 1808, Sweden and Russia were at war. When the Russians were invading Suomenlinna, the Russians brought dozens of artillery pieces to Vallisaari and Vallisaari overlooked Suomenlinna, after all, Suomenlinna surrendered to the Russians. Sweden ceded Finland to Russia, and Finland became a part of the Russian empire.

Vallisaari was renamed as Aleksanterinsaari ("Alexander Island"), in honour of the Tsar. The Russian period became the climax of fortification construction. Suomenlinna acted as an important part of the defense of St. Petersburg, the capital of imperial Russia. The Russians also began developing fortifications in Vallisaari. However, it was not until the Crimean War in 1853, that the construction gained its real motive power. [1]

For the pilots in Vallisaari, a new Luotsitalo (pilot house) was completed by 1878, and the pilots were ordered to relocate to the building. In 1910, Hylkysaari Island was designated as a new base for the pilots, but due to a lack of premises, some of them still remained in Vallisaari. The last pilots left the island as late as in the early 1920s.

In the years preceding WWI, the batteries got modernized with concrete constructions, a gunpowder magazine was built, a brick barracks for officers was built, and many storage buildings. However, Vallisaari and Kuninkaansaari began to lose their importance in role of defense. [1]

The Finnish Independence Era

The role of acting as military area of the two islands continued after Finland had become independent in 1917. Weapons were stored in Vallisaari and Kuninkaansaari until very recently. In addition to the functions of the Finnish Defense Force, a residential area was emerged in Vallisaari, with its residents being civilians employed by the state of Finland. The island was at its liveliest in the 1950s, when more than 300 people were living there. The last resident left the island in 1996. [1]

The Finnish Defense Forces announced that they would give up the islands in 2008. In 2013, Metsähallitus Parks & Wildlife Finland started a project to prepare the opening of

the islands to visitors. This unique nature tourism destination will be opened in May 2016. [1]

2.1 Market Potential

The euro zone's only Nordic member Finland is struggling to its own economy. Finnish economy is currently under recession for already four years. The Bank of Finland has forecasted that the national economy will begin to recover at a slow rate from the year 2016. The unemployment rate will improve to 9.2% in 2016 after rising up to 9.4% in 2015, according to Bank of Finland. [2]

Cleantech Finland project department pointed out that clean technology industry played a flip back, with the rapid growth under the overall economic situation that Finland's recession background, now it has replaced forest industry, became second largest pillar after ICT industry.

The latest statistics show that in 2011, the largest proportion of Finnish economy was still the ICT industry, with the output value of 45 billion euros; followed by the forest Industry, with the value of 21.7 billion euros; clean technology industry ranked third, with the value of 21.4 billion euros. By 2012, the rapidly growing clean technology industry with the 15% growth rate compared to 2011, the output value reached 24.6 billion euros, rose to the second-largest industry in Finnish economy.

The main areas of Cleantech Finland includes: energy saving, renewable energy, waste recycling and reuse, clean production, materials and products, consulting services, water management and wastewater treatment, green building, air quality protection, measurement and analysis. Amongst them, energy saving has been always an advanced and focused field. Roughly 59% of Finnish clean technology companies is working on solutions to improve their energy efficiency. In addition, 48% of the companies involved in the business of renewable energy production, conversion and transportation.

Finland's clean technology industry mainly rely on exports, more than half of the total income of clean technology every year comes from abroad. In 2012, the industry's main exporting partners are Germany, China, Sweden, France and Russia.

Cleantech Finland project department has been running an Investigation for 74 clean technology companies and they found that the most interested market in the next few years would first be China, following by Russia, Germany, Sweden and Brazil. In addition, their interests to Indian and other EU countries were also on the list.

The industry believes that the rapid development of Finnish clean technology has a great deal with international market demand, the industry's attention to the development strategy and the Finnish government’s support.

For the future development of the industry, surveys has obtained results of three conclusions:

First, ecological protection and economic development both can be achieved, but needs to be supported and encouraged by public policies;

Second, Finland needs to further develop domestic renewable energy market to ensure the international competitiveness of enterprises;

Third, providing financial support for key overseas markets is a good way of promoting Finnish clean tech growth and exports. [3]

2.2 Impact on Tourism

The Quantitative goals set by the Finnish government with cooperation of different ministry and private sectors as the Finland's Tourism Strategy 2020 are as follows:

