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Development of and Possibilities for the Economic Valuation of Ecosystem Services in the Göta Älv

Master of Science Thesis in the Master Degree Programme, Infrastructure and Environmental Engineering

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Department of Civil and Environmental Engineering
Division of Water Environment Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2014
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Abstract

Access to water is essential for all life on earth. It is used for drinking water, food production, industrial processes and recreation. The ecosystem services that water provides are important for human health and welfare and have therefore a high economic value. This value is often overseen in decision-making, which result in an undervaluation. The value of drinking water is only a small part of the total resource. With a growing population and a changing climate the need for a sustainable and integrated management plan for water resources is urgent.

This study aims to identify the ecosystem services that are connected to the river Göta älv and estimate at which level they have been developed and economically evaluated. It will also investigate however the current information can be used as a foundation for decision-making and education in water management.

The motivation for this topic is the initiative from the European Union to achieve good water quality for all waters and to develop a pricing system for all goods and services related to water. As a response to this the Swedish government has decided that the concept and value of ecosystem services must be integrated in decision-making, economic perspectives and political matters by 2018.

The methodology includes a literature study where previous investigations regarding economic valuation of ecosystem services are reviewed and applied using benefit transfer. The case study is the river Göta älv, located in the southwest part of Sweden. The river has, together with the connecting lake Vänern, the largest runoff area in Sweden.

The identified ecosystem services are categorized in three groups; provisioning, regulating and cultural services. The results show if the ecosystem services are tangible, quasi tangible or intangible for valuation. The values are estimated by using a ranking system; high, medium and significant. The valuation possibility and state of development are graded on scales with six different levels. Only the value of drinking water and water for industrial use achieved the highest score in both categories. Genetic material scored lowest. Parts of the result came out as expected. There is a lot of on-going research in this field and the improvements of valuation methods are unmistakable.

Key words: Ecosystem services, benefit transfer, mitigation, valuation, water quality, water management

Contents

1. Introduction

1.1 General

Water is one of our most important resources. Secure water sources and a safe water distribution system is vital for life and the function of our society (Millenium Ecosystem Assessment, 2005). However the value of sufficient drinking water is only a small part of the total value of the resource. The environments in and close to water serve as habitats for many ecosystem services that are decisive for the wellbeing of our planet. Degradation of nitrogen and phosphorus, climate regulation and biodiversity are some of them. There are also cultural and recreational services like fishing, boating and bathing that are dependent on functioning and healthy ecosystems. All these goods and services are considered a public resource and are in many situations taken for granted. This has resulted in many ecosystem functions and services are being overlooked and undervalued in decision-making and political statements. This is partly due to the difficulties in assessing the economic value of the world's ecosystem services (Farber, et al., 2006). Because of their nature as public goods their value is not represented in the usual market and the access is not managed by supply and demand.

Ecosystem services that are found in and in the surroundings of the river Göta älv can be divided into different groups where some are tangible, only partly tangible or intangible. Monetary values would be useful in cost-benefit analyses and contribute to reveal the true benefit of a project. The most challenging part is to estimate the values that are based on human preferences and therefore have a very high uncertainty since the marginal usage and cost curves cannot be applied.

The ecosystem aspect is usually overlooked in decision-making due to the difficulties in addressing them with economic values (Farber, et al., 2006). Since many ecosystem services represent non-market benefits they must be handled with valuation methods that capture human preferences and willingness to pay. These valuation methods have not yet been fully developed for all ecosystem services, which is a very important step towards finding the true value of water.

The world is facing a global water crisis. Climate change and a rapidly increasing population expose the water systems to huge stresses (Constanza, 1997). The values and attributes of the world's ecosystem services have to be identified in order to secure the access for future generations and the wellbeing of the planet. This has motivated the European Union to take action and implement a Water Framework Directive for all member countries to apply (European Union, 2006). The aim of the directive is to improve and secure the water quality for all water resources by the year of 2015 (WATECO, 2003). The directive also points out the importance of finding the true value of water and water related ecosystem services. Monetary valuation of natural resources is currently a highly debated subject since it could be used as a foundation for decisions regarding funds for maintenance and land use.

This Master's thesis will be carried out as a case study for the river Göta älv, located in the southwest part of Sweden. The river serves as a drinking water resource for ten municipalities with approximately 700 000 people and trends show that this number will increase in the future (Göta älvs vattenvårdsförbund, 2005). The effects of climate change combined with a growing population put a lot of stress on the urban structures in the region and increase the vulnerability (Ashley, et al., 2011). In order to be more and better prepared for facing the effects of the climate change and decrease the vulnerability, cooperation between the different municipalities with common goals and actions is necessary (Göteborgsregionens kommunalförbund 2013-05-02, 2013).

The river provides the region with waterpower, transportation of goods and several industries are dependent on the water for cooling and processes (Göta älvs vattenvårdsförbund, 2005). It also has a high recreational value due to tourism, bating and other activities. Balancing the pressure from all different stakeholders with the necessity of a more sustainable approach towards the environmental aspects is and will be very important. A central approach is to further investigate and map the conflicts related to how the assets of the river are used (Brännlund & Kriström, 2012). Improvements in how the negative effects on the river environment are handled in the planning of activities are important for protecting valuable eco system services. Otherwise losing these services will result in economic costs for the society in the future.

1.2 Aim and hypothesis

This study aims to identify the ecosystem services that are connected to the river Göta älv and estimate at which level they have been developed and can be economically evaluated. It will also investigate how current information can be used as a foundation for decision-making and education in water management. This includes;

- Identifying the ecosystem services that can be found in and connected to the Göta älv

and answering;

- How well have the different aspects of the value of these services been identified and developed?
- How well can the identified ecosystem services be economically valued?
- Is the current situation and amount of information enough to use as a foundation for decision making and for educational purposes in water management?

The hypothesis for this study is that economic values of ecosystem services can be identified and used as a foundation for decision-making and for educational purposes in water management.

1.3 Limitations

The study area will be limited by the boundaries of the lake Vänern and the city of Gothenburg where the river enters the ocean. For the study to be of manageable extent it will also be limited to ecosystem services that are feasible to find and evaluate. The project will also be limited to literature studies. No field studies or measurements will be implemented; all results that are evaluated will be found in the literature or from interviews.

The result will not consider changing preferences over time or the fact that attention, education and knowledge in some cases change a person's willingness to pay. Neither will it consider preference differences due to appearance or generation.

1.4 Distribution

The next chapter will provide a literature review to give necessary theoretical background information and motivation for the topic of the study. Thereafter the methodology chapter will describe the study site and its attributes and environmental conditions. It will also describe how the different ecosystem services will be approached; how they are evaluated and valued. The following chapter is the result and discussion part where all results are presented and commented. There will also be a discussion about whether the aim of the thesis was achieved. The last chapter of the study is dedicated to conclusions and recommendations where the most important results and outcomes will be presented followed by recommendations on how the study should be complemented.

2. Literature review

This chapter aims to give useful background information and motivation for the topic of the thesis. It will mention the European Water Framework Directive and how it is implemented in Swedish legislation with focus on the economic aspects. It will also provide information about biodiversity, ecosystems and ecosystem services, most importantly how they can be valued.

2.1 The European Water Framework Directive

Increasing pressure on the water resources and impaired environmental conditions has motivated the European Union to implement a Water Framework Directive (referred to as WFD) (European Union, 2006). Water management is now one of the top priorities. The main purpose and key concept of the directive is to manage good water quality for oceans, surface water and groundwater by 2015 (WATECO, 2003). The global water crisis is one motivation for the implementation of the directive. The water of Europe is a part of the global water cycle and therefore an important part of the global water crisis. Water does not follow human boundaries; it connects different countries and different continents. To manage and control water quality the WFD is formed to follow the water and catchment areas and not national and political borders. The directive claims that water is not a product; it is a legacy that must be maintained.

The purpose of the WFD is shortly to:

- Protect European waters from further damage and protect water resources
- Promote a long term aspect to protect the water resources and a sustainable water use
- Protect the aquatic environments from emissions and toxic substances
- Reduce present and further contamination of groundwater
- Mitigate the consequences from droughts and flood events

The directive gives all member countries the obligation to work with the same questions regarding water quality. An important concept of the work is focusing on integrating different management areas (WATECO, 2003). The main principles of the implementation of the WFD can shortly be described as achieving good water quality in all surface or ground waters by the year 2015, both ecologically and chemically (Andersson , et al., 2006).

2.1.1 The economic aspect of the Water Framework Directive

It has been acknowledged that the true value of water is much higher than the price we pay for drinking water and handling of sewage (Lundqvist, 2004). With the WFD the concept of water services has been introduced and resulted in a more market related approach that separates water services, water usage and water related activities. To help the member countries to a more united approach towards the economic elements of the WFD the European Union has formed a group, WATECO, whose main goal has been to develop guidance to how to use the WFD.

The role for economics in a water policy is summarized in the WATECO guidance from 2003 as a tool for

- Understanding the economic profits that occur from improving the ecological and chemical status in a river basin
- Identifying the most economic way to achieve the environmental objectives that are related to water resources
- Assessing the economic impact on different stakeholders from suggested measures that aim to improve the water quality
- Further develop financial and economic tools that might be of assistance to achieve environmental objectives

The European Union has, in the WFD, acknowledged the importance of implementing a water pricing policy in order to achieve a more sustainable use of the water recourses (European Union, 2006). To use this price to achieve both environmental goals and reflect economic principles it must include financial, environmental and resource costs.

Assessing the economic values provides the stakeholders with information they are all able to relate to and it can therefore be used as an efficient tool in decision-making processes (WATECO, 2003). It can be useful when comparing different alternatives and to identify who pay, gains and suffers from an implemented action.

