Bridging to the common ground, adapting to climate change through sustainable estuarine land use

A study of the Inner Forth, Scotland.

Pontus Ambros

Master Thesis Series in Environmental Studies and Sustainability Science,
No 2016:019

A thesis submitted in partial fulfillment of the requirements of Lund University International Master's Programme in Environmental Studies and Sustainability Science (30hp/credits)

LUCSUS
Lund University Centre for Sustainability Studies

Bridging to the common ground, adapting to climate change through sustainable estuarine land use

A study of the Inner Forth, Scotland.

Pontus Ambros

A thesis submitted in partial fulfillment of the requirements of Lund University International Master's Programme in Environmental Studies and Sustainability Science

Submitted May 16, 2016

Supervisor: Asso. Prof. Kimberly Nicholas, LUCSUS, Lund University

Abstract

This thesis looks at climate change adaptation strategies in the Inner Forth region in Scotland. The region is expected to suffer from climate change induced stresses such as flooding, sea level rise and storm surges. To cope with these changes, a new coastal adaptation strategy has been suggested, based on soft solutions such as wetland creation and managed realignment. This has caused a dispute, where many farmers feel that their agricultural practices and cultural heritage is threatened. It has led to a division between stakeholders where private landowners feel excluded from the development. This thesis investigates if there is a solution with a sustainable land management that can answer to needs of the local community, the landowners and the coastal wetlands. I answer that question through three sub questions, looking at landowner values, their current and future strategies to cope with climate change and the landowners' response to the suggested adaptation strategies.

The data was collected by interviewing landowners, using open-ended questions, participatory mapping and a sorting exercise. The results showed that land values where different between different landowner groups, where private landowners favoured ecosystem services of agricultural character, while councils and NGO landowner's favoured services that maintained habitat protection among other values. Almost all landowners favoured natural flood protection, however it is clear that this service means different things to different landowners. The study also showed that several landowners were concerned about the climate induced changes and that little is currently done to cope with these problems. Private landowners were reluctant to flooding land, mainly due to two reasons, loss of livelihood and cultural heritage.

The discussion concludes that the output of ecosystem services will change regardless of adaptation strategy and that different services are favoured by different strategies. This shows why several private landowners favours the current static flood defence, although they are facing increased costs and greater risks. I argue that a common solution, must involve all the aspects of sustainability (human capital, nature capital and intergenerational understanding). All of these aspects are currently available among the stakeholders of the region, although not included. By including private landowners in the future adaptation strategy, a sustainable land use is more likely to be achieved.

Keywords:
Ecosystem services, Managed realignment, Climate adaptation, Landowner, Saltmarshes, Land use

Word count: 13 721

Acknowledgements

There are several persons that have helped making this thesis possible and I am thankful to every one of them. Thank you to all the researchers that I met and worked with at Lund University and in the OPERAs project. It has been a great experience to learn from you and I hope to work with you again in the future. I also want to thank all the lovely people I met during my stay in Scotland, working with you was a great pleasure and motivation.

Some people deserve special thanks for their time and support that they have given me. They are:

My supervisor Asso. Prof. Kimberly Nicholas, for great scientific guidance and support throughout the thesis process. Thank you for all the help and for keeping a firm belief in my capabilities.

PhD student Anja Liski, for making visit in Scotland possible and for being a great colleague in the field. Thank you for everything.

Ph.D. Torsten Krause, for interesting discussions that helped me develop my thoughts about the governance aspect in the Inner Forth.

My fellow students Noor Nasir, Ellen Redford and Laura Siepmann, for being a great sounding board and helping me to realize that master thesis writing is anything but easy. You have been a great moral support.

My extended family of LUMES, for two unforgettable years. Without you my study experience would have been very poor.

Finally I want to thank my family for believing in me and supporting me through years of education. A specially thanks goes to my mother and father, who supported and encouraged my dream of doing science. Without you, none of this would have been possible. Also a big thanks to my sister Linnéa!

At last I would like to end with some wise words that have guided me through the many hours of work on this thesis.

"To achieve great things, two things are needed; a plan, and not quite enough time."
–Leonard Bernstein

Table of content

1. Introduction

1.1. Research context

This thesis takes place in the era of the humans, referring to the grand scale human induced changes to the planet. These changes suggest that we have entered into a new geological era, the Anthropocene (Rockström et al., 2009; Zalasiewicz, Williams, Haywood, & Ellis, 2011). As a species, we are now virtually impacting all of the ecosystems on the planet (Ma, 2005). We have altered the composition of the atmosphere (IPCC, 2014a), and caused major changes to both terrestrial and marine ecosystems (Ma, 2005; UNEP, 2012). We are quickly approaching a critical point, where we as a species risk to destabilizing our own life support system (Rockström et al., 2009). My research project takes place in the context of the Anthropocene, investigating human and nature relationship in Scotland, explicitly researching the estuarine land use development in the Inner Forth.

1.2. OPERAs project, Scottish exemplar

My study was done in connection to the EU funded research project OPERAs. OPERAs stands for "Operational Potential of Ecosystem Research Application" and aims to bridge the gap between the academic knowledge of ecosystem services and their practical application (OPERAs, 2016). The project consists of several work packages and exemplars. The exemplars are case studies, where components of the project are tested and researched (OPERAs, 2016). This thesis was researched and written in cooperation with the Scottish exemplar. The thesis aims to contribute to the research being done within exemplar, as well as contributing to a greater knowledge in the field of sustainability science.

1.3. The Inner Forth

The Inner Forth is defined by the river Forth (Fig. 1). It has its source in Loch Ard in south western Scotland, about 25 km west of the town of Stirling. The river serpentines through the landscape eastward, going through the town of Stirling and passes the towns of Alloa and Grangemouth. All along the river, tributaries like the river Carron, Devon and Black Devon feeds into the Forth. Finally the Inner Forth empties into the estuary fjord known as the Firth of Forth. Found on the southern shore of the Firth of Forth, is the Scottish capital Edinburgh.

In this paper, I have specifically study the area known as the Inner Forth. The term Inner Forth is commonly used by councils, NGO's and the public, and broadly refers to the area of the Forth stretching from the village of Fallin to the town of Grangemouth (Appendix 1). The whole of Inner Forth is influenced by tidal changes, with variation up to 6 meters (Forth Ports, 2016), creating large areas of intertidal wetlands. The Inner Forth River is bordered by four different councils, Falkirk, Clackmannanshire, Stirling and Fife.

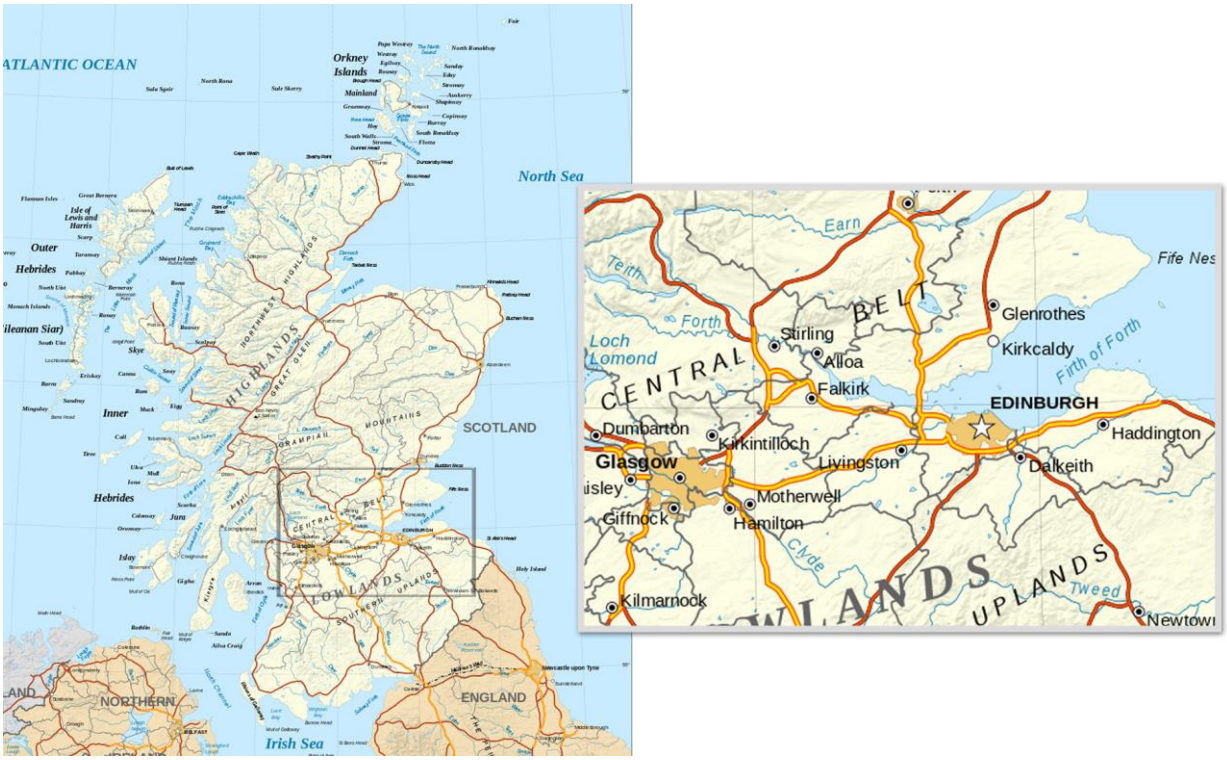


Figure 1, Scotland and the Inner Forth. Maps showing the location of the Inner Forth in Scotland. Figure adapted from original image by Eric Gaba, retrieved from (Wikimedia Commons, 2016).

1.4. The challenges in the Inner Forth

This thesis looks at some of the sustainability challenges of the Inner Forth region. Specifically looking at how land use would be changed by different climate change adaptation strategies.

1.4.1. Climate change in the Inner Forth

Anthropogenic climate change will cause changes to the biophysical structures all over the planet as the average temperature is rising (IPCC, 2013). These changes will ultimately cause alternations in the ecosystem services that relies on those structures. The Inner Forth region is no exception.

1.4.1.1. Weather changes

An exact temperature increase is hard to estimate, since it depends on how successful future greenhouse gases are mitigated (IPCC, 2013). But rough estimates show that by the mid-century, the Inner Forth can expect an average increase between 0.6°C and 3.3°C in winter and 1.0°C to 4.5°C in summer (Murphy et al., 2009). The same model predicts that winters will have an average change of precipitation between -1% and +30%. In the summers the precipitation changes are expected have an average change of -27% to +6% (Murphy et al., 2009). The large range of these estimates are due to the uncertainty in mitigation pathway. But all of the estimates stretches from a low emission scenario to a high (Murphy et al., 2009). Although the broad range of uncertainty, IPCC (2014b) estimates that a low emission scenario is unlikely and that a global average warming of at least 1.5°C is to expect. It

is therefore fair to assume that the changes to the Inner Forth climate will be more towards the extreme. Under these conditions, it is reasonable to expect that by the mid-century, winters will be rainier and summers will get dryer and average temperatures will increase year round (Murphy et al., 2009). Although these changes might seem to be moderate, they are likely to cause great disturbances to life as we know it (IPCC, 2014a).

1.4.1.2. Sea Level Rise

An even greater change of temperature will occur towards the poles (IPCC, 2013). This brings an increased melting of land- and sea ice, causing sea level rise (SLR) (IPCC, 2013). The global average sea level is expected to rise with about 24 to 30 cm by the mid-century and up to 40 to 63 cm by the end of the century (IPCC, 2013). In Scotland, some of the SLR is compensated by the land uplift, which for the Inner Forth area is roughly 0.5 mm/year (Lowe et al., 2009). Compensating for the uplift, the Edinburgh region is estimated to have a SLR of 20 to 40 cm, by the end of this century (Lowe et al., 2009).

1.4.1.3. Storm surges

Not only SLR will play an important role in the Inner Forth. Storm surges is short term weather events that can amplify tides and the SLR, causing extreme water levels (Lowe et al., 2009). That amplification will grow more intense with climate change. Estimations show that by the end of the century, a once in a 50 years storm, could bring up to a 1 meter of increased sea level, compared with a similar storm of present day standards (Lowe et al., 2009). Although the occurrence of such storms are rare, smaller and more regular storms will also increase in intensity (Lowe et al., 2009).

1.4.1.4. Climate change induced stress

Combining these estimates, the Inner Forth is likely to experience climate change induced stress. Precipitation patterns will become more irregular and the effects of SLR will be strengthened by storm surges (Lowe et al., 2009; Murphy et al., 2009). These changes are predicted to have a decisive consequence for the socio-economic development in Scotland (Holman, Harrison, & Metzger, 2016).

1.4.2. Salt marshes

One of the most characteristic features of the Inner Forth landscape, are the large mudflats and saltmarshes. As discussed in this thesis, the saltmarsh plays a central role in the regions adaptation strategy and supplies its inhabitants with important ecosystem services. Salt marshes are located within the intertidal zone, stretching from the low water mark to the high water mark. The lowest and most outer area is often referred to as the mudflats, mostly consisting of mud and algae. Further up the land is exposed to less water coverage, giving the possibility for other species to be introduced. This area is generally known as saltmarshes (Foster, Hudson, Bray, & Nicholls, 2013; Hughes, 2004).

1.4.2.1. Importance of saltmarshes

The importance of saltmarshes is well acknowledged (Ma, 2005). Saltmarshes provide humans with several important services and products. Perhaps the most visual is the reduction of waves and absorption of water, which provides coastal communities with erosion control, storm protection and natural flood protection (Barbier et al., 2011; Zhu, Linham, & Nicholls, 2010). Except from these most obvious services, saltmarshes are also providing several other important services, such as nutrients cycling, dilution of pollution, water purification, food supply and cultural benefits (Barbier et al., 2011; Foster et al., 2013).

The saltmarshes are also an essential part of the coastal zone, which interlinks the marine habitats with the terrestrial (Ma, 2005). This interlinkage has a great primary production, which makes them an important habitat for several species (Hughes, 2004). They are important nesting, feeding and breeding ground for birds (Hughes, 2004), as well nursing ground for fish and other marine species (Ma, 2005).

1.4.2.2. Declining saltmarshes

Coastal wetlands are on a global decline, threating both ecosystems and the livelihoods of those who depend on them (Ma, 2005). Similar trends can be seen more locally, as many of the saltmarshes in the United Kingdom are declining (Kirwan, Temmerman, Skeehan, Guntenspergen, & Fagherazzi, 2016). The exact reasons behind the saltmarsh decline is contested. Climate change has often been seen as a factor, but its true effect on saltmarshes is unclear. A recent study showed that SLR might not have much of an effect to the saltmarshes, due to their capabilities of migrating vertically (Kirwan et al., 2016). But as the climate is warming other threats might appear. An increased abundance of bioturbatory species (sediment living) could causes a more fragile sediment structure, leading to an increased saltmarsh erosion (Foster et al., 2013; Hughes, 2004). At the same time, weather irregularities can cause both an increase and a decrease the capabilities of the saltmarshes. With warmer climate, evaporation increases leading to a higher salinity in the saltmarshes. This increase can ultimately change the composition of species and create diversity poor saltpans (Hughes, 2004). Increased precipitation might on the other hand cause a positive effect on the saltmarshes, as the increased water flows brings more sediment and nutrients to the intertidal zone (Hughes, 2004).

Although salt marshes has proved to keep pace with a SLR of up to 50 mm/year, SLR can still cause a decline of saltmarshes due to human infrastructure (Kirwan et al., 2016). The concept of coastal squeeze is a well-known phenomenon, where the migration of saltmarshes are stopped by human infrastructure (fig. 2), such as a seawall (Doody, 2004; Foster et al., 2013; Hughes, 2004; Kirwan et al., 2016). The implications of coastal squeeze could lead to devastating effects to the coastal ecosystem, resulting in the loss of the ecosystem functions and services they supply. In the Inner Forth, as good as

all the saltmarshes subjected to the threats of coastal squeeze, since all of the low lying areas are protected by either a seawalls or another static structure.

