ASSESSMENT OF SPATIAL-TEMPORAL DISTRIBUTION OF REEDLAND ECOSYSTEM SERVICES: A CASE STUDY OF WEERRIBBEN-WIEDEN NATIONAL PARK THE NETHERLANDS

LYDIA BAKECURA
February, 2015

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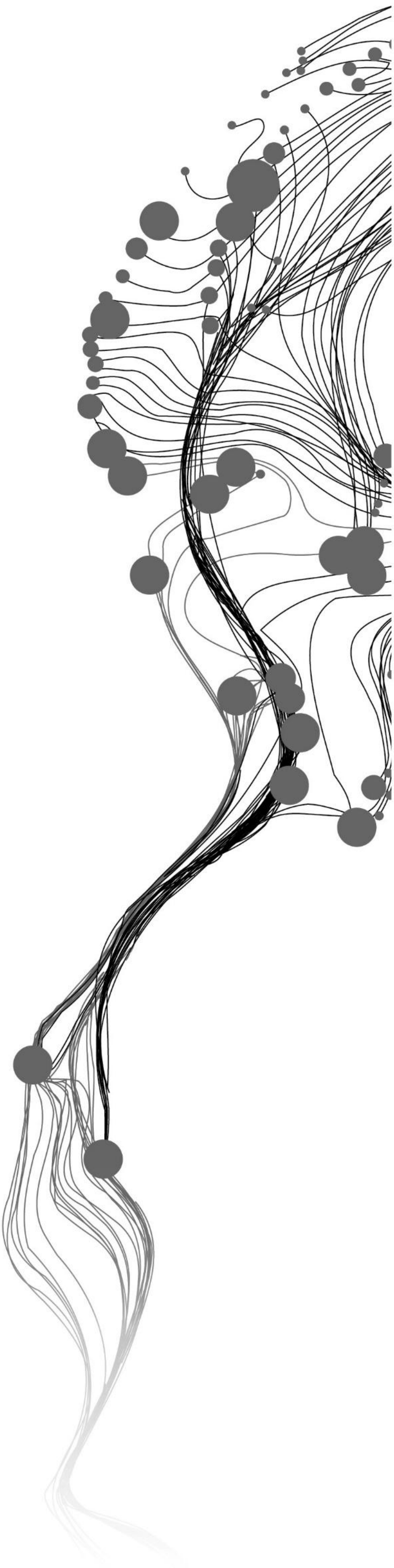

ASSESSMENT OF SPATIAL TEMPORAL DISTRIBUTION OF REEDLAND ECOSYSTEM SERVICES: A CASE STUDY WEERRIBBEN-WIEDEN,THE NETHERLANDS

LYDIA BAKECURA
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ABSTRACT

Benefits from ecosystem services may be identified and achieved through assessing the values that stakeholders attach to the services within their reach. This study seeks to examine the variation of spatial and temporal distribution of reed land, the ecosystem services provided by Weerribben-Wieden national park and how different stakeholders value and obtain benefits from these services and eventually support alternative management strategies. Three main ecosystem services were assessed in this study and these were; reed production, recreation and habitat for key species. To assess the distribution of these ecosystem services and other location characteristics that contribute to the supply in the study area, seven land cover classes were identified and these were: reed land, forest/woodland, wetland vegetation (quaking bog), swamps, water, natural grassland and pasture grassland. Other indicators considered as contributors to the supply of these services in the area were: roads both local and regional, canoe routes, cycling routes, parking lots, harbour locations and built ups or rentals. Stakeholders have always benefited from ecosystems through the provision of ecosystem services. It is important to identify all stakeholders involved in the utilization and conservation of ecosystem services and their perception towards these services. Stakeholders were defined as "any group or individuals who can affect or is affected by the ecosystem services". To assess the valuation of ecosystem services, an online questionnaire survey to different stakeholder group representatives was used. Stakeholders often attach different values to ecosystem services, depending upon their cultural background and upon the impact of the services on their income and or living conditions. Habitat for key species was valued most, followed by reed production, and lastly recreation. To ensure a continuous flow of these benefits, different strategies and recommendations aimed at protecting ecosystem services for example integrated management plan for the Weerribben-Wieden area with special attention of maintain reed cutting as an activity, minimising conflicts in the use of ecosystem services through proposing solutions to the conflicts that are responsive to all of the stakeholders interests and keeping focus on interests rather than leadership positions, keeping biodiversity conservation as the most important function without neglecting recreation activities were proposed. Ecosystems therefore, provide various goods and services to the society which in turn directly contribute to people's well-being and economic wealth. So understanding spatial temporal distribution of ecosystem services can be a stepping stone towards good management strategies and therefore, towards sustainable ecosystem services development in the study area.

Key words: Ecosystem services, stakeholders, valuation, conflicts, management.

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1. INRODUCTION

1.1. Background

Common reed (phragmites australies) forms part of wetland ecosystems in many parts of the world. The Ramsar convention on wetlands defined wetlands as "areas of marsh, fen, peatland or water, weather natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters"(Ramsar convention, 2010). So, wetlands are areas where land and water meet and mingle and they are unique ecosystems that are found at the edge of aquatic or terrestrial systems. Wetlands cover about 6% of the earth's surface (Best et al., 1993).

Wetlands occur at all latitudes, from the polar areas to the tropics, and occur in most countries (Wolff, 1993). Wetlands are among the worlds' most important but also most threatened natural resource (Best et al., 1993). Ricaurte et al. (2013) mentioned that, wetlands have been degraded over the past decades to the extent that their ecosystem services have significantly reduced. This is because their functions could not successfully compete for space with other land use. The Millennium Ecosystem Assessment (2005), indicates that, wetlands are the habitats that have been most affected by development and they are lost more rapidly than any other Habitat in the world. Nonetheless, wetlands perform a number of ecosystem services, some of which are well recognized and others are less so, and are internationally recognized as one of the most important ecosystems for the conservation of biodiversity.

One of the most common plant found in wetlands in Europe, is reed. Reed is a rhizomatous perennial tall grass species with the largest geographical distribution of any flowering plant (Achenbach et al., 2013; Eller and Brix, 2012). Reed plays an important ecological role, especially as stabilizer of lake and river shores and as a filter against pollutants (Fogli et al., 2014). Common reed is used as treatment for wastes and act as habitat for many organism (Kiviat, 2013). Reed is found in the littoral zones of lakes, along rivers and canals and in shallow fresh water swamps where it forms a dense monospecific stand (Achenbach et al., 2013). It often forms extensive stands called reed beds. Reed beds represent an important habitat for plants, birds and invertebrates including many rare and vulnerable species, for example, sow thistle (sonchus paulusttris), marsh pea (lathyrus palusstris) and many others (Valkama et al., 2008).

Common reed is a wetland plant genus that has been utilized by man since ancient times (Slobbe et al., 2006). Reed has been reported to be one of the dominant wetland plant species in The Netherlands. Some of the reed land ecosystem services include fodder, a raw material for crafts and for construction purposes including thatching houses an industry that provide employment to local reed farmers (Slobbe et al., 2006). It has became popular for pulp and paper production in recent years. Reed land has been used in sewage water treatment, waste treatment, soil stabilizer and as a source of bio energy (Kuhlman etal., 2013).

The Netherlands covers a total area of 41864km², of which 16% is regarded as internationally important wetlands and 7% of it has been registered internationally on the Ramsar convention list (Best et al., 1993). The Netherlands is rich in wetlands, most of them are currently protected. 63% of the nature reserves in The Netherlands contain wetlands (Best et al., 1993). The nature of wetland areas in The Netherlands, has

been strongly shaped by the extraction of peat creating a distinctive pattern of turf ponds called "Petgaten" in Dutch (Lamers et al., 2002). Like in many other type of wetlands around the world, most peat land areas are under the protection of a national nature policy plan. This is due to their unique characteristics, and the large areas have been recognized as Ramsar site "wetlands of international Importance".
In The Netherlands, reed has been recognized as an important part of the wetland ecosystem especially where it can be directly linked to the survival of specific wild life (Fogli et al., 2014), Reed lands also support various recreational and economical activities (Ludwig et al., 2003; Valkama et al., 2008), and reed is used as a constructed wetland for purification of surface water. Studies have shown that 26% of The Netherland lies below sea level and 40% is at a risk of flooding therefore, reed is a convenient land use for water buffering and it also provide a buffer between human activities like cattle grazing and wetland wildlife (Kuhlman et al., 2013; Kiviat, 2013).

Ecosystems provide various goods and services to the society which in turn directly contribute to people's well-being and economic wealth (Millennium Ecosystem service Assessment, 2003). According to De Groot et al., (2010), ecosystem functions are intermediate between ecosystem process and services and can be defined as goods and services that satisfy human needs directly and indirectly. As population grows, the demand for ecosystem services increases. Consequently, human actions such as overexploitation of ecosystem services are reducing the capacity of the ecosystem to meet those demands (Millennium EcosystemsAssessment, 2005). Such actions may temporarily support local livelihoods although, they might become unsustainable and danger future generations to meet their own needs.

Ecosystem services are commonly divided into four categories that benefit humans. These services include, provisioning services, regulation services, habitat/support services and cultural services (TEEB, 2010). Ecosystems have the capacity for providing a diversity of services. For example, reed ecosystems have support services like providing habitat for a variety of key species such as nesting birds, regulation services such as water supply, production services such as providing fodder for animals, raw-material for handcraft and building, cultural services like recreation and tourism, and also for education purposes (Hein et al., 2006). The demand for reed land ecosystem service is increasing due to different factors such as population growth and land-use change (Millennium Ecosystem Assessment, 2005). Human population pressure, increases the demand for provision of services, some not entirely recognized by local communities especially regulation and cultural services. Similarly, local livelihoods depend heavily on the provision of these services.

It is important to identify all stakeholders involved in utilization and conservation of ecosystem services and their perception towards these services. In this context Hauck et al, (2014) defined stakeholders as "any group or individual who can affect or is being affected by ecosystem services". Nature conservationists, reed farmers and tourists have been identified as the major stakeholders involved in the utilization and management of reed in the Netherlands. Stakeholders often attach a different value to ecosystem services, depending upon their cultural background and upon the impact of the services on their income and or living conditions. These different interests result into different visions on the management of the area. Environmental policies formulation with the direct participation of stakeholders can enhance the contribution of ecosystems to human well-being and reduce the negative impacts (Best et al., 1993) such as damaging nesting birds caused by repeated reed mowing.

Actions to increase the supply of a particular service may impact other service. Therefore, identification of scales and the stakeholders allows the analysis of potential conflicts in environmental management, especially between local stakeholders and stakeholders at larger scales. To ensure a continuous flow of benefits of an ecosystem in the society, different strategies are developed to safeguard ecosystems that provide these services. These strategies include combining of ecosystem services with biodiversity conservation policies and creating market incentives for ecosystem protection. This could lead to a win-win situation where biodiversity is conserved while society understands its value (Willemen et al, 2013).

To support decision making, researchers are contributing to increase the knowledge on the ecological and social system and understanding the factors that cause changes in ecosystem and their services. To explore the contribution of ecosystem service to local livelihoods several approaches are needed to determine which part of society is profiting from which specific ecosystem service (Willemen et al., 2013). This information is useful in order to explore the contribution of ecosystem to local livelihood and trade-offs between beneficiaries and flows of service (Willemen et al., 2013). For example, stakeholders can be asked to assign relevant weights to different ecosystem services in the area. This gives a picture on how different stakeholder value different ecosystem services within their reach, and provide also valuable input to decision making by creating alternative management approaches for ecosystem services.

Increasingly, researchers are studying different methods for mapping ecosystem services and finding spatial indicators to assess the ecosystems. Studies have shown that numerous methods to map ecosystem services exist and reviews of methodologies are also available (Maes et al., 2012). There are different methods identified for mapping of ecosystem services like multi-criteria analysis, gap analysis for conservation planning and hotspot identification (Brown, 2004). Maes et al, (2012) noted that, a simple method to map ecosystem services is to assess ecosystem services directly from land cover map. Thus, the use of ecosystem service maps are important for environmental planning and this can only be achieved through optimizing biodiversity or ecosystem services conservation or human welfare.

However, mapping approaches that take into account the underlying mechanism which drive ecosystem services delivery are therefore more likely to produce realistic map on ecosystem services supply but require significant investment in terms of data acquisition and expert knowledge (Maes et al., 2012). For conceptualizing the ecosystem services it is important to know that these services can be mapped across a landscape depending on where and how the benefits from ecosystem services are distributed and realized spatially.

1.2. Problem statement and Justification

The main constraint for reed conservation in the Weerribben-Wieden is the heavy demand for ecosystem services coming from different stakeholders with conflicting interests. Local stakeholders benefit from the reed and fish resources of the area that are of little importance at the national scale whereas, national stakeholders are more interested in biodiversity conservation (Hein et al., 2006). This leads to conflicting opinions on the management of the area. For example, reed cutters prefer to cut reed when it is one year old in order to get the best price for the reed whereas, nature conservationists would like to restrict reed cutting as birds needs two-to four year-old reed for nesting. The social value that stakeholders put into the service can provide relevant information for the management of these services, safeguard biodiversity and protect other ecosystem goods and services. Information about ecosystem services provided by reed land ecosystem and the challenges to preserve reed land ecosystem is still missing in the Weerribben-Wieden national park. Little is elaborated on the spatial and temporal distribution of the reed land ecosystem services and values. Such information is crucial for conservation of this important ecosystems. The enhanced understanding of reed lands ecosystem services is a key for future success in meeting the long term demand of different stakeholders.

1.3. Research objectives and questions

The overall objective of the study is to examine the spatial- temporal distribution of reed land ecosystem services within Weerribben-Wieden National park and to be able to support alternative management strategies.

Specific Objectives

1. To analyze the spatial and temporal variation of reed land ecosystem services in Weerribben-Wieden between 2000 to 2013
2. To examine how different stakeholders value different ecosystem services in Weerribben-Wieden
3. To assess the conflicts in the use of ecosystem services in the Weerribben-Wieden National park.

Research Questions

The following research questions will be addressed to achieve the specific objectives.

Specific objective 1

- What ecosystem services are provided by the reed lands of the Weerribben-Wieden National park?
- What are the land cover classes and other location characteristics that contribute to the supply of ecosystem services in reed land in the Weerribben-Wieden?
- What are the changes in land cover between 2000 and 2013?
- What are the changes in ecosystem services between 2000 and 2013 in Weerribben-Wieden?

Specific objective 2

- Which stakeholders benefit from ecosystem services and at which scale?
- How have different stakeholders in this area valued reed land ecosystem services since 2000 to-date?

Specific objective 3

- What are the causes of conflicts in the use of ecosystem services in this area?
- How do changes in ecosystem services affect different stakeholders in Weerribben-Wieden?
- What are current strategies to resolve conflicts in this area?

2. CONCEPTS AND DEFINITION

This chapter introduces the theories and ideas that exist in literature which support and provide insight into the subjects reviewed and their application adopted during this study are also presented.

2.1. Ecosystem services

Ecosystem service research is rapidly growing and the term itself may be new but an understanding that nature provide services for human welfare has been known since ancient days (Fisher et al.,(2009). There seem to be a consensus on a general meaning of ecosystem services which is repeatedly cited in the literature.

1. The capacity of ecosystem to provide goods and services that satisfy human needs directly or indirectly (De Groot et al., 2010)
2. Aspects of ecosystem services utilized actively or passively to produce human well-being (Fisher et al.,(2009)
3. Benefits people enjoy from the ecosystem which affect them directly and they are needed for the maintenance of other services. (Millennium Ecosystem service Assessment, 2003)

For this study, the definition of ecosystem services is adopted from (De Groot et al., 2010) to mean goods like food, building materials and services such as water purification, climate regulation that are obtained from nature and satisfy human needs and wellbeing directly or indirectly.

The Millennium ecosystem assessment categorized these services into four categories i.e. provisioning, regulating, culture and supporting services. These services were further described in the table below.

Table 1: Category of ecosystem services

Ecosystem services	Description
Provisioning services	Products obtained from ecosystems, e.g. fresh water, food, fiber, fuel, genetic resources, biochemical, natural medicines and pharmaceuticals,
Regulating services	Benefits obtained from the regulation of ecosystem processes e.g. water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation e.g. droughts, floods, storms
Culture services	Non material benefits people obtain from ecosystem through spiritual enrichment, cognition development reflections, sense of place, cultural heritage and ecotourism
Supporting services	These are services that are necessary for the production of all other ecosystem services. They defer from provisioning, regulating and cultural services in that their impacts on people are often indirect or occur over a very long time.

Source: (Millennium Ecosystem service Assessment, 2003)

2.2. Ecosystem service cascade framework.

This is a useful framework that shows the links of ecosystems, ecosystem services and benefits to humans. This frame work connects the ecosystem in a form of a ladder to human wellbeing and through the flow of ecosystem services.(Maes et al., 2012). An ecosystem provides an arrangement and procedure that supports ecosystem functions which are defined as the capacity or potential to deliver (Maes et al., 2012). Ecosystems are derived from ecosystem functions and represents the flow of service in relation to the benefits and values that people derive from an ecosystem. This is in agreement with (de Groot et al., 2010) in an example given in Figure1. This was used as a guideline for this study in assessing the ecosystem services benefits and values that contribute to human wellbeing for different stakeholders in the study area.