2.1.2 Implementing the water framework directive in Swedish legislation

The implementation of the WFD in Swedish politics and legislation has led to a different approach to handling water management. One of the most significant organizational and substantive changes since the implementation of the WFD is the structure of water management (Lundqvist, 2004). Instead of working with political and administrative boundaries the water management is carried out with natural catchment areas. The country has been divided into five water districts with their own authority (Vattenmyndigheten, u.d.). These authorities' main task is to coordinate and control the management of the water districts in accordance to the statutes of the WFD. The new administrations for water management operate in cycles of six years after which the member countries of the EU will use the WFD to coordinate actions to (Jordbruksverket, 2013);

- Promote sustainable usage of the water resources
- Decrease damage on the aquatic ecosystems
- Decrease contamination of the ground water
- Decrease emissions of toxic compounds

The introduction of the Swedish 16 environmental quality objectives will provide guidelines for environmental actions at all society levels (Naturvårdsverket, 2012). The objectives indicate changes that are needed to achieve a healthy environment for this generation, but are not legally binding for authorities or individuals. National authorities are responsible for monitoring and evaluating the development and results of implemented actions. The work with preserving and improving the water quality is represented in the following objectives:

- Natural acidification only
- Zero eutrophication
- Flourishing lakes and streams
- Thriving wetlands

The Swedish environmental objectives are also dependant on actions from the EU to decrease emissions that have impacts on, for example, the acidification of water and land. This calls for great ambition and integrated environmental politics in the EU and UN.

Since more information is needed to determine which actions that are needed to achieve good ecological and chemical status the deadline has been postponed to the year of 2021 (Vattenmyndigheten, 2009). The first step towards this ambition is to investigate which actions are required. Another important aspect is that there can be no degradation in water quality (Andersson , et al., 2006). It is important to prevent worsening of the current state, not only implement improving and repairing actions.

The Swedish government has also decided that the concept and value of ecosystem services must be integrated in decision-making, economic perspectives and political matters within the year of 2018 (Miljödepartementet, 2013).

2.2 Ecosystems and ecosystem services

An ecosystem is a structure of plants, animals, microorganisms and the non-living environment interacting and functioning as a single unit. In a well-defined ecosystem these interactions are often mostly limited to within the boundaries. Only weaker interactions across the boundaries occur. A boundary between two ecosystems could for example be the transition between a forest and a lake. These two systems have strong interactions within their systems and weaker interactions across the boundary.

”Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from eco- system functions.”

According to the above definition by (Constanza, 1997), ecosystem services are the direct or indirect services that humans obtain from the earth’s eco systems. Their benefits to humans are in both monetary and non-monetary terms (Everard, 2012). The concept includes both services, for example climate regulation and treatment of nutrients, and goods, for example food and drinking water. Ecosystem services can be described as flows of material, energy and information coming from the natural capital stock (Constanza, 1997). To produce these ecosystem services one or in many cases several ecosystems are needed. The correlation is not a one-to-one relationship. The ecosystems have functions and produce services that are interdependent. Even though they can still be separated and added as different services. Ecosystem services can together with human capital and services contribute to the production of human welfare.

This report categorize ecosystem services into three different groups, see table 1. These groups contain both purely natural and human-modified ecosystem services and goods.

Table 1 Ecosystem services in Göta Älv

Ecosystem service	Benefit
Provisioning services	
Drinking water	Provision of drinking water
Water power	Energy is produced at four waterpower stations
Industrial use	For processes, cooling and as recipient
Transport	Transport of goods
Genetic material	Provision of medicines and genes for resistance to plant pathogens
Regulating services	
Waste treatment	Treating waste and storm water from for example agriculture, industries, WWTPs and sewers
Regulation of greenhouse gases	Ability to store carbon dioxide by producing organic material
Overflow regulation	The river can adapt to different flows and regulate the water levels in Vänern
Weather regulation	Effects on temperature, humidity, wind, water and precipitation
Cultural services	
Good water quality	The experience of good water quality
Recreational fishing	Sports and recreation
Leisure boating	The values connected to sports, recreation and tourism
Bathing	The value of bathing possibilities
Water views	Increased assessed values for residential and operative buildings
Research and education	The river is used for sampling and studies in research and for educational purposes
Spiritual and religious values	Spiritual and religious values

2.2.1 Provisioning services

Provisioning ecosystem services are the processes that provide for example drinking water, food, genetic resources and energy (Lundy & Wade, 2011). There is a constant flow of provisioning services but that does not mean that they should be considered as infinite (Millenium Ecosystem Assessment, 2005). This flow can be measured and described as biophysical production, for example cubic metres of drinking water. The provision is, as for other types of manufactured goods, dependent on both the flow and the stock.

The valuation possibility for provisioning services are mostly tangible but for some services, or parts of values of services, intangible.

2.2.2 Regulating services

Regulating ecosystem services refer to benefits such as climate and weather regulation, water treatment and overflow protection (Lundy & Wade, 2011). Most of the regulating services have tangible values but some of them are difficult to identify and find.

2.2.3 Cultural services

Cultural ecosystem services are defined by (Constanza, 1997) as benefits and values of non-material characteristics associated with ecosystems. They are often valued by their aesthetic, educational or spiritual attributes and non-material benefits. This can be different kind of recreational and spiritual values. Due to the complexity of this definition there are often difficulties when cultural ecosystem services are included in decision-making (Satz, 2013). The values of these services are mainly identified by hedonic pricing methods, which are based on people's willingness to pay for them. The challenging parts of including cultural ecosystem services in environmental assessments are;

- Accounting for trans boundary benefits
- Handling the plurality of values that different people connect to one ecosystem service
- Finding a valuation method and unit

Recreational values are an important part of this category. Water is used as a medium where the recreational activities and occupations take place (The Geological Survey, 1962). The economic value for this service depends on the intensity of use and number of users. The valuation possibilities for the services in this category are quasi-tangible; it is possible to estimate parts of the total value but making an exact estimation is not possible at this time.

2.3 Biodiversity

The following definition of biodiversity was declared by the United Nations at a conference regarding sustainable development and environmental aspects in Rio de Janeiro in the year of 1992.

"The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

This definition focuses on the high number of different layers and dimensions which biodiversity represents. According to the definition, biodiversity includes diversity in roughly three different levels; diversity of species, of genes and ecosystems (Slootweg, et al., 2006). It also points out how biodiversity can be considered the foundation of ecosystems and ecosystem services and thereby be directly connected to human survival and welfare. It is a critical and important parameter both in natural and human-managed ecosystems.

2.4 The ecosystem approach

The concept of sustainable development is an integrated approach where economic and social welfare is dependent on a viable use of supporting ecosystems and natural stock (Everard, 2012). The ecosystem approach refers to a strategy for integrating sustainable management of water, land and living organisms. It will help achieving a balance between sustainable use, conservation and equitable use of the natural capital stock. An ecosystem approach uses technical methodologies that focus on different structures of biological levels and therefore provide applications that integrate all organisms and their environments. Using this approach can improve the results in decision making since it includes the interactions between different elements of a whole system. These methods require a special management approach due to the complexity of ecosystem functions and structures. Combined with the lack of appropriate operational tools and policies it is a great challenge to practice these principles. However, the pragmatic approach can be found and provided by a description of the high number of benefits that humans derive from ecosystems through ecosystem services and goods. If these difficulties can be defeated the ecosystem approach has proven to be an effective tool for policy- and decision-makers. Especially when managing many different ecosystem services at different scales.

Sometimes a cost-based approach can be useful to identify the cost of substituting or mitigating an ecosystem service (Swinton, et al., 2007). This estimation can be considered the lowest cost for a change in an ecosystem, which can be very useful. According to (Everard, 2012), a view where the different structures and layers are considered will include more stakeholders. This will result in a more extensive participation, which will contribute with useful insight and result in fewer conflicts.

2.5 Valuation of ecosystem services

The value of an ecosystem service can be classified into three different parts, ecological, socio-cultural and economic values, see figure 1 (Constanza, 1997). The ecological value indicates biodiversity, renewability, resilience and integrity. These functions have important roles in different processes that are essential for life. Socio-cultural values are connected to human recreation and well-being. Many people are willing to pay for the access to lakes and other recreational areas.

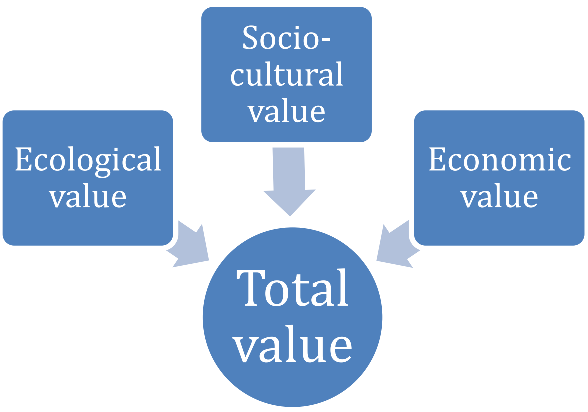

Figure 1. The value of an ecosystem service

2.5.1 Monetary valuation of ecosystem services

Assigning ecosystem services an economic value is both difficult and fraught with a high number of uncertainties (Constanza, 1997). This is because these values are dependent on human preferences and experiences and can therefore not always be described with demand, usage and supply curves. There is a significant risk of underestimating the value of ecosystems connected to water, especially those which provide a larger extent of services (Sander & Haight, 2012). Estimating ecosystem services to a lower value than their actual value might cause them to be underrepresented in decision-making and policies.

Ecosystem services are often excluded in decision making due to the difficulties that are found in assessing and valuing them (Villamagna, et al., 2013). These difficulties result in a lack of useful and available data. Addressing this problem has led to increased inventories of ecosystem services.

The value of ecosystem services cannot always be defined as the true supply of a good or service; it is rather described by the apparent availability and demand of the service. If this is the case the valuation can be achieved by using hedonic pricing or other methods based on willingness-to-pay. Using these methods, without biophysical assessment of supply, results in high uncertainties and errors, especially when involving benefit transfers (see chapter 2.7). There are also many ecosystem services that are produced and consumed without passing through any economic system (Constanza, 1997). They do however contribute to human welfare, sometimes even unnoticed.

The market system often fails to find and identify the intangible values that are connected to the regulating and cultural ecosystem services (Villamagna, et al., 2013). The total economic value of an ecosystem service can be divided into different parts, see figure 2.