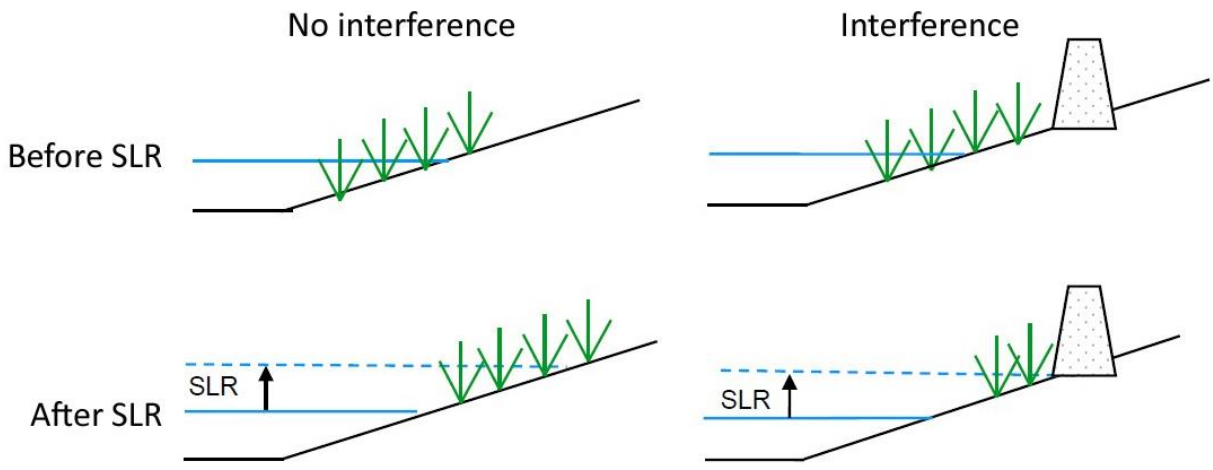


Figure 2. Coastal squeeze. Adapted from Zhu et al. (2010), showing how coastal squeeze effects saltmarshes. Pictures to the left show how SLR is causing saltmarshes to undisturbed migrate vertically, while the pictures to the right show the how human made sea defences interfere with their vertical migration and causes a "coastal squeeze".

1.4.3. Saltmarsh conservation initiatives

In response to some of the projected environmental changes, a group of stakeholder has formed the so called Inner Forth Landscape Initiative (IFLI). The group aims to strengthen the community values of the area and works with three major topics, cultural heritage, environmental protection and local history (IFLI, 2016). The IFLI consists of three out of the four councils in the area, the Royal Society for the Protection of Birds (RSPB), the governmental organization Scottish Natural Heritage (SNH), among others (IFLI, 2016). The group is funded from the Heritage Lottery Fund and has implemented several projects. They are organizing local events and runs several nature conservation projects, such as the further development of the Black Devon Wetlands (IFLI, 2016).

One major projects is the Inner Forth Futurescape, led by RSPB who is also the leading partners in the IFLI. The Futurescapes aim to extend the wetland conservation in the area and reinitiate wetlands all along the Inner Forth (RSPB, 2016). Although not mentioned specifically, such wetland creation would most likely involve a managed realignment of the coastline, where seawalls are breached and currently drained land would become flooded. The conflict and controversy with this project is that most of the land mentioned in the Futurescape project, belong to private landowners conducting agriculture practices. Although the project is supported by some of the core stakeholders in the IFLI as well as

Scottish Environmental Protection Agency (SEPA) and Scottish Wildlife Trust (RSPB, 2016), the project has not developed further and has seemingly stagnated.

1.4.4. Conflicting interests

The Futurescape project covers an area of about 2000 ha, which will be investigated for nature conservation practices (RSPB, 2016). This area has different types of land usages and is owned by several different landowners. As shown in my thesis, the attitude towards these changes are far from unified. And several of the landowners have a reluctant attitude towards giving up their land for nature conservation purposes. Similar projects of managed realignment has proved to be difficult, due to the reluctance to retreat land to marine environments (Foster et al., 2013; Luisetti et al., 2011) This land use conflict is the basis of this thesis, as it tries to understand the current landowners interests and perceptions of the changes in the Inner Forth. Ultimately trying to locate a common adaptation strategy for the inhabitants in the region.

1.5. Research question

As earlier mentioned, the Inner Forth is expected to suffer from multiple stresses in the future. These involve ecological stresses (coastal squeeze) and climate change induced stresses (floods, storm surges and sea level rise), to mention a few. At the same time, there are economic and cultural interests to keep the land productive. This causes a conflict of interest, between the traditional land use and the newly suggested adaptation strategies. I aim to investigate if there is a land use solution that can answer to all of the needs in the Inner Forth, including both the human and nature aspects.

Research question (RQ)

Is there a sustainable land management that can answer to the needs of the local communities, landowners and a healthy coastal environment?

In order to answer the main research question, I have located three sub-questions that needs to be addressed. The first sub question (SQ) is aiming to answer what the local landowners consider the most important values of their land. This is important for understanding if there are mutual interests and potential conflicts.

Sub question 1 (SQ1)

What are the most important provisioning, regulating and cultural ecosystem services to the Inner Forth landowners?

To cope with the future changes in the Inner Forth, it is also essential to understand how landowners currently cope with environmental stresses and how they adapt to changes in their environment.

Likewise it is important to understand how the landowners are seeing the future changes and how they plan to cope with them.

Sub question 2 (SQ2):

What are landowners' current strategies and attitudes towards the changes caused by climate change in the Inner Forth?

Since one of the adaptation strategies is a managed realignment of the coastline. The third question aims to understand how the landowners relate to these suggested changes and understand how they view future creation of wetlands and flexible flood defences.

Sub question 3 (SQ3):

How does the landowners of the Inner Forth relate to the suggested changes in coastal flood defence?

2. Theoretical background

2.1. A framework based on sustainability science

To cope with environmental changes on both a local and a grand scale, the field of sustainability science has gained ground in recent years (Miller, 2012). This paper takes its standpoint from the sustainability science perspective and aims to approach the case study of the Inner Forth from an interdisciplinary approach. All according to the basic foundation of sustainability science, where human wellbeing is interlinked with a diverse and prosperous ecosystem (Miller, 2012). There are several definitions and concepts used to explain and understand sustainability (Wu, 2013), but in this thesis I take an entry point using the concept of ecosystem services (ES). ES links human capital and well-being to its foundation in nature, acknowledging the importance of the planets ecosystems (de Groot, Alkemade, Braat, Hein, & Willemen, 2010; Potschin & Haines-Young, 2011; Wu, 2013).

2.2. The essentials of ecosystem services

It is essential for this study to understanding how different types of ecosystem services affect the life along the Inner Forth. To understand the processes and interaction of the Inner Forth landscape, I am basing the paper on Potschin and Haines-Young (2011) definition of ecosystem services. They conceptualize ecosystem services in accordance with the following (fig. 3). Biophysical structures and processes (a.k.a. natural capital) creates the possibilities for species to interact with one another. These interactions are called ecosystem functions. These interactions are in turn creating services and products that benefits and sustain human life. When they do so, that service or product is called an ES. The ES benefits human society in different ways and to better understand these benefits, one should translate them into measurable values (Potschin & Haines-Young, 2011). Depending on the human usage and management of these ecosystem services, pressures apply to the re-generation of new services (Potschin & Haines-Young, 2011).

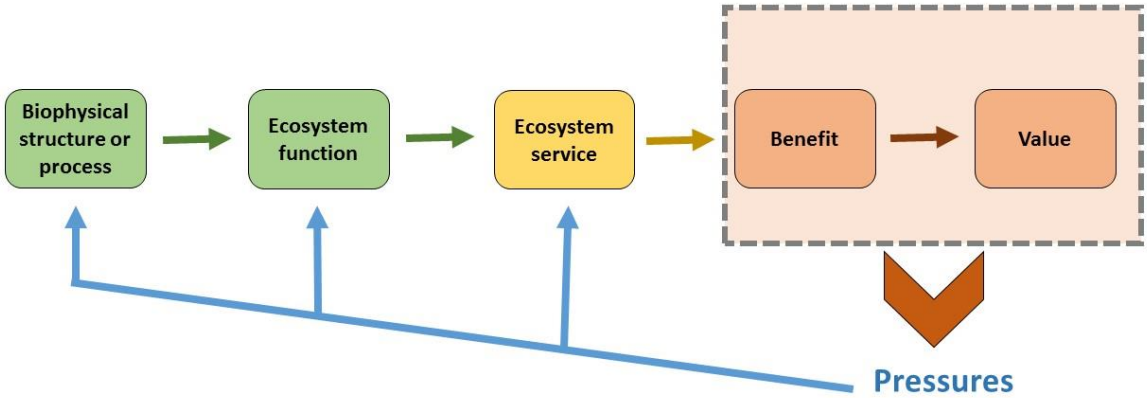


Figure 3. Framework of ecosystem services. Framework showing the relation between nature and human wellbeing, through the usage of ecosystem services. First presented by Potschin and Haines-Young (2011).

In my thesis, the ES are structured and divided into subgroups in accordance with Common International Classification of Ecosystem Services (CICES) version 4.3. CICES divides all ES into three sections; provisioning, regulating and cultural. These sections then divides further through a five level hierarchy, finishing with single services and products (CICES, 2016).

2.3. Linking theory to the research questions

In order to fully answer the overarching research question, all the sub questions needs to be addressed.

2.3.1. Linking values to ecosystem services (SQ1)

The first sub question aims to understand the values of the landowners and this was done by having landowners ranking ES present on their land. Since the values are connected to benefits, ES, ecosystem functions and biophysical processes, it is possible to estimate what type of ecosystem landowners prefer (Potschin & Haines-Young, 2011).

2.3.2. The choices of adaptation (SQ2 & SQ3)

When answering the question on adaptation strategy and changes in flood defence, I have chosen to limit this study looking at two options. The first one is the current land use and adaptation strategy, with seawalls as primary coastal defence. The second option is the more recently suggested strategy

of managed realignment (MR). There are potentially more adaptation strategies that could be implemented in an environment such as the Inner Forth (Zhu et al., 2010). But rather than trying to find a new adaptation strategies, I am investigating how the two current options are looked upon and if there can be a compromised solution between them.

2.3.2.1. Coastal adaptation

Zhu et al. (2010) describes three general adaptation approaches in coastal communities. You can choose to protect an area using seawalls and other static defences (present adaptation strategy in the Inner Forth). This approach can be referred to as the protective or static strategy. In this thesis, this option is referred to as the static adaptation strategy. Another option is to accommodate flooding by accepting it and adapting buildings and land usages to be under water at times. Such an approach is generally referred to as the accommodated strategy. Since the accommodated strategy has not been suggested for the Inner Forth, it is not further discussed in this thesis.

Finally you can adopt a strategy of planned retreat (Zhu et al., 2010), which in the case of the Inner Forth would be a MR. To complicate things further, a MR refer to the realignment of the coastlines both seaward and landward (Esteves, 2014). In other words, a MR does not necessarily have to be a planned retreat. However, that would not be the case in the Inner Forth, where MR refers to a planned retreat strategy.

2.3.2.2. Hard and Soft solutions

When implementing any adaptation strategy, a diversity of technics can be used. Since this paper is not looking at details in the specific strategies, I am using a categorization of these implementations based on description made by Sovacool (2011). In his paper, adaptation strategies and implementations are narrowed down to hard and soft solutions. Where hard solution refers to human engineered infrastructure, such as a seawalls or dams, while soft solutions refers to ecosystem based solutions, such as wetland creation and winding of rivers (Sovacool, 2011).

2.4. Static adaptation strategy

The static adaptation strategy, suggest that the current sea boarder should be maintained (Zhu et al., 2010). It involves mostly hard solutions, such as seawalls, sea dikes, etc. (Zhu et al., 2010) If successful, such an adaptation strategy would allow for a continued agricultural practices along the river (Zhu et al., 2010). Nevertheless, the static nature of the strategy would cause problems to the intertidal zone due to rising sea levels (Doody, 2004; Foster et al., 2013; Hughes, 2004; Kirwan et al., 2016).

2.5. Managed realignment

The idea of a MR involves the creation of large wetland areas. (Esteves, 2014; Zhu et al., 2010). In the Inner Forth, the areas affected by the retreat would mainly be agricultural land and industrial wastelands. Usually, the designated area is flooded by opening the static flood defences. The flooded land will over time become the primary flood defence as the saltmarsh colonizes the area (Garbutt, Reading, Wolters, Gray, & Rothery, 2006). In order to avoid that the flooding spreads to nearby sites, a seawall or other static flood defence can be built around the newly flooded land. This is then referred to as the secondary flood defence. The greater area of created saltmarshes, the more it reduces the forces of nature, allowing the secondary flood defence to be significantly smaller and in need of less maintenance (Garbutt et al., 2006).

3. Methodology

3.1. Interviews, sorting exercise and participatory mapping

To answer the research questions, an interview template was created including open ended questions and a sorting exercise to determine the interviewed landowner's preferences of ES. The following process was carried out to collect the data.

3.1.1. Survey area

The sample of landowners were geographically constrained to the area defined by the rough estimates of the Inner Forth Futurescape project, excluding sites in the council of Fife. All of the landowners had property adjacent to the river or in close proximity to the river (Appendix 1).

3.1.2. Identifying landowners

The first step was to identify all the landowners within the survey area. Residential landowners in villages and towns were excluded.

The initial contact with the target group was established through the Scottish governmental department and land registry, "Register of Scotland" (ROS). They provided contact details to a handful of landowners, which in turn were contacted via post and phone calls. The remaining landowners were contacted with help from the interviewed landowners, local community and online search sites. A total of 20 landowners was identified in the area. 10 of them agreed to be interviewed, 6 declined and 4 was not reachable. Due to lacking information from ROS, it is unclear if there are any other unidentified landowners in the region. But through mapping and discussions with people of the local community, that number is most likely marginal and could possibly only consist of a handful of people.

Out of the known 20 landowners, a majority were private farmers. A few of the sites are owned and managed by councils and one site is owned by the RSPB. One area is the estate of Earl of Mar, while another is managed by a trust (table 1).

Ownership	Number of landowners
Private	15
Council	2
NGO	1
Trust	1
Estate	1

Table 1. Landowners of the Inner Forth.

3.1.3. Time and surveyors

The interviews were conducted from the 19th of February to 9th of March, 2016. All of the interviews were conducted by the author.

3.1.4. Sample size and adjustments

11 interviews were scheduled and accomplished. 10 of which was with local landowners. The remaining interview was done with the RSPB, as land managers of a site owned by the Clackmannanshire council. The survey was slightly adjusted to the ownership structure of each landowner, as wording such as "farmers" was changed to "council" or "NGO", depending on the landowner.

3.1.5. Research ethics

A letter of consent was written based on ethical standards of University of Edinburgh and Lund University (Appendix 2). Prior to each interview, the landowner was informed how the data would be used and for what purpose the interview was done. A letter of consent confirmed all agreements and were signed before the interview started. The letter of consent ensured the anonymity of each landowner and clarified if the landowner could be anonymously quoted and how collected spatial data could be used. Those landowners that are mentioned by name (councils and NGO) have approved being so.

3.1.6. Interview procedure

When first contacted, the landowners were shortly introduced to the research project over phone or via mail. Before the interview, each landowner was informed how the data would be used and for what purpose the interview was done. The interview proceeded with the interviewer following a combined protocol and transcript, with structured interview questions (Appendix 3). The protocol mainly consisted of question generating qualitative data. One questions was structured as a sorting exercises, generating qualitative data on how the landowner valued ES.

3.1.6.1. Open ended questions

Demographic data was collected from each private landowner. The rest of the questions were grouped into four categories investigating; (1) Land management practices, (2) property location and history, (3) experience and adaptation to floods, storm surges and sea level rise and (4) opinion on wetland restoration. Answers were collected both through written text, audio recording and using participatory mapping. To ensure the coherency throughout the survey, the following three terms were described during the interviewed: storm surges, flooding and SLR

3.1.6.2. Using ecosystem services to understand land values

In addition to the interview questions. A sorting and weighing exercise was used to better understand how individual landowners valued the ES from their land. The ecosystem services were based on CICES framework (CICES, 2013) and had been translated into ES present in the Inner Forth region (Appendix 4). The CICES framework was translated into 13 provisioning services, 14 regulatory services and 11 cultural services. Each ES was printed on a colour coded card, based on the three sections; provisioning, regulatory and cultural services.