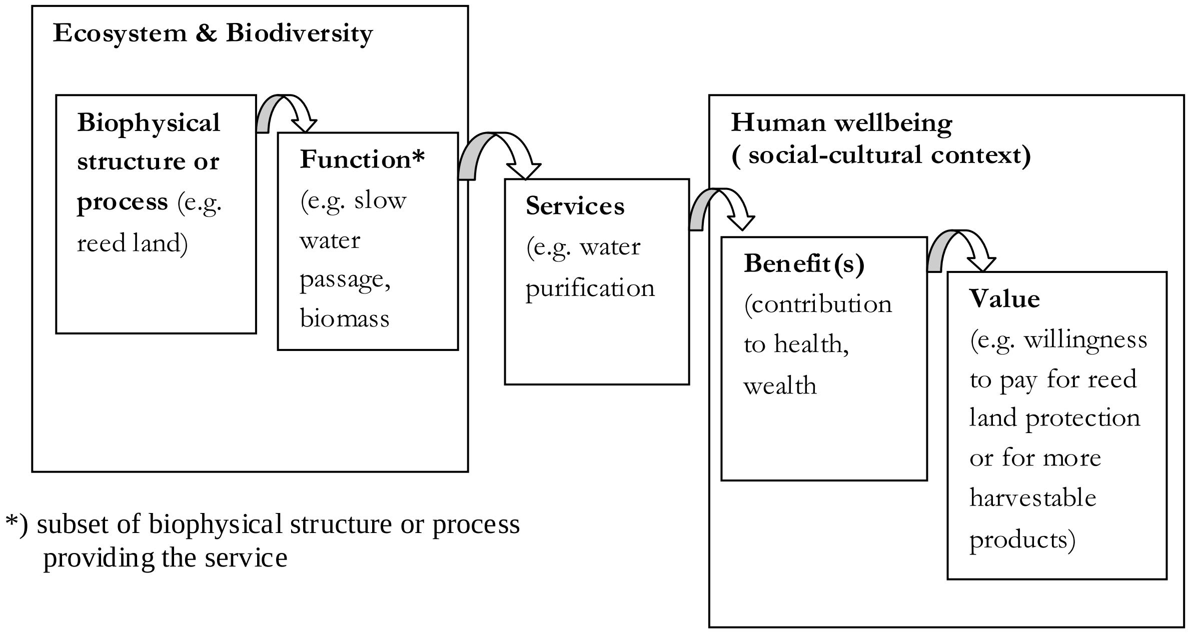


Figure 1: Ecosystem services cascade framework adopted and modified from de Groot et al., (2010)

2.3. Mapping ecosystem services

Mapping provides a coherent process for identification and valuation of ecosystem services (Lopes and Videira, 2013). This was further affirmed by Palomo et al.,(2013) who articulated that, mapping provides an arena for capacity building and for the incorporation of experimental knowledge in a spatially open manner. A number of studies have mapped the supply of multiple ecosystems in different ways at global, continental, national or local scale (Crossman et al., 2013). Satellite data contribute to the provision of different types of information that is needed for the assessment of ecosystem service this includes land cover mapping (Millennium Ecosystems Assessment, 2005). Land cover and land use maps are most used indicators in mapping approaches (Maes et al., 2012) and are important to assess ecosystem services.

2.4. Image classification

Image classification process involves conversion of multi band raster imagery into a single band raster with a number of categorical classes that relates to different type of land cover. Land cover classification is the procedure often used for quantitative analysis of remote sensing image data. The five steps for land cover classification are adopter from Han et al, (2002); 1) Establish the land cover types into which the image is to be classified, 2) Select representative pixels from each of the land cover classes to be used as training data. The location can be obtained from field visits, available maps and recent aerial photographs and visual or colour interpretation, 3) Use the training data to approximate the classifier algorithm to be used for image classification. 4) Using the trained classifier, classify every pixel in the image into one of the desired land cover types. 5) Produce maps that summarize the results of the classification.

The process involves assigning pixels to classes each pixel is treated as an individual unit composed of value in several spectral bands. There are two types of image classification methods supervised and unsupervised classification. In supervised classification, the approaches require reference data with which to adjust the segmentation parameters so that the image objects best approximate the target objects (Belgiu and Dr Guţ, 2014). In this approach an image is classified using spectral signatures obtained from training samples polygons that represent distinct sample areas of the different land cover type to be classified (Nagi, 2011). For this study the supervised classification was used.

2.5. Valuation of Ecosystem services

Ecosystem service valuation is used by the Millennium Ecosystem service Assessment, (2003) to indicate "the process of expressing the value for a particular good and service in a certain context like decision making usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines such as sociology, ecology and others". There are several ways to describe values in relation to ecosystem services as given in literature but the most detailed description of different types of value is given by Häyhä and Franzese, (2014) in Table 2.

Table 2: Different types of values in relation to ecosystem services

Value type	Definition
Market value	The exchange value or price of a commodity in the open market
Direct use value	The value attached to products and services provided by nature for direct consumptive (e.g., timber and food) or non-consumptive use (e.g., recreation and esthetic experiences)
Indirect use value	The value attached to indirect utilization of ecosystem services, through the positive externalities that ecosystems provide (e.g., flood protection and carbon sequestration)
Intrinsic value	The value of environment and life forms for their own sake.
Existence value	The value attached to the knowledge that species, natural environments, and other ecosystem services exist, even if the individual does not contemplate ever making active use of them
Bequest value	A willingness to pay to preserve the environment for the benefit of other people, intra and inter-generationally
Option value	Benefits derived from having the option of using, directly or indirectly, the ecosystem in the future (a willingness to pay a certain sum today for the future use of an asset)

Valuation of ecosystem services is considered as an essential approach to help the assessment of different alternatives for ecosystem management. Among the reasons for carrying out the valuation of ecosystem services include; (Millennium Ecosytem service Assessment, 2003)

- To assess the overall contribution of ecosystems to human well-being
- To understand the use of ecosystems by stakeholders
- To assess the positive and negative impacts of different alternatives for ecosystem management.

Debates on how to assign values to ecosystems and their services are ongoing (Häyhä and Franzese, 2014). Understanding what is the value of ecosystem and their services, how to value them and limitations of such a value is vital method to assess ecosystem services. The choice and preference stakeholders put on services strongly determines on the management and willingness to pay for that service. Current methods have added more measures for valuation services such as social values. These are values that stakeholders assign to the ecosystem services according to their perception and rank them according to their importance. These valuations are based on the fact that people value ecosystem services for different benefits without putting restrictions on economic ones (Brown, 2004).

Table 3: Typology value and their description based on previous studies and adopted for this study (Brown, 2004)

Value	Description
Economic	Are valued because they provide economic opportunities such as fisheries, tourism or processing
Subsistence	Area valued because they provide necessary food and materials to sustain people's lives
Biodiversity	Area valued because they provide places for a variety of plants, animals and wildlife
Recreation	Area valued because they provide places for outdoor recreation activities and experience
Cultural	Area valued because people can continue to pass down tradition, wisdom and a way of life
Historical	Area valued because they are places and things of natural and human history
Future	Area valued because they allow future generation to know and experience the areas as they are now
Learning	Area valued because people can learn more about the environment
Spiritual	Area valued because they are sacred, religious, spiritually important
Therapeutic	Area valued because they make people feel better, physically and /or mentally

In order to have a proper valuation of ecosystem services, Hein et al., (2006) gave an important discussion on steps involved in valuing those services and their relationship. The framework is applicable to all ecosystems but generally, it is more useful to be applied in natural and semi-natural or modified ecosystems.

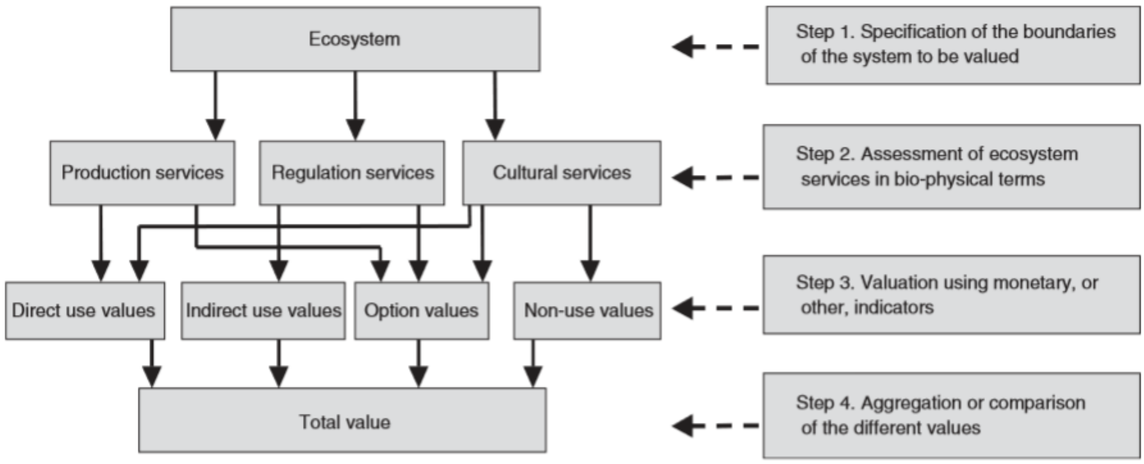


Figure 2: The ecosystem valuation framework (after Hein et al., 2006)

In the framework four steps were considered and these are: 1) Specification of boundaries of the ecosystem to be valued, 2) assessment of the ecosystem services supplied by the system, 3) valuation of the ecosystem services and 4) aggregation or comparison of the values of the services. This valuation method for ecosystem services was used as a guideline for this research.

2.6. Ecosystem service trade-off and dynamics

The supply of ecosystem services can change over time. Trade-offs take place when the provision of one ecosystem service is reduced as a result of improved use of another ecosystem service or when more of a particular ecosystem service is detained by one stakeholder at the expense of others. These trade-offs occur among the stakeholders as well as among the ecosystem service being derived in any location, and they can be understood in a different way (Howe et al., 2014).

The importance of understanding the trade-offs is that it can help identify the services likely to be most difficult to manage jointly, and also help to identify interactions that necessitates more attention. By evaluating the dynamics, management options that might produce similar or better results with less conflict can be more effectively considered. This improves the understanding of the full implication of management choices such knowledge is critical for maintaining healthy ecosystems and the essential services they provide.

Change detection is a founder mental concept of identifying difference in the state of an object or phenomenon by observing it at different times (Nori et al., 2006). Studies have shown that, pressure on all ecosystem services are likely to increase globally, as a result of increasing demand on natural resources from a growing human population and certain regions are experiencing rapid changes in ecosystem services (Howe et al., 2014) due to rapid needs of those services. It is important to understand the dynamics of a changing ecosystem focusing not only on a single ecosystem but also consider several ecosystem services in the same system.

3. MATERIALS AND METHODS

3.1. Study area

The research was conducted in Weerribben-Wieden National park in the province of Overijssel, in the municipality of Steenwijkerland in The Netherlands (Figure 3). Weerribben-Wieden National Park is a Ramsar site located in the central part of the Netherlands between 52°48'N-5°53'E (Cusell et al., 2014). It is characterized by a maritime (sea) temperature climate with a mean annual precipitation of about 800 mm. The area was declared a Ramsar site in 1980 and a national park in 1992 (Ramsar, 2014).

The Weerribben-Wieden national park was identified as a unique largest fresh water wetland in North-west Europe and it is known to be a peaceful oasis, a space for plants and animals to grow and for people to enjoy themselves. The Weerribben-Wieden National park covers a total area of 10,500 ha of which The Weerribben consists of 3.500 ha and The Wieden 7.000 ha (IVN- National park Weerribben-Wieden, 2014).
The area is managed by Forest service (Staatsbosbeheer) which is a governmental body, Natuurmonumenten (The Netherlands Society for Nature and Environment) an NGO, and a few hundred hectares are owned by private landowners. Together they ensure that visitors continue to enjoy the area without putting the protected flora and fauna at risk. The management partnership of the area is done between the park managers, Ministry of Economic Affairs, the province, municipalities, the water board, business people and residents. The groups work in consultative body of the national park to maintain its natural environment (IVN-National park Weerribben-Wieden, 2014).

The physical appearance of this area is a result of peat extraction that happened in the past where peat extraction was the main activity in the region for centuries. A thick layer of peat was formed during Middle Ages and it was a common knowledge that dredged and dried peat could serve as fuel. Excessive extraction of peat led to digging of long trenches which created a narrow strips of land which were left for the extracted peat sods to dry on. These strips are called "ribben". A "weer" is the site where peat was cut. However, these strips were so narrow that later alone some were swept away by wind and water especially in heavy storms which eventually created large lakes mostly witnessed in the lower part of the area The Wieden (IVN- National park Weerribben-Wieden, 2014).

Regardless of how protected the area may be, the creation of the Weerribben-Wieden has been due human interventions. Peat digging was still a very important activity in this area until 1920 where peat mining was abandoned due to the fact that it was no longer profitable and local population gradually shifted to reed farming which became a major source of income.

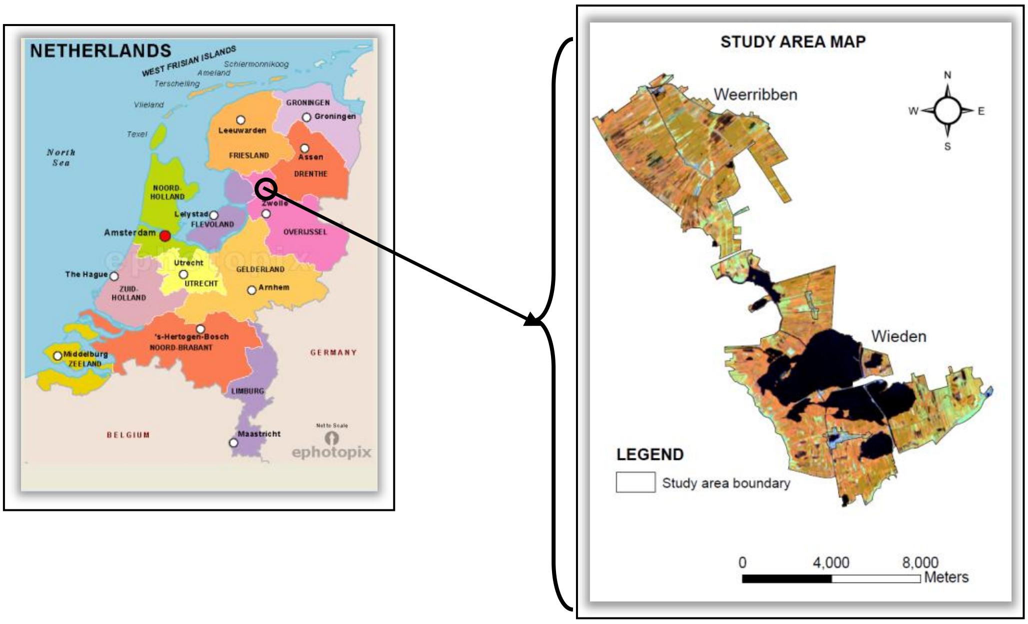


Figure 3: Map showing study area

3.2. Methodological framework

The overall approach to study the spatial temporal distribution of reed land ecosystem services consisted of three steps. First, mapping land cover and ecosystem services in the study area since 2000 to 2013, second, valuation of ecosystem services based on stakeholders perception, third, assessing ecosystem services conflicts and management based on changing land cover in the study area. These methods are described in the methodology flow chart presented in Figure 4.

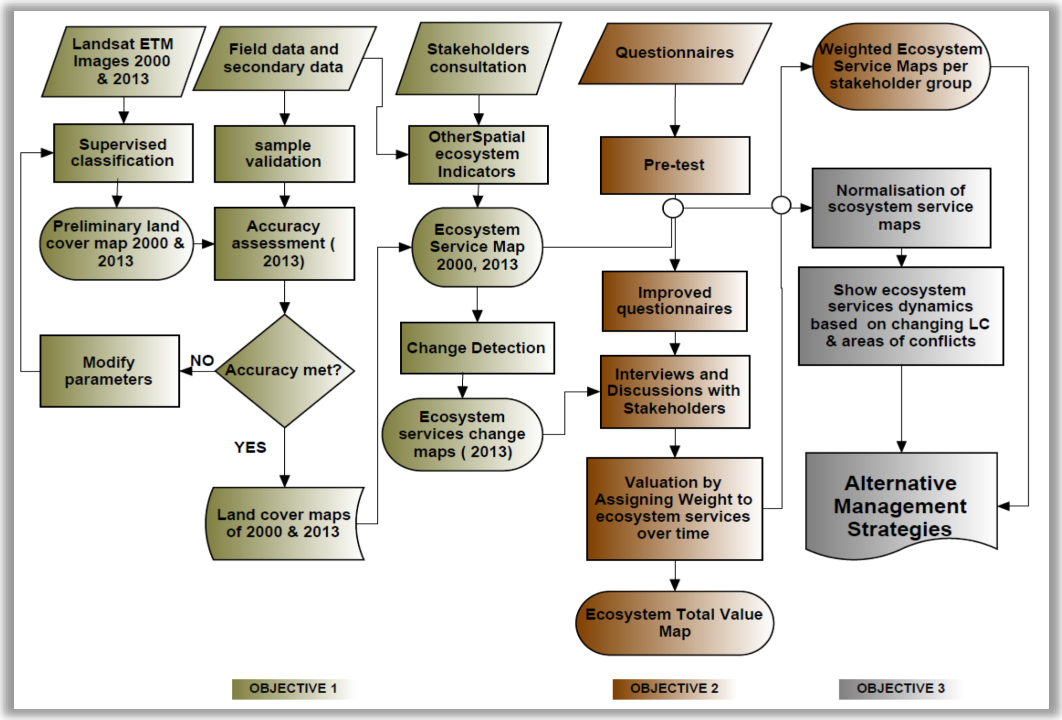


Figure 4: Methodology flow chart

3.3. Land cover mapping

Land cover information was derived from LANDSAT TM image acquired on 13th. May. 2000 with path /row of 198/23 and LANDSAT ETM+ image of 21st July 2013 with path/ row of 197/23 respectively. These images were obtained and used for land cover mapping and assessing change dynamics on ecosystem services Table 4. The images have a projection of UTM WGS 84 and zone 32N, with four bands 1-6 corresponding to Red, Green, Blue and Near Infrared.