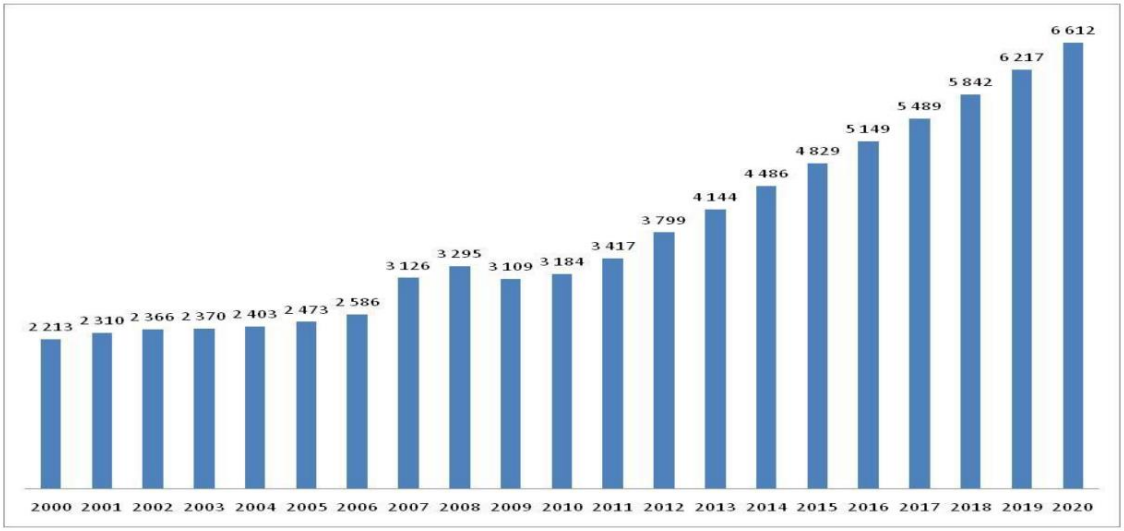
- Share of GDP, at 3.8% in 2007, will increase to 5.1%.
- Government tax revenues, at 4 billion euro in 2008, will increase to 7.5 billion euro.
- The number of jobs in tourism industries will grow from 130,500 in 2007 to 171,000.
- Tourism receipts, at 11 billion euro in 2007, will increase to 20.7 billion euro.

The number of international arrivals staying at least overnight in Finland, will grow from 3.4 million in 2009 to 5.1 million. [4]

From the perspective of national economy, inbound tourism is the most efficient way to increase the income that will generate from the tourism industry. It's been for a while that the foreign demand for tourism has been growing steadily, at the end of recession, it is expected to appear a rising trend within an expected timeframe.

In the 2000s, international tourism to Finland has been growing steadily. In 2009, a total number of 5.7 million international tourists visited Finland, it is roughly 50% more than the year 2000 as shown in Fig.1. Within that period, the number of tourist that was visiting for the day has more than doubled. According to Tourism Economics, a US-based tourism consultancy, international tourism receipts will double in the period 2010–2020. [4]

Fig.1 Development of International Tourism Receipts



Source: Statistics Finland (Years 2000–2009) and Tourism Decision Metrics (Years 2010–2020)

The key elements of Tourism industry will be developed on the basis of business potential and benefits. The significance of the tourism industry will grow in Finland during the strategy period, employing people and generating tax revenues for the government, local authorities throughout the country.

During the strategy period, both public sector and tourism trade will be aiming for improving the industry's economic significance, this includes ensuring the competitiveness, improving the business opportunities and improving systematic cooperation across sectoral boundaries. [4]

2.3 Environmental Impact

2.3.1 EPI

Environmental Performance Index (EPI) it's a method of quantifying the environmental performance of each different countries, it assessed and ranked countries' performance on 2 major areas: protection of human health and protection of ecosystems. The United Nations Sustainable Development Goals (SDGs), adopted in September 2015, has a similar but parallel approach, with the 17 goals and 169 targets to guide the global development. With the alignment of these two official goals and index, it provides a baseline for evaluating environmental performance of each country and shows how far away each of them are from reaching the global targets.

EPI 2016 was developed by many different bodies, Yale University, Columbia University, World Economic Forum and Joint Research Center of the European commission. [5]

From the trend of EPI reports in the past years we can see that the ranking of Finland has been wobbling in the top 20, every year there is more and more countries being assessed and ranked in the report, different background of their environmental issues has been affected the results, also the new indicators have some influence in it. In 2016, there is 180 countries being ranked, it can be the most authoritative report in the history of EPI, and as the indicators are so complex, it has covered so many different aspects, and this report is trustworthy to read it.