The interviewed landowner/manager was then asked to rank the cards of each section, from most important to least important. If they were not aware of the existence of a certain ES in their land, that card was removed from the ranking.

3.1.7. Data analysis of the sorting

Due to a fairly small sample size, the data analysis was limited to a comparing medians and mode (most occurring value). All calculations were done using the statistical software, IBM SPSS statistics 23. A general ranking for the whole sample was estimated primarily based on the median. In the cases where two or more ES had the same median, the service with the highest ranked mode was prioritized. If there was still a draw between services, the ES that had the highest sample size got the higher ranking. When an ES had a median ranking of four or higher, that services was considered key.

3.2. Describing the landowners

The landowners were divided into three sub-groups, depending on their ownership structure. The groups are: private landowners, council landowners and NGO landowners.

3.2.1. Description of private landowners

Seven private landowners were interviewed. The private landowners were all operating a farming business, providing between 20%-100% of their income. All the interviewed private landowners were men, with the exception from one case where the interviewee was the wife of the farmer. Their age differed between 48 years to 71 years. One had received a degree from a higher education. One had a degree from a further education (college), while all the others had gone through secondary school or similar types of education.

3.2.2. Description of council landowners

The Inner Forth flows through four councils. These are Falkirk, Clackmannanshire, Stirling and Fife. Fife council is outside the study area and was therefore not contacted regarding their landownership. The remaining councils were all contacted asking about their land possessions along the Inner Forth. Stirling council claimed to have sold all their riverside landholdings to private landowners and was therefore not interviewed. Falkirk council directed me to their Planning and Environment Unit that

manages some of their council owned sites. Clackmannanshire council directed me to their sustainability team.

3.2.3. Description of NGO landowner and manager

The NGO that owns the land along the Inner Forth is The Royal Society for the Protection of Birds (RSPB). RSPB is the biggest nature conservation organization in the United Kingdom with over a million members (RSPB, 2016). They are an active member of the IFLI and runs several projects in the region, such as the Inner Forth Futurescape (IFLI, 2016, RSPB, 2016). The RSPB also lease and manage one of the sites owned by the Clackmannanshire council. They were therefore interviewed with regards of both their land possessions and the land leased from Clackmannanshire council.

4. Results

4.1. Current land use situation

In order to better understand the values and opinions of the landowners, this section aims to give a general understanding of the current land use situation.

4.1.1. Land management and income

The land along the Inner Forth is mainly managed with two different purposes, nature conservation and agricultural production. The land owned by the councils and the RSPB is predominantly managed for nature conservation purposes. Sometimes that includes grazing animals for the purpose of creating certain types of environments. The private owned land is on the other hand predominantly managed for agricultural production. Grains and hay is what is mostly produced. Some land is used to produce animal fodder and straw, while other areas are used for grazing cattle. One of the private landowners rented land to horse owners.

The RSPB and the councils, had no or a negligible income from their land. While the private landowners where more or less dependent on the income from their land. The span of land dependent income stretches from about 20% to 100% (figure 4). Some of the landowners had side business, earning their remaining income from other agricultural related work.

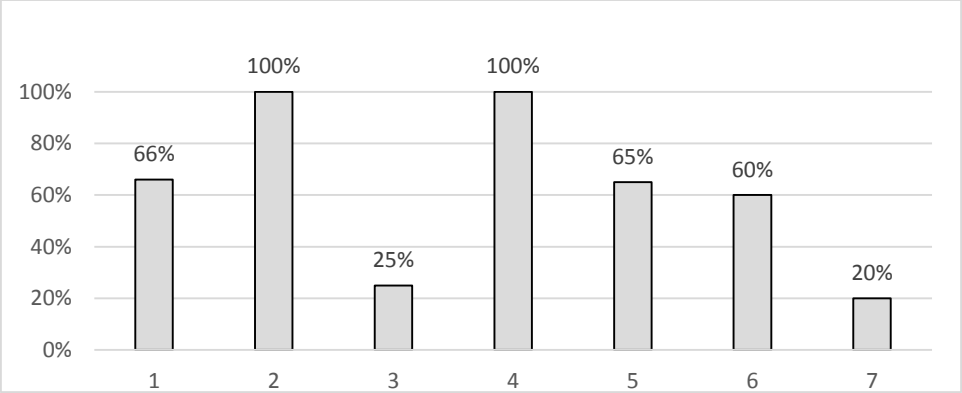


Figure 4, Private landowners' income from the land. Approximate spread of income from the land among private landowners. X-axis present the different farmers.

One of the farmers is actively changing his/hers land management, by increasing the diversity of crops in the crop rotation. The RSPB and Falkirk council both aimed to improve the nature conservation of their sites by refining their land management. The other landowners were not actively changing their land use.

4.1.1.1. Support for agricultural practices

All of the private landowners received a European Union farm subsidy called the Single Farm Payment (SFP). The SFP is payed out to each farmer based on their land use and how many hectares that are

used for farming. In return the farmer needs to comply with certain rules and restrictions. Many farmers mentioned that farming had gotten less profitable and that it was getting much harder to survive only on their farming business. The SFP helped most farmers to maintain the farming practices and ensure that they could break economically even. This relation was well described by one of them saying:

"(speaking about the SFP) Which I would rather not have if we had a good value for our crops, because the crops we are selling now are barely breaking even. So the single farm payment makes a huge difference to us..." –Farmer 3

Two of the farmers said that the SFP had decreased over the last year. The council landowners got no land use support, while the RSPB had gotten a single grant to transform their site to their purposes.

4.1.1.2. Support for the maintenance of flood protection

None of the landowners received any type of support for maintaining the flood protection. At the same time are landowners obliged to ensure that their land by the river has a proper flood protection. The responsibility of providing the flood protection is more or less up to the landowners and the councils are not entitled to maintain or control the seawalls in the area. As described by one farmers:

"*Well, there were negotiations with the council, but they had no interest. Saying "the seawall is yours, it is up to you to repair it"." – Farmer 7*

Although all land and property owners in Scotland are responsible to keep themselves safe from flooding (SEPA, 2015). There is still an unclear situation regarding the responsibilities of those landowners owning and maintaining the infrastructure that keeps many of the communities safe from flooding.

4.1.1.3. Support for habitat protection

Only Falkirk council had obtained a grant for nature conservation. Although none of the private landowners got any such funding, it should be mentioned that in order to get a full subsidies from the SFP. Farmers need to comply with certain environmental aspects, such as maintaining hedges and keeping strips of grass along the river.

4.1.2. Motivation

The motivation to the land use was specific for each group of landowners. Among the private landowners, the most common motivation was that they were born into farming. All the private landowners managed land that had been passed on to them from their previous generations. It was seen as important among all of them to carry on their ancestors farming. Some claimed that farming was the only thing they wanted to do and that they were born with the purpose of farming.

The motives of the council landowners were understandably different. Their motivation was closely connected to the intentions of their land possessions and is also governed by several legislations and directives. Clackmannanshire council works together with RSPB to manage one of their sites for nature conservation and to increase the accessibility to nature for the local population. Their main motive is to increase the publics' accessibility to nature, as well as improving the local environment. Falkirk council's primary objective was nature conservation.

The RSPB's general motivation is to maintain and improve the protection of nature. Their site specific motivation was to visualize that an intertidal habitat can be created on land that had been undergoing a MR. Their land possessions was bought for the purpose of working as a research site and saltmarsh habitat. The motive behind the RSPB lease is the same as the current landowner, Clackmannanshire council.

4.1.3. Goal of land use practices

Although the private landowners had more or less the same motivation why they managed their land, they did not share the same goal. Three general answers were given to the question of the goal of their land use. (1) Passing on the farm to next generation and ensure the family heritage, (2) Make a living and (3) improve and develop their business. Three out of seven farmers mentioned that the passing on the family heritage of farming was their goal. While five out of seven farmers mentioned that making a living of the land was their primary objective. Three farmers mentioned the improvement of farming and business development. Some farmer mentioned more than one goal. Interestingly, the farmers showed quite a different mentality towards the goal of making a profit. One farmer answered the following:

"We look to grow professionally and look to grow good quality crops, we want to sell a good quality product and maximize the yield and earning potential" –Farmer 3.

This can be compared to one answer given from the other side of the spectrum:

"Just trying to make a living, we're quite happy just making a living." – Farmer 2

The councils gave different types of answers. It is clear that the councils are not as economically dependent on their land along the river, as some of the farmers are. Their primary goals are instead to conserve the environment and improve the accessibility to some site for the local communities. RSPB have a specific goal for the site that they own. They wish to create a saltmarsh habitat and improve the quality of the wetlands in the area. They also use their site to test different strategies for MR.

4.2. Ranking ecosystem services

The three categories of ES were ranked separately and showed both differences and commonalities in the values among the three groups of landowners.

4.2.1. Provisioning services

Out of the 13 provisioning services, three had a median rank higher than four and was therefore considered as key. As shown in (table 2) “Crop, fruit and vegetable production” was the highest ranked provisioning services, with both a median and a mode of 1. Second most important was “Grazing, hay production and crops for animals”, with a median rank and mode of 2. The third key provisioning services was “Livestock and other domesticated animals (beekeeping etc.)” which had a median of 2.5 and a mode of 1. These three ecosystem services are all closely connected to the agricultural production of the land.

The remaining ecosystem services were ranked based on the same principal. As visible in (fig. 5), it is possible to distinguish an overall order of the combined ranking.

All landowners, provisioning services

	Median	Mode	N Valid
Crop, fruit & vegetable production	1.00	1	8
Grazing, hay production, & crops for animals	2.00	2	10
Livestock & other domesticated animals (beekeeping etc.)	2.50	1[a]	10
Energy from biofuels, wood & energy crops	5.00	4	7
Food from fishing and hunting	5.00	4[a]	5
Wild food (mushrooms, berries, etc.)	5.00	5[a]	5
Surface water, irrigation & livestock water	5.50	3	8
Drinking water supply	6.00	3[a]	5
Aquaculture	7.00	3[a]	3
Biogas from manure	8.00	8	4
Animals for labour	8.50	4[a]	2
Timber, peat, & ornamental plants	9.00	6[a]	5
Ground water, irrigation & livestock water	9.00	9	7

a. Multiple modes exist. The lowest ranking is shown

*Table 2, Ranking of provisioning ecosystem services, all landowners***.** *Table is showing median, mode, valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).*

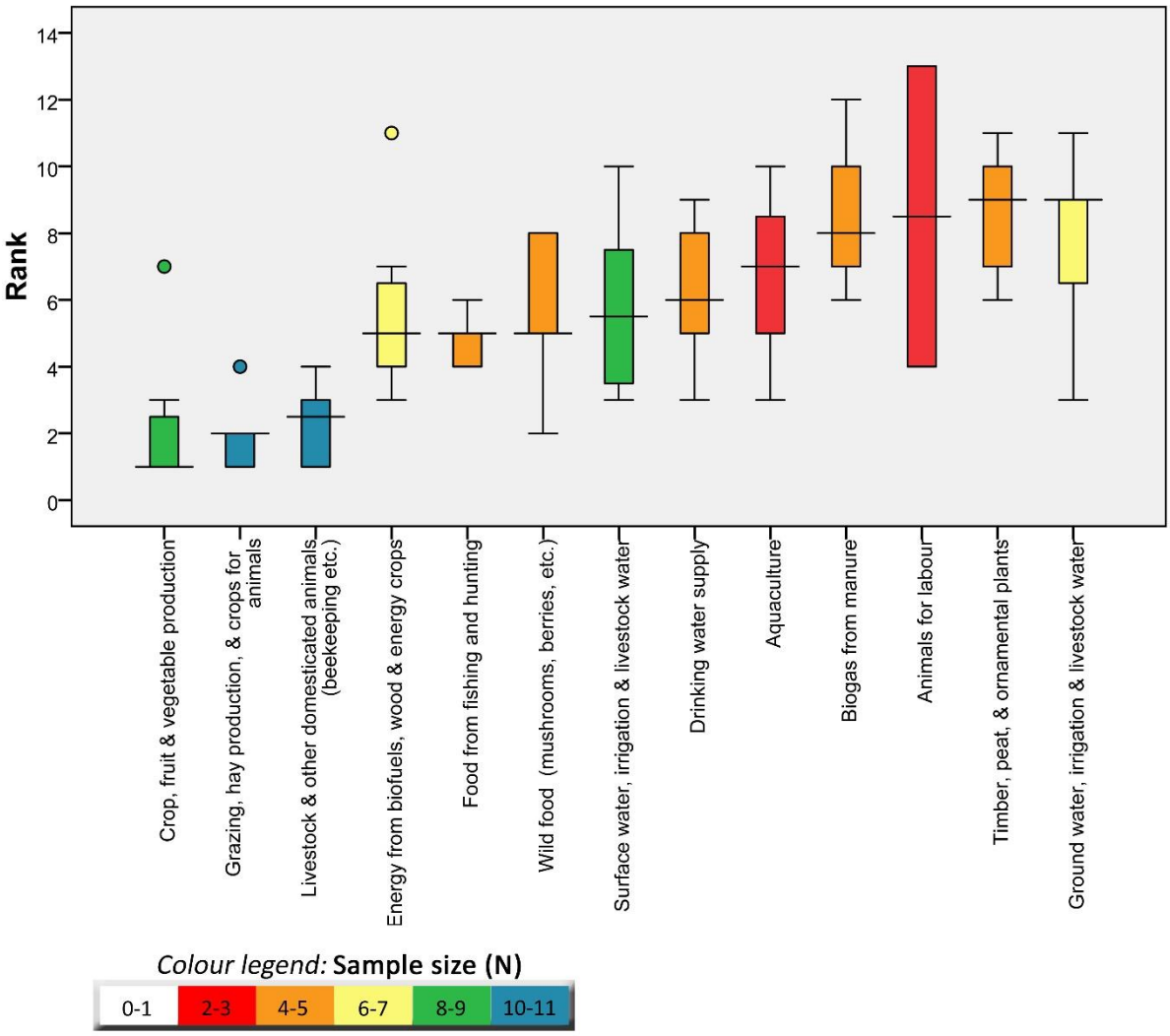


Figure 5, Ranking of provisioning ecosystem services, all landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.1.1. Private landowners

All of the private landowners are using their land for some sort of agriculture practices. The ranking of provisioning services among private landowners was summarized according to the same procedure. Just like the summary made for all of the landowners, "Crop, fruit and vegetable production", "Grazing, hay production and crops for animals" and "Livestock and other domesticated animals (beekeeping etc.)" came out as the most important (Table 3) (Fig. 6). The following provisioning services followed a similar pattern from the ranking of the total group.

Private landowners, provisioning services

	Median	Mode	N Valid
Crop, fruit & vegetable production	1,00	1	7
Grazing, hay production, & crops for animals	2,00	2	7
Livestock & other domesticated animals (beekeeping etc.)	3,00	3	6
Animals for labour	4,00	4	1
Energy from biofuels, wood & energy crops	5,00	3[b]	4
Food from fishing and hunting	5,00	4[b]	3
Wild food (mushrooms, berries, etc.)	5,00	5	3
Surface water, irrigation & livestock water	6,00	4[b]	5
Drinking water supply	6,50	3[b]	4
Ground water, irrigation & livestock water	7,00	3[b]	5
Biogas from manure	8,00	8	3
Timber, peat, & ornamental plants	9,00	7[b]	3
Aquaculture	10,00	10	1

b. Multiple modes exist. The smallest value is shown

Table 3, Ranking of provisioning ecosystem services, private landowners. Table is showing median, mode, valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).

