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# *Project „Reed beds – freshwater ecosystem services assessment"*

*Final report*

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*In cooperation with:*

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Project Final Report
Project „Reed beds – freshwater ecosystem services assessment"

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## Abstract

The project „Reed beds – freshwater ecosystem services assessment“ is one of the few projects focused on ecosystem services in Croatia. It's the first project focused on assessing ecosystem services of one ecosystem on a national level and has included testing of new methods for ecosystem services assessment. Reed beds habitat is one of the wetland habitats and it's one of the most importat one for biodiversity conservation, and therefore it is listed on the List of endangered and rare habitats of national and European importance represented on the teritory of Republic of Croatia (Annex II of the Ordinance on kinds of habitat types, habitats map and threatened and rare habitat types, Official gazette of the Republic of Croatia 18/14). Inspite of its importance, this habitat isn't directly protected on a European level (The Habitats Directive, 92/43/EEZ), only indirectly through The Birds Directive (Directive 2009/147/EZ). Due to these reasons, this seemingly uninteresting habitat which provides many benefits for people can provide excelent case study for ecosystem services assessment.

Through the project activities, 35 pilot study areas for assessment were chosen. The analysis of providing ecosystem services has been conducted on these pilot study areas and it was proven that reed beds have a theoretical potential for providing the large spectrum of ecosystem services; depending on their type, size and location. They have the potential to provide all of the provisioning services related to genetic material and production of both cultivated and indegenious species of flora and fauna, including aquaculture species, which can be used for nutrition, material or as energy source, respectively using CICES v5.1 classification – all services from division of biomass and genetic material of all living creatures (including seed, spors and gamete production). As far as biotic regulative and supporting reed beds ecosystem services go, the most important ones are: Maintaining nursery populations and habitats (Including gene pool protection) (2.2.2.3.), Hydrological cycle and water flow regulation (Including flood control, and coastal protection) (2.2.1.3.), Regulation of chemical composition of atmosphere and oceans (2.2.6.1.), Regulation of temperature and humidity, including ventilation and transpiration (2.2.6.2), Regulation of the chemical condition of freshwaters by living processes (2.2.5.1), Regulation of the chemical condition of salt waters by living processes (2.2.5.2.), Decomposition and fixing processes and their effect on soil quality (2.2.4.2), Pest control (including invasive species) (2.2.3.1), Control of erosion rates (2.2.1.1.), Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals (2.1.1.2), Bio-remediation by micro-organisms, algae, plants, and animals (2.1.1.1). Also, reed beds show potential in providing all cultural ecosystem services.

As a part of the project a detailed assessment and analyses of the ecosystem service „Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy„ was obtained. First of all, multicriterial analysis were done on all of the 35 sites, using the following criteria: reed beds area (ha), raw material availability, the posibility of exploiting reed, the posibility of using the raw material for energy production, other raw materials (agricultural, forestal) availability, habitat importance in nature protection and lastly, change in land use. According to these criteria, among the pilot study areas, one area, „Kuti“, has been selected as a case study for a detail analysis of a selected service. „Kuti“ case study analysis has shown that, using only raw materials taken in the areas which are already being regularly mown (16.67 ha), without the further encroachment in the reed beds ecosystem, could effectively be used as a heating source. Economical analysis has shown that total income in that case, concerning the sum of income from the years sale of fuel briquettes and avoided heating expences, would sum up to 82,847.00 HRK per year. For the same service, another analysis was conducted, concerning the potential conflict with another ecosystem service named „Maintaining nursery populations and habitats (Including gene pool protection)“ and it has shown that these two services do not necessarily have to be in conflict if the management of the area, where reed beds can be found, include biodiversity protection and conservation through protection of the most endangered species in balance with the ecosystem services and their use.

When developing management plans for these areas, each protected area should be considered separately, taking into account the main characteristics of reed beds and the surrounding area.

# Contents

# 1. INTRODUCTION AND BACKGROUND

## 1.1. Project objectives

The project "Reed beds - Freshwater Ecosystem Services Assessment" is one of the few projects about ecosystem services assessment in Croatia, whose the main goal was to set up an ecosystem accounting framework for reed beds habitats and to evaluate the ecosystem services of this habitat type on a national level, by testing new methods for assessing ecosystem values. In order to achieve the objectives of this project, first it was necessary to asign value and to present an overview of ecosystem services provided by reed beds for selected pilot study areas. Moreover, to analyze the same pilot study areas from the aspect of providing the ecosystem service "Using wild plants (land and water, including mushrooms and algae) for energy production" and selecting the most suitable pilot study area as a case study for further analysis. Then, a detailed assessment of the ecosystem service "Using wild plants (land and water, including mushrooms and algae) for energy production" was made.

Reed beds, pilot habitat type was selected due to its importance for biodiversity in Croatia but also due to relatively big quantity of data available about this habitat type. Reed beds are by their structure mostly monocultures. The predominant part consist of common reed - Phragmites australis (Cav. Trin. Ex Steud., Poaceae), but occasionally other species can be found within the stands of Phragmites, e.g. Typha sp. or Carex sp. Phragmites australis is a typical wetland species of perennial grass and covers a wide range of humid habitats under the condition that its deep lying rhizomes can reach the ground water table (Rodenwald-Rudescu, 1974). Reed bed habitat is a humid habitat of great importance for the biodiversity conservation, especially birds species biodiversity. Reed beds are listed on the List of endangered and rare habitat types of national and European importance represented on the territory of the Republic of Croatia (Annex II of the Ordinance on the List of Habitat types, Habitat Map and Endangered and Rare Habitat types, NN18/14) as habitats of multiple endangered species. Despite its importance, this habitat type is not directly protected at the European level though the Habitats Directive (Directive 92/43/EEC) but only indirectly though the Birds Directive (Directive 2009/147/EC).