Fig.2 EPI 2016 Rankings

Rank	Country	Score	Peer Comp.*
1	Finland	90.68	↑
2	Iceland	90.51	↑
3	Sweden	90.43	↑
4	Denmark	89.21	↑
5	Slovenia	88.98	↑
6	Spain	88.91	↑
7	Portugal	88.63	↑
8	Estonia	88.59	↑
9	Malta	88.48	↑
10	France	88.2	↑
11	New Zealand	88	↑
12	United Kingdom	87.38	↑
13	Australia	87.22	↑
14	Singapore	87.04	↑
15	Croatia	86.98	↑
16	Switzerland	86.93	↑
17	Norway	86.9	↑
18	Austria	86.64	↑
19	Ireland	86.6	↑
20	Luxembourg	86.58	↑
21	Greece	85.81	↓
22	Latvia	85.71	↓
23	Lithuania	85.49	↓
24	Slovakia	85.42	↓
25	Canada	85.06	↑
26	United States of America	84.72	↓
27	Czech Republic	84.67	↓
28	Hungary	84.6	↓
29	Italy	84.48	↓
30	Germany	84.26	↓
31	Azerbaijan	83.78	↑
32	Russia	83.52	↑
33	Bulgaria	83.4	↓
34	Romania	83.24	↓
35	Belarus	82.3	↑
36	Netherlands	82.03	↓
37	Armenia	81.6	↑
38	Poland	81.26	↓
39	Japan	80.59	↑
40	Cyprus	80.24	↓
41	Belgium	80.15	↓
42	Costa Rica	80.03	↑
43	Argentina	79.84	↑
44	Ukraine	79.69	↑
45	Cuba	79.04	↑
46	Brazil	78.9	↑
47	Montenegro	78.89	↓
48	Serbia	78.67	↑
49	Israel	78.14	↑
50	Macedonia	78.02	↑
51	Panama	78	↑
52	Chile	77.67	↑
53	Tunisia	77.28	↑
54	Jamaica	77.02	↑
55	Moldova	76.69	↑
56	Venezuela	76.23	↑
57	Colombia	75.93	↑
58	Dominican Republic	75.32	↑
59	Fiji	75.29	↑
60	Taiwan	74.88	↑
61	Albania	74.38	↓
62	Trinidad and Tobago	74.34	↑
63	Malaysia	74.23	↑
64	Morocco	74.18	↑
65	Uruguay	73.98	↑
66	Philippines	73.7	↑
67	Mexico	73.59	↑
68	Belize	73.55	↑
69	Kazakhstan	73.29	↓
70	Dominica	73.25	↑
71	Kyrgyz Republic	73.13	↓
72	Tajikistan	73.05	↓
73	Peru	72.95	↑
74	Jordan	72.24	↑
75	Guyana	71.14	↑
76	Bolivia	71.09	↑
77	Mauritius	70.85	↑
78	Namibia	70.84	↑
79	Botswana	70.72	↑
80	South Korea	70.61	↑
81	South Africa	70.52	↑
82	Paraguay	70.36	↓
83	Algeria	70.28	↑
84	Turkmenistan	70.24	↓
85	Samoa	70.2	↑
86	Bahrain	70.07	↑
87	Qatar	69.94	↑
88	Honduras	69.64	↓
89	Guatemala	69.64	↓
90	Equatorial Guinea	69.59	↑

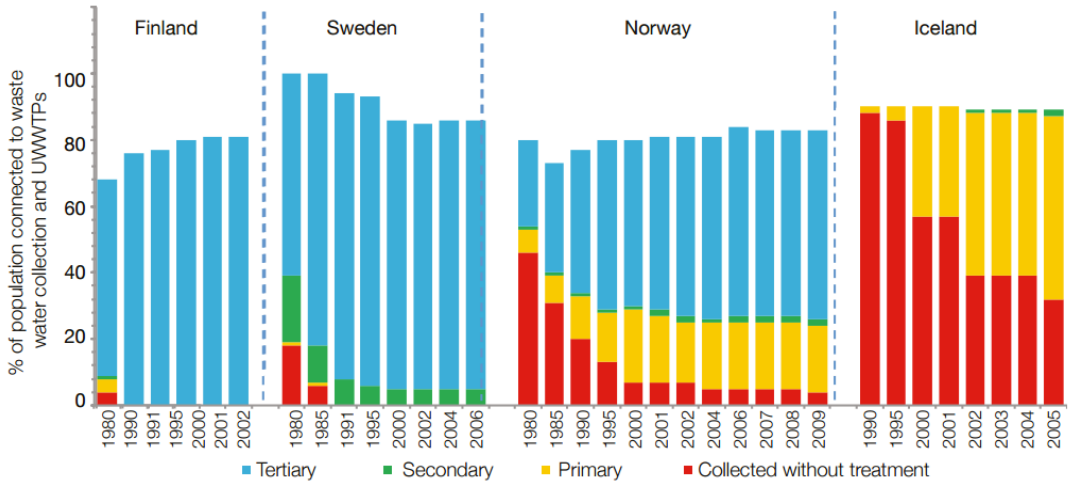
* The Peer Comparison column identifies whether a country performs better or worse than countries in its region.

As shown in Fig.2 Finland has won the first place worldwide, followed by Iceland, Sweden, Denmark, and Slovenia. Finland's top ranking comes from its commitment of achieving a carbon-neutral society that does not exceed nature's carrying capacity by 2050, meaning a society that can be under development sustainably for indefinite time. As well as a vision that is full of actionable goals and measurable indicators of sustainable development. Finland's goal of consuming 38 percent of their final energy from renewable sources by 2020 is legally binding, and they already produce nearly two-thirds of their electricity from renewable or nuclear power sources. [5]

In addition to the rankings, the 2016 EPI provides an overview of global environmental performance, identifying the key trends and the status for high-priority issues. Out of 9 key trends, the most relevant to Finland is '23 percent of countries have no wastewater treatment'. Finland has excellent quality of drinking water, every household has access to drinking water from the taps. The SDG goal number 6 states 'ensure availability and

sustainable management of water and sanitation for all.' Out of 8 targets of this goal, Finland has achieved most of them.

Fig.3 The European Environment Agency (EEA) collects and reports data on the percent of the population connected to different levels of wastewater treatment.



Source: EEA-Eurostat, 2013.

From the Fig.3 we can clearly understand why Finland got the first place despite other factors, just on the wastewater treatment, it has shown the world its importance.

From the year 1980, most of the European countries started to develop their wastewater treatment, within 10 years, Finland was the first one to achieve with most population on the tertiary stage which were traceable, even though it's not 100% that is on paper, but with that early age and high achievement, the result is remarkable.