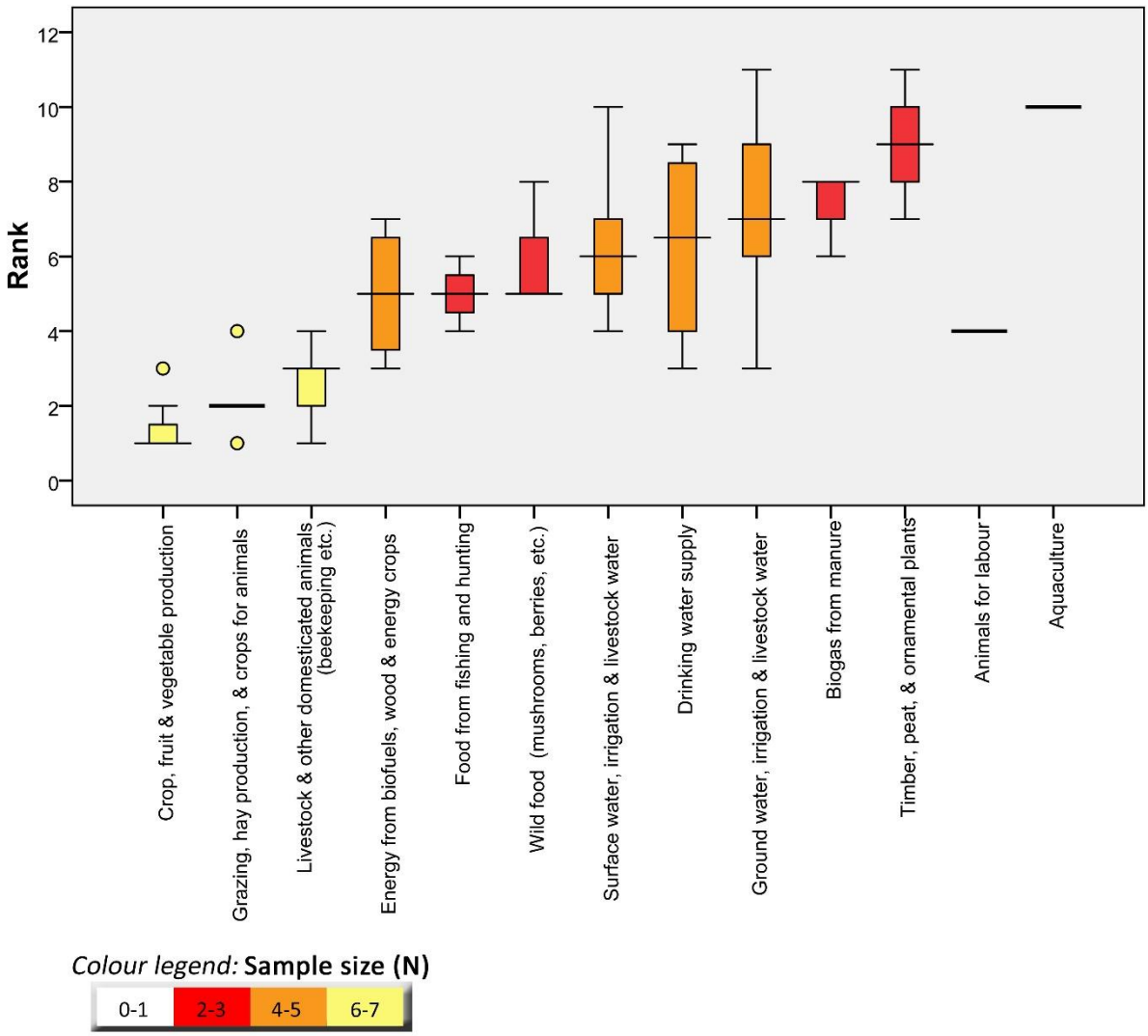


Figure 6, Ranking of provisioning ecosystem services, private landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.1.2. Council landowners

Since only two councils where interviewed, the sample was too small for any descriptive analysis. Instead were the sample compared in its original form (Fig. 4). The councils seems to care less about "Crop, fruit and vegetable production". This can be explain by their current land use. None of the two councils have any ongoing agricultural production on their land, with the exception Council 1 leasing pastures to local farmers. The representative for Council 2 did not consider that any provisional services existed on their land, with one exception "Livestock and other domesticated animals (beekeeping etc.)".

Council landowners, provisioning services

	Council 1	Council 2	Total N
Livestock & other domesticated animals (beekeeping etc.)	1	1	2
Grazing, hay production, & crops for animals	2	-	1
Surface water, irrigation & livestock water	3	-	1
Food from fishing and hunting	4	-	1
Energy from biofuels, wood & energy crops	5	-	1
Timber, peat, & ornamental plants	6	-	1
Aquaculture	7	-	1
Wild food (mushrooms, berries, etc.)	8	-	1
Ground water, irrigation & livestock water	9	-	1
Crop, fruit & vegetable production	-	-	
Drinking water supply	-	-	
Biogas from manure	-	-	
Animals for labour	-	-	

Table 4, Ranking of provisioning ecosystem services, council landowners. Table is showing the two councils and their ranking of provisioning services, as well as indicating the sample sizes.

4.2.1.3. NGO landowner and manager

Also the sample of the NGO was too small for any descriptive analysis. The data is therefore presented in its original form (table 5). “Crop, fruit and vegetable production” was ranked lower than the total sample. Likewise the case of the councils, this can be explained by the fact that the NGO does not perform any agricultural production on neither their own land nor the land they are leasing.

NGO Landowner & manager, provisioning services

	NGO as landowner	NGO as manager	Total N
Grazing, hay production, & crops for animals	1	1	2
Wild food (mushrooms, berries, etc.)	2	-	1
Aquaculture	3	-	1
Livestock & other domesticated animals (beekeeping etc.)	4	2	2
Food from fishing and hunting	5	-	1
Drinking water supply	6	-	1
Crop, fruit & vegetable production	7	-	1
Surface water, irrigation & livestock water	8	3	2
Ground water, irrigation & livestock water	9	-	1
Timber, peat, & ornamental plants	10	-	1
Energy from biofuels, wood & energy crops	11	4	2
Biogas from manure	12	-	1
Animals for labour	13	-	1

Table 5, Ranking of provisioning ecosystem services, NGO landowner and manager. Table is showing how the NGO ranked the provisioning services, as well as indicating the sample sizes.

4.2.2. Regulating services

The summary of the regulating services, showed a less clear pattern than the other two groups of ES. In general, the ranking is more inconsistent among the landowners. For example "Maintenance of soil quality, through nitrogen fixation & composting", ranked both first and last. Although there are less of a pattern in the data, it is possible to draw some conclusions from it. Four ecosystem services scored a median rank of less than four (table 6). First came "Natural flood protection" with a median of 2 and a mode of 1. Followed by "Habitat protection", "Living things supported by saltwater" and "Maintenance of soil quality, through nitrogen fixation & composting", which all had a median of 3. It can be assumed that these top four ecosystem services were the key. The only remark that should be mentioned is that "Living things supported by saltwater" was only ranked by 5 out of 11 landowners. All of the landowners that ranked it, ranked it high, but most landowners do not consider this service to exist on their land.

The remaining ten regulating ecosystem services were all ranked based on the same principle (fig. 7) (table 6). The certainty of the ranking was variating between the samples, but in general are the data either spread over the whole ranking scale or only valued by a small number of landowners.

All landowners, regulatory services

	Median	Mode	N Valid
Natural flood protection	2.00	1[a]	11
Habitat protection	3.00	1[a]	11
Living things supported by saltwater	3.00	1[a]	5
Maintainance of soil quality, through nitrogen fixation & composting	3.00	2[a]	9
Living things supported by freshwater	4.00	2[a]	10
Storm protection	4.00	2[a]	9
Erosion control	4.00	4	9
Natural pest and disease control	6.00	4	9
Pollination & seed dispersal	6.50	4[a]	10
Carbon storage	7.00	6[a]	3
Filtration and dilution of pollution	8.00	8	6
Waste treatment & water purification	9.50	5[a]	6
Drought protection	11.50	14	4
Modifying local air quality and temperature, humidity and wind	13.00	13	3

a. Multiple modes exist. The lowest rank is shown

Table 6, Ranking of regulating ecosystem services, all landowners. ***Table is showing median, mode,*** *valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).*

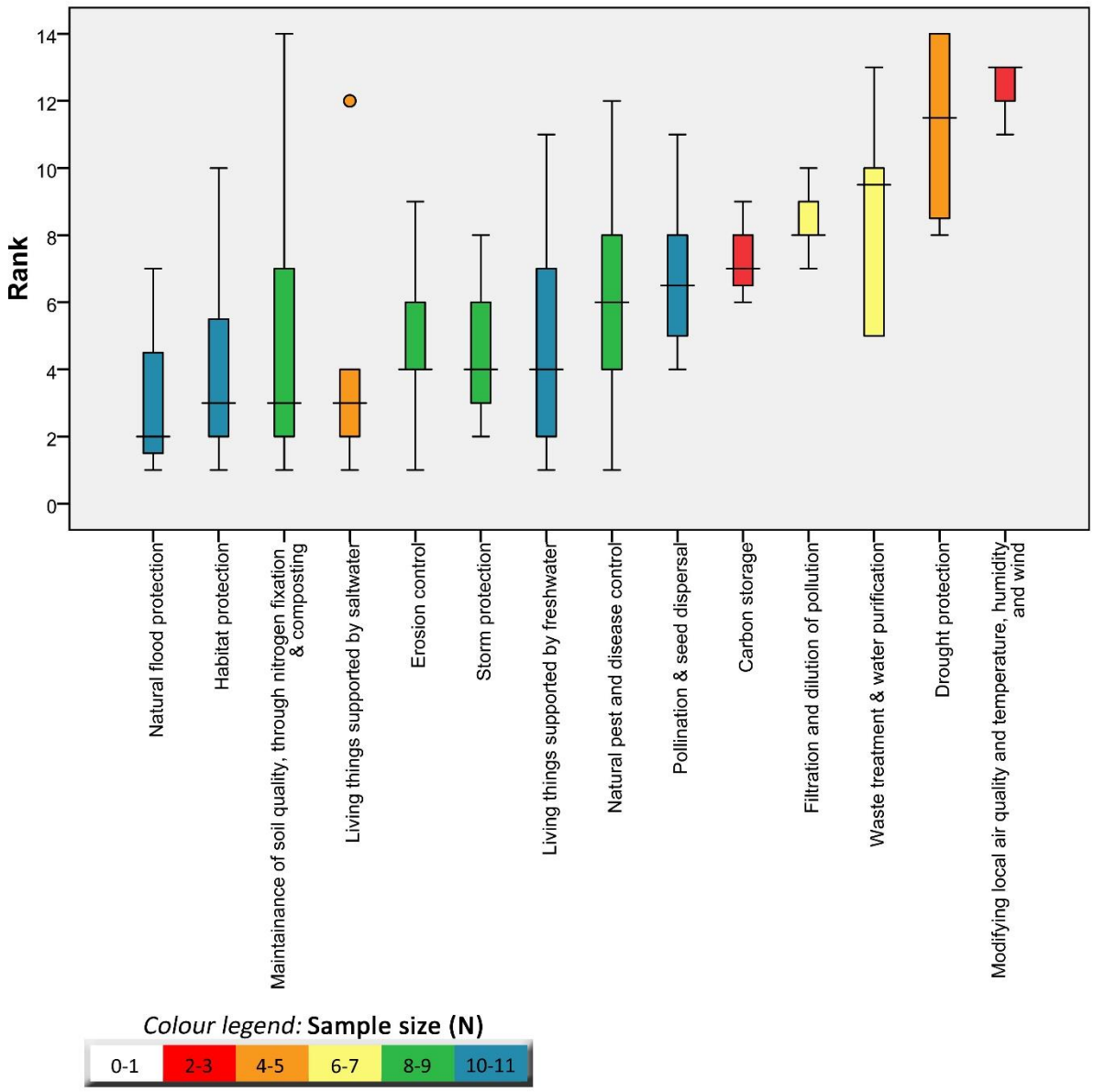


Figure 7, Ranking of regulating ecosystem services, all landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.2.1. Private landowners

Looking at the ranking made by the private landowners, some differences are visual (fig. 8). The private landowners considered "Storm protection" to be more important than the other landowners (table 6 & table7). Some other distinguishable differences are the "Habitat protection" that is considered less important by the private landowners, only having a median of 5.00, compared to the total sample were the median is 3.00. One explanation to this difference is that both the councils and the NGO consider

that “Habitat protection” as one of their key task with their land management, while the private landowners manages the land for other purposes. Another striking difference is the value of “Living things supported by saltwater”, which had a median of 3.00 among all the landowners. Only one private landowner considered that this service was existing on his/her land and gave it rank of 12.

Private landowners, regulating services

	Median	Mode	N Valid
Natural flood protection	2.00	1	7
Maintainance of soil quality, through nitrogen fixation & composting	3.00	2[b]	7
Storm protection	3.00	2[b]	6
Erosion control	4.00	4	7
Natural pest and disease control	4.00	4	7
Habitat protection	5.00	3[b]	7
Living things supported by freshwater	6.50	1[b]	6
Pollination & seed dispersal	6.50	7	6
Waste treatment & water purification	7.50	5	4
Filtration and dilution of pollution	8.00	8	4
Carbon storage	9.00	9	1
Drought protection	11.00	8[b]	2
Modifying local air quality and temperature, humidity and wind	11.00	11	1
Living things supported by saltwater	12.00	12	1

b. Multiple modes exist. The highest ranking is shown

*Table 7, Ranking of regulating ecosystem services, private landowners**.** Table is showing median, mode, valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).*

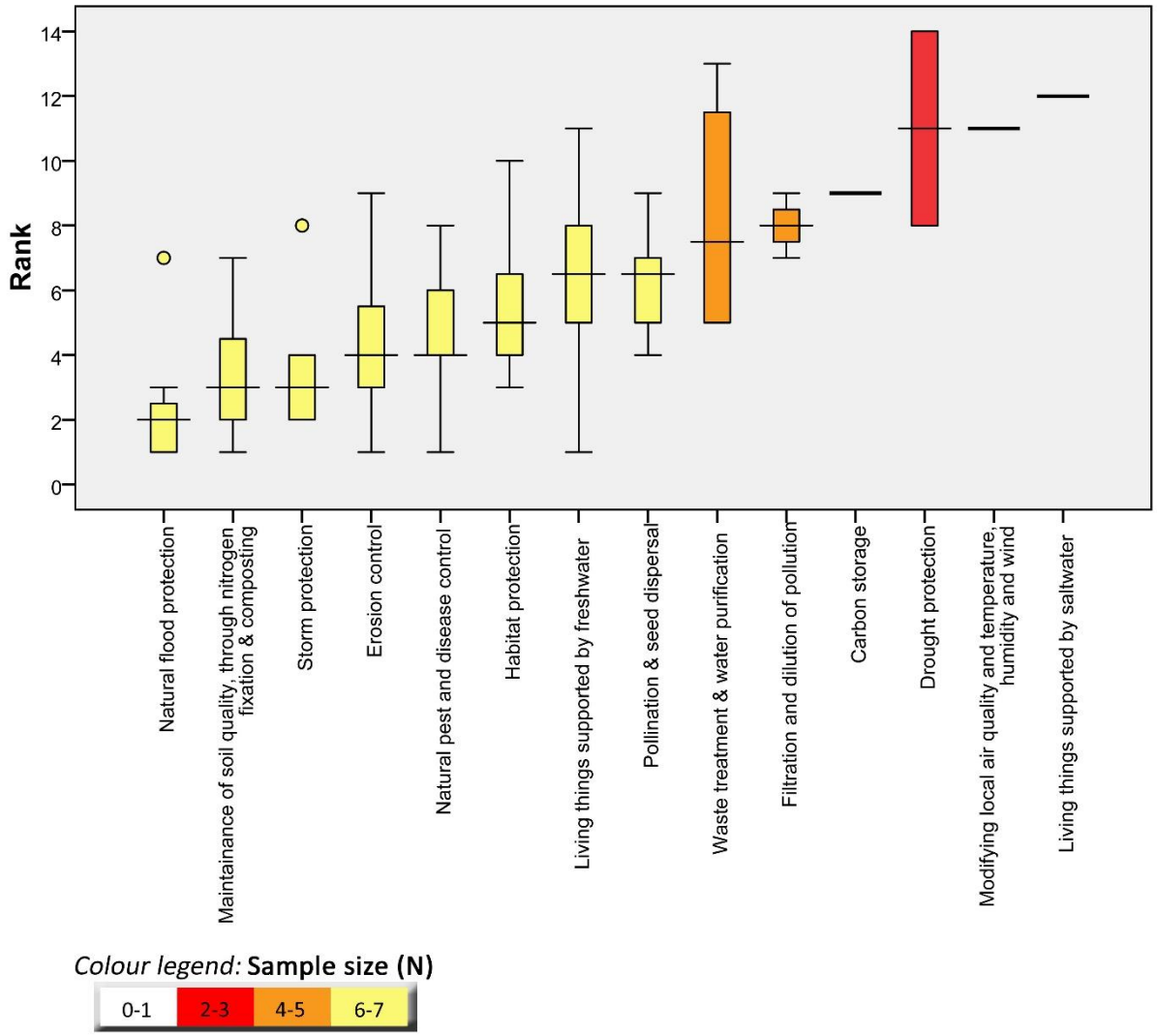


Figure 8, Ranking of regulating ecosystem services, private landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.2.2. Council landowners

Both of the councils ranked had the same three ecosystem services in their top three (table 8). Those were "Living things supported by saltwater", "Living things supported by freshwater" and "Habitat protection". "Natural flood protection" was also considered to have some importance, since both of the councils ranked them as number five. Comparing with all of the landowners, "Maintenance of soil quality, through nitrogen fixation & composting" was considered significantly less important. One council ranked it last while the other saw it as non-existing. "Living things supported by saltwater" was ranked higher compared to the private landowners. This can partly be explained by the purposes of

the council owned land, where the councils aims to create certain habitats promoting both fresh and salt water environments.