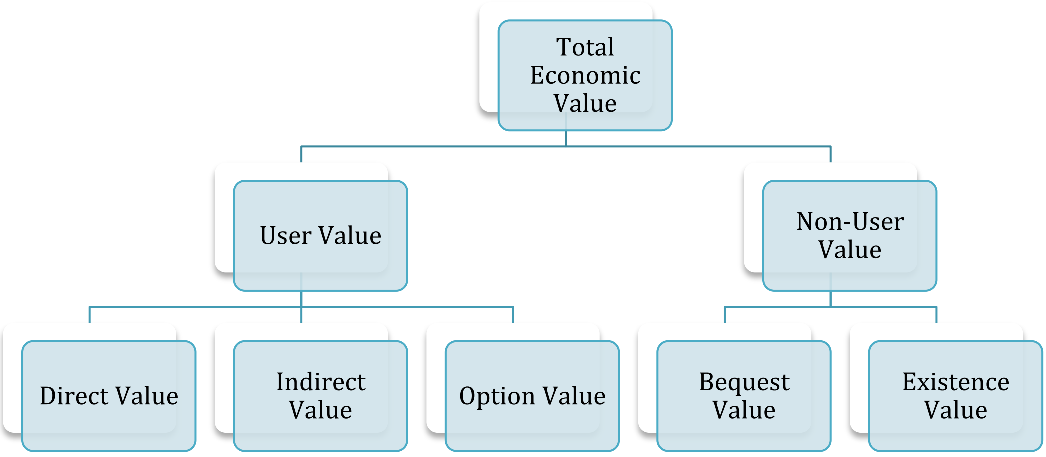

Figure 2 The economic values of ecosystem services

The first step is to divide the *total economic value* into *user values* and *non-user values* (de Groot, et al., 2006). The user values can be described as the direct, indirect and optional values of an ecosystem service. These categories represent values that can be used or consumed directly and the functional values that are extracted from environmental services. The optional value characterises the willingness to use a good or service in the future. The non-user values represent the benefits that can be derived from a service without using it. The existence value identifies that people are willing to pay for a service even if they never intend to use it. This could for example be a national park or the protection of species. There is also a value in the desire to pass values or legacies to future generations; this is referred to as a bequest value. The concept of the total economic value has been broadly used as a framework for assessing values of ecosystems and ecosystem services

2.5.2 Water as a common resource

As mentioned earlier, many ecosystem services are difficult to value in monetary terms due to the fact that they are not represented in the usual market. In a perfect market economy the distribution of resources can be solved efficiently and in favour of the society (Brännlund & Kriström, 2012). A perfect market economy can be characterized by to the following attributes:

- Many buyers and sellers with small market shares
- No cooperation between buyers or sellers
- Homogeneous goods
- Perfect information transfers
- No external effects or common goods

A perfect market economy is also optimal according to Paretos principle, where no one can get a better situation without someone else getting a worse situation. The last attribute is the primary reason why most ecosystem services cannot be included in the ordinary market system.

External effects are effects that are not represented in the market price for a good or service. The concept includes both positive and negative effects. With the presence of external effects a market system can never achieve a Pareto optimal situation (Brännlund & Kriström, 2012). A widely discussed issue is who should pay for the external effects. Either the polluter pay or the one suffering from the pollution pays. According to today's situation, both scenarios are likely.

2.5.3 Common goods and services

Many ecosystem services can be categorized as common resources. According to the standard model the common resources can be described as a single service or source that has many users or stakeholders (Rahmi, 2011). Problems occur when the users intend to exploit it in a way that is inefficient for both the other users and the sustainability of the resource. Water systems and environments consist of several resources, such as fish and fresh water. When different stakeholders want to utilize a resource for their own individual purposes and preferences conflicts usually arise (Lundqvist, 2004). Water is a unique resource considering that it cannot be owned or managed by a single user. Due to its attributes as a continuous medium all activities will affect numerous users and stakeholders. For the same reason it is concluded that water cannot be considered an infinite resource. There are too many interests who claim their right to use it for their own purposes and with their own opinion about how to secure the access for the future. The increasing number of stakeholders is forming a serious threat to sustainable use of the water resources.

A water resource can only be private if it is separated and does not affect the whole resource. External effects is an important concept in this discussion. It is the consequences that one stakeholder's activity causes other users. This is where economic valuation of ecosystem services becomes an important feature. The *polluters- pay* concept where the "winners" compensate the "losers" is theoretically a very good solution. However, due to the high possibility for conflicts it is practically difficult to apply without well-defined boundaries and rules regarding use of the resource. According to Ostrom there are eight different aspects that are important for solving the conflicts about commons and achieve a functioning and stable regulation system (Ostrom, 1990):

- Well defined boundaries where the terms for withdrawal is clear
- Open decision making in matters that regard all stakeholders
- Mutual supervision which is managed by the users themselves
- Accordance between regulation system and local conditions
- Appropriate sanctions where infringement to the common regulations matches the severance and momentary circumstances
- Predefined actions for handling conflicts
- Freedom for the association to state their own regulation and see to that it is complied
- Cooperation between different structures of stakeholders

It is important to acknowledge that external effects do not necessarily have to be of a negative nature. For example, a water power plant not only produces electricity but also contributes by decreasing the emissions of greenhouse gases. In this study the external effects are identified to complicate both the implementation of the polluters pay principle and the separation between the economic values of different ecosystem services.

2.5.4 The issue of double counting

As mentioned in the previous chapter external effects result in many ecosystem services providing both provisioning and cultural benefits, which can sometimes be difficult to separate (Satz, 2013). Double counting is a problem that occurs for interconnected benefits and external effects. Waterpower is one example where the service is beneficial both because it generates electricity and replaces alternatives that produce greenhouse gases. Fishing is both a provisioning and a recreational service and is also therefore an issue for double counting.

2.6 Valuation methods

The methods based on revealed preferences are often referred to as non-market methods or indirect methods (Brännlund & Kriström, 2012). They aim to assess values that are not represented at markets and therefore not dependent on supply or demand. To find these values there are different methods that focus on human preferences and willingness to pay. They seek valuation of ecosystem services based on direct market valuation, indirect market valuation and survey-based valuation. The following chapters will account for the methods that are connected to the results of this study.

2.6.1 Hedonic pricing

Hedonic pricing is an indirect method that identifies the value of a good or service by investigating people's willingness to pay.

This method is based on how the quality of ecosystem services can affect the final price of a good purchased by a customer (Brännlund & Kriström, 2012). The real estate valuation method is a common example of hedonic pricing where the attributes of an object with a favourable attribute valued to a higher price than another, in all other aspects, equal object. In this case the method is used to identify individual's willingness to pay for a water view or being close to water. The valuation process is done in a two-step procedure (Sjöström, 2007). First, construct a model that expresses the connections between the value of a property and the attributes of the property. With this model it is possible to estimate the implicit price on environmental quality for each separate case. Secondly the implicit price is modelled as a function of environmental quality and the social and economic attributes for each household. That relation is used to determine the marginal willingness to pay for a certain level of environmental quality.

2.6.2 Contingent valuation and stated preferences

The contingent valuation method is carried out as direct surveys where the selected people are asked about their willingness to pay for a certain good or service (Swinton, et al., 2007). One of the benefits with this method is that it is possible to value very specific scenarios. It is also possible to use this method to identify the values that people are willing to pay for a good or service they never intend to use directly, the existence values.

2.6.3 Travel Cost Method

Hotelling developed the travelling cost method in the 1940s with the purpose of valuing a national park (Sjöström, 2007). The method is primarily used for valuation of recreational values and is based on the connection between environmental goods or services and market goods (Brännlund & Kriström, 2012). This connection can, for example, be described as the willingness to pay for travelling to a location where a certain ecosystem service can be consumed or experienced. This method has been used for investigations that have been used in this study and is an important part of the value of many, mainly recreational, ecosystem services. It is also mentioned as a complementary study for many of the stated ecosystem services. The procedure for Hotelling's zone method can be described as follows;

1. Collection of data (number of visitors, where they come from etc.)
2. Definition of different travel zones and estimations of travel costs from each zone
3. Collection of data (income, education)
4. Calculation, visitors per capita for each zone
5. Estimation of the relation between travel costs per visit and number of visitors for each zone and visits per capita, income etc.
6. Construction of demand curves for each zone
7. Calculation of total consumer surplus

This methodology is based on a number of assumptions, which are not required to be fulfilled in practice;

- The travelling has only one destination
- The travelling generates no beneficial change
- The alternative cost for time is equal to the individuals' income
- Preferences are homogeneous within the zones

This method can also be used for estimating economic values and benefits in environmental site quality or elimination of existing recreational sites (Nillesen, et al., 2005).

2.7 Benefit transfers

Benefit transfers describe how to use existing knowledge and information to new settings and context (Rosenberger & Loomis, 2001). The concept is based on a method where the estimated willingness to pay for one object is used to value a different object. This procedure is applied mainly because willingness to pay surveys are, in most cases, very expensive and time consuming to operate (Sjöström, 2007). At the same time the economic valuation of environmental attributes has become more important and demanded in decision-making situations. The procedure is different depending on if the valuations regard only values or values and functions. The transfer of values can be done directly or be adjusted to also include income. Transfers of values imply that the average willingness to pay per household for one good is the same for a different good. The transfer of functions is done either by direct transfer or by a meta-regression analysis. The second alternative implies a more complex procedure where values and functions from many different studies are combined.

There are relatively high uncertainties when using benefit transfers. The objects are never identical and there might be different people in the group that values the objects (Sjöström, 2007). Important factors that change a person's willingness to pay are for example age, economy, education and preferences.

3 Methodology

This chapter aims to describe the methodology for this study and the general features of the study area, Göta älv.

3.1 General

This thesis is primarily a literature study. The material that has been used has been selected to contribute with previous studies about economic valuations of ecosystem services, both local and foreign material have been used. The literary material can be divided into different groups; Scientific publications, such as journal articles, reports, public information from websites and reports and investigations from municipalities. The process of finding relevant and updated information is challenging due to the development in this study field over the past years. Identifying up to date material will require access to the most updated research on ecosystem services. This information will be found in scientific databases and at the municipalities that are located within the study area. The selection of material will be decided depending on its relevance regarding time, place and related attributes. Due to the variation in accessible material for different types of ecosystem services the quality and accuracy will be very variable.

The study will partly be a review of other studies on economic valuation of ecosystem services. The result will be achieved using benefit transfers (see chapter 2.7) from one or several different studies.