A country of 5.5 million population could achieve this great result, it is truly the most livable country, its rapid development of clean technology has great contribution, with the international market demand, the industry's attention to the development strategy and the Finnish government's support, clean tech should be more invested and encouraged to be more developed for the benefit of human kinds and nature.

3 Case Study

3.1 Island Tourism Development in Maldives

Maldives is approximately 500km southwest of India. The Republic of Maldives is an islands chain consisting over 1000 islands, with the size of 820 km by 130 km. The area is more than 90,000km^2, but the land area altogether is less than 300km^2. In the region, there are roughly 200 islands are inhabited, 87 are used as resorts, few of them are used for industrial/agricultural purposes and the rest are uninhabited. [6]

The climate around Maldives is tropical, warm and humid all year round and with the average humidity of 80%. The mean annual rainfall in Malé the capital island is approximately 1980 mm. There's no rivers or streams in anywhere in the region of Maldives, but a few wetlands or freshwater lakes. The country's freshwater resources exist as groundwater.

Maldives locals rely on rainwater for drinking and groundwater for other purposes. Rainwater is collected from the roofs and stored in many different types of tanks. All of the islands have their own individual tanks as well as the community tanks. The situation is a bit different in Malé, everyone is accessible to desalinated water from the distributed pipe network. In Malé, desalinated water can be used for drinking as well as for other needs.

The need for water due to populated area that cannot solely rely on taking it from the nature, the government of Maldives started the project of desalination plants in the 1980s. Desalination is an expensive alternative in Maldives, but it's necessary in some islands. Desalination is widely used in many tourist resorts, these islands are solely for tourists, and each of them has its own small desalination plant. The islands are generating a huge amount of money from the tourists, this is the only affordable way to support the desalination operation. [6]

Here is some historical data of how the water system developed in Maldives according to the report. [6]

1906, first rainwater tank for public was built
1909, second rainwater tank built, total of capacity of 96,975L
1973, Maldives Water and Sanitation Authority (MWSA) established
1972-1974, population boom from 15279 to 29500
1978, cholera outbreak
1982, Shigella outbreak
1985, water supply and sewerage project
1988, first desalination plant installed
1995, Malé water and sewerage company (MWSC) formed

3.1.1 Freshwater Resources

The two main water resources are groundwater and rainwater. In the rural islands, people usually use rainwater for drinking and cooking, groundwater for other purposes.

Rainwater is collected and stored in many different types of tanks, it varies with material, and it can be made of steel, Ferro-cement, HDPE or fiberglass. Each islands has both community tanks and private household tanks. According to the report, since HDPE tanks has come out to Maldives in 1994, it has become the most popular one due to its simplicity of maintaining and high durability. Even the rainwater tanks are available there are often problems during the dry season, either the capacity is not enough or the area for collecting rainwater is too small.

According to the report, Beswick (2000) has done a calculation of showing the correlation between roof area, storage volumes and the supply 10 L/p/d of water (see Table 1). The calculations shows how different households, different tank sizes and roof area correlate to each other. For example a household of 4, would need a tank size of 2000L and a roof area of 24m^2.

Household Size (Persons)	Roof Area (m^2)	Tank Size- (Litres)	Supply (L/p/d)	Percentage of Supply Caught
4	24	2000	10	42%
6	24	2500	10	61%
8	24	5000	10	86%
8	36	4000	10	55%
10	36	4500	10	67%

Table 1. Rainwater Tank Sizing

The values in the table 1 pointed out that even though country's drinking water demand can be solved by increasing the capacity of collecting rainwater, but the other proportion of demand, water used for domestic purposes has to be solved by an alternative sources, which in this case it's the groundwater. The groundwater resources are in fact sensitive and weak towards pollution. When groundwater has been overused and reduced in its quality, as the brief history of Malé shown, desalinated water has become necessary.

3.1.2 Groundwater Resources

Although Maldives has few surface water resources in the form of lakes, rainwater has been harvested and stored in tanks, but the majority of water resources are stored as groundwater. The water table is found at a close surface, usually not more than 2 meters below the ground level.

On most islands, the freshwater lens is less than 12 meters in thickness, but in populated islands it is less than that, due to the overuse of groundwater. Therefore the groundwater is vulnerable in many ways. Because the water table is found at such shallow depths, they can easily be polluted from the human activities. Another reason that would be groundwater will increase in salinity as a result of over-extraction. When sea level rises due to global warming, it has increased the chances of saline intrusion, and therefore it has been a threat to Maldives' groundwater resources. [6]

3.1.3 Desalination in Maldives

When the water quality got reduced and not enough rainwater for collection and storage, desalinated water has become the only alternative way of providing a safe water supply. This is the case in the capital Malé and in the most populated island.

The first desalination plant in Malé was installed and completed in 1988 with the capacity of 200 m^3/day. With the increasing amount of population and the need for water, the capacity has been increased steadily and now it's at 5,800 m^3 /day. Due to its high price, desalinated water is not used for all purposes. It's been mostly used for drinking, cooking, bathing and other domestic purposes. Groundwater is mainly used for toilet flushing. The locals prefers to save money and collect rainwater instead of desalinated water for drinking.