Table 4: Satellite image data source

LANDSAT Images for Weerribben-Wieden National park				
Images	Path /Row	Date of acquisition	Resolution/RGB /Band combination	Source
LANDSAT Image TM 2000	198 / 23	13th.May	30m/451	USGS (United States Geological survey)
LANDSAT Image ETM+ 2013	197 / 23	21st July	30m/562	USGS (United States Geographic survey)

Source: (USGS - EarthExplorer, 2014)

3.3.1. Land cover class identification

The key Ecosystem services for this study area are; 1) Reed production, 2) Recreation 3) Habitat provisioning. In order to map these services, seven land cover classes were identified for this area.

1. Reed land
2. Water (lakes, ditches, water ways, canals)
3. Natural grassland
4. Forests/woodland
5. Swamps
6. Wetland vegetation/Quaking bog
7. Pasture grassland

The above land cover classes were used as indicators to map and valuing ecosystem services for this study Table 5. Roads and built-ups were also used although they were not listed on the above list because the layers were extracted from secondary source (Topografie, 2012) and overlaid on the classified images.

Table 5 : Ecosystem services and related land cover types in Weerribben-Wieden national park (Appendix 4 and 5)

Ecosystem services	**Land cover type**
Reed production	Reed land
Recreation (land and water recreation)	Roads Built- up areas Water
Habitat provisioning for key species	Reed land Water Swamps Forest/woodland Wetland vegetation (Quaking bog)

3.3.2. Classification

A LANDSAT image ETM+ for 2013 was classified using supervised classification to produce a preliminary land cover map using training data generated from Google maps. Training samples were used to identify the classes of LANDSAT ETM+ 2013 classification. Seven land cover classes in the study area were classified. In supervised classification, the quality accuracy and completeness of training data are crucial to produce higher quality accurate classification and hence a better change detection (Hussain,et al., 2013). A requirement of supervised classification is that the producer has sufficient known pixel for each class of interest or that representative signatures that can be developed for those class. Those sample pixels are known as training samples. The signatures that are generated from the training samples are different depending on classifier method used. For this study maximum likelihood classifier method with 6 bands and composite of bands 1,2 and 3 was used. The method considered the cluster centres but also shape and colour. This was chosen because the algorithm uses a probability function to compute the probability of a class to be correct for a pixel. The maximum likelihood classifier is one of the methods that is widely used in land cover mapping (Tolpekin and Stein, 2012).

The procedure undertaken to classify LANDSAT image 2000 and 2013 to develop a land cover map 2000 and 2013 followed the following steps. 1) Define sample areas using training data collected from Google earth image. 48 Samples were used as training samples to train the LANDSAT image 2013 and 35 samples for 2000 image respectively, 2) Create signatures for each land cover class for both images using ERDAS IMAGINE 2014. 3) Carry out the classification by comparing each pixel with class signatures and land cover class assigned. Mapping land cover is the first step of mapping ecosystem services and the resulting maps act as a basis for spatial information in the study area.

Field sample collection for land cover mapping.
The importance of the field work was to assess and collect land cover data relating to ecosystem services as well as ground truth points in the study area. The field points were then used as test sample points needed to perform accuracy assessment on the supervised classification. The field work was carried out on 3rd October and 31st October 2014. This started with reconnaissance survey carried out on 3rd October 2014 the aim was to get familiar with the study area. The actual field work was done on 31st October 2014 using IPAQ 214, printed hard copy of LANDSAT image of 2013, recording sheet and digital camera. Before undertaking the actual field wok, the IPAQ was prepared and tested for its accuracy prior to the field work day. During the preparation, backups were made using ECW format which is a format acceptable for IPAQ and correct datum configuration for the Dutch coordinates system (RD) were entered. The IPAQ was used for field navigation and at each sample point GPS coordinates were taken and recorded in the field data sheet (appendix 3). The sampling method used to collect test sample points from the field was through the stratified random sampling techniques considering group of samples which were homogeneous. The visual interpretation was used based on colour difference within the image plus supplementary data such as Google maps. This helped to determine different samples of land cover in the study area. During field work 12 samples were corrected.
Another point of consideration was accessibility such as roads therefore areas which were near roads and can easily be accessed were sampled.

3.4. Accuracy assessment

Quantification of the classification accuracy was done using independent sample points generated from the field observation and current aerial photos from Google maps and reserved for this process. These were used as test samples. 100 points in this case, were used to validate the supervised classification accuracy for image 2013. Sample scheme for sampling locations of test data collection was through stratified simple random sampling. After carrying out validation accuracy, an error matrix or confusion matrix for 2013 image was created and land cover map 2000, 2013 were also produced. ERDAS IMAGINE version 2014 was used to perform accuracy assessment and ArcGIS version 10.2.2 was used for spatial data analysis.

Table 6: Data set used to carry out classification and accuracy assessment for 2013 image

Data	Source
Training data	Generated from Google earth images May, 2014 (48 points)
Test data	Current aerial photo i.e. Google maps 2014 plus field observation (100 points)

3.5. Ecosystem Service mapping

The mapping of ecosystem services in Weerribben-Wieden national park based on land cover map 2013, literature review, consultations and spatial indicators. These helped in defining methods for mapping the following ecosystem services.

3.5.1. Reed production

The mapping of reed production ecosystem services took a simple approach suggested by (Burkhard., et al 2010). Land cover explains a considerable part of the variation in a spatial supply of ecosystem service therefore, can be used to assess reed production. Mapping reed production undergo the following steps summarised in Figure 5

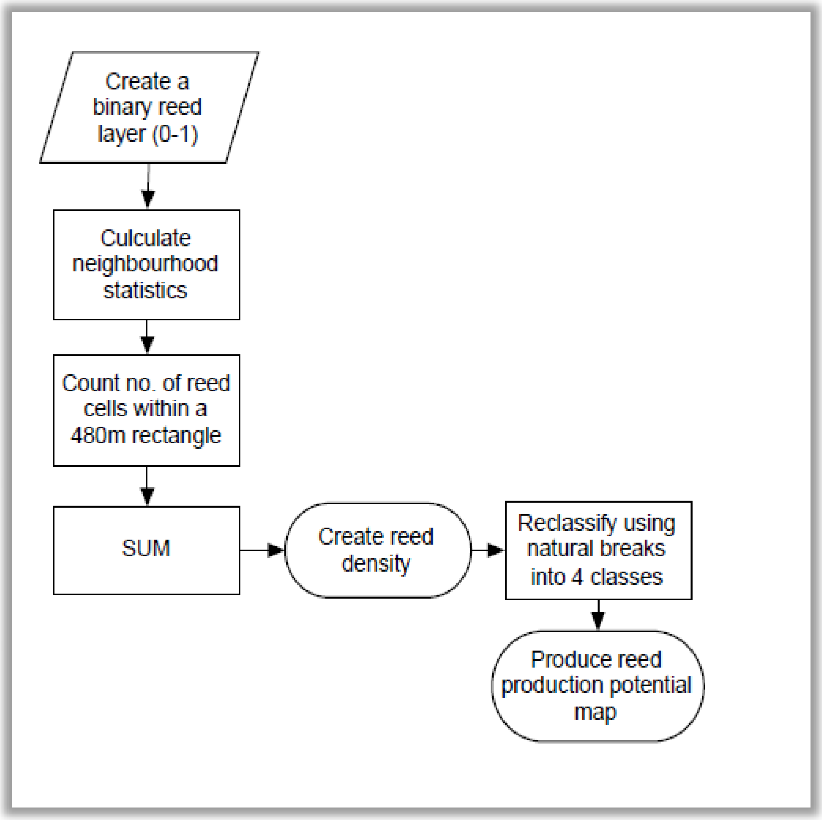


Figure 5: Methodology flow chart for mapping reed production potential

Step1) A raster layer of reed class was extracted from land cover map 2013 with classes (0-1), Step 2) Using spatial analysis tool in ArcGIS10.2.2, calculated density using neighbourhood statistics in this case, focal statistics was used with an aim of calculating each input cell location on a statistic of the value within a specified neighbour around it. A rectangle with 16 cell values in a 480 m was used. Using SUM calculated all the total of all values of cell in the neighbourhood and produced reed density. Step 3) The output was then reclassified using natural breaks excluded (0) and produced reed production potential map with class (0,1,2,3) corresponding to no production, low production, medium production and high production respectively. Density was calculated on the assumption that areas with high reed concentration were assigned high density zones which translates that they have high reed production compared to low density zones.

3.5.2. Recreation

The recreation ecosystem services were mapped based on the assessed recreation potential index in the study area. The method used to select the recreation potential was based on studies carried out by (Casado et al, (2013) ; Maes, et al, (2011). For this study, identifying and mapping recreation potential was based on the assumption that it is positively correlated to limited number of indicators such as presence of water bodies for example lakes, rivers, canals, ponds found in the area and which provides potential for recreation activities, accessibility and tourist facilities.

Accessibility indicators in this case included: water bodies, boat or canoe routes, location of harbours, roads both local and regional and cycling or hiking routes. Quality indicators included parking lots, location of rental agencies or built-ups and point of interests. The study did not separate land and water recreation because the aim was to map recreation potential in the study area and both were taken as one element for recreation. During the process some elements of recreation were not included in this study for example swimming, sun bathing, fishing and camping this was because there were not enough information to assess these forms of recreation either by primary data collection nor literature review. The description of data and data sources used is shown in Table 7.

In order to create potential maps for each indicator the following methods were applied. Canoe routes, cycling/hiking routes, location of harbours, point of tourist interests were identified and digitized from Google Earth. Other layers such as water bodies, roads, parking lots, built-ups were derived from different sources such as (Topografie, 2012). After digitizing the layers in Google Earth, they were converted into kmz format and imported into ArcGIS where they were converted into shape file format and merged together with the other layers from (Topografie, 2012) to create one single layer. Thereafter potential areas were calculated by performing density analysis using spatial analysis tool - density in ArcGIS. The output from this was masked out using the study area boundary and eventually created individual density map showing areas with low density, medium density and high density. These were given values of 1,2 and 3.

The output obtained from individual recreation indictor maps were further combined using raster calculator in ArcGIS to create a total combined maps that shows accessibility and quality in the study area. The process undertook the following steps: All accessibility indicator layers (water bodies, canoe routes, location of harbours, roads and cycling /hiking routes) with values corresponding to low, medium and high were added together using raster calculator, and later reclassified using natural breaks to produced accessibility combined map with values (1,2,3) where 1=low accessible, 2= medium accessible, and 3= high accessible.

Similar process of adding using raster calculator was used to produce the quality indicator map. In this case all quality indicators included: parking lots, location of built-ups and point of interests. All quality raster layers were added together and reclassified using natural breaks and produced quality combined map with layers (1,2,3) corresponding to low quality, medium quality and high quality.

There after a final recreation potential map was produced by adding up together all accessibility and quality reclassified with values (0-6). The output values was again reclassified into 3 values using natural breaks (0-2, 2-4, 4-6) and produced a final recreation potential map with values (1,2,3) showing areas with low recreation quality and low accessibility, Medium quality and medium accessibility, high recreation quality and highly accessible (Figure 6).

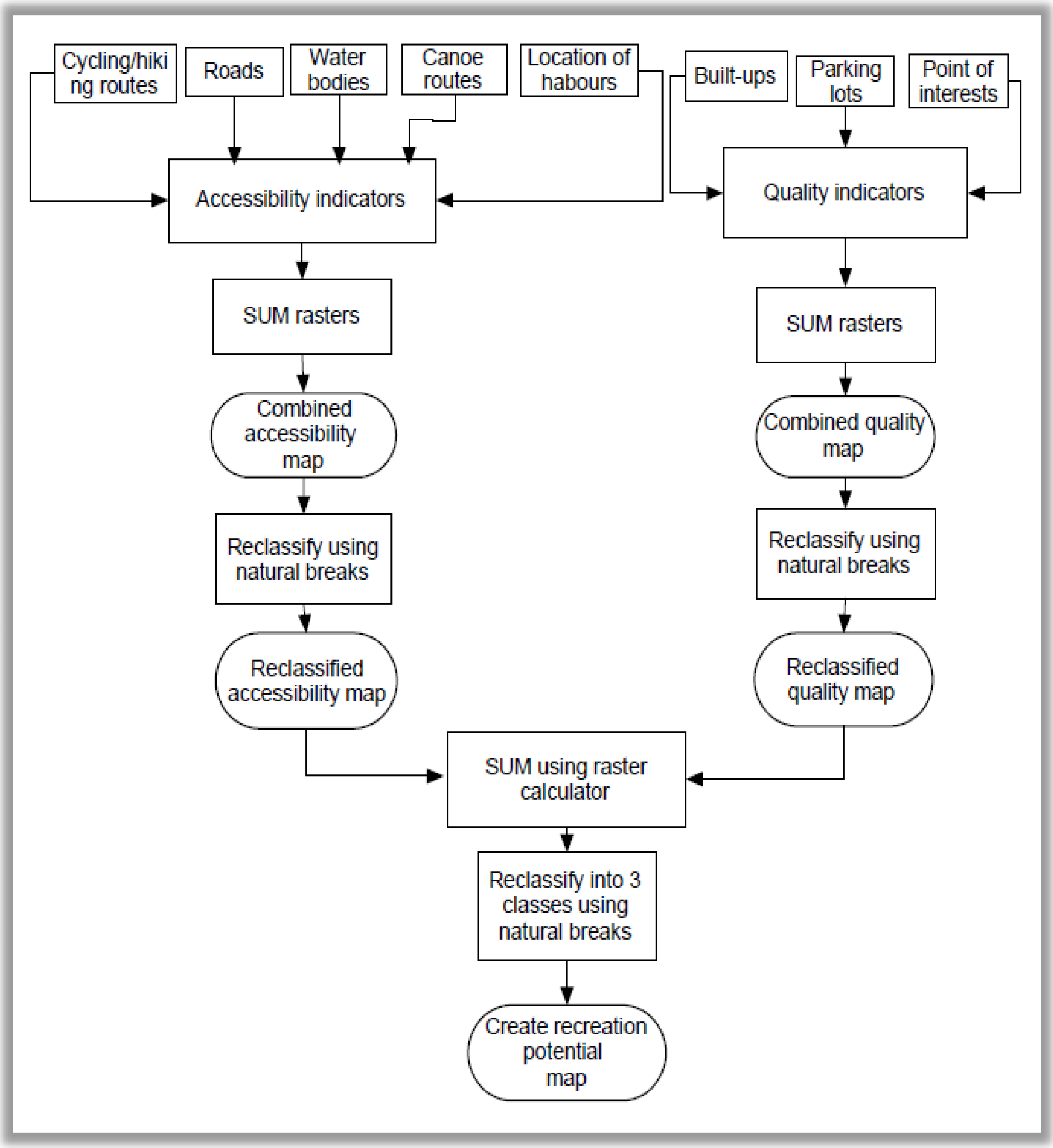


Figure 6: Methodology flowchart for mapping recreation potential ecosystem services map

Table 7: Data and data source for mapping recreation potential areas in Weerribben-Wieden national park

Data	Description	Data source
Water bodies	Water where recreation in taking place in the area. They include lake, rivers, ponds	(Topografie, 2012)
Roads	Accessible through local and regional roads	(Topografie, 2012)
Canoe routes	Water bodies with designed canoe routes	Extracted from Google Map
Cycling/hiking routes	Different routes that can easily be accessed by bikes or hiking in the area	(Topografie, 2012) (Natuurmonumenten, 2014)
Parking lots	Areas used for parking vehicles or bicycles	(Topografie, 2012)
Location of Harbours	A body of water or water areas where ship, boat, canoes are being sheltered	(Steenwijk, 2014) Extracted from Google Maps
Location of Rental agencies or built-ups	Areas where different facilities can be hired for example boat, canoe, ship, bikes accommodation etc	(Topografie, 2012)
Point of interests	Areas that contain interesting sites such as historical sites like museums, bird watching points, interesting plants and animals.	(Natuurmonumenten, 2014)

3.5.3. Habitat for key species

Reed land in Weerribben-Wieden national park supports rich and diverse range of birds, plants and mammals. Birds and mammals take advantage of reeds for food and shelter especially where the reeds are associated with open water and other semi-natural habitats while plants germinate and survival from reed land. Mapping key species based on suitability for their habitat in the study area.

a)**Key bird species**

Key bird species in the Weerribben-Wieden are; Great reed warbler, Reed bunting, Sedge warbler, Savi's Warbler, grass hopper warbler, the purple heron and bittern. These birds were selected for this study because they use reed for their food and nesting. They are ground breeders and require wet sports to protect themselves against the predators (IVN- National park Weerribben-Wieden, 2014). Mapping their habitat considered reed land as their habitat and indicators that contribute to their disturbance in their habitat. These disturbance indicators included density of roads, location of harbours, parking areas and built-ups. Although in section 3.5.2 these were identified as good indicators for recreation in the study area, for bird species they were considered as disturbing indicators. A single habitat suitability map for reed birds was made to cater for all the birds species that uses reed as their habitat in the study area.

In order develop the habitat suitability map for key bird species, the following steps were undertaken. Step 1) Raster layer 4 in total for each disturbance indicators with values (1-3) were added together using raster calculator. Step 2) Produced total disturbance map with values (0-12) Step 3) Reclassify using natural breaks, exclude (0) the values were reclassified into 4 values (0, 1, 2, 3). Step 4) Produced total disturbance reclassified with values (0,1,2,3) where 0=no disturbance, 1= low disturbance, 2=medium disturbance, 3=high disturbance respectively.