Council landowners, regulating services

	Council 1	Council 2	Total N
Living things supported by saltwater	1	3	2
Living things supported by freshwater	2	2	2
Habitat protection	3	1	2
Erosion control	4	0	1
Natural flood protection	5	5	2
Carbon storage	6	0	1
Storm protection	7	0	1
Filtration and dilution of pollution	8	0	1
Drought protection	9	0	1
Waste treatment & water purification	10	0	1
Pollination & seed dispersal	11	4	2
Natural pest and disease control	12	0	1
Modifying local air quality and temperature, humidity and wind	13	0	1
Maintainance of soil quality, through nitrogen fixation & composting	14	0	1

Table 8, Ranking of regulating ecosystem services, council landowners. Table is showing the two councils and their ranking of regulating services, as well as indicating the sample sizes.

4.2.2.3. NGO landowner and manager

Like the councils, the NGO did consider “Habitat protection”, “Living things supported by saltwater”, “Living things supported by freshwater” and “Natural flood protection”, to be of particular importance (table 9). Their answers correspond quite well with the councils and distinguish itself from the private landowners on “Maintenance of soil quality, through nitrogen fixation & composting”.

NGO landowner & manager, privisioning services

	NGO as landowner	NGO as manager	Total N
Habitat protection	1	1	2
Living things supported by saltwater	2	4	2
Living things supported by freshwater	3	3	2
Natural flood protection	4	2	2
Storm protection	5	6	2
Erosion control	6	0	1
Carbon storage	7	0	1
Pollination & seed dispersal	8	5	2
Waste treatment & water purification	9	0	1
Filtration and dilution of pollution	10	0	1
Natural pest and disease control	11	0	1
Maintainance of soil quality, through nitrogen fixation & composting	12	0	1
Modifying local air quality and temperature, humidity and wind	13	0	1
Drought protection	14	0	1

Table 9, Ranking of regulating ecosystem services, NGO landowner and manager. Table is showing how the NGO ranked the provisioning services, as well as indicating the sample sizes.

4.2.3. Cultural services

The cultural services had a high number of valid samples for all ES. Almost all landowners could refer to these services and ranked them. Three cultural services emerged with a median rank higher than four. These were “Preservation of nature for future generations” with a median of 2, “Enjoyment of nature” with a median of 3 and “Educational purposes” with a median of 3.5. Especially “Preservation of nature for future generations” was considered important, since all of the landowners gave it a rank between 1 and 4. As visible in (table 10) and (fig. 9), the remaining cultural services had a greater spread in their ranking. “Spirituality and/or religious connection”, “Indirect experience (photos, films, etc.)” and “Symbolism (e.g. the thistle as a national plant)”, had a low importance.

All landowners, cultural services

	Median	Mode	N	
			Valid	Missing
Preservation of nature for future generations	2.00	1[a]	11	0
Enjoyment of nature	3.00	2	11	0
Educational purposes	3.50	1[a]	10	1
Sense of place	5.00	5[a]	11	0
Cultural heritage	5.50	1[a]	10	1
Birdwatching	5.50	3	10	1
Outdoor activities (hiking, boating, fishing, hunting, etc.)	6.00	3	11	0
Research purposes	7.00	10	9	2
Spirituality and/or religious connection	8.00	6[a]	9	2
Indirect experiance (photos, films, etc.)	8.00	9	9	2
Symbolism (e.g. thistle as a national plant)	9.00	10	9	2

a. Multiple modes exist. The highest ranking is shown

Table 10, Ranking of cultural ecosystem services, all landowners. Table is showing median, mode, valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).

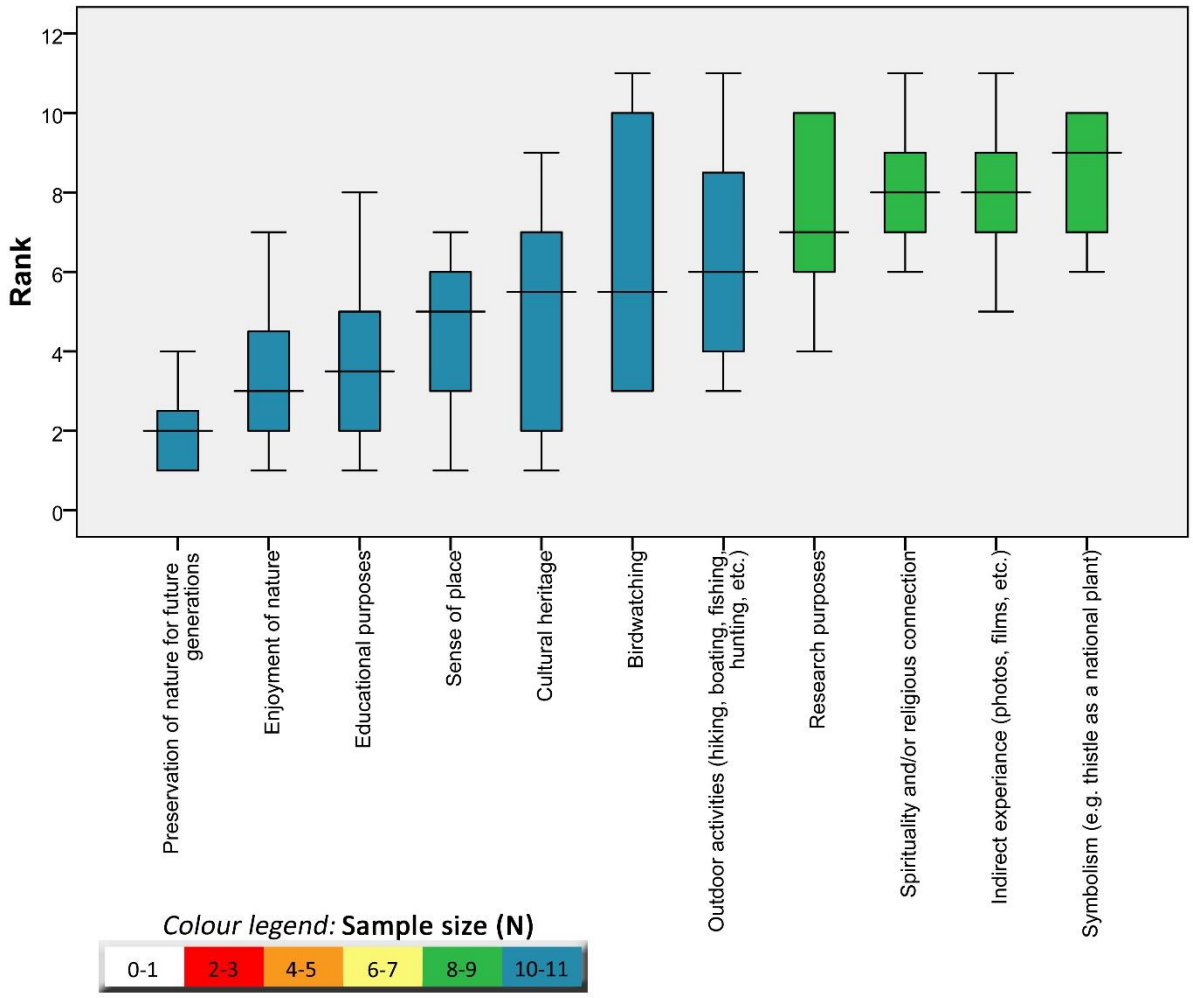


Figure 9, Ranking of cultural ecosystem services, all landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.3.1. Private landowners

When distinguishing the private landowners from the total group of landowners, only two cultural services emerged as key, “Preservation of nature for future generations” and “Educational purposes” (table 11) (fig. 10). “Cultural heritage” was also very important to about half of the private landowners. But this service also had a greater spread among the group, where some private landowners though the “Cultural heritage” to be less important. Comparing the private landowners with the combined group of landowners, it is clear the private landowners regarded “Birdwatching” and “Research purposes” as less important.

Cultural services, private landowners

	Median	Mode	N	
			Valid	Missing
Preservation of nature for future generations	2.00	1[b]	7	0
Educational purposes	2.50	1[b]	6	1
Cultural heritage	4.00	1[b]	7	0
Enjoyment of nature	4.00	2[b]	7	0
Sense of place	5.00	5	7	0
Outdoor activities (hiking, boating, fishing, hunting, etc.)	6.00	3[b]	7	0
Indirect experiance (photos, films, etc.)	7.50	5	6	1
Symbolism (e.g. thistle as a national plant)	8.00	7[b]	7	0
Spirituality and/or religious connection	8.00	8[b]	6	1
Research purposes	8.00	10	6	1
Birdwatching	8.50	11	6	1

b. Multiple modes exist. The highest ranking is shown

Table 11, Ranking of cultural ecosystem services, private landowners. Table is showing median, mode, valid and missing samples. Ecosystem services were ranked according to importance, from top to bottom. Ranking primarily based on median, secondarily on mode and last based on valid sample size (ranking further described under methodology).

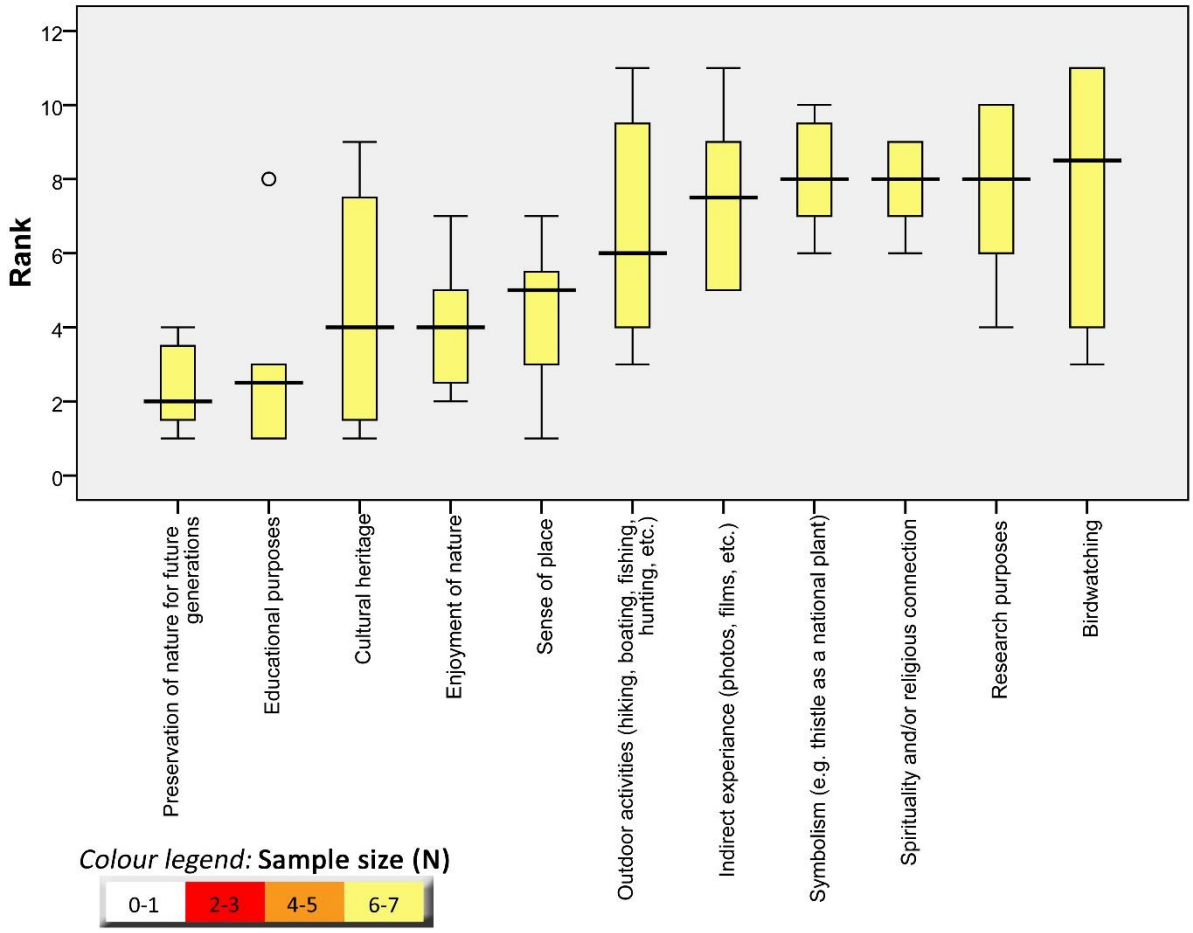


Figure 10, Ranking of cultural ecosystem services, private landowners. Median visualized with wider transecting line. 50th percentile are indicated with the bars. Error bars indicates the spread of the full sample, excluding any potential outliners indicated by dots.

4.2.3.2. Council landowners

The council landowners indicated likewise that "Preservation of nature for future generation" are among the most important values on their land. "Enjoyment of nature" and "Birdwatching" was also considered important. The answers of the two councils were somewhat divided on "Sense of place". Council 2 thought that "Educational purposes" was of great importance. As seen when comparing (table 10) and (table 12), the councils' answers correlate quite well with the total group of landowners.

Council landowners, cultural services

	Council 1	Council 2	Total N
Preservation of nature for future generations	1	2	2
Sense of place	2	6	2
Enjoyment of nature	3	1	2
Birdwatching	4	3	2
Cultural heritage	5	0	1
Educational purposes	6	4	2
Research purposes	7	7	2
Outdoor activities (hiking, boating, fishing, hunting, etc.)	8	5	2
Indirect experiance (photos, films, etc.)	9	0	1
Symbolism (e.g. thistle as a national plant)	10	0	1
Spirituality and/or religious connection	11	0	1

Table 12, Ranking of cultural ecosystem services, council landowners. Table is showing the two councils and their ranking of cultural services, as well as indicating the sample sizes.

4.2.3.3. NGO landowner and manager

Just like all of the other landowner groups, the NGO ranked "Preservation of nature for future generations" and "Enjoyment of nature" among the most important. The answers given by the NGO representatives, were different from each other. This can be explained by the different purposes of the sites that the NGO representatives manages. The leased site is predominantly created for outdoor activities and accessibility for the local community. While the site owned by the NGO is created for the purpose of nature conservation and research. This is reflected in the ranking made by the NGO (table 13).