3.2 Case study– the river Göta älv

The river is situated in the south part of Sweden and extends from the lake Vänern to Gothenburg where it enters the ocean (Göta älvs vattenvårdsförbund, 2005). It is the most water rich river in Sweden and has been used as drinking water source since the end of 1800. Today the river provides ten municipalities with approximately 700 000 people with drinking water.

The urbanization and industrial expansion resulted in negative impacts on the water quality, mainly organic compounds, phosphorus and nitrogen (Vattenmyndigheten, 2009). Comprehensive and well-planned actions have restored the water quality and decreased the impacts from industry and agriculture. To achieve a sufficient ecological and chemical status in the river there is still much work to be done.

3.2.1 Catchment area

The catchment area that belongs to Vänern and Göta älv is the largest in Sweden, see figure 3. It covers 50 233 square kilometres which equals a tenth of Sweden (Göta älvs vattenvårdsförbund, 2005). The largest part of the area runoff to the lake Vänern, only about 3500 square kilometres of the total area is situated below the lake and run off to Göta älv. The area is mainly located in Västra Götaland and Värmland but covers over all six different counties and a small piece of Norway. The average flow in the river is approximately 550 cubic meters per second (Klimat- och Sårbarhetsutredningen, 2006).

Figure 3 The Göta älv catchment area

The catchment area, besides Göta älv, includes 25 tributaries (Vattenmyndigheten, 2009). The largest ones are Säveån, Slumpån, Lärjeån, Grönån and Mölndalsån. The average water flow is 550 cubic metres per second out of which three quarters enters the Nordre river when Göta älv diverges in Kungälv. Several areas within the river basin are objects of national and international interest. These areas are referred to as Natura 2000 sites and are protected by the European Union due to their environmental values.

Adjacent to the river there are five urban areas; Gothenburg, Kungälv, Lilla Edet, Trollhättan and Vänersborg. There are also large agricultural areas, which is one of the main sources of nutrient leakage together with depositions and point sources (Göta älvs vattenvårdsförbund, 2005). The wastewater treatment plant, Ryaverket, in Gothenburg represents the most significant point source.

3.2.2 Future environmental development of the area

Climate change will have an increasing impact on the raw water quality and the water distribution system in the regions close to Göta älv (Göteborgsregionens kommunalförbund 2013-05-02, 2013). The area is assumed to face threats like overflows, landslides and an increased sea level. The average annual temperature will increase in the whole country and the amount of precipitation is assumed to increase in the north part of the country and decrease in the south parts. The changes in local climate will probably result in more extreme weather events such as heavy rains and high winds (Göteborgs Stad, Stadskansliet, 2006).

SMHI has made a prediction of how the climate change will affect Gothenburg and the area around Göta älv using the "Rossby Centrets regionala atmosfär- oceanografi-modellsystem, RCAO. It describes the atmosphere, land, ocean and ice masses (Göteborgs Stad, Stadskansliet, 2006). The simulations show that the average temperature might increase with 3-4 degrees Celsius and the number of days with a temperature above 5 degrees will increase from 200 to 250 days within 100 years. This means that the climate zones will be moved further north. According to the simulation it is also likely that there will be a decrease in precipitation during the summer period and an increase during the rest of the year.

It is more difficult to say how the water levels will be affected in the future (Göteborgs Stad, Stadskansliet, 2006). The primary reason for increased sea levels is that the water expand at a higher water temperature but also the melting process of glaciers. Adapting to climate change should be an important part of the regions urban renewal plan and since the regions adaptive capacity depends on the substitution rate it might be necessary to plan up to 100 years ahead (Ashley, et al., 2011). The regions adaptive capacity is dependent on how its structure and buildings are able to stand both current and future exposure.

The effects from climate change in combination with a growing population put a lot of stress on the urban structures in the region and increase the vulnerability (Ashley, et al., 2011). There are four key components that will decide how vulnerable an urban area is to stresses and disturbances; the capacity to threshold, cope, recover and adapt. To become more and better prepared to face effects of the climate change and decrease the vulnerability, a cooperation between the different municipalities with common goals and actions are necessary (Göteborgsregionens kommunalförbund 2013-05-02, 2013).

The water resources are unequally distributed in the region around Göta älv (Göteborgsregionens kommunalförbund 2013-05-02, 2013). There are several different collaborations regarding substitution water provision between the different municipalities. Especially the municipalities near the coastline; Öckerö, Tjörn, Stenungsund and parts of Kungälv are examples where the water resources are insufficient during summer. The region is currently working together to find common goals and solutions to these kinds of issues. The water asset is considered a common resource regardless which municipalities are geographically favoured. The vision for the region is;

- Tasty and healthy drinking water
- Secure access to good quality fresh water
- Robust water distribution systems

3.3 Valuation of ecosystem services in Göta älv

This chapter aims to identify and describe the valuation methods for some general ecosystem services that can be found in the river Göta älv and its surroundings. Depending on their characteristics they will be divided in to three different categories; provisioning, regulating and cultural services. The ecosystem services that cannot be awarded an exact economic value but are still possible to estimate roughly will be given an expected value in accordance with a system from Morrison, 2012, see table 2.

Table 2 Valuation categories

Category	Expected values
High	Billion SEK
Medium	Million SEK
Significant	<Million SEK

Drinking and sewage water has a tangible value that can be identified in the water fees decided by the municipalities. This information can be found in documents where the fixed costs for different sized water gauges and with statistics for how the users are reported. There are also small differences in the variable cost for water consumption between the municipalities.

The economic value of *waterpower production* is also a tangible value that is dependent on the amount of produced electricity and the current market price. The amount of produced electricity is obtained from the resent or current annual production. There are four different plants that are assumed to be equal in all aspects except how much energy they produce.

To estimate the total value of the water power that is produced in Göta älv the waterpower production is also an important ecosystem service because it replaces energy production that has high emissions of greenhouse gases, such as carbon dioxide. In this study the value of reducing carbon dioxide emissions will be estimated with the amounts of carbon credits that a coal power plant produces compared to a waterpower plant.

The carbon footprint from waterpower is mainly connected to the construction and decommissions of the plant and will not be investigated in this study. Therefore the comparison between the emissions of carbon dioxide from waterpower and coal power will be the total amount of carbon dioxide from a coal power plant.

The *access to industrial water* is essential for the production and activities in the facilities. It is used for cooling processes and as recipient. The value for the ecosystem service is tangible and consists of the economic turnover and profits made by the company for the specific factory. A difficulty for this study location is that many of the factories located in the area are only a part of a larger concern. Therefore it is difficult to get numbers for specific facilities. For some of the industries it is also possible to value the products that are manufactured in one place.

The likeliness of negative effects from the industrial activities and how they alone affect the economic values is not considered in this study.

The value of Göta älv *transportation of goods* can be compared to using trucks or other means of transportation for the same amount of goods on the same distance. However, transportation on rivers often includes transshipment, which is difficult to include in a general estimation.

The waters ability to treat itself from waste material such as nutrients, metals and hydrocarbons is an important ecosystem service. It has been valued in several studies, which have been applied for the case study and used to estimate a corresponding value for Göta älv. Most studies that have been used focus on treating water in wastewater treatment plants, in constructed wetlands and in storm water ponds.

Overflow regulation is an important ecosystem service that prevents overflows, both in the river itself and in Vänern. The outflow from Vänern into Göta älv can be regulated and adjusted due to the current amount of water. The economic value for this service is the cost for overflow protection and avoided costs for damages at overflows. This information can be found in reports and other scientific documents.

Weather regulation has an economic value due to its effects on the air temperature. The value is quasi-tangible due to the possibility of future values. Currently, the cooling effect can be measured in monetary terms. This value will be found in literature and transferred to Göta älv.

The value of *regulation of greenhouse gases* is a quasi-tangible service. It can partly be identified by applying results from different sites. Constructed wetlands are used as references.

The value of *recreational fishing* is estimated by investigating the price for and number of sold fishing permits in the area.

The value of *leisure boating* in Göta älv can partly be estimated by investigating the costs for boat parking and by searching for statistics and information about boat tourism.

The *bathing spots* in the study area are valued by applying a study from the beach at the lake Anten in Alingsås municipality using the Travel cost method. The selection of bathing spot is limited to only include EU standard bathing spots located in or in waters directly connected to Göta älv.

Increased property values due to water views or presence of water is identified by using information that can be found at real estate agencies.

Research and education is difficult to estimate because it requires very extensive and time consuming studies. Some schools and universities are randomly selected and investigated. Depending on their location and environmental profile they are scored and valued differently.

Good water quality is valued by applying previous studies transferred from other sites to Göta älv. Some information can also be found in reports and documents from the municipalities.

Genetic resources and *spiritual and religious values* are assumed to be intangible.

4. Results and discussion

This chapter will present and discuss the results for the identified ecosystem services.

4.1 Provision of drinking water

As mentioned earlier the river Göta älv serves as water source for about 700 000 people in ten municipalities. The provision of drinking water is financed with fees paid by the users (Göteborg Kretslopp och Vatten, 2014). The fee represents a fixed and a variable cost and is meant to finance the water treatment and distribution. The fixed cost is decided depending on how much water the property needs and the size of the water gauge. The variable cost is decided from the water usage. Table 3 shows how the fee is decided in the municipality of Gothenburg. "Qn" represents the water flow through the gauge and is measured in cubic metres per hour and DN is the inner diameter of the gauge.

Table 3 Drinking water cost

Size of the water gauge	Fixed cost (SEK/year)	Variable cost (SEK/m^3)
qn 2,5 (single-family homes)	2621	15,42
qn 2,5	5241	15,42
qn 6	12578	15,42
qn 10	26201	15,42
DN 50	31441	15,42
DN 80	83862	15,42
DN 100	125764	15,42
DN>100	Special investigation needed	15,42

A complete assembly of users in the different price categories for Gothenburg municipality can be found in appendix. The total income from the fixed water costs is, for Gothenburg, 141 535 420 SEK. The total water consumption in Gothenburg is approximately 40,3 million cubic meters per year (Göteborg Kretslopp och Vatten, 2014). The variable income from drinking water can be estimated to 621 426 000 SEK. This gives a total minimum value of drinking water estimated to 762 961 420 SEK for one municipality in the study area.