The final habitat suitability map for key bird species was produced using reed density layer reclassified into classes 0,1,2 and 3 minus disturbance layers and with their levels of disturbance 0,1,2 and 3 (See section 3.5.1) the subtraction process was done using raster calculator in ArcGIS. All the negative values were reclassified as 0 meaning not suitable. The final habitat suitability map for key birds species was then produced (See Figure 7 for summary of methodology followed).

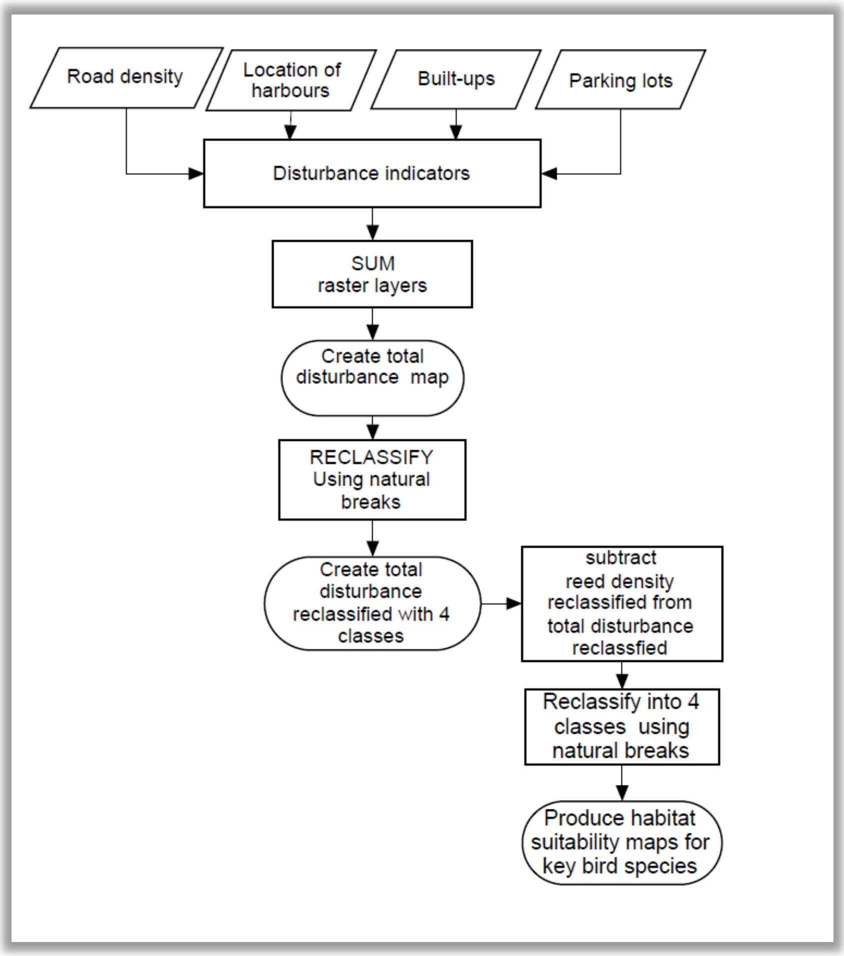


Figure 7: Methodology flowchart for mapping key bird species

b) **Key plant species**

Key plant species in Weerribben-Wieden included: Great fen sedge which belongs to *Cyperaceae* family, Round leaved, Mush lousewort, Sundews and Lesser butterfly orchid. All representative stakeholders groups identified the land cover for these plant species as wetland vegetation. Mapping of the habitat for key plant species considered the land cover type. This was because of the insufficient information regarding indicators contributing to their disturbances in Weerribben-Wieden. Hence mapping was done based on stakeholders' knowledge and assumption that, the condition in wetland vegetation areas such as soils moist provides the best suitable habitat for plants species and also since plants do not move the research considered stability of plants in their habitat. A raster layer for wetland vegetation (Quaking bog) was extracted from land cover map 2013 and was used to map areas where these plants are mostly found in the study area. Figure 8 summarises the steps taken to produce habitat suitability map for key plant species.

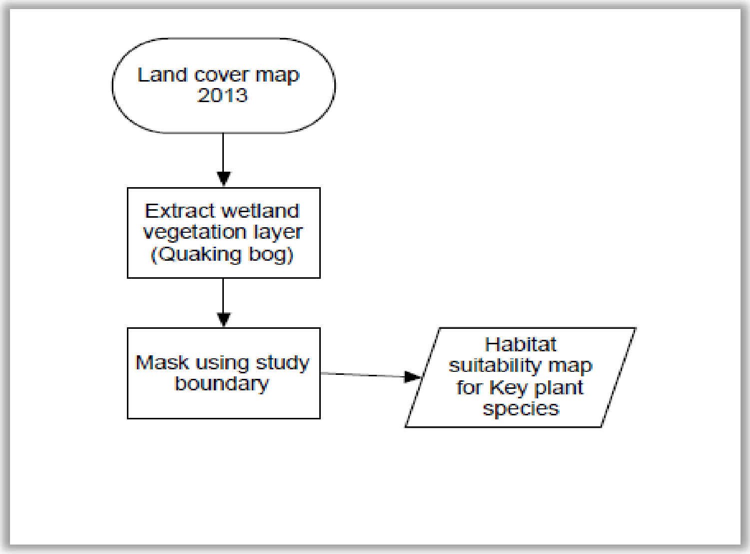


Figure 8: Methodology flowchart for mapping habitat for key plant species.

c) **Key mammals**

Important mammals in Weerribben-Wieden national park are Otter and European Pine marten.

The Otter (*Lutra lutra)*

This is the most important mammal in the Weerribben-Wieden national park and is now used as park symbol (IVN- National park Weerribben-Wieden, 2014). The habitat of the otter has two parts. They must have both a piece of land and water in order to survive. The land near the water is meant to provide sufficient shelter for the otters. The otter keep their young ones on land and therefore they need either vegetation or rock structures as shelters (Habitat traker, 2015).

Figure 9: The Otter in its natural habitat

These mammals used to be common in the area but they were hunted until they became entirely extinct. Otter were reintroduced in the Weerribben-Wieden between 2002 and 2008. Studies have shown that generations of Otters are currently present in the park and its vicinity (IVN- National park Weerribben-

Wieden, 2014). Mapping habitat for Otter considered land cover as swamp. This was on assumption that since Otters prefer land and water, swamps were taken as the most suitable habitat for these mammals this was because in swamps we can find water from streams or rivers flowing and also a mixture of vegetation which makes it suitable place for Otter. Also mapping considered indicators that contribute to their disturbance for example road density were considered in mapping the Otter habitat. Road density were taken as the most disturbing indicator causing most of the registered dead Otters in the traffic accident in the study area (Koelewijn et al., 2010).

In order to develop a habitat suitability map for otters, the following steps were taken (Figure 11). Step1) A binary layer of swamp class was extracted from land cover map 2013 with classes (0-1), Step 2) Using spatial analysis tool in ArcGIS, calculated density using neighbourhood statistics in this case, focal statistics was used with an aim of calculating each input cell location on a statistic of the value within a specified neighbour around it. A rectangle with 16 cell values in a 480m was used. Using SUM calculated all the total of all values of cell in the neighbourhood and produced swamp density. Step 3) The output was then reclassified using natural breaks excluded (0) and produced swamp production potential map with class (0,1,2,3) corresponding to not present, low presence, medium presence and high presence respectively.

Step 4) The final habitat suitability map for Otters was produced by subtracting road disturbance reclassified with 4 classes (0,1,2,3,) corresponding to no disturbance, low disturbance, medium disturbance and high disturbance from swamp reclassified with values (0,1,2, and 3) using raster calculator. A final habitat suitability map for Otters with 4 classes (0,1,2 and3) corresponding to not suitable, low suitable, medium suitable and high suitable was then produced.

European pine marten (*Martes martes*)

Figure 10: The European pine marten in its natural habitat

The European pine marten belongs to the most diverse carnivore family, the mustelids (mustelidae) which contains 59 species grouped into 22 genera (Mullins Jacinta et al., 2010). Their optimal habitat appears to be woodlands with an incomplete canopy and dense understory vegetation. They also prefer climbing or running on tree branches, although they are also relatively quick runners on the ground. Mapping European pine marten species considered its natural habitat and disturbing indicators while in their habitats.

In Weerribben-Wieden national park the mammal was identified to be found in wood land or forest and mostly active during the night (IVN- National park Weerribben-Wieden, 2014).
The most disturbing indicator for these mammal was identified as road density whereby most casualties of pine marten are caused by road accidents (Mullins Jacinta etal., 2010).

Mapping habitat suitability for European pine marten took the following steps as illustrated in Figure 11. Step1) A binary layer of forest/woodland class was extracted from land cover map 2013 with classes (0-1), Step 2) Using spatial analysis tool in ArcGIS, calculated density using neighbourhood statistics in this case, focal statistics was used with an aim of calculating each input cell location on a statistic of the value within a specified neighbour around it. A rectangle with 16 cell values in a 480m was used. Using SUM calculated all the total of all values of cell in the neighbourhood and produced forest/woodland density. Step 3) The output was then reclassified using natural breaks excluded (0) and produced forest/woodland production potential map with class (0,1,2,3) corresponding to not present, low presence, medium presence and high presence respectively.

Step 4) The final habitat suitability map for European pine marten was produced by subtracting road disturbance reclassified with values (0,1,2, and3) from forest/woodland reclassified with values (0,1,2,3,) corresponding to no disturbance, low disturbance, medium disturbance and high disturbance using raster calculator. A final habitat suitability map for European pine marten with 4 classes (0,1,2 and3) corresponding to not suitable, low suitable, medium suitable and high suitable was then created.

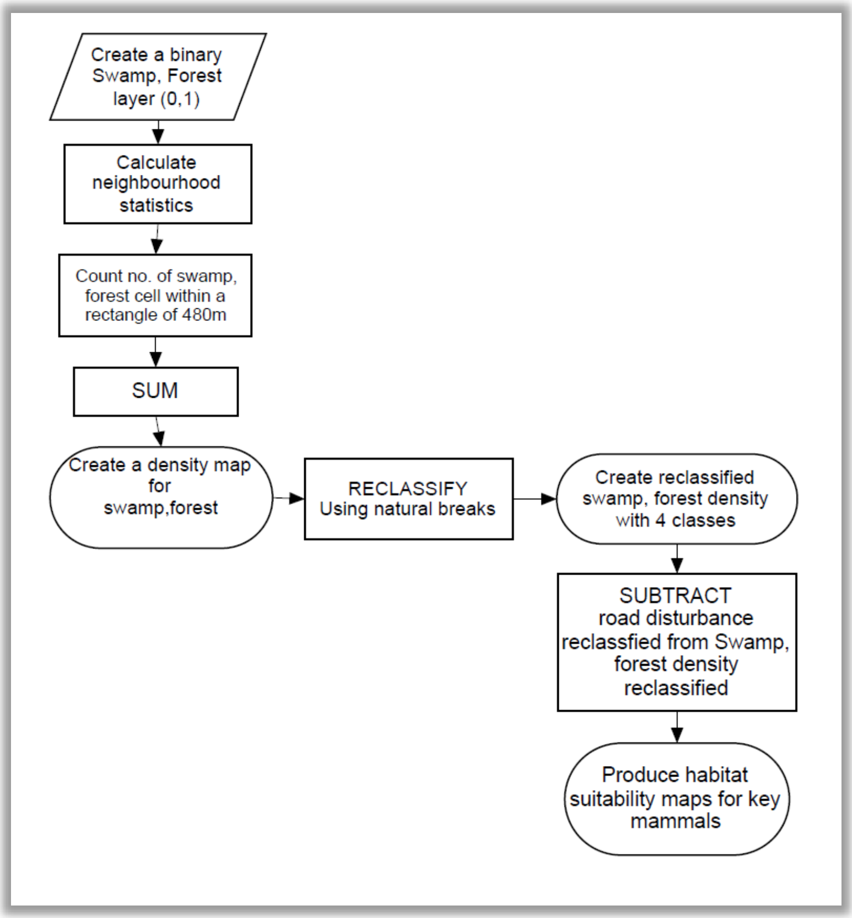


Figure 11: Methodology flow chart for mapping habitat for key mammals

3.6. Stakeholders based valuation for ecosystem services

The assessment of ecosystem services valuation applied for this study was adopted and modified based on the valuation framework suggested by (Hein et al., 2006) Figure 2. To obtain a better understanding of the perceived benefits and values of reed land ecosystem services by different stakeholders in Weerribben-Wieden national park, a questionnaire survey was performed in December 2014. The survey focused upon different stakeholders individual views and opinions perceived on benefits and values from reed land ecosystem services in the area. Several open and multiple choice questions were designed to enable respondents to articulate their values and feelings associated with reed land ecosystem services in the Weerribben-Wieden national park. Before the actual data collection a questionnaire (Appendix 7) was pre-tested for its clarity.

An online questionnaire was designed using Survey Monkey software and was sent to 10 different stakeholder group representatives with a flyer (appendix 6) introducing the topic and the objectives of the study. These stakeholder groups were; reed farmers, nature conservationists, tourism operators and provincial government officials active in the Weerribben-Wieden national park. These stakeholders were selected because they were considered as key informants who have more knowledge about the study area. The questionnaire was designed in English with a possibility to be filled in English and Dutch, which is the most spoken language. See appendix 7

3.7. Assessing ecosystem service dynamics

Human activities over time have resulted into different scale of changes in ecosystem services such as reed land. However, the acquisition of multi spectra satellite data or images in recent times have supported the detection and identification of land cover changes and their services. Similarly, using stakeholders knowledge has also contributed a lot in assessing complex dynamics of ecosystem services in an area. So, the assessment of ecosystem dynamics was based on the theory that understanding the dynamics is affected not only by environmental or biophysical components but also with various socio-economic factors which makes its assessment rather complex (Getahun et al., 2014) . To prevent or minimise further changes in ecosystem services, it is important to understand how and why changes are occurring in an area. The identification of drivers of ecosystem service dynamics which is rooted in a way humans live includes detecting the rate of occurrence, the spatial and temporal scale of change and examining the changes in quality and quantity of ecosystems. Hein et al., (2006) mentioned that, complex dynamics are increasingly recognised to be of the major importance for ecosystem management. So, in order to assess ecosystem services dynamics in Weerribben-Wieden National park, a questionnaire survey (appendix 7) was used and supplemented by literature reviews. This gave a foundation in assessing these spatial temporal dynamics of ecosystem services in the study area since 2000 to 2013.

3.8. Assessing ecosystem service conflicts and management

A conflict is defined as "difference within a person or between two or more people or group of people that touches them in a significant way" (Madden and McQuinn, 2014). Conflicts often manifests itself in expressed disagreement among people who see incompatible goals and potential boundary in achieving these goals (Peterson, 2011). Conflicts are unavoidable outcome of human interaction but it is the effects of conflicts that determine whether the conflict is constructive or damaging. Hence, assessing ecosystem services conflicts and their management help in revealing where these conflicts can be found and who is affected. The aim of establishing deep rooted conflicts help to develop a transformation mechanism to sustainable conflict and address expected future conflicts. In Weerribben-Wieden national park the assessment of ecosystem service conflicts and management, based on literature reviews and questionnaire survey conducted during the study. This was used as a mean of attaining more information regarding conflicts in the use of ecosystem services and how their being managed in the study area.

4. RESULTS

4.1. Land cover mapping

4.1.1. Land cover classification

Supervised classification was done based on 7 land cover types described in the Table 8. The image characteristics for each land cover type based on Google Earth image and LANDSAT image 2000, 2013 is shown in Appendix 1 and 2. However, some land cover classes were not easily identified on LANDSAT image for example built up areas and roads so they were not included in the land cover classification. Vector layer of built up and roads were derived from (Topografie, 2012) and later overlaid on the classified image. Furthermore, some of the water bodies such as streams, the resolution of LANDSAT was not fine enough to capture them during classification a vector layer was also overlaid from (Topografie, 2012). The land cover maps generated from LANDSAT images of 2000 and 2013 are presented in the Figure 12a and b respectively.

Table 8: Land cover type description

Land cover type	Description
Reed land	Area covered with reed which is a rhizomatous perennial tall grass species, with the largest geographical distribution of any flowering plant.
Forest / woodland	Forested areas which are predominantly covered by trees with close canopy and showing areas of mixed vegetation that arose naturally.
Water bodies	Areas comprises of lakes, rivers, ponds, canals and ditches.
Swamp	A low wetland where water from streams or rivers collects in a shallow flat area before flowing out in another stream or river
Pasture grassland	Areas that are covered with short grass of a single species that is homogenously presented on the ground and are suitable for grazing
Natural grassland	Areas that are dominated by different or mixed herb and grass species that are largely controlled by natural processes, even when some human management activities such as mowing take place.
Quaking bog/wetland vegetation	Floating mat area of thickly woven mosses and vegetation that forms across the surface of shallow water and may shake when walked on.

Land cover map of Weerribben-Wieden 2000, 2013 is shown in figure 12 a and b.