Outside of Malé, desalination is widely used in the tourist resorts. Each resort island has its own desalination plant. Those desalinated water that's produced is mostly used for bathing, guests are recommended to buy bottled water for drinking. The responsibility for operation and maintenance of the plants is held by the island office, it operates in the same manner as a local government office. [6]

3.1.4 Comparing Finland with Maldives

The water that coming straight from the pipes in Finland, has several steps of treatments before it arrives in the resident's glass. Finnish water is something that Finns are really proud of, the water is drinkable even in many of the lakes. Comparing to Maldive, Finland in the 1980s has already achieved roughly 70% of the population covered with tertiary treatment for water, on the Maldives' side, they just got started their desalination project. Finland has high level of environment regulations, which brings more competitions amongst the Finnish companies. Hence, there is many sustainable innovations that has delivered in the waste water treatment sector year after year.

In Finnish companies, waste water is also seen as a major source of renewable energy. During the chemical treatment process, through anaerobic digestions, it could generate more biogas with a high energy value. The waste water treatment industry in Finland has high standards and strict regulations that dictates development of new technologies, with these advantage, it makes them truly a world leading players in waste water treatment industry.

4 Sustainable Water Supply

4.1 Water from Air

Amongst all the water resource we have on earth, 2.5% of it is fresh water, there is lack of safe drinking water in many areas around the world. With over 7 billion people on earth, 783 million don't have access to clean water.

There is a unique way of extracting water from humid and ambient air, it is so called atmospheric water generator. It operates in a very similar way compare to dehumidifier. Humid air would pass through a cooled coil, causing vapor to condense. The rate of producing water depends on the many factors, temperature, humidity, the volume of air passing through the coil, and also the machine's capacity of cooling. For water extraction from air, this is the most common method, but usually it's powered by coal-based electricity, it results to be one of the worst water source due to carbon footprints. But if we connect to the renewable energy source we have in Finland, this will turn into a most desired way of producing water. [7]

Fontus has developed a way of extracting water from the air, but water extraction from air is a slow process. The self-filling bottle from Fontus works at the rate of 17 ounces per hours, it's good for personal use, but does not solve the problem of water crisis, the bottle does not filter out air pollution.[8]

Average drinking water consumption for tourist visiting the islands was roughly calculated with roughly 8 ounces per person per glass and 5 glasses of water per day that is 40 ounces. With the current model of *Fontus Airo* it is required roughly 230 pieces to operate 24 hours per day and 7 days per week, with that amount of water being produced from air, then it is capable of supplying water even in the summer peak. [9]

There is another incredible innovation of extracting water from air, this works in places where there is no special requirement needed, it produces 32 Liters of water per day minimum, and no plumbing is needed. It requires an electricity connection and it will

work. It is ideal for homes, business or restaurants. The mechanism is similar, these models draws air into the machine through filter, then it goes through a filtration process, an ultraviolet let sanitization, there is also pre-carbon filter, post-carbon filter and reverse osmosis all built-in the machine. After filtration process, it's pumped to the top of the machine for storage.

Manufacturing water depending on the size of the model, the model *WFA100* on good conditions it will produce 1500L / day; smallest one *WFA3* will produce 25L / day. With this solution in consideration to solve the whole water consumption issues on the islands it can be easily solved. Taking account of drinking water, water used for hygienic purpose, roughly around 23 pieces of these machines would cover all the water usage even in the summer peak time. [10]

4.2 Natural Reservoir

A reservoir is a storage space for water, usually it means by the artificial lakes, pond or dam, seasonal changes of runoff and rain mostly feed the reservoir. The stored water can be used for irrigation, drinking purpose after purification or to produce hydro power. On the Vallisaari Island there is 3 reservoirs open to the air, their sizes varies. One of them is included in the first phase of the project, with rough dimension of 1 hectare and 4 meters depth, it's sufficient enough to store water up to roughly 40,000 Tons.

Reservoirs can be controlled by restricting flow and preventing draining away through cracks of container or natural existing water body. Water would slowly loss due to evaporation and depending on the different types of sediments at the bottom of the reservoir. They can be very useful on the islands where there isn't sufficient enough of fresh water supplies. Water can be obtained from the reservoir through a pipeline network. In the case of Vallisaari island, the reservoir is a natural lake, the water surface is lower than the ground, the only way to take the water out is by using a pump, pumping consumes electricity, therefore it would be supportive if electric grid would be connected to close by. If the reservoir would’ve been on the higher ground, during the transportation of the water, the kinetic energy can be used to produce hydropower.

Many reservoirs often allow some recreational activities, such as fishing and boating, some rules may apply for the safety reasons and to protect the quality of the water and the ecology of the surrounding area. Around the reservoirs, it is recommended to have less constructed recreation such as history sign post, bird watching post and hiking route guide.

4.3 Green Roofs, Rainfall and Runoffs

Many of the old buildings on the islands that should already have fungi and mosses growing all on the roof, these green roofs has various benefits. They could serve purposes such as absorbing rainwater, providing insulation to buildings, create nesting place for wildlife and also it helps to lower the air temperatures.