NGO landowner and manager, cultural services

	NGO as landowner	NGO as manager	Total N
Preservation of nature for future generations	1	2	2
Enjoyment of nature	2	1	2
Birdwatching	3	8	2
Research purposes	4	0	1
Educational purposes	5	4	2
Sense of place	6	5	2
Cultural heritage	7	7	2
Indirect experiance (photos, films, etc.)	8	9	2
Outdoor activities (hiking, boating, fishing, hunting, etc.)	9	3	2
Symbolism (e.g. thistle as a national plant)	10	0	1
Spirituality and/or religious connection	11	6	2

Table 12, Ranking of cultural ecosystem services, NGO landowner and manager. Table is showing how the NGO ranked the cultural services, as well as indicating the sample sizes.

4.2.4. The most important ecosystem services

Summarizing the overall trends in the ranking of ES, it is clear that some services are more important than other. “Crop, fruit and vegetable production”, “Grazing, hay production and crops for animals” and “Livestock and other domesticated animals (beekeeping etc.)” are all regarded as important. Especially among the private landowners, whose livelihood often rely on these services.

The regulating services showed less of a clear pattern, and the different types of landowners thought different services were important. “Habitat protection” was important among the councils and NGO. While “Natural flood protection”, “Maintenance of soil quality, through nitrogen fixation & composting” and “Storm protection” are of key importance for most of the private landowners.

Out of the cultural services were “Preservation of nature for future generation” the absolute most important. It was top ranked in all of the landowner groups and every participant gave it a ranking of four or higher. It shows that this service is of great importance. The other cultural services showed a greater spread in their ranking, although “Enjoyment of nature” was ranked high by most of the landowners.

4.3. Strategies and attitudes to climate induced changes

4.3.1. Storm surges

Six of the landowners had experienced a storm surge on their land at least once. Some had experienced it several times. Three landowners never experienced any storm surges, one of which is a council. This council has experienced storm surges on other sites, but not on their land possessions along the Forth. One landowner had experienced localized flooding in connection to storm surges, but it is unclear if this had to do with short or long term weather event.

Storm surges seems to be something that happens with some frequency in the region, since many landowners mention events dating back to the 1970's until present day. The landowners who experienced the storm surges were asked how this affected their land management. The RSPB mentioned that this caused no harm to them, since the goal of their land is to create saltmarshes which are benefited by supply of saltwater. One farmer and one council said that the damages from storm surges had not affected their land use. But for the remaining five landowners, all private, most mentioned the temporary damage that salt water causes to the land. Some had to apply more salt tolerant crops to the damaged land, such as grass. Three farmers mentioned that they had heighten or strengthen the seawall in response to storm surges.

The concern for storm surges is divided. Some of the landowners mentioned that they were in general concerned, although that concern does not necessarily apply to their own land. Clackmannanshire council representative mentioned:

"In a wider context, yes. (But) not really in connection to the Black Devon Wetlands. You see if that happens it is a natural thing and it may just add more natural variety if you get more brackish water into the system." – Clackmannanshire representative

Other landowners are have a more direct concern of their land, although it might not be their biggest worry. As mentioned by one farmer:

"Everything is a concern, but storms are not more of a worry than other things." – Farmer 5

There is also a large section of landowners that are not worried about storm surges. This could have to do with them having not experiencing any storm surges or that they live in a place naturally protected from storm surges. Other non-worried landowners attribute their lack of concern to the fact that they have taken preventive measures. One farmer said:

"We used to be concerned about the part down here, but we've seen how well it has been doing this year. When all the other places have been flooded, that place has actually done well. But we have done repair work to the seawall there". – Farmer 1

There are no unified concern for storm surges among the landowners, and those who are worried seems to be less worried about their own land and more worried about storm surges in the greater region.

4.3.2. Flooding

The landowners were asked about their experiences of flooding events. Unlike the storm surges, these flooding events referred to long term weather events causing high water flows from precipitation. None of the landowners mentioned any major flooding events and five of them had never experienced any flooding on their land. Four experienced reoccurring local flooding connected to the season. This could for example be larger puddles on a rain saturated fields or short term flooding from a smaller stream or a tributary.

Those landowners that experienced localized flooding, had all adapted by adjusting their land use by leaving the land in fallow for time of the year or planting water tolerant crops like grass.

The mentality towards the risk of floods are divided. The councils are worried about the flood risk in the area in general. But for their own sites along the Forth, none of them expressed any concern. RSPB has no worries about their own land due to its characteristics, but voice their concern of the potential environmental impacts that a bad flood response could have to the region.

Among the private landowners, one landowner is particularly concerned after losing some of his crops in a recent flooding. He/she claimed that the flooding was a consequence of the hydrological changes created by a newly restored wetland. But such a statement is hard to prove without further analysing the site. Another private landowner was concerned of the localized flooding from one of the tributaries. But said that he/she tried to cope with that risk through precautionary work and maintenance. Most of the private landowners are not concerned about flooding. Although not concerned, some landowners are actively maintaining their water ways, ditches and seawalls, trying to limit the risks of flooding.

4.3.3. Sea Level Rise

The landowners were asked whether or not they had experienced any SLR. Their answers differed from first-hand experiences to the denial of SLR. Three landowners clearly said that they had notice a SLR. One farmer said:

"We have seen how the sea level has been rising over the years. It is obvious. So we have raised the banks (seawalls). Sea level is definitely rising" – Farmer 5

Both of the councils said that it was unclear if they had experienced any first-hand SLR, but expressed their concerns about it. The same goes with some of the farmers that denied experiencing it first hand,

while at the same time accepting the scientific evidence of a SLR. This shows clearly when asking if people are concerned about SLR. Five farmers expressed their concern for SLR. One farmer said:

"In general yes, but it has not affected our farming practices yet…" –Farmer 3

One farmer answered that he/she had no concern for SLR, saying:

"Well if the average sea level was to rise considerably, then obviously I would be. But it never happened. So I have no reason to." –Farmer 4

The farmer does not deny climate change, but does neither believe that he/she will be affected by it. This could have certain explanations, but it most likely has to do with the location of his/her farmer, located on the top of a hill close to the river.

One farmer denied that the sea level was rising, saying:

"I think it all comes back to bad maintenance… …there is no maintenance!" –Farmer 1

Although there is a great concern among the landowners, there are little done to combat it. Clackmannanshire council has adopted a planning policy, denying further development to areas that might be affected by SLR. Some of the concerned farmers have taken preventive measures by heightening the seawall and improve their drainage. The RSPB consider their site as a preventive measure, since it helps absorbing water at high tides.

4.3.4. Governance aspects of extreme weather events

All of the landowners were asked if they had been included in any discussions regarding the environmental changes and adaptation strategies. Their answers differed between the landowner groups, where councils and the RSPB were involved while the private landowners were not.

4.3.4.1. Involvement of landowners

None of the private landowners claimed to have been taking part in any discussion regarding an adaptation strategy. Some farmer mentioned that he had been contacted by the RSPB to discuss it. However, it seem to be a problematic relationship between the RSPB and many of the farmers, so none of these discussions had been taken any further. The involvement of RSPB in the adaptation strategy can be explained further from a comment given by the RSPB representative:

"Because in many ways, don't want to blow our own trumpet, but RSPB is the organization that is leading the way and suggesting these things. So we are suggesting it to other people and so… So you probably meet some landowners that say that we suggested to them that they do the manage realignment as it is always something we would suggest, to stick a hole in the sea wall and flood your land. But that is a part of what we are looking at." –RSPB representative

So the RSPB do work with many types of adaptation strategies, MR being one of them. At the same time it seems like the RSPB is one of few organizations actually addressing the landowners with these questions.

The councils has seemingly taken on a more community based adaptation strategy, mainly working with the local communities in the urban areas. As mentioned by Clackmannanshire council representative:

"The council is always looking towards public safety first. That is the driver. And then we see what environmental pros and cons that come out of the scheme. We will try to minimize the environmental consequences of any scheme. That is the potential to get a good environmental kickback from it." – Clackmannanshire council representative

Both the council landowners and the RSPB felt included in the adaptation strategy.

4.3.4.2. Inclusion

When asking the private landowners if they felt included in the decision making. None of them did. About half of the farmers would not like to be included, while the other half saw it in their interest to be included. As mentioned by one farmer:

"There should be, at least the local farmers and landowners and just not farmers, but people who just stay in the country. Should all be involved in deciding in what's going to happened" – Farmer 1

4.4. Response to flooding land

To investigate the willingness of the proposed changes in flood defence and saltmarsh creation, private landowners showed reluctance, while council and the RSPB were more interested in the further development of such flood defence.

Most of the private landowners could not see any of their land being flooded. None of them saw any possibilities to maintain a production in a land that would be part-time or full-time flooded. When asking if economic compensation would make it more attractive, three farmers said that it would. One farmer was uncertain, while another gave an ambiguous answers. Two farmers said straight out no.

The farmers are generally reluctant to change in the direction of the MR strategy. It has to do with several different reasons, but one common views is the feeling of giving up the fight against the sea. As expressed by one of the farmers:

"…it goes against the grain of a farmer that has through generations put so much work into the seawall." –Farmer 7

Another common reason is the economic losses and the effects on the land caused by the newly developed saltmarshes. As mentioned by one of the farmers when given the question if he would ever consider converting parts of his land to wetlands:

"…I've seen how bad it works (talking about the RSPB owned site). If I had land that was not productive, you know, and it was not any good to anybody. Then yes, by all means I would do that, but all of our ground is vital to our income basically. And it is good productive farmland. There is values to it in certain places in the country. If there was really bad land and not maintained or whatever. But for us personally, I don't think so." –Farmer 3

The RSPB land manager working on leased land from Clackmannanshire councils, mentioned that the leased land would be well suited for further wetlands development. The owner, Clackmannanshire council, is also open for this suggestion. Leaving the management strategy of the site to their tenant. Falkirk council has also some wetlands, but explain the further development of them as follow:

"Work has previously been done to look at the potential for managed realignment on the Forth north of the River Carron, including public attitudes to this. Some people were keen on the idea but there was also a lot of nervousness about flooding areas of land that are currently within the sea defences. At that time Councillors (elected politicians) were not prepared to support a large-scale managed realignment project. –Falkirk council representative

Since the RSPB owned site already is a wetland. They cannot convert more land and is instead refining the saltmarsh habitat they have created.

5. Discussion

5.1. The outcome of adaptation strategies

This section aims to highlight the differences in output from the two adaptation strategies. The exact outcome is hard to estimate, but several studies describe the experiences from similar project in England and elsewhere. Based on those studies, I will try to estimate the potential impacts that the two adaptation strategies can have on the ES in the Inner Forth.

5.1.1. Impacts on the provisioning services

Regardless of adaptation strategy, change will occur in the output of provisioning services in the Inner Forth (Fig. 11). Considering the valuation by landowners, it becomes obvious that the two adaptation strategies benefits different interests of provisioning services.

Assuming that the current static adaptation strategy can be kept, it is likely that crop production and most other agricultural practices can be maintained in a similar fashion of today (Zhu et al., 2010). The same goes with timber, peat and ornament plant production, where no literature which suggests that the production would change under the static adaptation strategy. Nonetheless, it is likely that food from fishing and hunting would decrease, as this service is dependent on the saltmarshes (Doody, 2004). Since a static defence would cause a decrease of the saltmarshes (Doody, 2004; Foster et al., 2013; Hughes, 2004; Kirwan et al., 2016), this service would most likely be reduced.

Looking at the other adaptation strategy of MR, it is obvious that crop production would be impossible as areas become flooded by saltwater (Kirwan et al., 2016; Zhu et al., 2010). However, not all agricultural practices might be impossible to maintain. Grazing is a common practice in intertidal wetlands and it can be assumed that that livestock and other domesticated animals can be kept for production (Zhu et al., 2010). Timber, peat and ornament plant production are likely to disappear since these kinds of land based plants are intolerant to saltwater (Kirwan et al., 2016). For the same reason, there are possible drawbacks in biofuels, wood and energy crops production. Since a planned retreat would allow saltmarshes to migrate and increase in size. The saltmarsh based services are not endangered in the same way. Healthy saltmarshes creates a good nursing ground for fishes and increases the general production of food for birds and other intertidal species (Foster et al., 2013). Food from fishing and hunting might therefore increase if a MR is implemented.

Regarding the remaining provisioning services, the output is more uncertain and harder to define. It is unclear how wild food such as berries and mushrooms would be affected, since the species providing these services are not specifically defined in this thesis. The development of aquaculture is also unclear, since there are no aquaculture present in today's Inner Forth. The drinking water supply is

today very small and as good as all the landowners have drinking water supplied from the public water system. It can therefore be assumed that the changes to the drinking water supply remains irrelevant. Biogas from manure and animal labour are currently not in use in the Inner Forth. But since none of these ES are directly connected to the land itself, they are assumed to be unaffected.

The surface and ground water is connected to the hydrology, morphology and soil composition of the sites (Spencer & Harvey, 2012). Under the current protective strategy, landowners have adopted a drainage system which quickly removes access water from the land. If a planned retreat strategy would be applied, the hydrology would be drastically changed (Blackwell, Hogan, & Maltby, 2004). Spencer and Harvey (2012) points out that little is known about the exact effects of the hydrology in areas that been undergoing a MR, as well as the areas surrounding the site. Since the Inner Forth region has a large agrarian sector, the hydrological changes in the land could change the output of certain types of crops. I therefore argue that it is of great importance that more research is conducted, investigating the changes in hydrology.

	Landowners' importance			Adaptation strategy	
Ecosystem service	Private	*Council*	*NGO*	*Protective*	*Retreat*
Crop, fruit & vegetable production	Key	Non-key		□	↓
Livestock & other domesticated animals (beekeeping etc.)	Key			□	□
Wild food (mushrooms, berries, etc.)	Non-key		Key	?	?
Food from fishing and hunting	Non-key			↓	↑
Aquaculture	Non-key		Key	?	?
Drinking water supply	Non-key			□	□
Timber, peat, & ornamental plants	Non-key			□	↓
Grazing, hay production, & crops for animals	Key			□	□
Surface water, irrigation & livestock water	Non-key	Key	Non-key	?	?
Ground water, irrigation & livestock water	Non-key			?	?
Energy from biofuels, wood & energy crops	Non-key			□	↓
Biogas from manure	Non-key			□	□
Animals for labour	Non-key			□	□

↑ = Increase in ES output	□ = Unchanged or stable ES output
↓ = Decrease in ES output	? = Unknown change

Figure 11. Importance of the ecosystem services and impacts of the adaptation strategies for provisioning services. The figure shows the key importance among the three groups of landowners as well as the potential impacts of a static adaptation strategy and MR. Key and non-key importance is based on the landowners' valuation. Arrows, boxes and question marks shows the expected outcomes of the two adaptation strategies.

5.1.2. Impacts on the regulating services

Most literature suggests that regulating services are likely to be benefited from a MR and reduced by static flood defences (Fig. 12). Mainly since a lot of these services are connected to the well-being of saltmarshes.

As earlier mentioned, it is likely that static defences will cause the destruction of saltmarshes and thereby the regulating services they produce. Several provisioning services are directly connected to saltmarshes and its ecosystem functions and biophysical structures. Waste treatment, water purification, filtration and dilution of pollution are all regulating services which are benefited by saltmarshes (Barbier et al., 2011). Some of the landowners' key regulating services, like storm protection and natural flood protection are closely connected to the health and size of saltmarshes (Barbier et al., 2011; Luisetti et al., 2011; Zhu et al., 2010) and these services would decline if saltmarshes were reduced. Maintenance of soil quality was an important aspect for private landowner, partly due to its importance for their agricultural practice. Nothing suggest that the natural upkeep of soil quality would change under a static adaptation strategy.

A MR would ensure the flexibility of the saltmarshes and provide the possibility for them to be enlarged. That would in turn generate a more erosion control, increased flood protection and reduce the forces of storm surges (Barbier et al., 2011; Luisetti et al., 2011; Zhu et al., 2010). These are important aspects, considering that they are important to landowners and that climate change is likely to increase the pressures on the coast (Lowe et al., 2009). Although saltmarshes do provide an output of several important regulating services, it is debated if MR sites do preform as good as pristine wetlands. Spencer and Harvey (2012) suggest that the output of services from restored saltmarshes are significantly lower compared to pristine saltmarshes. If they are right, the positive effects of a MR might be over exaggerated. Nonetheless, a managed realignment do allow pristine saltmarshes to migrate (Zhu et al., 2010) and maintain its regulating services. The potential of storing carbon is increased if a MR would be implemented (Luisetti et al., 2011).