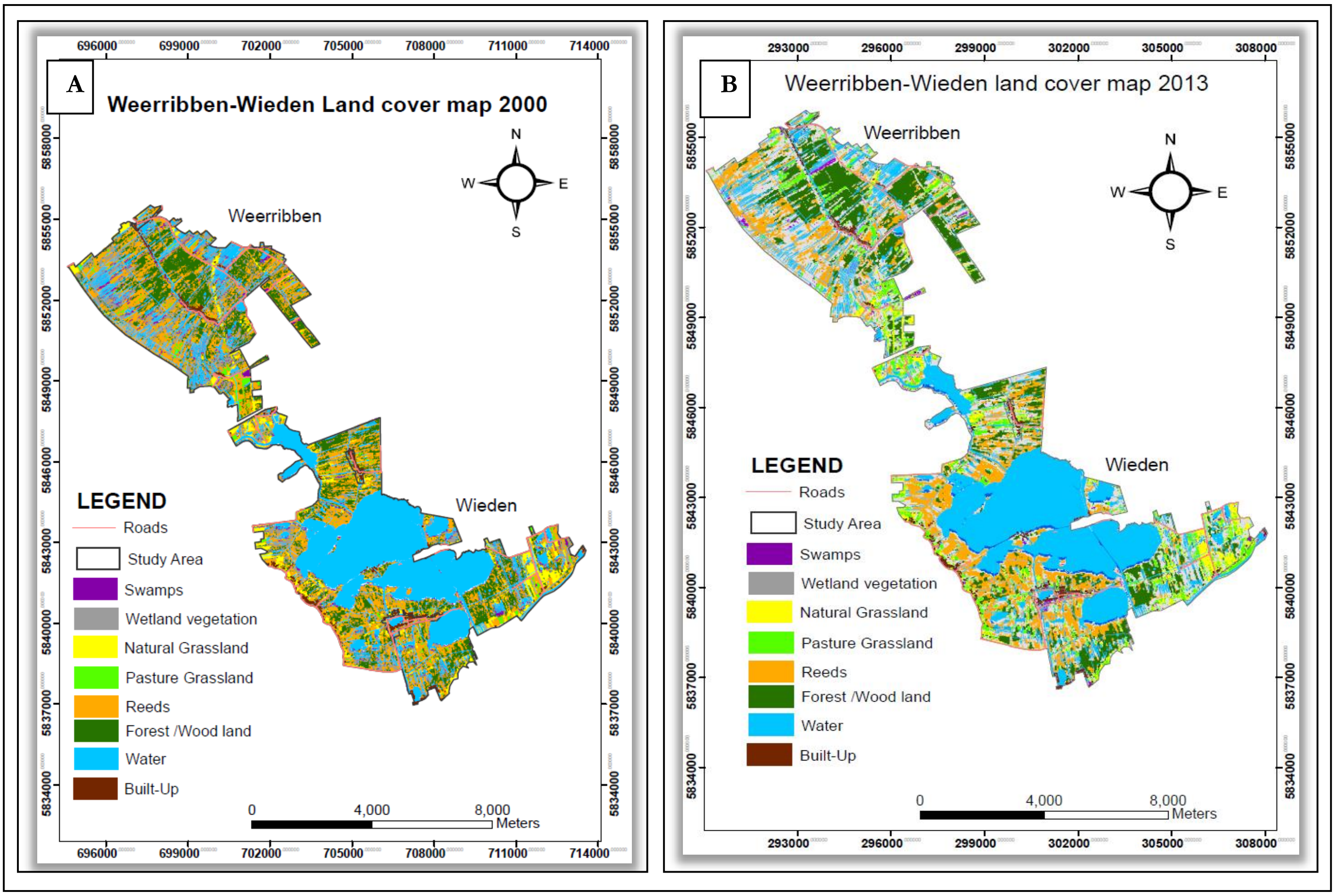


Figure 12: Land cover maps 2000 and 2013

4.1.2. Accuracy Assessment

The accuracy assessment was based on the classified LANDSAT image 2013 using 100 sampling points obtained from field observations (12) and other points (88) generated from current aerial image in Google maps of 2014. The accuracy assessment report is shown in table 8 below. The accuracy assessment was carried out by comparing a sample of pixels from the classification results of the image to the accurate geographic data that are taken from the ground truth data collected during the field work. Classification error matrix indicating overall accuracy, producer's accuracy and user's accuracy was produced. The overall accuracy was calculated by dividing the number of corrected pixels per class with the total number of the reference pixels for the class. The producer accuracy represents the probability of a point in the field being correctly classified while the user accuracy represents the probability of a random point on the map correctly classified.

Table 9: Accuracy assessment report

Class Name	Reference Totals	Classified Totals	Number correct	Producer Accuracy	User Accuracy	Kappa
Water	15	15	14	93.33%	93.33%	0.9216
Pasture grassland	17	17	11	64.71%	64.71%	0.5748
Natural grassland	21	7	6	28.57%	85.71%	0.8192
Reeds	12	14	12	100%	85.71%	0.8377
Forest/woodland	14	16	14	100%	87.50%	0.8547
Swamp	11	16	9	81.82%	50.00%	0.4382
Wetland vegetation	10	13	7	70.00%	53.85%	0.4872
Totals	100	100	73			
Overall Classification Accuracy= 73.00% Overall Kappa Statistics = 0.6867						

In general, the class reeds and forest/woodland has the highest producer accuracy which is 100% followed by water, swamps, wetland vegetation, pasture grassland and natural grassland. However, for the user accuracy, the class Water has the highest user accuracy of 93.33% followed by forest/woodland, reeds, natural grassland, pasture grassland, wetland vegetation and lastly swamps. Therefore, class reeds and forest/woodland have the highest probability that the pixel on the map represents the type of class on the ground. Whereas for swamps and wetland vegetation, some of the pixel were mixed up with water and therefore poorly classified.

4.2. Ecosystem services maps

The results presented here are for mapping ecosystem services in Weerribben- Wieden national park i.e., reed production, recreation and provisioning of habitat for key species such as birds, plants and mammals.

4.2.1. Land cover identification in relation to ecosystem services

During online survey stakeholders were asked to locate where different ecosystem services can be found. Different land cover types and their relationship to ecosystem services are shown in Figure 8. All stakeholders (6) confirmed that the land cover for reed production is reed land, also all stakeholders located land cover for water recreation to be water bodies, while habitat for important bird species two land cover types were identified first, reed land and second, swamps meaning that for important birds species, they are found in swampy areas as well as reed land. Also (6) said that important plant species are mostly found in wetland vegetation, and finally, important mammals (6) said they are largely located in forest/woodland. These results shows that if one wants to locate these ecosystem services there is a high probability of finding these services in the given land covers. However, there is also a likelihood that the same services can as well be located in other land cover types such natural grass land and pasture grassland as shown in Figure 8. These were the perception of the stakeholders in the area. From this background it helped in mapping ecosystem services as presented in the proceeding sections.

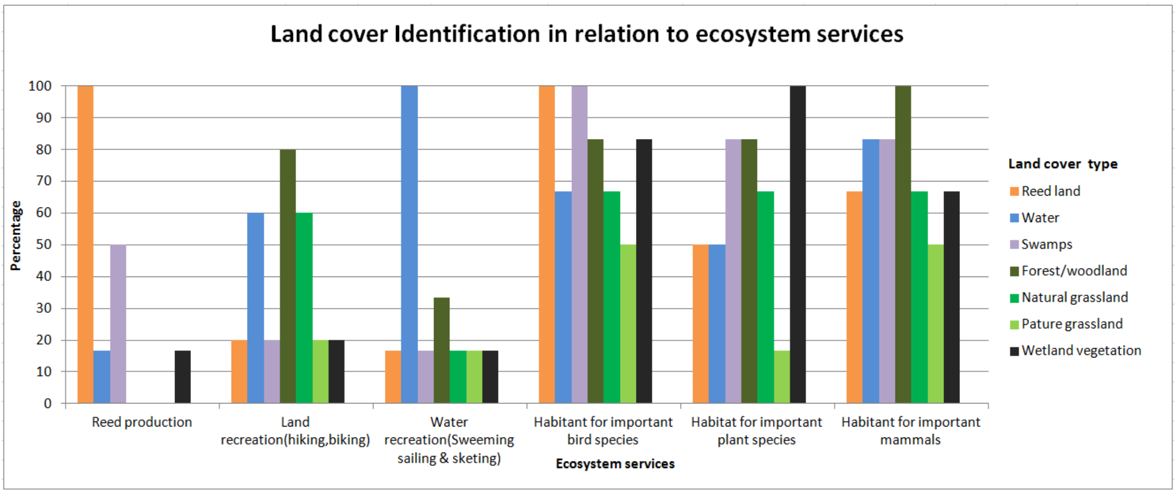


Figure 13: Land cover identification in relation to ecosystem services

4.2.2. Reed production map

The reed production ecosystem service map presented in Figure 14 shows the reed land production potential in Weerribben-Wieden national park. The visual interpretation for reed production ecosystem service map indicates that, the biggest part of Weerribben has the highest potential for reed production as compared to Wieden. Unlike Wieden, the biggest part is covered by a large water body that is to say, two big lakes that covers also a big portion of the area with deep water and therefore, a few remaining area is suitable for reed growth. This is in agreement with (Altartouri and Jolma, 2010) who mentioned that, the deeper the water in a location, the lower chance for reed to grow there and the closer a location to a river mouth, the more suitable it is for reed to grow. This similar situation apply in Weiden, which makes most of the areas have no production potential for reed growth.

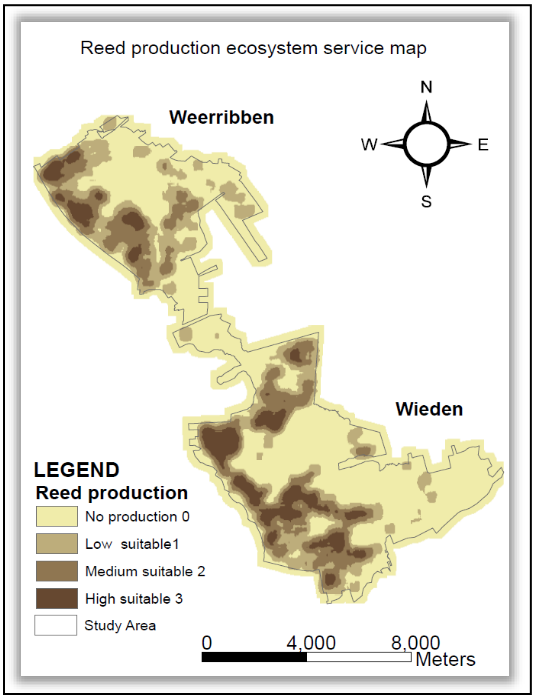


Figure 14: Reed production ecosystem service map.

4.2.3. Recreation potential maps

The individual recreation density maps for the study area are represented in Figure 15. The visual interpretation of results shows that, although the Weerribben-Wieden is a protected area, but the area is easily accessible for recreation. There are different routes allowing people to enter the area and enjoy different services and this is possible either by water or by road. These routes include boat/canoe routes, roads both local and regional and cycling/hiking routes. The study looked at water body that provide the possibilities for water accessibility in (Figure 15a) the results shows the high water body density in Wieden compared to Weerribben the high density could be attributed by the big water bodies located in the Wieden. Although, Weerribben have no big water bodies as Widen, the area was observed to have more water routes than Wieden and hence easily accessible. Weerribben have small water bodies with different boat/canoe routes entering the area as compared to Wieden this makes the area more accessible by water than Wieden (Figure 15 b). It was further observed that although Weerribben can easily be accessible by water, most harbours are located in Wieden (Figure 15 c).

For road accessibility, the visual interpretation of results shows that Wieden is more accessible by road as compared to Weerribben and there are also more opportunities for cycling/hiking in Wieden compared to the Weerribben (Figure15d and e). For visitors who would like to get accommodation such as hotels, bars and restaurants, rent a boat and bicycles the study considered location of these facilities as built-ups and it was observed that Wieden has more of those facilities as compared to Weerribben (Figure 15f). This shows that a lot of business activities regarding recreation take place in Wieden than Weerribben. The study also looked at parking facilities (Figure 15g) and the results indicated that Wieden have more parking facilities than Weerribben. Finally, this study looked at points of interest such as bird watching, historical sites for example museums and the results shows that most point of interest are found in Wieden compared to Weerribben (Figure 15h).

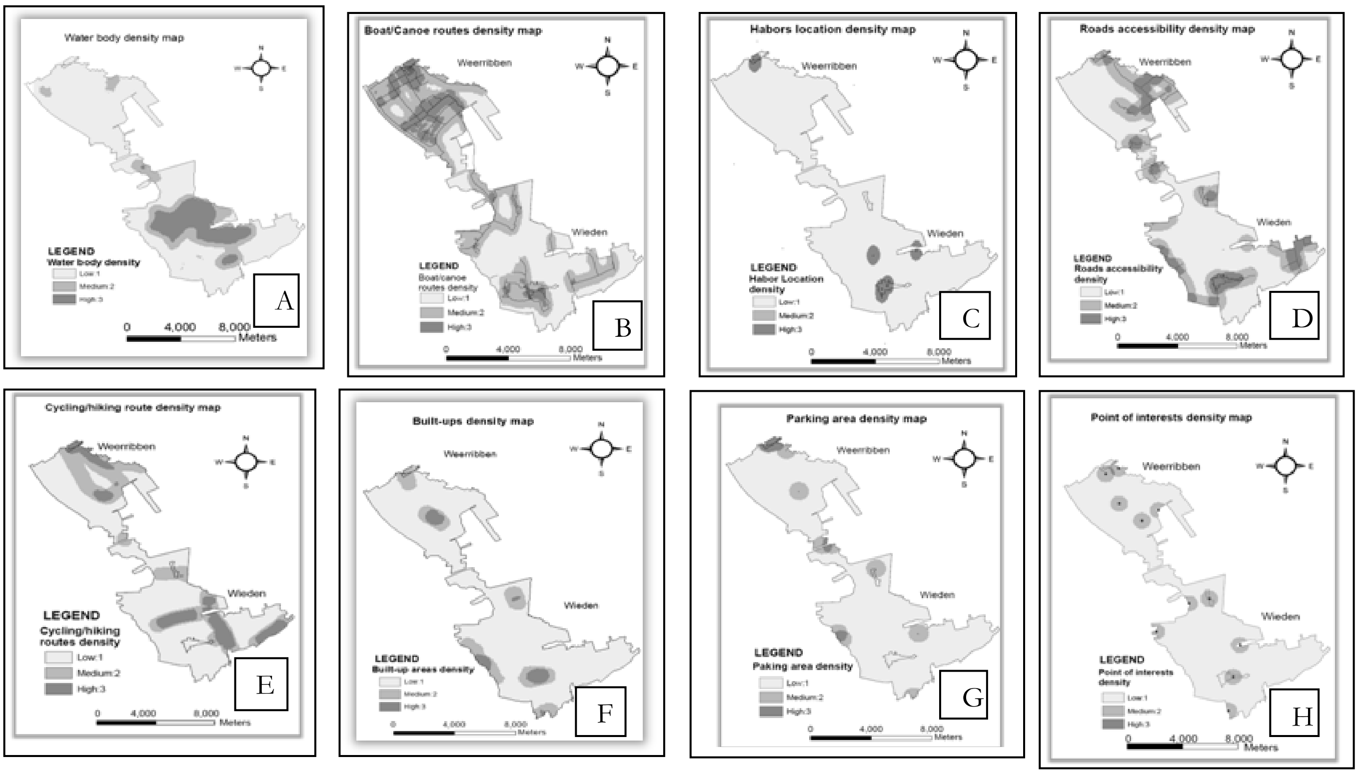


Figure 15: Individual recreation indicator maps a) Water body, b) Boat or Canoe routes, c) Location of Harbours, d) Road accessibility, e) Cycling or hiking, f) Built-ups, g) Parking area, h)Point of interests.

The results obtained from combined recreation indictors are presented in Figure 16. Figure 16a shows accessibility potential of the study area. Whereas Figure 16b shows the quality of the area. The visual interpretation of the results indicates that Weerribben has the highest accessibility potential compared to Wieden. While for the quality it can be visualised that Wieden has more recreation quality compared to Weerribben. This makes Wieden more attractive to tourists than Weerribben.

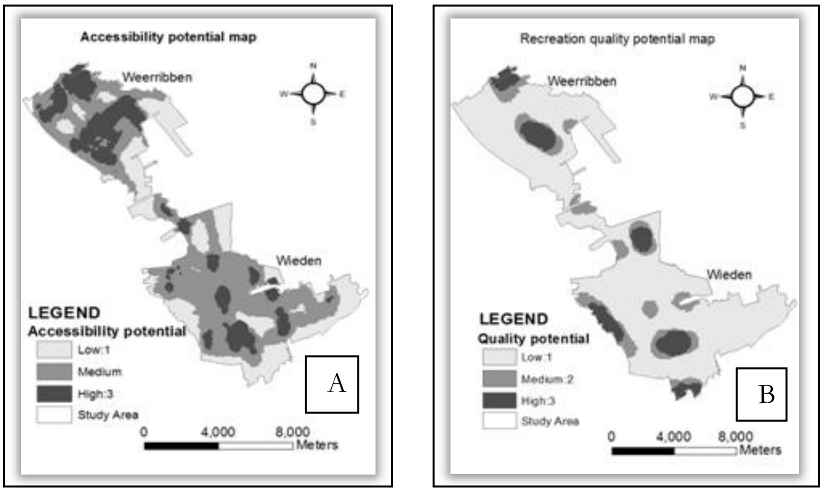


Figure 16: Combined recreation indicator maps a) accessibility and b) quality of the area.

The final recreation ecosystem service map is presented in Figure17. The Figure shows areas with low accessibility and low quality, Medium accessibility and medium quality and high accessibility and high quality. The visual interpretation of the results reveals that the concentration of recreation quality and accessibility is clearly seen in both areas. This indicates that Weerribben and Wieden has potential for recreation.