Green roofs are used for the benefits of the following facts:
-Reduce heating
-Natural Habitat Creation, it provides nesting places for animals
-Filtering pollutants as well as filters out heavy metals in rainwater
-absorbing carbon dioxide in the air, this helps to lower respiratory disease rates
-Helps to insulate sound, the soil can help to block lower frequencies and the plants can block higher frequencies [11]

With green roofs, water is stored by the soil then consumed by the plants and after that it is returned in the form of oxygen to the atmosphere through Photosynthesis process. As of excess rainfall, the rainwater can be stored through flowing pass green roof, it does the primary filtration process, filtering out pollutants and heavy metals, so in a way it is cleaner than rainwater straight from the sky. This method also reduces pressure on sewers, reduce pollution and downstream flooding. The roofs can be designed on one edge lower than the others, so the rainwater would be collected at the same point, and then drain down to the storage room of every house, it can be later used for gardening purpose and flushing toilets. These steps is aiming to improve the urban ecology, it does cooling at the same time to the buildings.

4.4 Monitoring Wells

Groundwater is another source of freshwater. Groundwater is usually treated with the reverse osmosis method, it is known as the most effective and modern way of treating groundwater. The so-called reverse osmosis has a very simple principle, putting pressure on the raw water side so that pure water molecules would pass through membrane and produce pure water. Other impurities and harmful substance would not be able to pass the membrane. Due to the very small space in the membrane that is used for filtration, it can effectively filter out water that contains bacteria, viruses and various harmful substances.

Monitoring wells provide groundwater samples that can be analyzed to detect the groundwater quality as well as the water level to see the groundwater movement. They can also be used to estimate the hydraulic characteristics of aquifers. However, the monitoring wells typically have a longer open intervals for retrieving water samples or testing aquifers.

Monitoring wells not only serves as the purpose of monitoring and analyzing groundwater, but also connects to the aquifers, this would allow access to groundwater. In this way, monitoring well is built for two purposes in one step, it is a very beneficial measure.

4.5 Comparison of Waters

Different types of water has different purposes in real life, here is a comparison table to show the ability of what each type of water can do and can't do, to differentiate and to see the values of recycling water. See table 2.

Table 2. Different usages of different types of water

		Drinking	Flushing toilet	Shower	Irrigation	Livestock
Water from air		√	√	√	√	√
Reservoir			√		√	√
Pipe water		√	√	√	√	√
Rainwater			√		√	√
Groundwater			√			
Bottled water		√	√	√	√	√

5 Sewage Treatment

Sewage in this thesis it is considered waste and wastewater. According to the historical reasons, the two islands was isolated for military performance, not much technology has been implemented on the islands. On the competition booklet, it states ‘neither of the islands have sewage networks. The sewage system is based on the use of closed underground containers or composting toilets.’ [12] There it comes to the challenging part of all. The old methods that exists on the islands for treatment is obviously not the ideal case anymore, and to show-case the cleantech of Finland, it is best to completely replace them with these new technology and new solutions.

5.1 Source Control

The very first step in restoring waste and wastewater is controlling the source where it came from. It must be prevented from the beginning before the release of the contaminants. Essentially, there are two main approaches of controlling the source. One is that the source is extracted and removed, other one is let it be isolated at the same place. Extraction and removal may not be feasible if the source is scattered around. Furthermore, extracting the source requires a nearby facility of willing to accept the waste.

The alternative source control measure, waste isolation involves three main steps. Firstly, surface drainage is modified so that runoff moves around the source. If it is not altered manually, runoff can erode the soil cover and transport waste compositions, either in solution or suspension. Secondly, a low permeability cap must be placed over the source. Usually, the cap consists of compacted clay or synthetic material. The purpose of the cap is to prevent additional leachate from forming. Thirdly, a barrier should be constructed around the waste to restrict it laterally and shift any groundwater flowing toward it.

5.2 Centralizing Bio-Waste

A very practical example of source control is by centralizing the waste. Most of the waste are either recyclable or biodegradable. Dry toilets / composting toilet is one of the best options.

A composting toilet is a type of toilet that uses mainly aerobic processing method to treat the human excreta, in most case feces. Composting toilets produces composts that may be used for agricultural soil's enrichment, also known as the natural fertilizers, it is commonly used in rural areas. These toilets usually consumes little or absolutely no consumption of water and it is used as an alternative to flush toilets. They are used in situations where there is no water supply or sewage system. They are in use in many roadsides and national parks as the public toilets in Sweden, Canada and other north countries. They are also used in rural areas for holiday homes in Sweden and Finland.

As there is some composting toilets already exist on the island, but the limited number of them couldn't manage the huge tourist flow during the summer season, a large integrated composting toilets would be a good support to solve the issue. By large it meant for several toilets placed in a row, common container from several composting toilets next to each other, easier to treat, easier to control. By integrated it meant for different purpose, they generate biogas and biogas is primarily methane (CH4), it can be used as a cleaner energy than any other fossil fuel. The material from composting toilets can be suitable as an organic fertilizer or soil amendment for agriculture. It is worth to mention that there is a special type of dry toilet with urine separation, which allows urine separately collected into different container, first of all, makes the bio-waste lighter in weight and more concentrated and secondly the urine can be treated without an extra process.

Bio-waste and solid waste that's produced on the island will be composted on-site. If the waste is later sent to mainland, treated first then landfilled, it will cost lots of money and during that time the waste is getting rotten, it generates more harmful gas than if it was composted in early stage. Generated waste such as cardboard, plastic, metal or en-

ergy waste will be first compressed and baled, then transported to the mainland for further treatment.