If the water in Göta älv for some unexpected reason would be insufficient as drinking water there are supplies in the lakes Rådasjön and Delsjöarna (Göteborgsregionens kommunalförbund 2013-05-02, 2013). According to the Regional water distribution plan it is difficult to achieve a plan with solutions for reserve water for all municipalities. This is due to the variable conditions and locations. It is also, for some cases, difficult to achieve the requirement for the reserve water source to cover close to a hundred per cent of the demand. The overall situations in the region are that the possibilities for reserve water are insufficient. Gothenburg, for example, is well prepared and able to cover the demand at both drinking water plants but will not have enough water resources at an event causing a longer interruption.

The mentioned values are the primary contributions to the total economic value of the service. They represent a high tangibility. The attention for water related issues has increased in society debates lately. In order to ensure secure water quality for future generation the water related issues need to be addressed in both regional and local politics. This ecosystem service is well developed and the valuation possibility is high. The tangible values do however only represent the current incomes from water taxes. If the prices increase people would still pay for it. Access to water is essential and is safe to assume that the actual willingness to pay is much higher than the current prices. With this aspect in mind the value of drinking water is tangible but difficult to estimate. The answer to the question how much a person is willing to pay for drinking water is probably close to everything.

4.2 Water power production

The construction of the water power stations for electricity production began in the end of 1800 (Göta älvs vattenvårdsförbund, 2005). Today there are four facilities that are used for production; Vargön, Hojum, Olidan and Lilla Edet, see table 4. The waterpower received from Göta älv is one of the largest supplies in the south of Sweden. The power stations situated in Göta älv has an annual production of about 1,5 TWh which corresponds to a fourth of the total waterpower production in Sweden. The value of the electricity production is the market price for the total electricity production (Björklund, et al., u.d.).

Table 4 The parameters for calculating the value of the water power stations in Göta älv

Station	Vargön	Hojum	Olidan	Lilla Edet
Capacity [MWe]	34	180	77	43
Electricity production per year [GWh]	165	1000	250	210
Fall [m]	5	32	32	7
Price [SEK/kWh]	0.4035	0.4035	0.4035	0.4035

Calculations show that the value of the total electricity production in all waterpower plants is 655, 69 million SEK with the estimated electricity price of 0,4035 SEK per kilowatt-hour (Nordic green energy, 2014) (Vattenfall, 2010) (Vattenfall, 2010) (Vattenfall, 2010) (Vattenfall, 2010).

A modern coal power plant releases approximately one kilogram of carbon dioxide per produced kilowatt-hour of electricity (Vattenfall AB, 2011). This corresponds to one carbon credit á one tonne per thousand kilowatt-hours. The value is based on the price for carbon credits at the Swedish society for nature conservation, 150 SEK each (Naturskyddsföreningen, 2014).

The value of the waterpower plants as power sources that does not have any carbon dioxide emissions is the value of the carbon credits that can by carbon emissions that correspond to producing the same amount of electricity in a coal power plant. This number is estimated to 244 million SEK. This gives a total value for the ecosystem service waterpower production equal to approximately 900 million SEK.

This value is partly misled since not all tonnes of carbon dioxide that are released are paid for. These uncertainties categorize this ecosystem service as very well developed but not as high on valuation possibilities.

4.3 Industries

Several industries are dependent on the water from Göta älv for processes, cooling and as recipient (Göta älvs vattenvårdsförbund, 2005). The possibility to use the river for these purposes is an important ecosystem service whose economic value can be found and estimated in the profits made by the companies. Table 5 shows some companies that use the river in their production and their approximate turnover. These numbers can be used as a guideline value for the industrial value of Göta älv. To get a more accurate result there are other factors, such as the costs for moving the activities to different locations and a more detailed investigation of the companies' economic situation. Some of these industries are only one of many facilities for the company and therefore the importance of their specific location might vary.

Table 5 Industries that use Göta älv

Company	Municipality	[kSEK]
Sävenäs avfallskraftvärmeverk	Gothenburg	1 207 000
SKF AB	Gothenburg	2 500 000
Eka Chemicals	Ale	4 947 325

Sävenäs waste-to-energy plant is a part of Renova, which is a company owned by the municipalities Gothenburg, Lerum, Partille, Kungälv, Ale, Tjörn and Öckerö (Renova, 2013). Renova administers the waste management in the municipalities, including transportation and disposal. The Sävenäs facility is a waste-to energy plant where waste is combusted in favour of distance heat. The plant uses water from Säveån as recipient and for cooling processes. According to Jonas Axner, production and process manager at Renova, it is difficult to estimate the turnover for the plant alone since the activities within the company include other operations that take place at different locations. However, it is possible to value the distance heating and electricity that is produced at the plant. The price for distance heating is roughly estimated to 0,6 SEK per kWh. The produced amount of district heating was 1 704 359 MWh in the year of 2013 and the delivered electricity was, the same year, 264 893 MWh plus intern consumption (Göteborgs Energi, 2014) (Renova, 2013).

SKF AB has been one of the world's leading suppliers of bearings (SKF AB, 2013). The facility in Gothenburg is, as many others of SKF's factories, located close to a water source. The factory is dependent on water from the river for the production. The factory located in Gothenburg uses water from the river Säveån and is located close to where it falls into Göta älv. The economic turnover for the facility in Gothenburg is 2,5 billion SEK per year (Andersson, 2014).

Eka Chemicals (Företagsfakta, 2013) is a part of the large company Akzo Nobel, which mainly produces performance concepts and chemicals for the pulp and paper industries (AkzoNobel, 2014). The economic turnover for the factory in Ale is 4,95 billion SEK (2012).

The economic valuation possibility for this service is tangible but the precise value is difficult to find due to the difficulties with finding the right information. However, it is likely that this ecosystem service has a very high economic value.

There is, overall, more focus on the negative effects that originate from the industries. Emissions of hazardous substances that are released to the water increase the need for water treatment. With this focus the benefits from the industrial production has not been given much positive attention in this field. The level of development is considered low due to the fact that there is little accessible information regarding this subject.

4.4 The value of Göta älv as a waterway

Shipping goods on waterways is a much more cost efficient transportation than using roads or railways (Trafikverket, 2013). There is an on-going negotiation whether the navigation on Göta älv and the lake Vänern should be extended or phased out. A discontinuation of the water traffic would result in a number of external effects and increase the costs and pressure on humans and the environment. These external effects will be greenhouse gases, air pollution, more pressure on the infrastructure, increased accident rates and increased traffic noises. Closing the Göta älv- Vänern waterway will result in twice as many tonne kilometres with trucks and by the year of 2030 the traffic will increase with 140 000 trucks and 1500 trains. If the decision will be to close the river from goods transports it will be necessary to renovate some of the water gates.

This study will assume that the reconstruction and reparations on the river will be seen. Constructing new floodgates will cost approximately 2,8 billion kronor (2012) (Trafikverket, 2013). Since waterway transports are more cost efficient than alternative transportation the savings will be 2,3 billion SEK according to the Swedish road administration. It will also be possible to increase the volume of transported goods with 100% to 3,9 million tonnes per year in 2030. However, according to the economic investigation where the two alternatives where compared, a development of the boat traffic is not beneficial. This is mostly due to the high costs for transhipping and the investment cost. There are on the other hand high economic values in avoided emissions of carbon dioxide. According to Trafikverket 2014, information about emissions of carbon dioxide from heavy trucks is fallible and therefore difficult to compare with other means of transportation (Johansson, 2014).

The highest value for using transportation on Göta älv is found in the external effects that will arise from proceeding with the restoration and extension of the channel. For example the already mentioned benefits from using transportation that produce low amounts of carbon dioxide and the cultural values from restoring and reintroduce the long tradition of goods transportation on Göta älv and Vänern. This is a project that will most likely show its benefits over a long time period. Due to the high number of external effects and the saved carbon credits, the value for this ecosystem service is categorized as high.

4.6 Waste treatment

The water that enters an area through precipitation is, depending on the type of land cover and amount of impervious surface, transformed into groundwater, storm water runoff or vapour (Ashley, et al., 2011). In the urban areas large amounts of the water will runoff the impervious surfaces and enter the sewer system. On its way it is likely to transport hazardous substances such as metals, hydrocarbons and inorganic compounds. At heavy rains, which put large pressure on the sewer pipes, the water is likely to overflow the sewers and enter the water sources untreated.

Göta älv serves as a recipient for wastewater, storm water and runoff from agricultural areas. This causes harmful substances such as metals, hydrocarbons and nutrients to pollute the water and jeopardize the water quality (Göta älvs vattenvårdsförbund, 2005). Metals and hydrocarbons could, for example, damage animals and plants in the water whereas too high amounts of nutrients lead to eutrophication.

An important ecosystem service is the waters ability to treat itself from these substances. Organisms in the water degrade some pollution while some attach to particles and are left in sediments. The value of this service can be estimated by investigating the costs from treating the water at a wastewater treatment plant or facilities for detaining water in constructed ponds or wetlands. In a study from 1997 the ecosystem service waste treatment in lakes and rivers has been estimated to 665 US dollars per hectare and year (Constanza, 1997). When these values are transferred and applied to Göta älv, which has an area of approximately 23,5 square kilometres (=2350 hectar) according to Eniro , the result is 10,4 million SEK.

An important aspect of the problem is the overflows in the combined pipes in the sewer systems. A report from Gothenburg municipality, 2001, compares the economic costs for replacing the old combined pipes and constructing ponds in order to relieve current pressure on the pipes (Falk, 2007). The study concludes that in almost all case studies it is more expensive to construct a storm water pond than to make adjustments in the pipe systems. However several other benefits that are difficult to measure in economic terms were gained with the ponds. An improved pipe system where more water is transported is likely to increase the pressure on the wastewater treatment plants, which might lead to needs for improved capacity.

Constructed wetlands is a technology that has increased due to its low impact on the global warming, low operational and maintenance costs and its high energy efficiency (Hafeznzami, et al., 2012). The advantage with this method is that it uses water with appropriate plants and microorganisms to degrade nutrients, organic substances and heavy metals by using only natural processes. This method protects not only the drinking water but also the aquatic environments. The cost for constructed wetlands is very dependent on the location. A study from Bromölla municipality estimates the cost for constructing ponds in order to delay the transportation of storm water (Björklund, et al., u.d.). The result shows approximately 2,3 SEK per cubic meter and year.