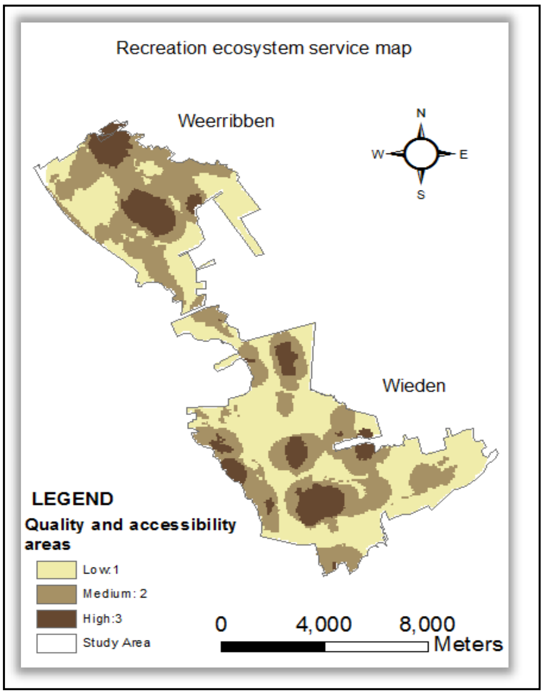


Figure 17: Recreation ecosystem service map showing areas with high recreation quality and are highly accessible.

4.2.1. Habitat for key species

a) Key bird species

The key bird species mentioned above use reed land as their habitat (Figure 14). There are different indicators that contribute to their disturbance in their natural habitat. These indicators are presentenced in Figure 18 they included: roads density, harbour locations, built ups and parking areas. So, where these indicators are highly concentrated in the study area, indicated that the abundance of the species is likely to be low compared to areas with less concentration. The visual observation of these indicators in the study area shows more disturbance of roads, harbours, built-ups and parking places in Wieden compared to Weerribben.

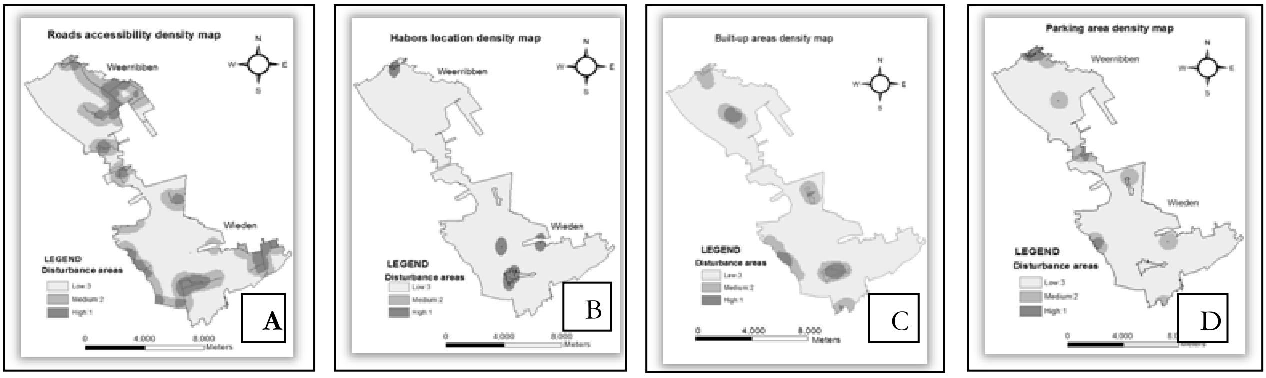


Figure 18: Disturbance indicators for key bird species. a) Roads b) Harbours location c) Built-ups d) Parking area.

Figure 19 show the results from the combined disturbance indicators in the study area. The interpretation of these results indicates that Wieden has more of these disturbance indicators compared to its adjacent area Weerribben.

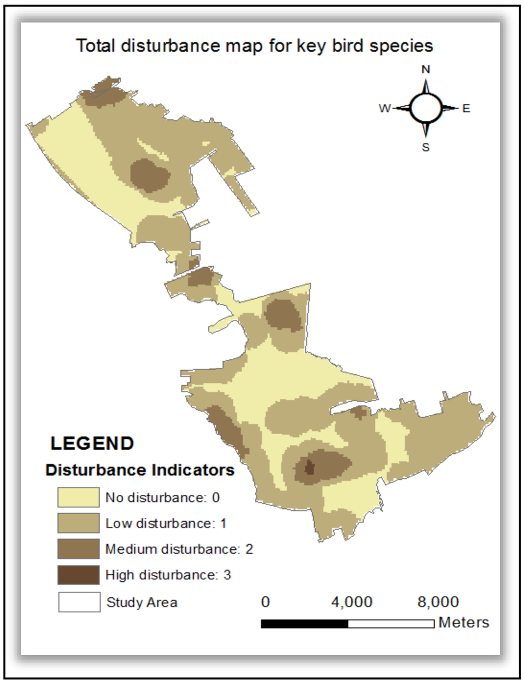


Figure 19: Total disturbance map for key bird species

The final map of habitat suitability for key birds is presented in Figure 20. The visual interpretation of the results indicates that a big portion of the Weerribben area is a suitable habitat for key bird species this could be attributed to more concentration of reed production in the areas (Figure 14). Meaning that, the area is well managed with less disturbances and so more quiet environment for the birds to feed on and rest. For Wieden the low suitability for the birds could have been as a result of disturbing indicators that pass through the area which contributes to noise and hence less suitable environment for birds.

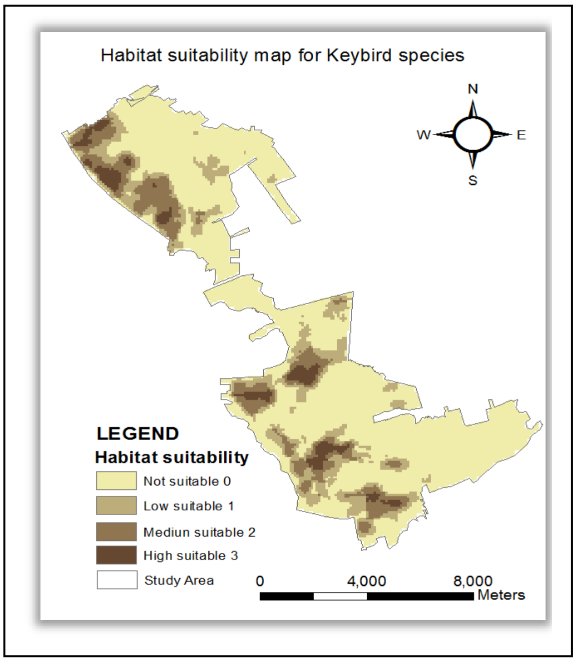


Figure 20: Habitat suitability map for key bird species

b) Habitat for key plant species

Based on the visual interpretation of results for wetland vegetation (Quaking bog), indicates that Weerribben has more wetland vegetation compared to Wieden and this means that, most important plant species are more likely to be found in Weerribben than Wieden.

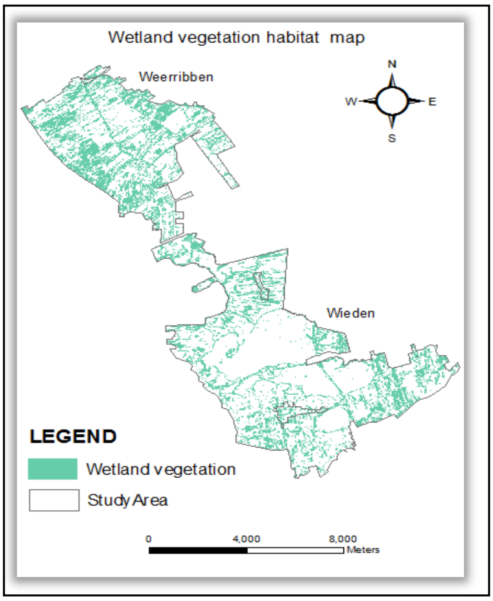


Figure 21: Wetland vegetation habitat map for key plant species

c) Habitat for key mammals

The Otter

According to the results in Figure 22a, shows high concentration of swampy areas in Weerribben compared to Wieden. This means that, the most suitable habitat for otters are found in the Weerribben than in the Wieden part (Figure 22b). Similarly, Figure 22b shows more disturbing indicators that is to say roads in Wieden than in Weerribben. Roads, as already been indicated in section 4.2.1(Figure 18 a), pose a threat to these mammals because many of them die in traffic accidents. The two factors explain why Weerribben has most suitable area for otters than Wieden.

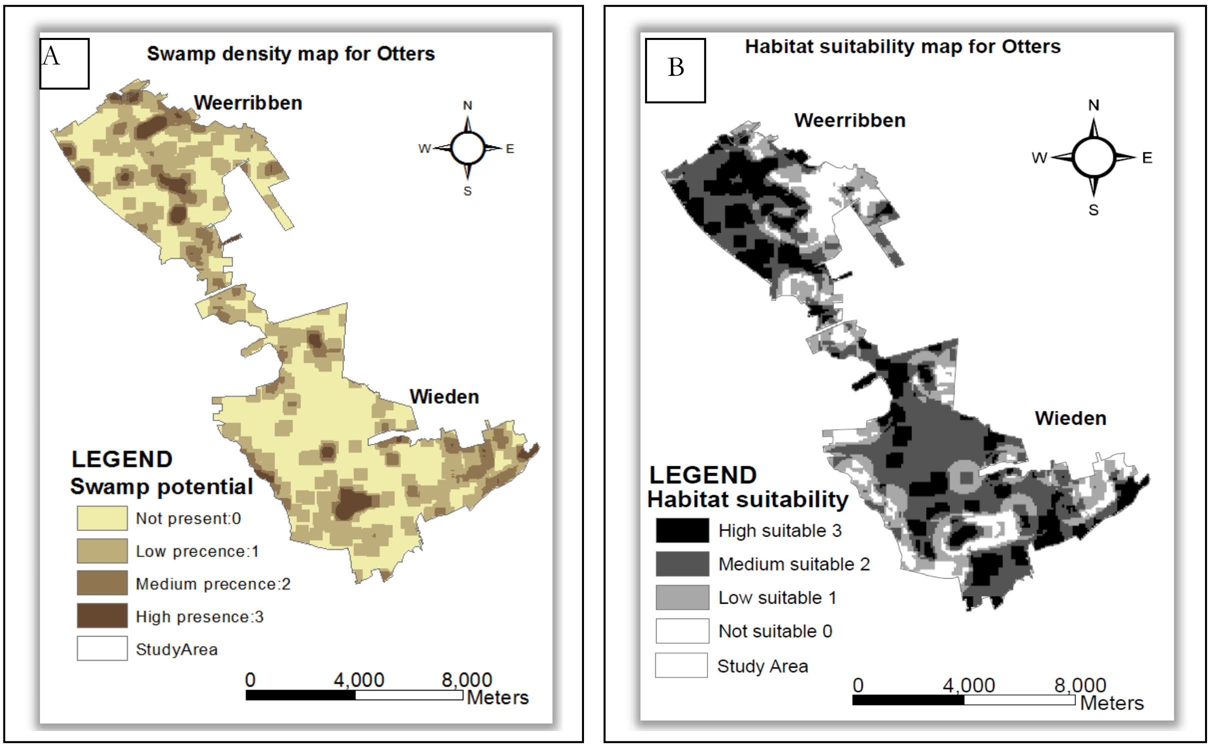
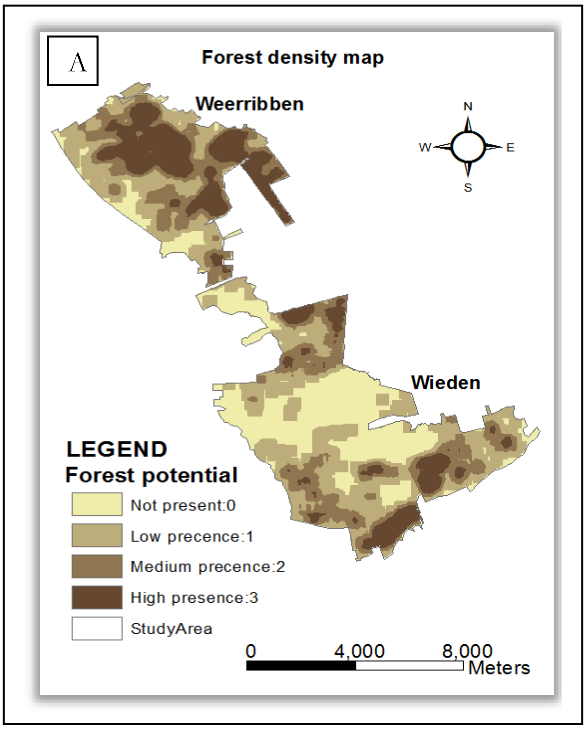


Figure 22: Map showing swamp density a) and habitat suitability for Otters b)

The European pine marten

The results presented in Figure 23a, show that there are fewer forests in wieden than Weerribben. Since these mammals live mainly in woodland or forests, their suitable habitat are found more in Weerribben than in Wieden. Figure 23b shows more concentration of woodland/forests in Weerribben and more disturbing factors in Wieden. There are more roads as presented in 4.2.1 (Figure 18a) in Wieden than in Weerribben part. Roads contribute to the reduction of those mammals found in Wieden. This explains why Weerribben have more suitable areas for these key mammals than Wieden. All the same, mammals found Weerribben-Wieden national park die in road accidents hence road density becomes their reducing factor.



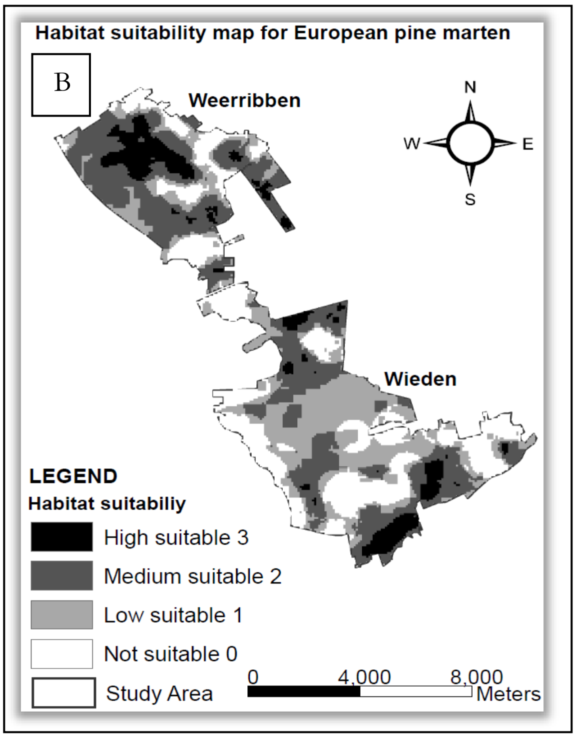


Figure 23: Maps showing forest density a) and habitat suitability for European pine marten b)

Generally, based on the results of ecosystem services mapped in the study area indicated that, there are many ecosystem services hotspots and also many coldspots which were not randomly scattered but rather occur in particular patterns that leads to the expression of distinctive hotspots and coldspots of ecosystem services as shown in the results. However, where there were more of coldspots (0 or 1 value) contributed to a reduction of that particular ecosystem services and more hotspot (2 or 3 value) contributed to the supply of those ecosystem services in the study area.

4.3. Ecosytem services Valuation

The results presented in this section represents the views and opinion of stakeholders based valuation of ecosystem services from the questionnaire survey conducted in the study area.

4.3.1. Description of the respondents

An online questionnaire was sent to 10 stakeholders group representatives of which 6 responded to questionnaire. 2 of the respondents were female compared to 4 male respondents.

2 of the respondents fell in the category of age group (30-40), 2 were in the category of (60 and above) whereas the other 1 was in the category of (40-50) and 1 in (50-60) respectively. The youngest respondents was between 30-40 years (2) while the oldest was aged 60 years and above (2). None of the respondents was below 30 years.

Age of Respondents

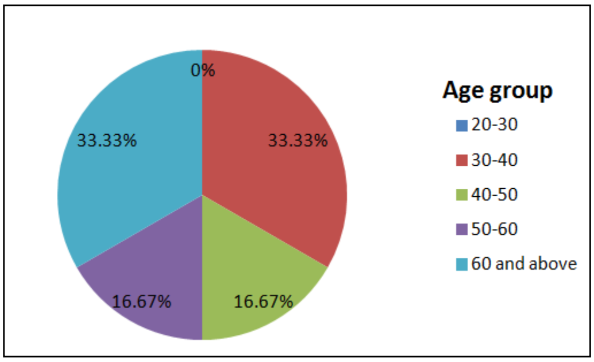


Figure 24: Age of respondents (n=6)

Income received from ecosystem services

Most of the respondents to questionnaire 66.67% earn 0-10% from ecosystem services whereas 33.33% get more than 50% income from ecosystem services in Weerribben-Wieden national park. This indicated that almost all respondents were not completely depending on ecosystem services in the study area they had other sources of income which were not revealed during the survey.

Occupation of the respondents

Among the respondents 2 were environmentalists, 1 reed farmers, 2 governmental officers, and 1 was both reed farmer as well as tourism operator. These represented all the stakeholder groups in the study area.

4.3.2. Survey based valuation of ecosystem services

Stakeholders were asked to identify all the goods and services derived from Weerribben-Wieden national park which are of importance to human well being using this list.

a) Attractive housing and living conditions
b) Culture/historical values
c) Scientific/education values
d) Animal fodder
e) Harvesting reeds for thatching houses
f) Recreation and tourism
g) Beauty
h) Food

The results showed that, the national park is perceived to be important for its culture/historical values and recreation/tourism both identified by 100% of the respondents, for its beauty (by 80.33%), for scientific/education values (66.67%), one third indicated for attractive housing/living condition and harvesting reeds for thatching houses (16%), while 16% identified animal fodder as a service of the Weerribben-Wieden national park. None of the respondents mentioned food as an important service derived from the national park (Figure 2). So, culture/historical values and recreation/tourism are the perceived major services provided by the national park.