Dry toilets as one of the options, but it cannot be the only one. It has been implemented in many countries in rural areas for holiday use, for tourist that have lived in the city all their lives, might be a bit uncomfortable. Normal standard toilets should be built as well, needn't be much, it is most appropriate to build it at the most centric places, the tourist info center would be the one since that’s where everyone enters and leaves the islands.

5.3 Grey Water Treatment

Grey water by its definition is the type of wastewater that doesn't include water that has been contaminated with feces or neither is it coming from the toilet. Grey water usually contains mostly leftover food, dirt, grease, hair or it can also have other types of household cleaning products. Even though grey water is considered as waste water, but it is safe or sometimes good for using it as irrigation water in garden or yard, due to its source, it might contain nutrients that plants might need.

There is a reason to separate grey water from mixing it together with all other things into the sewer, because of its nature that it is easier to treat before it is mixed. Grey water treatment can be as easy as filtering sand. The innovation of bio-box/ easy-box has served the purpose of treating grey water. The mechanism is very simple, there is 3 filtration layers in the order of fibre, coarse foam and aqua clay from top to bottom respectively. All 3 layers stacked up and putted into a box with flow control, temperature control and an outflowing pipe, place it inside the grey water, it will start filtrating automatically.

6 Public Services

Public facilities provides the public a variety of public services, public goods, service facilities. According to the specific characteristics of the project it can be divided into many categories, such as education, health, culture, transportation, security and community services. Specifically, urban public facilities refers to municipal sewage treatment systems, municipal waste processing system, roads, bridges, ports, road signs, scenic spots and the city parks.

According to the general plan that has been provided, the islands would develop into a fully nature preserve tourism island. Therefore the island needs to be fully equipped with all the public service that can be provided to the tourist, to ensure the whole experience on the islands.

6.1 Tourist Center

Tourist center or info center, it's the first place that a tourist would want to go for information, guidance and help. Tourist center it's a place that provides visitors with information on the area's attractions, maps, and other items relevant to tourists. Often, these centers are operated at the very beginning of the entry, for example airport and harbor by the local government. Most often a tourist center is called simply an information center with big capital ‘I’ letter in green color.

As Vallisaari’s project plan in phase one is to open the guest harbor (Torpedolaituri) on the east side of the island, it is close to the center square (keskusaukio), it will be the most popular place on the whole island’s attractions. Therefore the tourist center should be built as a multifunctional center, it should include the regular services such as providing informations, maps, brochures about the island. Apart from these, rental services for bikes, shops for buying snacks and beverages, maybe even a post office.

6.2 Island Traffic

As the goal is to make the island equipped with clean tech, first and foremost prior thing is to restrict the carbon footprint. That can be done in various ways, one way is to use the energy-free vehicle, the bicycle. The island is very cosy to ride with the bicycle, roads are narrow, forest smells fresh in the summer, and it would be the best combination for tourist to experience the Finnish nature. Due to the historical reasons, the source of electricity that is provided on the island is a cable under sea from Santahamina (an island on the eastern side next to kuninkaansaari). Considering some population that requires more than a normal bike, electrical vehicles can be also the options for rental. Electrical charging station would be only at the renting place, the battery of the electrical vehicle should allow to go around the island few times.

6.3 Bunker/ Cave

From the early ages, the fortification was built for defense, storage for ammunition and nowadays there is almost no practical use. As the tourism is opening up, all of these bunkers from smallest of 32m^2 to biggest of 561m^2, they all can be utilized for the tourism industry. Along the route down from the west side of Vallisaari, several small bunkers can be used for corporate exhibition for their technologies. Companies can present their newest clean technology in the bunkers and give some freemium tryouts, due to the limited amount of bunkers and big numbers of clean tech companies, the exhibition could be rotated, in this way it's more challenging and it will create more innovative ideas.

These bunkers can be also changed to a warehouse, transformed to stores or even to grow mushrooms, converting into housing is also an option. With some repairing, it can be used as hostels for visitors. Some can also be transformed to entertainment purpose, for example bunker bars, cafes, tourist shops, these may also have a great impact for tourism.

Large bunker that goes few hundreds square meters can be transformed into a large "bunker restaurant". The restaurant will be arranged similar to a military canteen, waiters should have been served in military before, and possibly the menu is going to be written in the standard military telegram format, this will be a big distinguishing feature. On the summer peak season, the dining rooms would require some time in advance in order to book a place for a meal.