The cost for treating storm water in a wastewater treatment plant is, at Ryaverket in Gothenburg, 15 SEK per cubic meter. The maximum capacity at Ryaverket is currently eight cubic meters per second and during a normal year approximately fifty percent of that amount is storm water (Mattsson, 2012).

This ecosystem service is partly well developed but due to the many contributing factors the valuation possibility is difficult but tangible.

4.7 Overflow regulation

The hydrological cycle is the general denomination for movement of the water beneath, on and above the catchment surface. It is governed by a mass balance principle and relates to flooding as follows (Ashley, et al., 2011);

$$\text{Precipitation} = \text{Runoff} + \text{Evaporation} +/- \text{Storage}$$

Using this equation, floods can be defined as a natural physical phenomena influenced by geomorphology and spatial and social factors. This implies that flooding is often referred to as area specific abnormal extreme events. Flooding is also highly connected to the characteristics of the catchment area and river basin. Urban, rural or combined areas respond differently to exposure to high amounts of water. Flooding is the result of natural phenomena. The concept of floods as a disaster is an anthropogenic phenomenon that origins in the consequences they bring upon human societal functions.

One of the most important contributing factors to the level of severity is the discharge rate of open channels, rivers and streams. The water levels in Vänern and Göta älv are regulated at the water gate at the outflow from the lake (Göta älvs vattenvårdsförbund, 2005).

To protect the river surroundings from overflows dredging works are performed to maintain the shape of the riverbed (Swedish Geotechnical Institute, 2011). Erosion in the river causes sediment to fill the bottom and sides with gravel and other particles. According to an investigation from SGI the costs for dredging is 100 kronor per cubic metre for soil that is not contaminated. The masses must be put in an approved area that can be approximately estimated to 100 kronor per cubic metre.

There is also a value in using the river as a reservoir and to regulate the water levels in Vänern and in the river (Göta älvs vattenvårdsförbund, 2005). The possibility to control the water levels in the lake are very useful to prevent overflows in the cities around Vänern. This value is difficult to measure due to its uncertainty. The damage that comes from an overflow can be very variable and consist of both tangible, semi tangible and intangible values. In a report from the centre for Climate and Safety at Karlstad University, the social and economic consequences from an overflow in Vänern have been investigated (Andersson, et al., 3013). The damages from an overflow can be described as in table 6.

Table 6 Damages caused by overflows

	Direct	Indirect
Tangible	• Damage on buildings, inventories, infrastructure, vehicles, agriculture and forestry • Interruptions in business activities in the flooded area • Damage on flood protection facilities	• Interruptions in business activities outside the flooded area • Costs for evacuating people to new homes • Costs for evacuations and rescuing operations • Costs for decontamination and clearance
Intangible	• Death • Negative health effects • Interruptions in communication and community service • Environmental damage • Damage on cultural values	• Inconvenience during the reset period • Increased vulnerability to further interruptions or hazards

The study is based on identification of the risks and a system that weights them differently depending on their severity. With this approach the study identifies the five most vulnerable cities; Karlstad, Kristinehamn, Lidköping, Vänersborg and Mariestad and investigates different scenarios (Andersson, et al., 3013). The damage costs they present are categorized as medium to high.

The ecosystem service overflow regulation can be identified as the costs for installing overflow protection such as dykes and embankments. Arvika municipality has investigated the costs for overflow protection and estimated the costs for all arrangements to 80 million SEK (Arvika Kommun, 2014). The cost for managing the water regulation system between Vänern and Göta älv should also be added to the total value of overflow regulation. If these measures are not properly designed and installed there are other costs that will occur, such as those mentioned in table 6.

If there was a significant risk that the areas around Vänern would be flooded it is likely that the house prices would decrease significantly. However the exact number of this decrease is very difficult to estimate since it depends on the severity of the flood risk and the demand and supply on the real estate market.

The service of overflow protection is categorized as high but quasi-tangible since is it difficult to predict the costs for overflows in all affected areas. There are however much research on how overflows will affect different areas in the future due to climate change.

4.8 Weather regulation

The service of weather regulation describes how the ecosystems affect the microclimate in an area. Especially the local weather and climate are affected in urban areas (Bolund & Hunhammar, 1999). Studies made in USA show that the air temperature sometimes differ 0.7° C compared to rural areas. Installations of water sources in the cities have the ability to even out temperature deviations. Rivers, ponds and wetlands are examples of blue infrastructure that both serve as space for water and as microclimate regulators (Ashley, et al., 2011).

Water, as well as vegetation, has the ability to affect the temperature in urban regions. Stockholm is one example where the microclimate is regulated by the presence of water (Bolund & Hunhammar, 1999). Since the city is located on islands it is surrounded by large water bodies. Reported temperatures for different areas show that the temperature near the water is 0.6° C lower than the temperature in the more central parts down town. This phenomenon results in lower cooling and heating costs. One degree corresponds to approximately five per cent of the total heating cost for a single-family house. The amenability to find an economic value for this ecosystem service is however low, partly because it transferable across different sites (Farber, et al., 2006). The effect is very variable between different sites, which make it difficult to transfer the results from Stockholm to other areas. Therefore, since the reviewed studies imply that the micro climate regulation appears to be an external effect from green and blue infrastructure the development of the ecosystem service is considered poorly and the valuation possibility quasi-tangible, perhaps even close to intangible.

4.9 Regulation of greenhouse gases

The capacity of the Göta älv to regulate greenhouse gases can be found in its ability to store carbon, bind it and produce organic material. This is a valuable function since it improves the carbon dioxide and ozone balance in the atmosphere. Wetlands provide a very good environment for carbon sequestration and can store carbon dioxide for a very long time (Mitsch, et al., 2013). The valuation possibility for this service is tangible but there are few references. There has been an investigation regarding this in China, where the value of regulating greenhouse gases were 190 kronor per square metre water or wetland in the catchment area (Liu, et al., 2012). The area of Göta älv is, according to measurements in Eniro, 23,5 square kilometres, which with this method, gives a total value of 552 million SEK.

The value of regulation of greenhouse gases is very uncertain since the estimated value is transferred from only one study. The valuation possibility is quasi-tangible but very time consuming since the value is variable between different locations. According to the Chinese study the estimated value should be categorized as Medium to High.

4.10 Recreational fishing

The river Göta älv has great opportunities for recreational fishing (Göta älvs vattenvårdsförbund, 2005). Especially salmon fishing attracts people to use the water for sports and recreation. To estimate the economic value of recreational fishing as an ecosystem service one option is to use information about how many fishing permits that have been sold. This information has been collected from local municipalities and organisations. The difficulties with finding the total value are that the fishing permits are sold for specific areas that might cover waters other than Göta älv. There are also many different suppliers for the permits which make it difficult to achieve an exact valuation. The authority responsible for the distribution of permits did not have any useful statistics over the total amount of sold permits.

Table 7 and 8 show how many and which type of fishing permits that have been sold in different areas.

Table 7 Sold fishing permits in Trollhättan and Vänersborg

Area	Members card	Members card, salmon	Day permit	Day permit, salmon
Trollhättan/Vänersborg	529, 300 SEK	293, 500 SEK	73, 60 SEK	144, 100 SEK
Total [SEK]:				**323 980**

Table 8 Sold Fishing permits in the Gothenburg and Kungälv area

Area	Sold permits [pcs]	Price/permit [SEK]	Total value
Gothenburg	3000	167	501 000
Säveån	500	1700*	850 000
Norra Långevattnet	500	150	75 000
Kungälv/Stenungsund	2000	160	320 000
Total:			**1 746 000**

*Average cost for day permits and annual permits

The permits for the Gothenburg area can cover a day (50 SEK), one week (100 SEK) or a year (350 SEK). The calculations are based on an average price per sold permit since there is no information for each kind.

In order to further investigate this and get a more accurate result the travel cost for the users should be added to the total economic value. There is also likely an existential value for both fish and the possibility for recreational fishing in the river.

This should though be considered a rough estimation since the permits sometimes cover larger or smaller areas than those considered in this study. There are also other, indirect values that should be considered for a more accurate result. The fishing permits do not include the travel cost for transportation between the fishing area and home. There are also non-user values, both existential and bequest values. Including these values fishing possibility is categorized with a medium value that is well developed.

4.11 The value of bathing possibilities in and close to Göta älv

The value of the bathing spots related to Göta älv can be estimated using benefit transfer from a travel cost analysis. A previous study performed on the bathing spot in the lake Anten in Alingsås (Orakzai, 2008). The study uses Zonal Travel Cost Method and Individual Travel Cost Approach in order to account for both the local and travelling visitors. Only the local visitors will be regarded in this case because of the high number of different bathing spots. According to that study the beach at Anten has approximately 100 000 visitors per year, most of them during summer time. The valuation of the number of visitors at bathing spots connected to Göta älv is difficult due to the uncertainty in number of bathing spots and number of visitors. The material is based on a selection of the bathing spots that are classified with an EU standard, which means that they have approximately 200 visitors per day and have to maintain a certain water quality. The municipalities are obliged to perform four water quality tests every year between June and August (Lerums Kommun, 2012).

Table 9 show the bathing spots that has been selected, where they are located and an estimation of how many visitors they have per day during the summer, which is 92 days (June to August).

Table 9 Identified bathing spots in the study area

Bathing	Municipality	Visitors per day	Visitors per year
Aspen	Lerum	200/day	18 400
Drängseredsbadet	Lerum	200/day	18 400
Delsjön	Gothenburg	200/day	18 400
Humlebadet	Partille	200/day	18 400
Nääs	Lerum	100/day	9 200
Hyltornabadet	Lerum	100/day	9 200
Hjällsnäsviken	Lerum	100/day	9 200
Prästens brygga	Lerum	100/day	9 200
Skräcklan	Vänersborg	200/day	18 400
Nordkroken	Vänersborg	200/day	18 400
Total			**147 200**

The results from the study from the Anten show that the value of the beach can be estimated to 62,66 million SEK for 100 000 visitors with Individual Travel Cost Approach (Orakzai, 2008). This is assuming that the visitors are local. Applying the values from the Anten beach on the selected bathing spots in Göta älv gives a higher value due of the larger number of visitors.