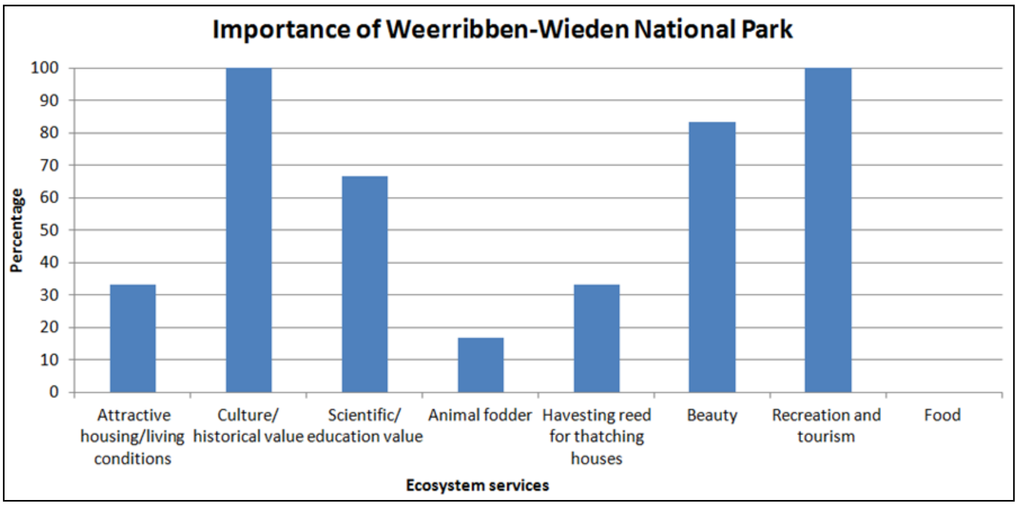


Figure 25: Important functions of Weerribben-Wieden National Park as indicated by respondents(n=6)

Figure 26 shows the results of how stakeholders valued ecosystem services in the study area by describing their level of importance. The results are presented in terms of numbers whereby, from stakeholders perspective (5 respondents) indicated that, habitat for key species that is to say birds and plants are the most important ecosystem service in the Weerribben-Wieden national park. When compared to reed production ecosystem services, (3) respondents indicated that reed production is considered important and for recreation (4) respondents revealed that land recreation is the least important ecosystem service. None of the ecosystem services was not important at all. This means that, there are variations between different stakeholders as regarded to the importance of these ecosystem services in the study area.

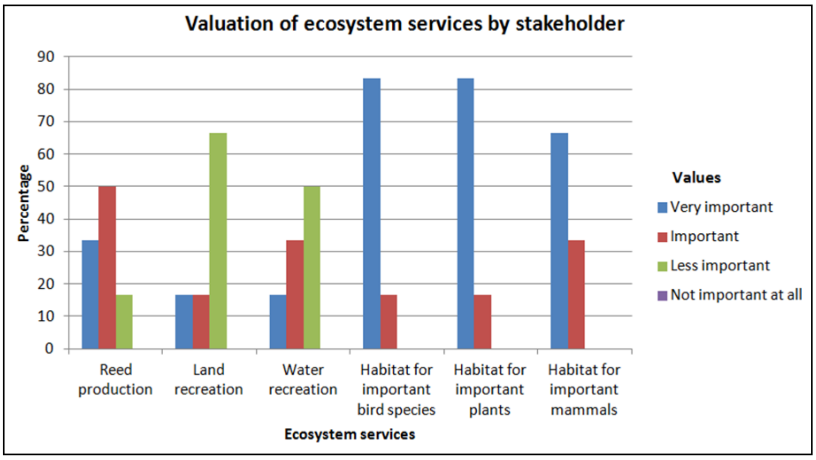


Figure 26: Valuation of ecosystem services by their level of importance as indicated by the respondents (n=6).

Figure 27, shows the results of the assigned weights of each of the ecosystem services identified in the study area. Stakeholders were asked to distribute 100 points in terms of weight assign to the different ecosystem services in the Weerribben-Wieden national park. Habitat for important bird species was given the highest average points (22 points), followed by habitat for plant species (21points), habitat for important mammal species (19 points), reed production (17 points), water recreation (12 points) and lastly (10 points) were assigned to land recreation. This was in agreement with the first presented results in (Figure 26). This means that habitat for important bird species are considered the most valued ecosystem services in the Weerribben-Wieden national park according to the stakeholders preference and land recreation the lowest valued ecosystem service.

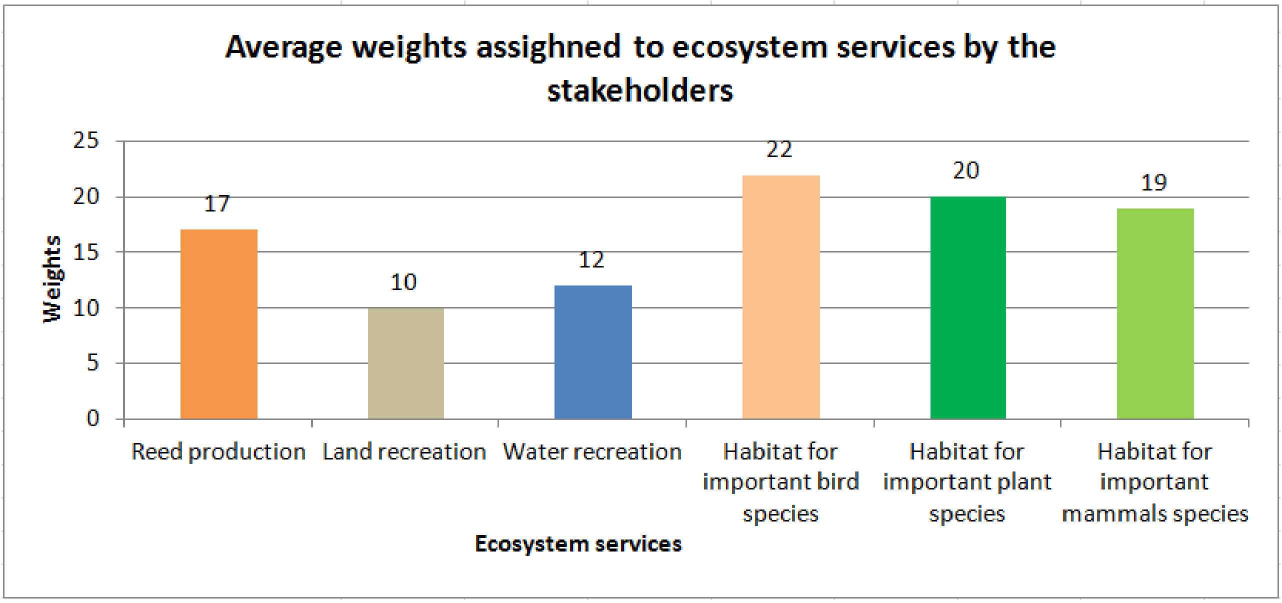


Figure 27: Average weight assigned to ecosystem services by the stakeholders (n=6)

4.4. Ecosystem service dynamics

In order to assess the changes that has been happening in Weerribben-Wieden national park, stakeholders in online questionnaire were asked to identify observed changes in the ecosystem services since 2000 to 2013. Respondents(3) acknowledged that they have observed changes since 2000 and 3 did not observe any changes. The identified changes were; development of recreation activities in the area for example sailing recreation, pressure on nature by the rapid developments of the intensive agriculture in the Weerribben-Wieden area. This implies that, changes in ecosystems may results into changes in ecosystem services and the effects of these changes are further presented in Figure 28.

4.4.1. Effects of land cover changes to the ecosystem services

Stakeholders identified changes in land cover since 2000 to 2013 and these changes included: increase in forest/woodland and reduction in reed land, they also identified increase in open water in the area. Stakeholders were asked to identified effects of land cover changes to the ecosystem services and the results indicated that changes in land cover affects ecosystem services in the following ways: i) Ecosystem services increase in supply, ii) it can lead to a reduction in the quality of ecosystem services, or iii) ecosystem services disappear from the location iv) changes in land cover do not have any impact at all.

These results revealed that change in land cover positively affect habitat for important plant species, habitat for important mammals and water recreation. 5 stakeholders said that these services increase in supply. On the other hand, 5 stakeholders also said that, changes in land cover negatively affect the ecosystem services by reducing the quality of the services leading to disappearance of ecosystem services from the location for example reed production and habitat for key bird species. 1 stakeholder said that, change in land cover have no effect on ecosystem services at all.

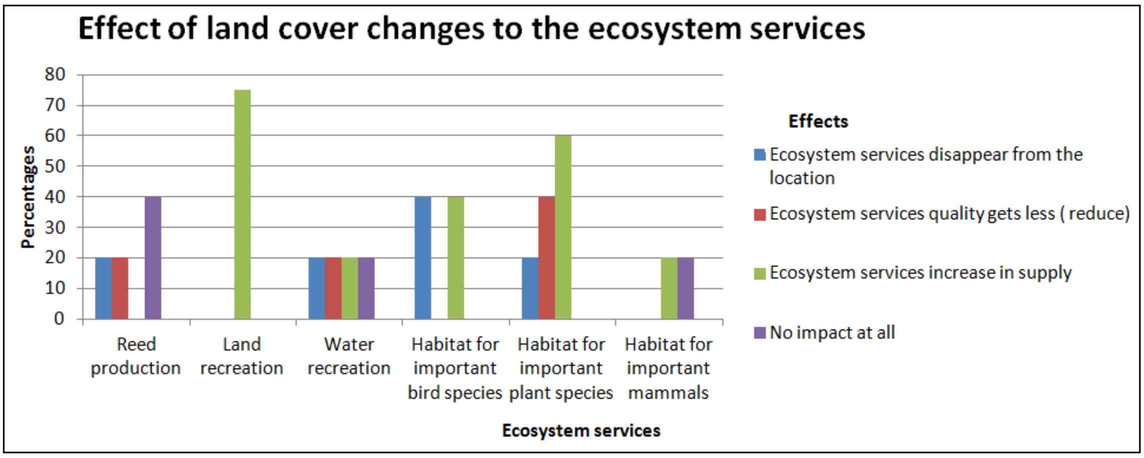


Figure 28: Effect of land cover changes to the ecosystem services.

From the above results, it can be concluded that changes in land cover have both positive and negative effects on ecosystem services as it was revealed by different stakeholders.

4.5. Ecosystem services management and conflicts

During the study, 5 respondents representatives confirmed that there are conflicts in the use of ecosystem services in the Weerribben-Wieden national park whereas, 1 representative was not aware of the conflicts in the study area. The majority of respondents pointed out that the major causes of conflicts lie between conservation, recreation and tourism activities. These activities mostly affect biodiversity especially bird species causing a lot of disturbances for the birds. Another cause of conflict was identified in reed production and harvest. Stakeholders acknowledged that reed production and harvest is important to some ecosystem but maintaining reed requires a lot of water this requires serious need for water management. Another conflict mentioned was struggle for readership positions on who is to be the in charge of the area. This has brought conflicts in the management of Weerribben-Wieden national park.

Although there are conflicts in the use of ecosystem services, stakeholders mentioned the current strategies in resolving those conflicts and these strategies included: different platforms where public opinions are being addressed but these platforms were not described in details. However, it was also revealed that, as far as conflicts are concerned in the Weerribben-Wieden, a good solution to those conflicts is not yet well established. This means that more issues needed to be addressed so as to come up with proper decisions in resolving the existing conflicts.

The survey also seeks to know whether the stakeholders were familiar with the management strategies in place. And it was made known that 3 were familiar with the management strategies, whereas 3 were not aware of the strategies. This was because some stakeholders were not directly involved in the management of the area and therefore, they had little knowledge about the strategies.

Respondents were asked to rate the management strategies indicating if they consider them very good, good, fair or poor. The results showed that 1 respondent (tourism operator as well as reed farmer) said that the strategies are good, while 1 respondent (reed farmer) said they are fair and the other 1 (environmentalist) also said the management strategies are poor. None of the respondents rated these strategies as very good. This means that there is a room for improvement of these strategies in order to have a conducive environment for all stakeholders.

5. DISCUSSION

5.1. Accuracy assessment and land cover classification

The LANDSAT ETM+ 2013 was assessed using the field data validation collected during the field work and Google maps point data of 2014. The overall accuracy assessment was 73% which was lower than the recommended 85% by Foody, (2002). The lower accuracy could be attributed to the medium resolution of the LANDSAT image that was used and the difference in the data of image acquisition and when the field validation was collected. This means that the data quality of 2013 image may render the output less appropriate to reflect all the difference of the land covers. Although the overall accuracy is low, the method was able to identify some of the individual classes to a reasonable degree. For example forest class parcels have little occurrence of misclassification. Reed land, water bodies are also correctly classified with moderate results. For a better accuracy high resolution image such as ASTER, GEO-EYE could be a better option for Weerribben-Wieden.

5.2. Land cover change

The study area have received some land cover change over the period of 2000 to 2013. This is visualised in both LANDSAT images of 2000, 2013. Wood land/forest areas are much more higher covering most parts of the area and reed land seems to be getting lower. This was further confirmed by the stakeholders in the questionnaire survey conducted, where 3 out of 6 stakeholders respondents mentioned that, they have observed changes of forest or woodland increasing at the expense of reed land. Additionally, reports have shown that, in the Weerribben around Kalenberg and the Wieden around Dwarsgracht and Belt Schutsloot there has been rapid growth of woodland brought about abandonment of reed farming, when reed land failed to generate enough money so the area was left un managed and as a result woodland stared to develop hence leading to changes in land cover (IVN- National park Weerribben-Wieden, 2014). This is in agreement with Millennium assessment findings " globally 15 to 24 ecosystem services investigated are in a state of decline" (Fisher et al., 2009). This similar situation is happening in reed land ecosystem services assessed for Weerribben-Wieden. Hence good management practices is required in order to avoid further decline in reed land. Open water development was another land cover change mentioned by stakeholders in the questionnaire. This was further confirmed by report made by Natuurmonumenten and Staatsbosbeheer, 19 hectares of floating vegetation has been restored in Wieden at the expense of unwanted birch, willow and alder. Newly dug channels has been developed to improve the supply of water in the area (Natuurmonumenten and Staatsbosbeheer, 2011). Hence leading to a change in water as a land cover.

5.3. Assessment of ecosystem services value

The Weerribben-Wieden national park is well known for its recreational potential, reed production and provision of habitat for key species.
The participants were employed as reed farmers, environmentalists, tourism operators and government officials. All participants live or work near or within Weerribben-Wieden national park. This shows that the stakeholder participants have reasonable knowledge of the natural resources around them. This was reflected also in online questionnaire survey where stakeholder participants were able to identify specific areas where ecosystem services are being collected and located.

A large number of stakeholders posses knowledge of the study area and their surrounding environment. Therefore, it was important to take advantage of their knowledge to give valuation on the ecosystem services within their reach. Their knowledge was used as a starting point in gaining a better understanding of the relationship between stakeholders and the their environment. As reed land is part of their environment, and ecosystem provide numerous benefits that is ranging from being a source of economic activity such as reed cutting an industry that have employed more than 220 people (Hein et al., 2006), to habitat for key species that have significant value to people's livelihood and recreation that brings about socio enjoyment, their needs consequently affect the way they treat the ecosystem.

Whereas, many studies often valued ecosystem services from economic and biophysical point of view (Raymond et al., 2009), in this study valuation was assessed based on stakeholders knowledge and opinions. Stakeholders were considered as one of the most important persons that are associated with the ecosystem and often attached to that particular ecosystem. This is in line with the definition suggested by Hein et al., (2006) in relation to ecosystem services valuation that, stakeholders are "any group or individuals who can affect or is affected by the ecosystem services". The variations found in spatial distribution of the ecosystem services across the various land cover type in all study area may prove the level of importance that the stakeholders attach value to a particular service. Thus, stakeholders valuation of ecosystem services was taken as crucial in the assessment of reed land ecosystem services in the study area because it makes the future of an ecosystem be linked with the lives and livelihoods of people (Norris et al., 2010).

5.4. Significance of the study and management recomendations

This study seeks to examine the variation of spatial and temporal distribution of reed lands, the ecosystem services provided by Weerribben-Wieden national park and how different stakeholders value and obtain benefits from these services. The assessment is important in order to reveal the interests of different stakeholders in ecosystem management and it can also be used as a basis for establishing compensation payments to stakeholders that face opportunity costs of ecosystem conservation. This is relevant in the context of The Netherlands where the national government is decentralizing the responsibilities for the management of nature reserves (Hein et al., 2006). Today, reed cutters in Weerribben-Wieden are confronted with a decrease in income as a result of lower management compensations and less profitable prices for reed due to import of reed from central and eastern Europe (Blust., 2008). Thus, the sector having a challenging economic prospect, it is not attractive anymore and successors who want to invest in the business are becoming rare (Blust., 2008). Therefore, it is strongly recommended that in the integrated management plan for the Weerribben-Wieden area, special attention should be paid to the maintenance of reed cutting activity as a profitable venture for the inhabitants. The study could therefore be of importance in increasing sustainable utilization of reed ecosystems. The result of this study could enable policy makers and planners make informed decision in monitoring, planning and coordination and proper budgeting for sustainable development.