There are still some uncertainties about several regulating services. Starting with drought protection, little is known about the potential affected by the two strategies. Drought is a marginal problem in the Inner Forth today, but it is unclear how much of a problem it will be in the future. The effect that MR has on pollination and seed dispersal is unknown. I have come across no studies that have been mentioning if any intertidal ecosystem directly contribute to such services. However, there are studies on the seed dispersal of saltmarsh plants, showing that newly established MR sites have a slow re-generation due to the lack of seeds and a slow dispersal (Spencer & Harvey, 2012). No studies that I

have found, has mentioned the effects of natural disease and pest control nor modification of local air quality and temperature.

Saltmarshes are known for having a high nutrients cycling, which improves the soil quality of the saltmarshes. However, the capabilities of nutrients cycling and uptake of restored saltmarshes are debated and more research is required to fully understand the biogeochemical cycle in MR sites (Spencer & Harvey, 2012).

	Landowners' importance			*Adaptation strategy*	
Ecosystem service	*Private*	*Council*	*NGO*	*Protective*	*Retreat*
Waste treatment & water purification	Non-key			↓	?
Filtration and dilution of pollution	Non-key			↓	?
Erosion control	Non-key			□	↑
Drought protection	Non-key			?	?
Natural flood protection	Key	Non-key	Key	↓	↑
Storm protection	Key	Non-key		↓	↑
Pollination & seed dispersal	Non-key			?	?
Habitat protection	Non-key	Key		↓	↑
Natural pest and disease control	Non-key			?	?
Maintainance of soil quality, through nitrogen fixation & composting	Key	Non-key		?	?
Living things supported by freshwater	Non-key	Key		□	↓
Living things supported by saltwater	Non-key	Key		↓	↑
Carbon storage	Non-key			□	↑
Modifying local air quality and temperature, humidity and wind	Non-key			?	?

↑ = Increase in ES output	□ = Unchanged or stable ES output
↓ = Decrease in ES output	? = Unknown

Figure 12. Importance of the ecosystem services and impacts of the adaptation strategies for regulating services. The figure shows the key importance among the three groups of landowners as well as the potential impacts of a protective strategy and managed retreat strategy. Key and non-key importance is based on the landowners' valuation. Arrows, boxes and question marks shows the expected outcomes of the two adaptation strategies.

5.1.3. Impacts on the cultural services

The impacts on cultural services are much harder to estimate. Mainly due to the lack of measurable indicators that is determined prior to the study. In this thesis, no such indicator was used and it is therefore hard to estimate the outcome of abstract services, such as cultural heritage or sense of place. Some studies tries to estimate the impacts of cultural services for areas that has been undergoing a MR. But these studies gives an incoherent view of the potential impacts, where one study expect increased in recreational activities (Luisetti et al., 2011), while another describes how these sites loses its aesthetic values (Mossman, Davy, & Grant, 2012). I therefore leave any further analysis of the cultural service, acknowledging the development of these values are dependent on the preferences of the observer.

The only cultural services that somehow can be quantitatively estimated, is birdwatching. Birdwatching is connected to the abundance and diversity of birds present in the area, and those aspects can be measured and estimated. As shown in Fig. 13, birds are expected to be one of the early inhabitants of MRA sites (Blackwell et al., 2004) and will benefit from the continued existence of saltmarshes (Hughes, 2004). Under a static flood defence, coastal squeeze will reduce the intertidal habitat and decrease the appearance of birds dependent on these habitats (Hughes, 2004).

A final conclusion is that the impacts on the cultural services are hard to estimate and would require a coherent use of indicators, which this study does not have.

	Landowners' importance			Adaptation strategy	
Ecosystem service	Private	Council	NGO	Protective	Retreat
Birdwatching	Non-key	Key	Non-key	↓	↑
Outdoor activities (hiking, boating, fishing, hunting, etc.)	Non-key			?	?
Research purposes	Non-key			?	?
Educational purposes	Key	Non-key	Non-key	?	?
Cultural heritage	Non-key			?	?
Indirect experience (photos, films, etc.)	Non-key			?	?
Sense of place	Non-key			?	?
Symbolism (e.g. thistle as a national plant)	Non-key			?	?
Spirituality and/or religious connection	Non-key			?	?
Enjoyment of nature	Non-key	Key		?	?
Preservation of nature for future generations	Key			?	?

↑ = Increase in ES output	□ = Unchanged or stable ES output
↓ = Decrease in ES output	? = Unknown

Figure 13. Importance of the ecosystem services and impacts of the adaptation strategies for cultural services. The figure shows the key importance among the three groups of landowners as well as the potential impacts of a protective strategy and managed retreat strategy. Key and non-key importance is based on the landowners' valuation. Arrows, boxes and question marks shows the expected outcomes of the two adaptation strategies.

5.2. Comprehending attitudes and opinions

As been shown in the previous section, different landowners consider different ES to be important. It is therefore little surprising that landowners tend to favour the adaptation strategy that it beneficial to their key values.

In general, private landowners are highly dependent on the agricultural production and feel a reluctance towards giving up land for several reasons. Their interest for a MR is therefore very low, since such an adaptation strategy would go against their interests and ultimately lead to loss of land and income. Instead they favour the static defence strategy where their agricultural practices are kept. Natural flood protection is also a key value, but as earlier mentioned there are no uniform understanding of what a natural flood protection is. There is a general belief among many of the landowners that a static defence can be kept through good maintenance and proper drainage.

Whether or not this is possible remains unsaid, but maintaining a static defence is likely to be increasingly expensive as saltmarshes decline and climate change induced stresses are increasing (Zhu et al., 2010). In the current situation, the landowners themselves that would pay for the increased maintenance of the static defences, like seawalls etc. Although five out of seven private landowners area concerned for SLR, this has not affected their trust in the static defences.

Both the councils and the RSPB are members of the IFLI, which is actively looking at alternative adaptation strategies like the MR. Although none of the councils are currently considering a MR, they have been discussing it. RSPB says that they do look at MR as one option, but also mention that it is not the only adaptation strategy they are investigating. However, it is clear that a MR would support the key interests of both the council and the RSPB.

A unified interest among all landowners was the natural flood protection. However, it is clear that they do not have the same idea of what it means in practice and if the future adaptation strategy should be a soft or a hard solution.

5.3. Opinion on flooding land

Since a soft implementations would involve creation of wetlands and intertidal saltmarshes, it became essential to investigate the landowners' opinion of such solutions. As presented in the result section, several private landowners showed a strong reluctance to flooding land that once been reclaimed by the sea, while the councils and the RSPB were more open towards such solutions.

Conflicts might emerge as some private landowners really considered their cultural heritage to be important. The cultural heritage they mentioned, was often referring to the pride they felt of maintaining the family heritage of farming. Giving up land to saltmarshes goes against their interest of maintaining a productive agriculture and creates a feeling of surrendering the intergenerational fight of claimed land.

Since the Inner Forth is not the first area with this type of conflicting interests (Luisetti et al., 2011), there are great possibilities to learn and understand how other areas have been coping with these types of challenges.

5.4. Finding a common ground

It is evident that there is a lack of involvement of the private landowners, as none of them felt included in the decision making. The lack of dialogue seems to have strengthen a further polarization on the matter of adaptation strategy.

Many of the private landowners showed mistrust towards the RSPB, and saw them as the primary advocate of MR and saltmarsh restoration. Although RSPB is an exponent of such a strategy, their agenda is somewhat broader than just flooding land. The councils' position is primarily decided by their elected politicians and no large scale changes seems to be afoot. Regardless of the landowners' position, there is very little agreement on a future adaptation strategy. To find a common ground solution, compromises are most likely inevitable and raises the question, who decides which ES are most important?

By taking a standpoint in sustainability science, it is essential that a compromised strategy involves aspects of both human and nature systems (Jerneck et al., 2011) as well as complying with a broad time spectra of past, present and future (Anderson, Teisl, & Noblet, 2016). I argue that all of these aspects are present among the current landowners. Nevertheless, as this thesis points out, most of the private landowners feel excluded from the discussions about adaptation strategy. It is important that these landowners get involved in a future adaptation strategy, in order for it to be successful and comply with the criteria of sustainability science. As pointed out by Schultz, Folke, and Olsson (2007), a success of a strategy is often dependent on the involvement and participation of a broad group of stakeholders.

Such involvement requires a trusted and objective mediator that can bridge the disagreements between different stakeholders and come up with compromised solutions (Schultz et al., 2007).

5.5. Limitation

This thesis is limited by the obvious constrains of time and funding. Therefore is the focus in this thesis primarily targeted on the group of landowners. It should also be mentioned that there are several other adaptation strategies, not mentioned in this thesis. Whether or not these would be suitable for the Inner Forth geography, public opinion and nature, is not investigated.

As pointed out by Fisher et al. (2008), ES are an anthropocentric view of the utility of nature. Essentially leading to arguments where nature is conserved for the sake of producing products to human well-being. By accepting the theoretical framework of ES, my arguments become limits to those anthropocentric values, inevitably leaving the bio centric valuation unmentioned.

6. Conclusions

This thesis do not aim to favour any specific adaptation strategy, instead I seek to portrait the two options in an objective and factual manner. After months working on the thesis, I have come to the conclusion that the problems surrounding the Inner Forth adaptation strategy, is more of a governance issue rather than a management problem.

It is clear that landowners have different values and therefore different interests regarding the land use along the river. In many cases these values are in direct contradiction to one another. Private landowners tend to favour the current system, since it allows them to maintain their agricultural practices and their cultural heritage. The RSPB aims to extend the saltmarshes, due to the many improved aspects for wildlife and flood protection. The councils are obliged to take the greater region in consideration before making any decisions, while at the same time complying with political support and a number of national and international agreements and directives.

In the meantime, the static flood defences are improved and maintained by the local landowners. It is uncertain if those flood defences will be able withstand the pressures of the future. But if they are kept three things are certain, the maintenance cost will be increase, the risk of coastal flooding will increase and saltmarshes are likely to be severely reduced. The responsibilities of maintaining the increased cost of the static adaptation strategy and the potential damage of a breach in the defence, would largely fall on the individual landowners. It means that the future agricultural practices in close vicinity of the river, will be more expensive and involve a greater risk. If landowners are willing to accept that risk, the decrease of saltmarshes are likely to reduce the output of ES.

The option of a MR is hardly accepted by several private landowners, who have both economic and personal reasons behind their reluctance to flooding productive land. Economic compensation would seemingly have no or a little effect on these opinions, showing how the arguments against a MR is deeply rooted in the mind set of private landowners.

In order to move the development of a new adaptation strategy forward, it is essential include the currently marginalised group of private landowners. Similar cases have shown that a successful adaptation strategy involves a broad range of stakeholders that are all included in the development of the region. In other words, it might not be the best of ideas to buy out private landowners, but rather to include them in a future adaptation strategy.

In conclusion, a sustainable land management is possible in the Inner Forth. But as this thesis points out, such a strategy would have to include a wider range of stakeholders including the private landowners. Compromises will most likely be unavoidable as the pressures of climate change become greater on both human and nature systems.

7. References

Anderson, M. W., Teisl, M. F., & Noblet, C. L. (2016). Whose values count: is a theory of social choice for sustainability science possible? *Sustainability Science*, 1-11.

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs, 81*(2), 169-193.

Blackwell, M. S. A., Hogan, D. V., & Maltby, E. (2004). The short-term impact of managed realignment on soil environmental variables and hydrology. *Estuarine, Coastal and Shelf Science, 59*(4), 687-701. doi:http://dx.doi.org/10.1016/j.ecss.2003.11.012

CICES. (2016). CICES: Towards a common classification of ecosystem services. Retrieved from: http://cices.eu/

de Groot, R. S., Alkemade, R., Braat, L., Hein, L., & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity, 7*, 260-272. doi:10.1016/j.ecocom.2009.10.006

Doody, J. P. (2004). 'Coastal Squeeze': An Historical Perspective*,* 129.

Esteves, L. S. (2014). What is Managed Realignment? *Managed Realignment: A Viable Long-Term Coastal Management Strategy?* (pp. 19-31): Springer.

Fisher, B., Turner, K., Zylstra, M., Brouwer, R., De Groot, R., Farber, S., . . . Balmford, A. (2008). Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research*,* 2050.

Forth Ports. (2016). Forth ports: Tide tables. Retrieved from: https://forthports.co.uk/marine/tide-tables/

Foster, N. M., Hudson, M. D., Bray, S., & Nicholls, R. J. (2013). Intertidal mudflat and saltmarsh conservation and sustainable use in the UK: A review. *J Environ Manage, 126*, 96-104.

Garbutt, R. A., Reading, C. J., Wolters, M., Gray, A. J., & Rothery, P. (2006). Monitoring the development of intertidal habitats on former agricultural land after the managed realignment of coastal defences at Tollesbury, Essex, UK. *Marine Pollution Bulletin, 53*(1–4), 155-164. doi:http://dx.doi.org/10.1016/j.marpolbul.2005.09.015

Holman, I. P., Harrison, P. A., & Metzger, M. J. (2016). Cross-sectoral impacts of climate and socio-economic change in Scotland: implications for adaptation policy. *Regional Environmental Change, 16*(1), 97-109.

Hughes, R. G. (2004). Climate change and loss of saltmarshes: consequences for birds. *Ibis, 146*, 21.

IFLI. (2016). Inner Forth Landscape Initiative: Welcome to IFLI. Retrieved from: http://www.innerforthlandscape.co.uk/

IPCC. (2013). *Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from Cambridge, United Kingdom and New York, NY, USA:

IPCC. (2014a). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (9291691437). Retrieved from Geneva, Switzerland:

IPCC. (2014b). *Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from Cambridge, United Kingdom and New York, NY, USA:

Jerneck, A., Olsson, L., Ness, B., Anderberg, S., Baier, M., Clark, E., . . . Lövbrand, E. (2011). Structuring sustainability science. *Sustainability Science, 6*(1), 69-82.

Kirwan, M. L., Temmerman, S., Skeehan, E. E., Guntenspergen, G. R., & Fagherazzi, S. (2016). Overestimation of marsh vulnerability to sea level rise. *Nature Climate Change, 6*(3), 253.

Lowe, J., Howard, T., Pardaens, A., Tinker, J., Holt, J., Wakelin, S., . . . Horsburgh, K. (2009). *UK Climate Projections science report: Marine and coastal projections*. Retrieved from

Luisetti, T., Turner, R. K., Bateman, I. J., Morse-Jones, S., Adams, C., & Fonseca, L. (2011). Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England. *Ocean & Coastal Management, 54*(3), 212-224. doi:http://dx.doi.org/10.1016/j.ocecoaman.2010.11.003

Ma, M. E. A. (2005). Ecosystems and human well-being: current state and trends: Island Press, Washington, DC.

Miller, T. R. (2012). Constructing sustainability science: emerging perspectives and research trajectories. *Sustainability Science, 8*(2), 279-293. doi:10.1007/s11625-012-0180-6

Mossman, H. L., Davy, A. J., & Grant, A. (2012). Does managed coastal realignment create saltmarshes with 'equivalent biological characteristics' to natural reference sites? *Journal of Applied Ecology, 49*(6), 1446-1456. doi:10.1111/j.1365-2664.2012.02198.x

Murphy, J. M., Sexton, D., Jenkins, G., Booth, B., Brown, C., Clark, R., . . . Betts, R. (2009). *UK climate projections science report: climate change projections*: Meteorological Office Hadley Centre.

OPERAs. (2016). About OPERAs. Retrieved from: www.operas-project.eu/about

OS data (2016). OS Maps. Retrieved from: https://www.ordnancesurvey.co.uk/

Potschin, M. B., & Haines-Young, R. H. (2011). Ecosystem services Exploring a geographical perspective. *Progress in Physical Geography, 35*(5), 575-594.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., . . . Schellnhuber, H. J. (2009). A safe operating space for humanity. *Nature, 461*(7263), 472-475.