The study from the lake Anten also shows that almost no visitors would visit the beach if the water quality were insufficient (Orakzai, 2008). About 80 per cent replied in a survey that they would not come if the beach was closed. This means that it is important to maintain good water quality in order to avoid loss in consumer surplus. Due to this fact it is also important to consider the value of the resources that the municipalities spend on maintenance to preserve good water quality at the bathing spots. It is also likely that the access of the bathing spots is important.

The valuation possibility for this ecosystem service is assumed to be well developed since the willingness to pay is connected to the quality of the beach and water. The visitors are less inclined to pay for a visit if the quality is insufficient.

4.12 The value of water views from real estates

The economic value of a property increases if it is located close to water or has a water view. This has been reviewed in a study by (Sander & Haight, 2012) which states that since a water view is likely to have an impact on local tax bases it has an effect on the pricing of family houses. This means that land use planning is a significant contributing factor to home sale prices and the increased property values should therefore be included in decision-making. The increased property values are also dependent on people's willingness to pay more for a home with a water view or presence of water.

The contributing factors for the increased value can be divided into two parts, the increase of the assessed value and the extra cost identified by willingness to pay. The assessed value is a fixed value that is decided with certain criteria whereas the increase based on human preferences is based on willingness to pay. This value is difficult to estimate since it is problematic to sort out how much of the price difference that is only related to the water (Löfgren & Hjärpe, 2001).

For this report this value was estimated with data from the real-estate agency Husman Hagberg through their agent Anders Petterson. From investigating properties sold in the central parts of Gothenburg he estimates the difference to an increase of 10-20 per cent. This number is compiled from real estate sales limited to the central parts of Gothenburg, but since it is a percentile increase it will be applied to the whole study area.

It is also likely that the value cost paid by the municipalities and property owners to preserve the views by keeping the riversides free from vegetation contribution to the total value. The valuation methods for this ecosystem service are well developed but difficult to estimate due to the high number of attributes that must be considered. To achieve a representable result a large selection of case studies is necessary, which is very time consuming. The value is categorized as Medium.

4.13 The value of research and education

The river has a high value in providing environments and material for field studies in different areas. This value is considered quasi-tangible, probably even intangible since no transferable study was found for this ecosystem service. There are however different approaches for finding the importance of access to nature for educational institutions. In a study made by (Moore & Hunt, 2011) wetlands are scored differently depending on location and use frequency. A selection of schools has been made and scored in a similar way but with some modification, see table 10.

Table 10 Scores for educational values

Score	6	4	2	0
Location	The river is located on campus of a school, university or other educational institution	The river is located <2 kilometres from school, university or other educational institution	The river is located <2 kilometres from school, university or other educational institution	
Use frequency	> 1 time per year	< 1 time per year	No educational use	

Four different schools have been randomly selected for participation in this study;

Flatåsskolan is located in the western part of Gothenburg and host students between the ages of six and twelve (Göteborgs Stad, 2014). They have an outspoken profile towards outdoor pedagogics and do a lot of projects that involve water and ecosystems. The location of the school also give high scores. It is located very close to the recreational area, Ruddalen, where the school has adopted a part of the forest, which is used for education and is taken care of by the students. They also have outdoor classrooms and a garden in the schoolyard.

Chalmers Universit of Technologyy is also located in Gothenburg and has a lot of research and educational projects that involves both ecosystem services in general and Göta älv directly. The campus is located in the central part of Gothenburg and at Lindholmen right next to Göta älv.

Mimers hus is a high school located in Kungälv. The school has no outspoken environmental profile but is located less than one kilometre from the Göta älv.

The school in *Marstrand* is located next to the ocean and has children between the ages of six and twelve. They want to take advantage of the small distance to the ocean and are planning cooperation with MSS, the sailing association on Marstrand (Kungälvs kommun, 2013).

The total value of research and education can partly be estimated with the total amount of resources spent on projects that in any way affect Göta älv. There is also the travel cost and the intangible value that represents knowledge and how the environment and learning methods affects the quality of education and life. This is a first attempt to find new approaches towards valuing learning.

The total value of the contribution to research and education is very well developed. The economic value can be estimated by compiling budgets for research projects and field trips. However this is an aspect that has not been given much thought or consideration. The service has a high future value due to the fact that knowledge about water quality and attributes. Since the Swedish government, as mentioned in chapter 2.1.2 has decided that knowledge of ecosystems and ecosystem services must be observed in education at all levels the value is expected to increase. Therefore it is categorized as high.

4.14 The value of boating in Göta älv

This value refers to boating as a recreational activity and sport. It will also include boat tourism on the Göta älv. There are a large number of leisure boats in Gothenburg due to its attractive archipelago and there are many parking spaces for boats in the river close to the ocean. They enable people with an interest for leisure boating to live in the city and still have access to their own boat close to their home. The relatively new living areas around Eriksberg and Sannegårdshamnen offer the possibility to rent a boat parking space. Figures regarding the number of spaces and the prices are shown in table 11.

Table 11 Example of boat parking spaces in Sannegårdshamnen

Boat size [m]	Amount [pcs]	Member cost [SEK/year]	Service cost [SEK/year]
2,6 x 7	65	20 000	6 250
3,1 x 9	14	25 000	6 875
3,6 x 11	17	30 000	7 500

There is also a high value connected to the tourism attributes for Göta älv. According to Västsvenska Turistrådet 3600 leisure boats pass through every year (Svedberg, 2012). Göta älv is also very important for the development and activities in Vänern, Göta channel (Göta kanal) and Dalslands channel (Dalslands kanal) and lakes. The financial turnover for the tourism coming from leisure boating has been estimated to 6.7 million kronor for the Dalsland channel, 41 million kronor for the area around Vänern and 8 million kronor for the Göta channel. These values can be added to the value of Göta älv because of its importance for the tourism and activity in these areas.

This ecosystem service is also likely to be affected from the decision about however the reparation and extension of the possibility to transport goods on the river is seen or not (Trafikverket, 2013). The possibility for leisure boating in the river will be preserved in both cases but there is a chance that the recreational values will decrease with a situation with more goods traffic. On the other hand, the Göta älv distance turned out to be mostly a transportation distance to other places.

The value of leisure boating as an ecosystem service is well developed, probably because it is an important contribution to the incomes from tourism. However, since it is mostly consisting of cultural values an exact valuation is difficult to achieve. With the present accessible material the value is however categorized as Medium.

4.15 The value of good water quality

The economic value of good water quality is difficult to estimate since it is based on human preferences. According to a survey regarding the urban environment in Gothenburg, done by the municipality in the year of 2012, two thirds of the local inhabitants pleased with the availability and quality of the water (Miljöförvaltningen , 2012). One of the positive effects from the improved water quality is the increased interest in recreational fishing in lakes and rivers.

The value of this service can be divided in user value, existential value and future value. A study made in Leeds, Great Britain showed that the willingness to pay for good water quality in the river Aire was 657-1509 SEK per household (Wattage, et al., 2000). The municipalities in the study area (Göteborg, Kungälv, Lilla Edet, Trollhättan and Vänersborg) has 306 228 households (Statistics Sweden (Statistiska Centralbyrån), 2014). With value transfer this results in a total value between 201 million SEK and 462 million SEK. This implies that the value of this ecosystem service is categorized as Medium to High. The uncertainties regarding this value are very high, both considering that the transfer is based on one single study and due to different site attributes.

Another aspect of this value could be found in avoided costs. To achieve good ecological and chemical status in the water the willingness to pay is lower and there are costs to restore the water quality. Identifying these costs and compare them to the benefits that came from the activities that caused the impaired water quality is important for decision making that concerns the water resources.

4.2 Uncertainties

Studies based on human preferences are always related to high uncertainties. Some of the aspects that were disregarded in this investigation are important to include in order increase the accuracy. Factors like changes in preferences due to age, education and experiences are important and are the main reason why valuations require frequent updates.

The uncertainties about the nature and proportion of the climate change and how to value the impacts is one of the most challenging aspects of ecosystem service valuation. It will be especially important for decision makers to understand how the management of these uncertainties should be carried out. The vulnerability to climate change, especially in the urban areas, will be an important issue for the municipalities to deal with.

The quality of the information received from different municipalities has been very variable. This results in some uncertainty in the valuations.

Sometimes there are spatial differences in where ecosystem services are produced and where it is consumed (Serna-Chavez, et al., 2013). This implies further challenges in mapping the economic profits from especially the provisioning services and how they contribute to human welfare.

4.3 Summary

The following chapter will start with summarizing the outcomes and then point out the most important results and of the study.

4.3.1 Provisioning ecosystem services

The result for the provisioning services is presented in table 12.

Table 12 Provisioning ecosystem services

Ecosystem service	Benefit	Evaluation possibility	Value (identity)	Value (economic)
Drinking water	Provision of drinking water	Tangible	Water fees, cost for reserve water	High
Water power	Provision of electricity from four water power stations	Tangible	The market price for the produced electricity Savings from avoided CO_2 emissions	Medium -High
Industrial use	Water for processes, cooling and as recipient	Tangible	Economic turnover for the industrial activities	High
Transportation	Transportation of goods	Tangible	The cost for alternative transportation	High
Genetic material	Provision of medicines and genes for resistance to plant pathogens	Intangible	Future values	Not investigated

The table shows that all provisioning services except for Genetic material are tangible. However, this study has shown that it does not necessarily imply that the service is possible to value with today's knowledge and resources.

4.3.2 Regulating ecosystem services

The result for the regulating ecosystem services is shown in table 13.