Biodiversity conservation such as key bird species, plants and mammals is by far the most important function in the study area according to the findings. Besides, reed production and recreation also have to be considered in order to ensure that these can develop in mutual and harmonious manner, an adopted and integrated management plan need to be implemented. Additionally, the assessment in conflicts involving local stakeholders should examine the historic and likely future relationship of the livelihood to the ecosystem and its services. It may be assumed that local stakeholders are the key resource users, therefore, patterns that have damaging impacts on the ecosystem which cannot be resolved as long as the people are allowed to continued access the area need not to be under estimated. Thus, stakeholder groups for example reed farmers have coexisted with their environment for generations without depleting the resource. It may not be correct to assume that sustainable use pattern can or will continue into the future but possibility should at least be evaluated and steps taken to enable such ecosystems to persist if possible. It is thus, recommended to use conflict assessment to clarify the interests and concerns of local stakeholders and to determine whether there might be possibilities for mutually acceptable approach to allow local stakeholders to continue occupy the protected area or use its resources.

Furthermore, keeping focus on interests rather than leadership positions is also another management recommendation. As already been seen in section 4.5 one of the causes of conflicts in Weerribben-Wieden national park is the struggle for readership positions amongst different stakeholders. A focus on interests rather than positions is a key to success of most conflicts resolution efforts (Lewis, 1996). Although it can be challenging to get stakeholders agree, it is recommended that explaining the difference between interests and position at the beginning of the processes is crucial. Thus, asking negotiators in the process to focus on interests than positions could be a central point of resolving conflicts. It is strongly advisable to propose solutions to the conflicts that are responsive to all of the stakeholders interests for a better management.

5.5. Limitations of the study

During the study, the researcher encountered a challenge of missing information which could have improved the findings. For example data on reed production capacity per farm per year (bundle/ha/ year) was not known. This could have given a clear insight on areas were reed is highly produced in the Weerribben-Wieden. So it was difficult to determine exact area with high reed production.
Furthermore, the images used was a serious challenge encountered during the study. The resolution was low for the study area (30 x 30m), thus it was very difficult to separate some of the mixed pixels for example quaking bog which was mixed up with water. A high resolution image could have been a better option for Weerribben-Wieden National park. Also, language barrier was another major constraint for this research. Most of the literature was written in Dutch language. Interpretation was majorly done using Google translation. However, the translation done by Google is not in most cases 100% reliable, and it was also very difficult for Google to translate big documents. This led, sometimes to inaccurate or even misunderstanding and missing some of the needed information.

6. CONCLUSION

The overall objective of the study was to examine the spatial- temporal distribution of reed land ecosystem services within Weerribben-Wieden National park and to be able to support alternative management strategies. This have been demonstrated through the use of remote sensing and GIS technology and with the help of stakeholders knowledge and experience. The following are the study conclusions.

What ecosystem services are provided by the reed lands of the Weerribben-Wieden National park?
Three main ecosystem services were recognised in the study area and these are reed production, recreation and habitat for key species. Apart from that, there are other ecosystem services that were identified by the stakeholders which are important in the study area for example water maintenance, water filtration, water storage and air filtering. These services provide good air and ensure a stable supply of water to the habitats. Water and air are key to the conservation of any habitat including that of mammals like otters. Water maintenance, water filtration and water storage provide security to the growth of reeds and other plants such as wet land vegetation (quaking bog) so, the preservation and further developments of habitat conservation is possible when water regime is not negatively affected.

What are the land cover classes and other location characteristics that contribute to the supply of ecosystem services in reed land in the Weerribben-Wieden?
There are seven main land cover classes in the study area, namely reed land, woodland or forests, natural grassland, pasture grassland, swamps, wetland vegetation or quacking bog and water. These majorly contribute to the supply of ecosystem services in Weerribben-Wieden national park but also roads both local and regional, hiking or cycling routes and built-ups are also found in the Weerribben-Wieden national park and contribute to accessibility and quality of the area.

What are the changes in land cover between 2000 and 2013?
Two major changes were identified in the study area. First, there is a reduction in reed land areas and an increase in forest or woodland. Secondly, there is a change in open water development. These were the most identified land cover changes by the stakeholders representative groups and confirmed with relevant literature.

What are the changes in ecosystem services between 2000 and 2013 in Weerribben-Wieden?
Changes in the ecosystem services noticed in the study area since 2000 to 2013 were: increase in recreation activities particularly sailing recreation, decline in reed production ecosystem services since some of the farmers abandoned reed farming as an activity. Another mentioned change was pressure on nature by the rapid developments of the intensive agriculture in the Weerribben-Wieden area.

Which stakeholders benefit from ecosystem services and at which scale?
It can be concluded that almost all stakeholders in Weerribben-Wieden benefit from ecosystem services in one way or another. For instance, local stakeholders i.e. reed farmers benefit from harvesting and sell of reeds the material for thatching houses, tourism operators and other local business are involved in letting

out bicycles, boats and canoes, hotels, bar and restaurants and earn income out of the business. Tourist get relaxation from nature surrounding them, where as conservationists benefit from protecting biodiversity.

How have different stakeholders in this area valued reed land ecosystem services since 2000 to 2013 ?

Different stakeholders in the study area showed different opinions with respect to value assigned to various ecosystem services and viewed these ecosystem services as vital to their livelihood. This was demonstrated in the questionnaire survey where stakeholders assigned values to different ecosystem services according to their preference. The distribution of ecosystem services and values assigned to each service depicts that high valued ecosystem services were those services that stakeholder group representatives attach more values or find more benefits to those services. While, low valued ecosystem services were those services that are of less importance to the people or find little benefit out of it. Hence, habitat for key bird species provide the highest ecosystem services followed by habitat for key plant species, habitat for key mammals, reed production, water recreation and lastly land recreation.

What are the causes of conflicts in the use of ecosystem services in this area?

The major cause of conflicts in the study area was revealed to be between conservation and recreation activities. This was due to disturbances caused by recreation activities for example hiking, cycling harbours that brings about noise disturbance especially to biodiversity such as birds. Another identified cause of conflicts in the study area was conflict over ruling power. Thus, It was not only reed cutting over biodiversity conservation as it was earlier identified in section 1.2, but also ruling power and recreation over biodiversity is also a big threat causing conflicts in the study area.

How do changes in ecosystem services affect different stakeholders in Weerribben-Wieden?

Changes in ecosystem services affect stakeholders in different ways, for instance, recreation and tourism pressure is increasing in Weerribben-Wieden national park. It was revealed that increase in recreation activities has brought about worries to stakeholders that consider nature as important since these activities affect key species such as birds that are being disturbed in their habitats due to recreation activities. This therefore, affects the environmentalists or nature conservationists that are concerned with biodiversity conservation. Other stakeholders revealed that the landscape in Weerribben-Wieden has become more beautiful and more animals are currently visible in the area which is a positive change to the environment.

What are current strategies to resolve conflicts in this area?

There are different forums where these conflicts are being addressed. However, from the results on valuation of ecosystem services it can be concluded that it is difficult to resolve conflicts between different stakeholders with conflicting interests within an area. This is because, it has been observed that every stakeholders has a different perception on how ecosystem services is important to the another. This could be one of the reasons as to why a good solution to those conflicts in the study area is not yet well established as it was revealed during the study.

In general, I can say that understanding spatial temporal distribution of ecosystem services can be a stepping stone towards development of good management strategies and therefore, towards sustainable ecosystem services development in the study area.

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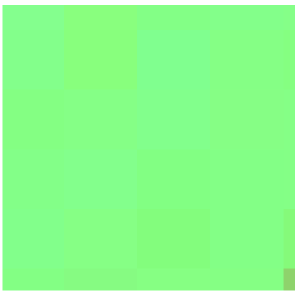
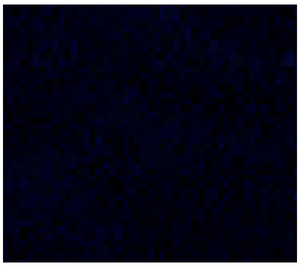
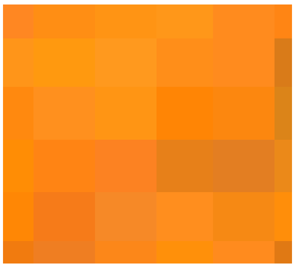
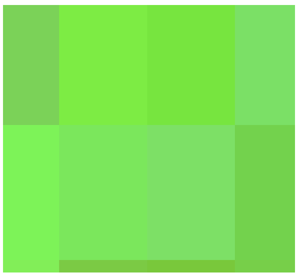
APPENDICIES

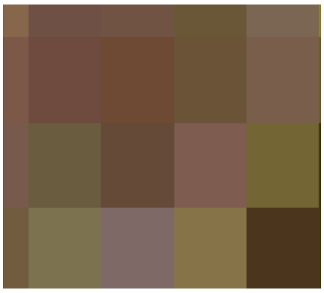
Appendix 1: Land cover classification key for 2013 image

Land cover type	**Description**	**LANDSAT Image**	**Google Earth Image**
Forest / woodland	Forested areas which are predominantly covered by trees with close canopy and showing areas of mixed vegetation that arose naturally.		
Water bodies	Areas comprises of lakes, rivers, ponds, canals, ditches used for different activities such as recreation.		
Natural grassland	Areas that are dominated by different or mixed species that are largely controlled by natural processes, even when some human management activities such as mowing take place		
Pasture grassland	Areas that are covered with short grass of a single species that is equally represented on the ground and are suitable for grazing		

Reed land	Area covered with reed which is rhizomatous perennial tall grass species that is largely distributed		
Swamps	A low wetland where water from streams or rivers collects in a shallow flat area before flowing out in another stream or river.		
Wetland vegetation/ Quaking bog	Floating mat area of thickly woven mosses and vegetation that forms across the surface of shallow water and may shake when walked on.		

Appendix 2: Land cover classification key for 2000 image

Land cover type	Description	LANDSAT Image 2000	Google Earth Image
Forest / woodland	Forested areas which are predominantly covered by trees with close canopy and showing areas of mixed vegetation that arose naturally.		
Water bodies	Areas comprises of lakes, rivers, ponds, canals, ditches used for different activities such as recreation.		
Natural grassland	Areas that are dominated by native species and are largely controlled by natural processes, even when some human management such as mowing occurs.		
Pasture grassland	Areas that are covered with grass suitable for grazing		

Reed land	Area cover with reed which is rhizomatous perennial tall grass species that is largely distributed		
Swamps	A low wetland where water from streams or rivers collects in a shallow flat area before flowing out in another stream or river.		
Wetland vegetation/ Quaking bog	Floating mat area of thickly woven mosses and vegetation that forms across the surface of shallow water and may shake when walked on.		

Appendix 3: Field data sheet

Data Sheet for Land cover classes Accuracy Assessment in Weerribben_Wieden NationalPark						**Sample No:**
Date:	**GPS** X					**Observer name:**
	RD Y					
ID	**Land cover**	**Yes**	**No**	Observation	**Evidence of ES**	**Other Remarks**
	Forest					
	Water					
	Reed					
	Quaking bog					
	Swamp					
	Natural grassland					
	Mown grassland					

Appendix 4: Pictures of different Land cover classes in the study area

Pasture grassland

Reed land

Natural grassland

Swamp

Wetland vegetation/quaking bog

Forest/ Woodland

Water body

Appendix 5: Pictures of ecosystem services in the study area

Reed production

Recreation

Habitat for key species

Appendix 6: Flayer used to introduce the research topic and the need for questionnaire to the stakeholders

UNIVERSITY OF TWENTE

Msc. RESEARCH ON

ASSESSMENT OF SPATIAL-TEMPORAL DISTRIBUTION OF REED LANDS ECOSYSTEM SERVICES CASE STUDY: THE WIERRIBBEN-WIEDEN NATIONAL PARK

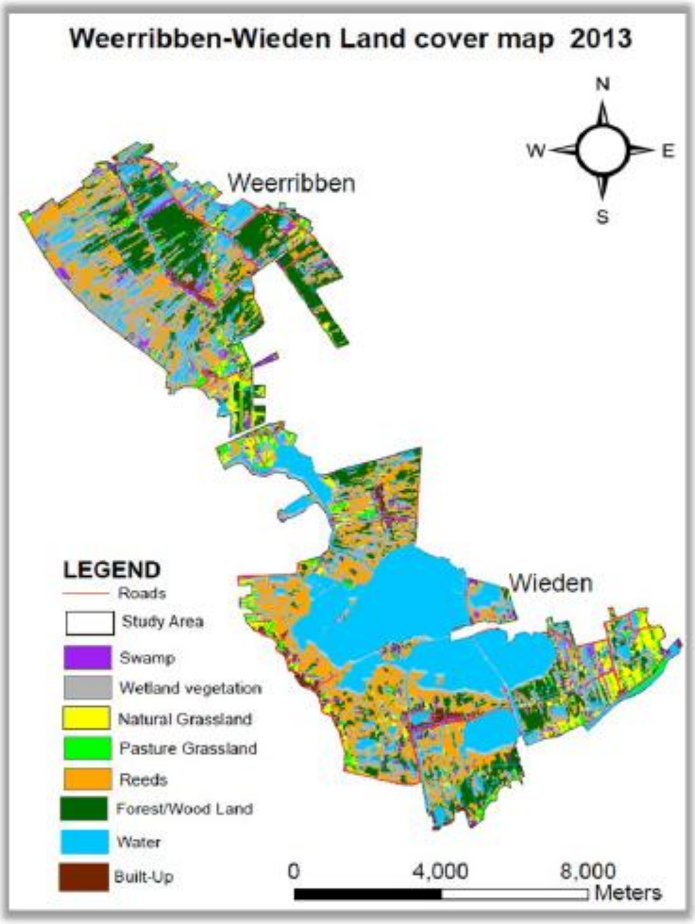
Ecosystem services refer to **goods** like food, building materials and **services** such as water purification, climate regulation etc that are obtained from nature and satisfy human needs and wellbeing

Ecosystem services examples

Reed production

Recreation

Habitat for Key species



Why study Ecosystem services? To be able to understand the changes that have been happening in Weerribben-Wieden national park and how different people react towards those chances in order to maintain their good living conditions

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Appendix 7: Questionnaire for respondents

SECTION A: RESPONDENT BACKGROUND

1 What is your name? ....

2. Gender

○ Male ○ Female

3. Age group

○ 20-30

○ 30- 40

○ 40-50

○ 50-60

○ Above 60

4. Place of residence (where do you live?)... ....

5. Occupation(which kind of job do you have?) ....

SECTION B: ECOSYSTEM SERVICES

6. Why is Weerribben-Wieden National park important? (*Multiple answers are possible)*

a) For food such as fishing
b) For growing animal fodder
c) For harvesting reeds for thatching houses (roof)
g) For it's beauty
d) For recreation and tourism activities
h) For scientific/education value
f) For culture/ historical value
e) For attractive housing and living conditions
Others (please specify)

7. Where can the following ecosystem services (listed in the column on the left) be found in Weerribben-Wieden? (land cover types listed on the right). Multiple answers are possible.

Ecosystem services	Location with Land cover						
	Reed land	Water	Swamps	Forest/ woodland	Natural grassland	Grassland for animal grazing	Wetland Vegetation
Reed production							
Land Recreation (hiking, biking, sailing)							
Water Recreation (Swimming, skating)							

Habitat for Important Bird species							
Habitat for important Plant species							
Habitat for Important mammals							

8. Which other important ecosystem services in the Weerribben-Wieden are missing from the list in question 7

………

………

9. Have you observed any changes in land cover in the Weerribben-Wieden since 2000 to date (see land covers listed in question 7 above)

- O Yes
- O No

10. If yes, which land cover changed and how?

………

………

SECTION C: CHANGES IN LAND COVER/ECOSYSTEM SERVICES

11. How do changes in land cover mentioned in question 10 affect ecosystem services in Weerribben-Wieden?

Ecosystem service	Effects				
	Ecosystem service disappear from the location	Ecosystem service quality gets less (reduce)	Ecosystem services increase in number	There is no impact at all	Not applicable
Reed production					
Land recreation					
Water recreation					
Habitat for Important Bird species					
Habitat for Important Plant species					
Habitat for Important mammals					

12. Which of the changes in ecosystem services mentioned in question 11 affected you and how?……………………………………………………………………………………………

………

SECTION D: ECOSYSTEM SERVICES VALUATION

13. Of the ecosystem services identified, what do you consider as the most important? score them according to your preference.

Ecosystem services	Very important	Important	Less important	Not important at all
Reed production				
Land recreation				
Water recreation				
Habitat for Important bird species				
Habitat for important plants				
Habitat for important Mammals				

14. If you would have to divide 100 points to indicate their importance, how many would you assign to the following ecosystem services? (the more points, the higher the importance). The total must sum up to 100.

Ecosystem services	**Score**
Reed production	
Land recreation	
Water recreation	
Habitat for important bird species	
Habitat for important plant species	
Habitat for important Mammals	

15. What percentage income do you get from the ecosystem services listed in question 14?

○ 0-10%

○ 10 -20%

○ 20-40%

○ 50% and above

SECTION E: CONFLICTS IN THE USE OF ECOSYSTEM SERVICES

16. Are there conflicts in the use of ecosystem services mentioned in question 14 in Weerribben-Wieden national park?

- ○ Yes
- ○ No

17. What are the causes of those conflicts?

....

....

18. How are conflicts currently being resolved in the Weerribben-Wieden national park?

……

……

SECTION F: MANAGEMENT STRATEGIES

19. Are you familiar with the current management strategies such as guidelines and regulations in Weerribben-Wieden national park?

- ○ Yes
- ○ No

20. If yes, how do you rate them?

- ○ Very good
- ○ Good
- ○ Poor

21. In your opinion how can these strategies be improved?

THANK YOU VERY MUCH!