6.4 Recreational Activities

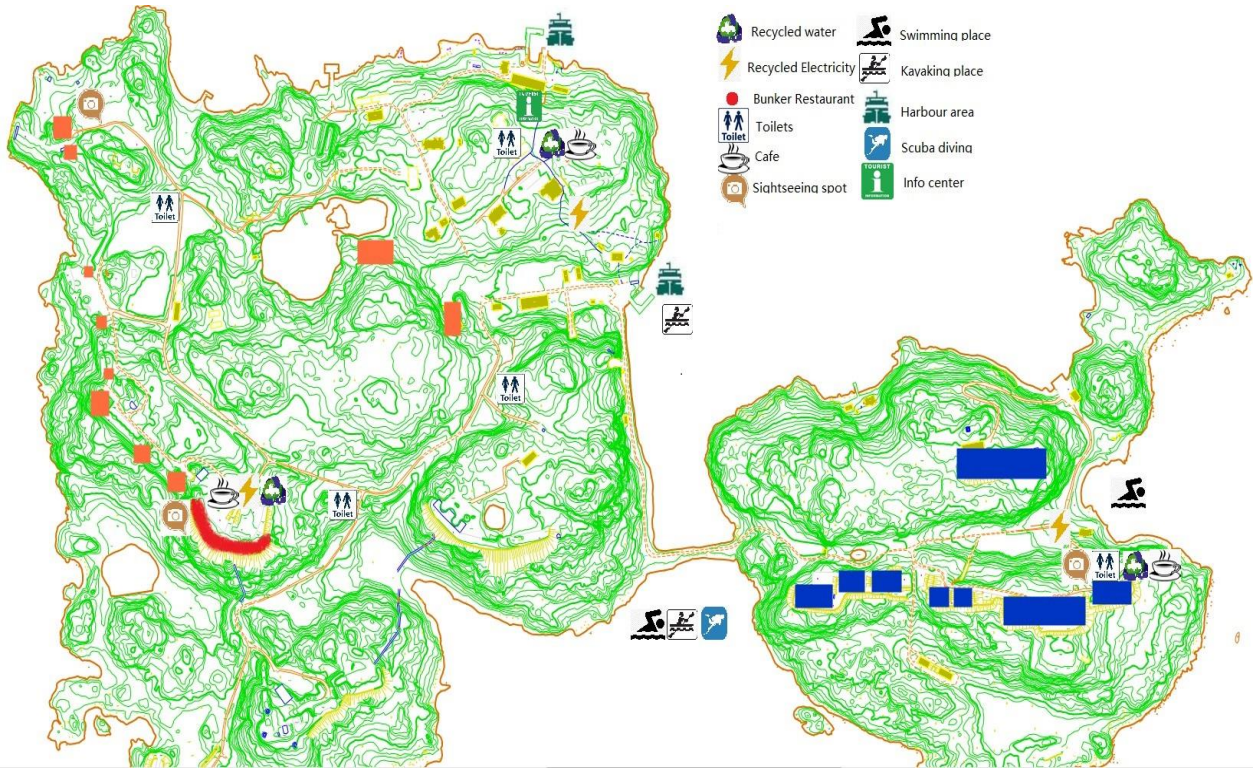
People expected water, beach and sun from an island and there will be no exception with vallisaari islands. On the very east of Kuninkaansaari there is a small bay could be the option to turn it into the beach. The underwater scenery will be spectacular near the beach, high-quality diving experience could be provided. There you can also choose to kayaking, scuba diving, boat tours around the different big and small islands nearby. This will be the most exciting and unforgettable experience. Hiking is also an option for tourist, the main scenic route on Vallisaari has pavement of roughly 3,4km that is completed and the condition it’s perfect for hiking. The richness in vegetation and tranquil mood makes you easily forget the muddy roads, or even intoxicated. When tourist has reached the peak, overlooking the entire archipelago, Vallisaari will be remembered in lifetime.

7 Conclusions and Recommendations

With the brief history of both islands, we can understand better how and why the islands have maintained their natural state so untouched. It is essentially important to preserve the natural state of the islands as they are, since it will be a unique experience for tourists.

From the Finnish tourism strategy, it can be clearly seen that it is a rapidly growing sector of the economy, and the Finnish government pays great attention to it. As well as the fast development in the clean tech, it has boosted the economy both financially and in an eco-friendly manner. There is no doubt that in EPI Finnish environment is ranked in the first place worldwide due to its multidisciplinary support to make it happen.

To put this research work into practise, here are some points and ideas that are worth mentioning.



All the orange blocks are bunkers large enough for hosting events, or for the use of storage or hostel purposes. For showcasing the Finnish know-how in the development of clean technologies, it would be beneficial if those bunkers were rented to companies for

rotating exhibitions of their clean tech products. It can be suggested that if clean tech products were used or displayed in exhibitions on the island, it would provide a perfect opportunity for companies to expand their markets.

The biggest bunker space in Aleksanterinpatteri could be used for serving military canteen food. This idea would match the military heritage of the island perfectly, and it could make the tourists feel like in the old times, when the military was still in charge of the islands.

Water is produced by the water from air machine plus the treated rainwater is also included. There will be an electricity grid connected from Kuninkaansaari, as well as energy generated from bio waste, renewable energy from the sea, all in all, this bunker would be a modern military canteen fully equipped with the latest clean technology.

These technology combinations apply also to the port area, where there is an extra service of renting bikes available. A bike is an environmental-friendly vehicle that is most suitable to use on the island.

On both sides of the road bridge between Vallisaari and Kuninkaansaari, it is very possible to arrange some recreational activities, especially in the summer season. For example scuba diving, kayaking and swimming could be organized. Later in the development phases, if the nearby archipelago is available, boat tours can be arranged for sightseeing.

The blue blocks serves mostly the same purpose as the orange ones. On the east side of the Kuninkaansaari, there is the only beach within the two islands. In the summer it is filled with tourists, and those bunkers can be used as resting places, providing cheap sleeping space or even storage space when people are relaxing on the beach. It is also equipped with an electricity grid and water from air machines, biogas and other renewable energy and a cafe, is also available during the summer heat.

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