Table 13 Recreational ecosystem services

Ecosystem service	Benefit	Evaluation possibility	Value (identity)	Value (economic)
Waste treatment	Treating waste- and storm water	Tangible	Costs for treating water in WWTP, constructed wetlands and storm water ponds	Medium
Overflow regulation	Regulating water levels	Quasi-tangible	Costs for dredging and overflow protection	High
Weather regulation	Effects on temperature, humidity, wind, water and precipitation	Quasi-tangible	Mainly increased temperatures	Significant
Regulation of greenhouse gases	Abillity to store CO_2	Quasi-tangible		Medium-high

The regulating services were identified as mainly quasi- tangible. The valuation difficulties were mainly found in the uncertain future scenarios. For example the knowledge waste regulation, is dependent of knowing all substances that enters the water and how they are received. The overflow regulation is dependent on knowledge about the worst case scenario to estimate its highest value.

4.3.3 Cultural ecosystem services

The results for the cultural ecosystem services are shown in table 14.

Table 14. Cultural ecosystem services

Ecosystem service	Benefit	Evaluation possibility	Value (identity)	Value (economic)
Good water quality	The experience of good water quality	Tangible	Willingness to pay for a better water quality measured with benefit-transfer methods	Medium –high
Recreational fishing	Sports and recreation	Quasi-tangible	Fishing permits and travel costs	Medium
Water views	Increased sales values due to increased willingness to pay	Quasi-tangible	Real-estate valuation method	Medium
Research and education	The river is used for research and educational activities, such as field studies and sampling	Quasi-tangible	Budgets for research and educational projects	High
Boating		Quasi-tangible	Costs for parking space and incomes from boat tourism	Medium
Bathing		Quasi-tangible	Travel costs, willingness to pay	High

The valuation possibilities for cultural services are quasi-tangible for almost all investigated services. This is mainly because they consist of many different values, which are estimated with high uncertainty methods. The only exception is *Good water quality,* which is categorized as tangible. It is only dependent on people's willingness to pay and therefore estimated with only one valuation method.

4.3.4 Development and valuation possibility

Table 15 show how the different ecosystem services are orientated regarding how well developed and identified the contributing factors of the ecosystems total value and how well they can be economically valued. The top row represent the economic valuation possibility and is based on the earlier mentioned criteria; tangible, quasi-tangible and intangible. Since the valuation possibilities within the group of quasi-tangible values are very variable there are three different levels of quasi-tangible.

Table 15 Developement and valuation possibility

	Tangible	**Quasi-tangible**	**Quasi-tangible**	**Quasi-tangible**	**Intangible**
Fully developed	Drinking water Industrial use	Water views			
Well developed	Waste treatment Water power production	Boating Bathing Recreational fishing			
Partly developed	Transportation		Good water quality	Overflow regulation Regulation of greenhouse gases	
Poorly developed			Research and education	Weather regulation	
Not developed					Genetic material Spiritual and religious values

It shows that the ecosystem services that have the lowest scores in both categories are Genetic material and spiritual and religious values. They have in common that they consist of cultural values that are difficult to identify and a very uncertain future value. Drinking water and Industrial use have the highest scores. They are found with simple valuation methods with low uncertainty and have been acknowledged for a very long time. Even though, it is most likely that these values will change in the future.

Figure 4 shows the relation between valuation possibility and how developed the techniques are for economic valuation for each ecosystem service. The differences are because some values are easier to find and estimate than others and can be handled with less advanced valuation methods. The axes of the diagram use the same scale from one to five as table 15.

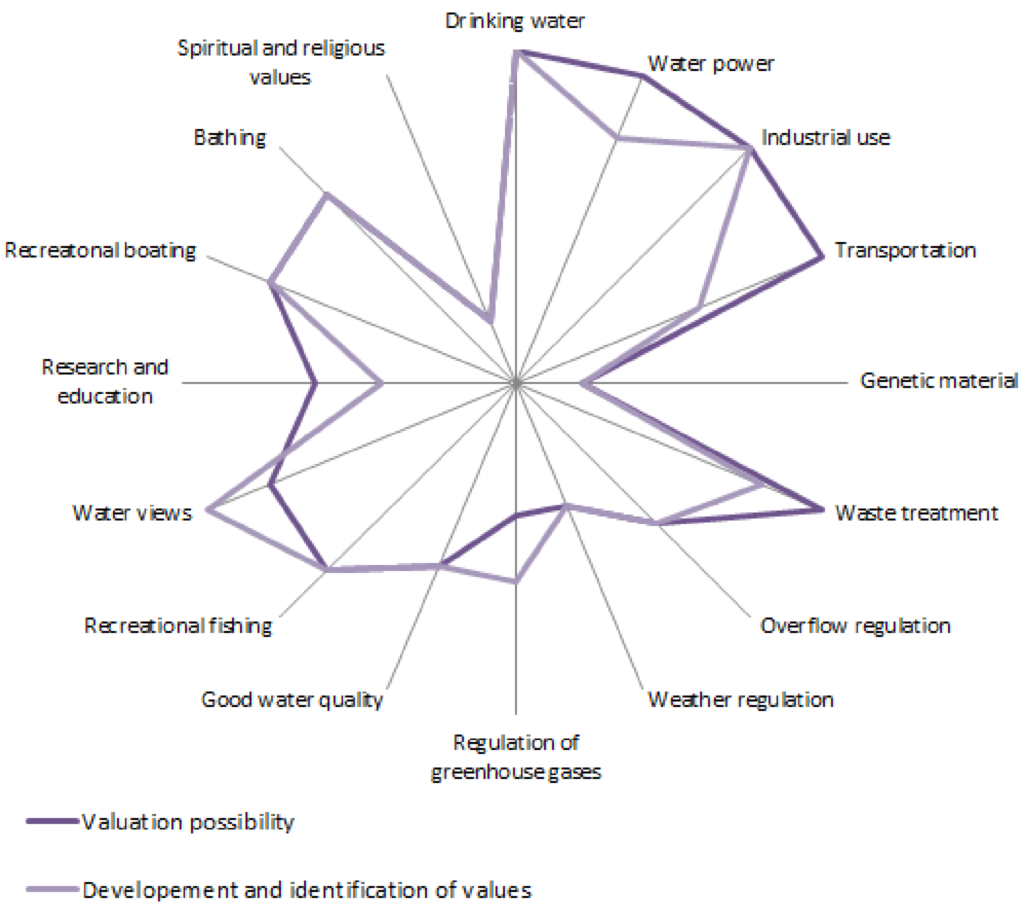

Figure 4. Relation between development and valuation possibility

5. Conclusions and recommendations

The results show that the economic values of the provisioning ecosystem services have been more developed and are over all easier to estimate. The goods and services they produce are easier to estimate with benefit transfers than the other services.

The regulating services aver all quasi-tangible and well developed. The uncertainty is the future values they provide, especially services that are important to care for now in order to use them in the future.

The valuation methods for cultural values are based on human preferences and willingness to pay, which implies that the information about these values must be frequently updated. This is due to the constant change in educational levels, income, trends and generations. This variability have not been considered in this study but will be important for benefit transfers and meta-regression analyses.

The implementation of the WFD is an important step towards a sustainable and integrated management of the water resources. Valuation of water has been acknowledged as a very important issue but the approach towards action is more delayed. With an increasing population and growing urban areas in the region the focus should be to implement a more integrated approach where the capability of blue infrastructure is raised. There is high capacity in this concept since it promotes the waters ability to create environments where natural processes help to improve the general water quality. This study show that constructed wetlands and ponds are efficient and sustainable tools to improve the capacity and possibilities for several ecosystem services. The city planning is and will be an important factor in improving the possibilities for assessing and protecting water related values.

In order to maintain and ensure access to good quality it is important to continue the work with extending the water protection area between Gothenburg and Vänern. Many ecosystems are trans boundary structures and require cooperation between the municipal boundaries. The water protection areas are important for the direct protection of the water source, which is an important first step in the process.

Introducing the theory of ecosystem valuation in education will provide a great challenge due to the fact that many of the actual values and valuation methods are associated with high uncertainties at many different levels. The guideline values can be used as a rough estimation but most importantly the development in the study area must, in larger extent, include ecosystem services in order to protect and ensure the nature and water environments. If they are excluded the values extracted from these environments will be lost. Therefore, the available material will be useful in order to visualize the environmental values and their economic relevance.

The attention for water related issues has increased in society debates lately. In order to ensure secure water quality for future generation the value of water related ecosystem services need to be further introduced in both regional and local politics.

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Appendix

User statistics for fixed drinking water costs in Gothenburg municipality.

Table 1 Water and sewer

Water gauge	Users	Annual cost	Total Annual cost
Single family house	33 247	2 621	87 130 413
Qn 2.5	6 094	5 241	31 941 092
Qn 5	23	10 468	240 769
Qn 6	4 329	12578	54 449 729
Qn 7.5	10	15710	157 096
Qn 10	2 882	26 201	60 401 821
Qn 12	10	25 134	251 339
Qn 16	4	33 544	134 174
Qn 18	44	37 705	1 658 998
Qn 20	6	41 917	251 500
Qn 22	6	46 085	276 509
Qn 24	3	50 290	150 869
Qn 26	2	54 502	109 004
Qn 30	6	62 890	377 337
DN 50	108	31 441	3 395 639
DN 80	69	83 862	5 786 506
DN 100	36	125 764	4 527 518
DN 150	5	314 411	1 572 055
Summer residence	126	2 525	318 087
Total:			**134 058 949**

Table 2 Only water

Water gauge	Users	Annual cost	Total Annual Cost
Single family house (qn 2,5)	86	1310	112 690
Qn 2,5	91	2621	238 484
Qn 5	3	5234	15 702
Qn 6	48	6289	301 870
Qn10	60	10479	628 749
Qn 30	7	31445	220 113
DN 50	1	15721	15 721
DN 80	12	41931	503 174
DN 100	12	62882	754 586
DN 150	7	157206	1 100 439
Summer residence	34	1 336	45 413
Total:			**3 982 354**

Table 3 Only sewer

Water gauge	Users	Annual cost	Total Annual Cost
Qn 2,5	124	2621	324 967
Qn 6	36	6289	226 402
Qn 10	29	10479	303 895
DN 50	2	41931	31 441
DN 80	1	62882	41 931
DN 100	5	1022	314 411
Special agreement 1	1	2581	1 022
Special agreement 2	847	2581	2 185 726
Special agreement 3	18	4344	78 183
Summer residence	21	1502	31 552
Total:			**3 539 531**

Total income from fixed taxes: 141 535 420 SEK