RSPB. (2016). About RSPB. Retrieved from: http://www.rspb.org.uk/about/

Schultz, L., Folke, C., & Olsson, P. E. R. (2007). Enhancing ecosystem management through social-ecological inventories: lessons from Kristianstads Vattenrike, Sweden. *Environmental Conservation, 34*(02), 140. doi:10.1017/s0376892907003876

Sovacool, B. K. (2011). Hard and soft paths for climate change adaptation. *Climate Policy (Earthscan), 11*(4), 1177-1183. doi:10.1080/14693062.2011.579315

Spencer, K. L., & Harvey, G. L. (2012). Understanding system disturbance and ecosystem services in restored saltmarshes: Integrating physical and biogeochemical processes. *Estuarine, Coastal and Shelf Science, 106*, 23-32. doi:10.1016/j.ecss.2012.04.020

UNEP. (2012). *Global Environment Outlook 5; Environment for the future we want*. Retrieved from

Wikimedia Commons. (2016). Image by Eric Gaba, retrieved from: https://commons.wikimedia.org/wiki/File:Scotland_map-en.svg

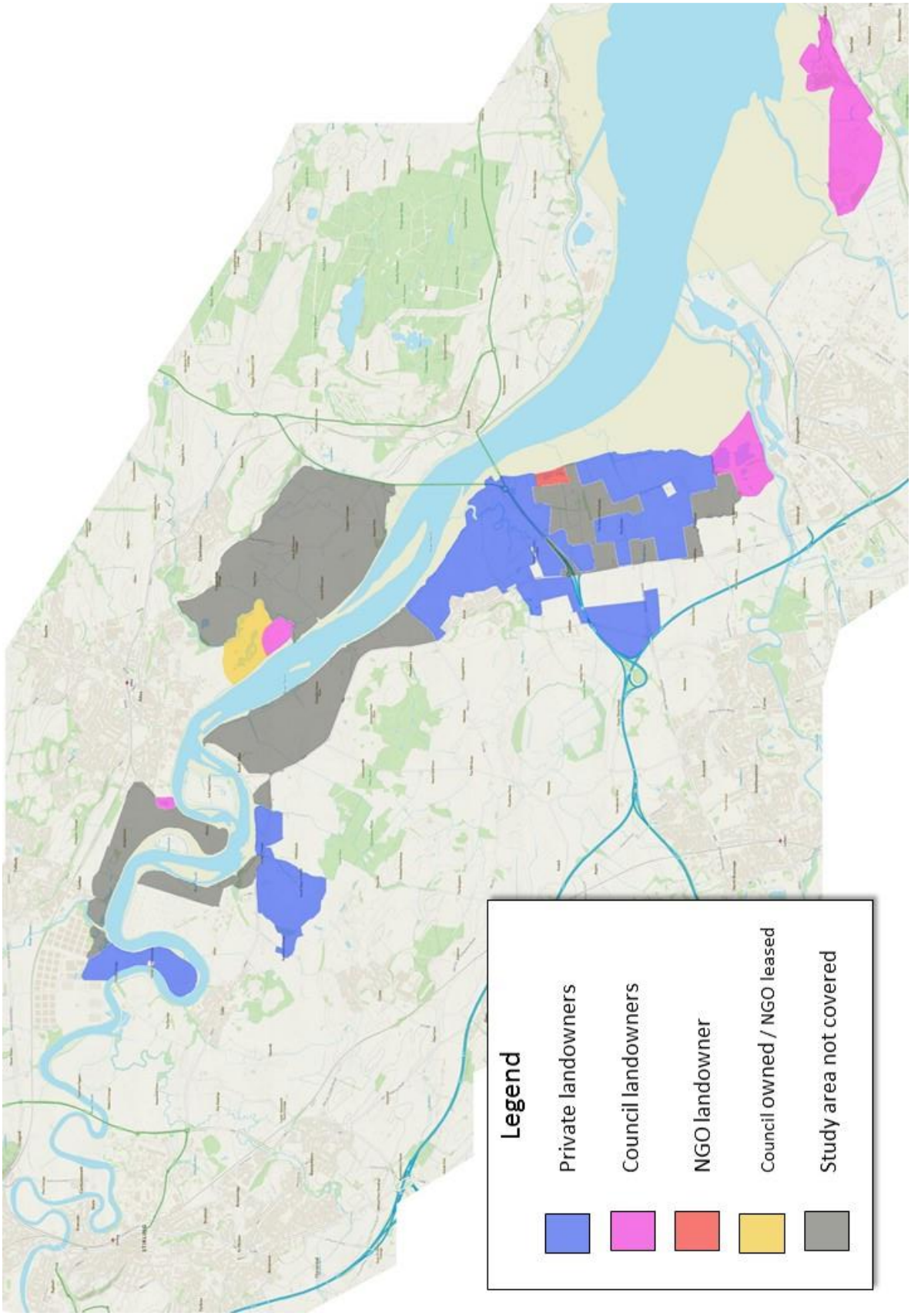
Wu, J. (2013). Landscape sustainability science: ecosystem services and human well-being in changing landscapes. *Landscape Ecology, 28*(6), 999-1023. doi:10.1007/s10980-013-9894-9

Zalasiewicz, J., Williams, M., Haywood, A., & Ellis, M. (2011). The Anthropocene: a new epoch of geological time? *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, 369*(1938), 835-841. doi:10.1098/rsta.2010.0339

Zhu, X., Linham, M. M., & Nicholls, R. J. (2010). *Technologies for climate change adaptation-Coastal erosion and flooding*: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi.

Appendix 1

Map showing the study area and the property of interviewed landowners. Contains OS data © Crown copyright and database right (OS data, 2016).



Appendix 2

Letter of consent.

Letter of consent to participate in research interview

1. I understand that the data collected from the interview will be analyzed by Pontus Ambros and his colleagues at Lund University and University of Edinburgh.

2. All raw data will only be accessible to Pontus Ambros, his thesis supervisors and OPERAs project colleagues in University of Edinburgh.

3. The analyzed data and results will be public. Primarily through the publishing of Pontus Ambros' master thesis at Lund University (published online and in print) and possibly also in a scientific journal.

4. None of the raw data will be published or shared to secondary users (other researchers).

5. All opinions and values stated during the interview will be collected anonymously.

6. Spatial data (answers indicated on map) might be linked to the landowners and can therefore not be considered anonymous, although names or properties will not be mentioned.

Additional consent

I agree that recorded spatial data can be published (non-anonymous) ☐

I agree that the interview will be audio recorded (for transcript of anonymous data) ☐

I agree that my answers can be quoted in text (anonymously) ☐

I hereby confirm that I have read, understood and agreed to the criteria above.

Signature of landowner / manager Location, date

Printed name of landowner / manager

Two copies of this document will be provided. One for the landowner and one for the interviewer.

Page 1/1

Appendix 3

Combined interview question and transcript.

Interview outline

*Before each interview, a map of the area 5*5 km will be shown and the landowner is told that she or he can interact with the map anytime during the interview.*

Date:
Site:
Farm:
Contacts to landowner:

A separate consent form will be filled out.

"First out I need to collect some demographical background data."

A) Demographical background

1. What is your age?

2. What is your gender?

3. What is your occupation?

4. What is the highest level of education you have received? *(circle)*

   Primary *Secondary* *Further education* *B.Sc.* *M.Sc.* *Ph.D.* *other*

In section B, Farming, I would like to better understand why you have chosen to be a farmer and what you do a little bit more in detail. All of the answers will kept anonymously and will not be traced back to you."

B) Farming:

1. What motivates you to be a farmer?

2. What is your goal for your farming? *If needed give example? Make a living? Family heritage?*

3. What percent of your income comes from your land?

4. What are the three main sources of income from your land?

5. Why have you chosen to manage the land they way you do?

6. Are you considering changing your land use in some way?

   "I am now going ask you if you receive any support for the way you use the land. This could be any type of economic benefits, tax benefits, help from people with expertise, etc"

7. Do you currently receive any type of support for your current land use?

8. Do you currently receive any type of support for maintaining flood protection?

9. Do you currently receive any type of support for habitat protection?

In section C, "I'm going to ask you about some different activities and benefits that you may value from your land. I'll ask you about three different groups. For each group, I'd like you to sort the cards for me from the ones you think are most important, to the ones you think are least important. It would be great if you could share your thoughts with me about why you've ordered them the way that you have, either as you're doing the sorting, or else at the end when you've finished. All of the cards have to be sorted and none of them can have the same ranking".

C) Ecosystem services, part 2

**Blue boxes for comments.*

Provisional	*Regulatory*	*Cultural*
1	*1*	*1*
2	*2*	*2*
3	*3*	*3*
4	*4*	*4*
5	*5*	*5*
6	*6*	*6*
7	*7*	*7*
8	*8*	*8*
9	*9*	*9*
10	*10*	*10*
11	*11*	*11*
12	*12*	

13	*13*	
	14	

In section D, "Now I'm going to ask you to take the top 3 cards from each group, and ask you to sort them all together, from most to least important. Again it would be great if you could share your thoughts with me about why you've ordered them the way that you have, either as you're doing the sorting, or else at the end when you've finished".

D) Ecosystem services, part 3

1. What do you think is the most important ecosystem services from your land (all together)?
   1 is most important, 9 is least important.

Ecosystem service	***# Beans***	***Comments***
1		
2		
3		
4		
5		
6		
7		
8		
9		

The interviewer introduces the "beans" which are used to indicate value. "I'm now going to introduce a valuation system. There are 25 beans in total. These represent what you value from your land, and not the monetary value from these services. I would now like you to distribute the beans among the nine cards in front of you, the more valuable the service is the more beans it gets. For example, is a card with 6 beans twice as valuable as a card with 3 beans. Again it would be great if you could share your thoughts with me about when valuing the services, either as you're doing the distribution or in when you are ready".

In section F, "This section aims to better understand the current and past land use practices along the Inner Forth and will be used for setting the context of the study. Any answers given in this section can be connected to the location of the farm and can be traced back to you by someone that is familiar with the area. If you which to be anonymous, I will still ask the questions but your answers will not be published in connection to the site."

E) Location

1. What is your property? *Ask landowner to draw the boundaries on the map.*

2. Who manages the land?

3. What do you produce on your land? *List crops*

4. Can you show me on the map where you produce each? *Ask the landowner to draw with key for later interpretation.*

5. How long have you managed the land?
   - **5.1** You personally
   - **5.2** Your family

6. Are there any land uses that have changed since you took over the management of the land?

"I would now like to ask you about storm surges, flooding and Sea level rise. With storm surges, I refer to damages and flooding caused by short time weather systems. While flooding refers to high water flows caused by long time precipitation. Sea level rise refers to the long term changes of the sea level."

F) Storm surges, flooding & sea level rise

Storm surges

1. For your land here, have you ever experienced any storm surges?

   1.1 If yes, when did this happen?

   1.2 If yes, how did this affect your land and your land use practices? *Ask to indicate on the map.*

2. Are you concerned about storm surges?

   2.1 If yes, have you taken any preventive measures to cope with these changes?

Flooding

3. For your land here, have you ever experienced any major flooding events?

   3.1 If yes, when did this happen?

   3.2 If yes, how did this affect your land and your land use practices? *Ask to indicate on the map.*

4. Are you concerned about flooding?

   4.1 If yes, have you taken any preventive measures to cope with these changes?

Sea level rise

5. For your land here, have you experienced any sea level rise?

   5.1 If yes, how did this affect your land and your land use practices? *Ask to indicate on the map.*

6. Are you concerned about sea level rise?

   6.1 If yes, have you taken any preventive measures to cope with these changes?

7. Have you as a landowner been informed about any potential risks concerning extreme weather and sea level rise?

7.1 If yes, by whom?

8. Have you been involved in any discussion about any adaptation to storm surges, flooding or sea level rise?

8.1 If yes

8.1.1 Does the adaptation strategy involve your land?

8.1.2 What type of adaptation strategy has been suggested for your land?

8.1.3 What do you think about these strategies?

8.1.4 How do the suggested strategies changes impact your livelihood?

9. Do you think that an adaptation strategy will be successful?

10. Do you feel included in the decision making and discussion?

10.1 If no, in what way would you like to be involved?

Before section G, "A common practice to increase flood protection is establish wetlands and areas that can be part time flooded. I therefore wonder if those kinds of measures would be suitable for you, and what you think about turning some land into a flooding buffer zone. I want to remind you that any answers given on the map, might be connected to you" (unless the landowner wished to be anonymous when filling in the letter of consent).

G) Flooded land

1. Are there parts of your property that you could allow being flooded in spring time and at other high water peaks? *Ask to indicate on map.*

2. Is there a land use practice, for example like grazing that would allow your land to still be productive during those times?

2.1 If yes, what type of land use?

3. Would you ever consider converting part of your land into a fulltime or part-time wetland?

4. Would economic compensation make it more attractive for you to convert part of your land to wetlands

"That was all the questions, I would thank you very much for your time and contribution to my research. And I will get back to you after I analysed the results. Thank you very much!"

Appendix 4

Translation of CICES. CICES v. 4.3 (CICES, 2016), translated into ecosystem services of the Inner Forth.

CICES					Translation of CICES
Section	**Division**	**Group**	**Class**		**Ecosystem service**
Provisioning	Nutrition	Biomass	Cultivated crops		**Crop, fruit & vegetable production**
			Reared animals and their outputs		**Livestock & other domesticated animals (beekeeping etc.)**
			Wild plants, algae and their outputs		**Wild food (mushrooms, berries, etc.)**
			Wild animals and their outputs		**Food from fishing and hunting**
			Plants and algae from in-situ aquaculture		**Aquaculture**
			Animals from in-situ aquaculture		
		Water	Surface water for drinking		**Drinking water supply**
			Ground water for drinking		
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing		**Timber, peat, & ornamental plants**
			Materials from plants, algae and animals for agricultural use		**Grazing, hay production, & crops for animals**
			Genetic materials from all biota		
		Water	Surface water for non-drinking purposes		**Surface water, irrigation & livestock water**
			Ground water for non-drinking purposes		**Ground water, irrigation & livestock water**
	Energy	Biomass-based energy sources	Plant-based resources		**Energy from biofuels, wood & energy crops**
			Animal-based resources		**Biogas from manure**
		Mechanical energy	Animal-based energy		**Animals for labour**
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals		**Waste treatment & water purification**
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals		
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems		**Filtration and dilution of pollution**
			Dilution by atmosphere, freshwater and marine ecosystems		
			Mediation of smell/noise/visual impacts		
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates		**Erosion control**
			Buffering and attenuation of mass flows		
		Liquid flows	Hydrological cycle and water flow maintenance		**Drought protection**
			Flood protection		**Natural flood protection**
		Gaseous / air flows	Storm protection		**Storm protection**
			Ventilation and transpiration		
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal		**Pollination & seed dispersal**
			Maintaining nursery populations and habitats		**Habitat protection**
		Pest and disease control	Pest control		**Natural pest and disease control**
			Disease control		

		Soil formation and composition	Weathering processes		**Maintainance of soil quality, through nitrogen fixation & composting**
			Decomposition and fixing processes		
		Water conditions	Chemical condition of freshwaters		**Living things supported by freshwater**
			Chemical condition of salt waters		**Living things supported by saltwater**
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations		**Carbon storage**
			Micro and regional climate regulation		**Modifying local air quality and temperature, humidity and wind**
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings		**Birdwatching**
			Physical use of land-/seascapes in different environmental settings		**Outdoor activities (hiking, boating, fishing, hunting, etc.)**
		Intellectual and representative interactions	Scientific		**Research purposes**
			Educational		**Educational purposes**
			Heritage, cultural		**Cultural heritage**
			Entertainment		**Indirect experiance (photos, films, etc.)**
			Aesthetic		**Sense of place**
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic		**Symbolism (e.g. thistle as a national plant)**
			Sacred and/or religious		**Spirituality and/or religious connection**
		Other cultural outputs	Existence		**Enjoyment of nature**
			Bequest		**Preservation of nature for future generations**