This project's intent is to serve as a model for: assessing reed bed's data availlability and data quality which CAEN has for implementation of an assessment, activating scientists and other relevant experts who could implement ecosystem services assessment and valuation to start working in this field which is still in humble beginning here in Croatia, raising interest on ecosystem services concept and ecosystem services assessment among different groups of stakeholders (scientists and other relevant experts, employees in public institutions for management of protected areas, local community, wider public), to enrich the knowledge of CAEN experts who will be introduced to a new method of the assessment and for introducting people to new valuation methods and raising public awareness about the importance of reed beds preservation.

This report will present the framework, the objectives and the final results as well as the recommendations of the project.

## 1.2. Ecosystem services concept – international framework

There are many definitions of what ecosystem services are. The Millennium Assessment (Millennium Assessment, 2005) states that ecosystem services are the benefits that people have from ecosystems, while some authors define them as aspects of the ecosystem's use (actively or passively) (Fisher and Turner, 2008) or as the states and processes by which natural ecosystems and species that make them, support and enable human life (Daily et al., 1997). It is important to emphasize that this concept recognizes people, which are potentially causing pressures on nature and the environment, as an integral part of the ecosystem. In spite of that, the concept itself is becoming an important tool in the nature protection and conservation. The importance of the concept of ecosystem services assessment has become particularly appreciated after adaptation of the Strategic Plan for Biodiversity 2011-2020 of the Convention on Biological Diversity (CBD, 2010). Furthermore, preservation of ecosystem services is embedded in Aichi Biodiversity Targets. Strategic Plan for Biodiversity 2011-2020 of the Convention on Biological Diversity (CBD, 2010) contains six goals with 20 actions to accomplish them and Goal 2 is specifically focused on ecosystem services. Implementation of this goal should be accomplished, firstly, by implementing Action 5. Action 5 demands from the member states that they must, with the help from the European Union, by the year 2014 chart and assess ecosystems and ecosystem services within their territory, and by the year 2020, assess the economic value of ecosystem services and integrate those values in the economic accounting system on a European and on a national level (AZO, 2015).

### 1.2.1. A typology of ecosystem services

There are several services classifications: classification by The Economics of Ecosystems and Biodiversity - TEEB), by Millennium Assessment, by The Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) and The Common International Classification of Ecosystem Services (CICES) developed by the European Environment Agency (EEA). In our research we used CICES classification (the latest version CICES v5.1.), to assess the ecosystem services, which divides ecosystem services in three basic categories:

- provisioning services,
- regulating and supporting services and
- cultural services.

Provisioning services cover ecosystem services which result in gaining products from the ecosystem; they include food, fiber, fuel, genetic resources, fresh water etc. Regulating and supporting services cover ecosystem services of regulatory processes like for example flood regulation, erosion rate control, climate control and supporting services necessary for functioning of provisioning, regulating and cultural services. Cultural services cover recreational, spiritual, religious, artistic, educational, and other intangible services. Every service type is then divided depending if it's biotic or abiotic and is described through the following five levels:

- Section – e.g. Provisioning services,
- Division – e.g. Biomass,

- Group – e.g. Cultivated terrestrial plants for nutrition, materials or energy,
- Class – e.g. Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes and
- Class type – e.g. Cereals (Crops by amount, type).

### 1.2.2. Reed bed's ecological functions as a base in providing ecosystem services

Constanza et al. (1997) have recognized the enormous global economic significance of wetland ecosystems, asigning their services the value of 4,9 trillion US dollars a year, while the contribution of services of all ecosystems was estimated to be around 33 trillion US dollars a year. Moreover, although wetland cover only 1.5 % of the Earth's surface, wetland ecosystems provide up to 40 % of all global ecosystem services (Zedler and Kercher, 2005). Consequently, a high contribution of wetlands and other humid habitats, including reed beds, is recognized on an international and national level to ecosystem services.

Depending on the groundwater level, two types of reed beds can be distinguished, "submerged reed beds", which are flooded for at least a month of the season, and "terrestrial reed beds" where the water table lies below the ground for most of the time and which are generally rich in helofits and other swamp species, although Phragmites remain the dominant one in this kind of habitat (Toth and Szabo, 1961). "Terrestrial reed beds" often aren't a natural part of the landscape but only a substitute for natural vegetation which has been affected by a more or less continuous negative human impact on the former vegetation. Primarily, due to the multiplication of rhizomes, Phragmites can form dense reed beds that have multiple ecological functions and provide many benefits to humans.

Reed beds ecologically act as a structural element and as a source of food for highly specialized fauna, making them wetland habitats of great importance for the biodiversity conservation, especially for the swamp birds and fish biodiversity. Phragmites rhizomes stabilize the sediment by holding the substrate together, they protect the shore by dissipating the wave energy - slowing down the speed of the wave and mitigating their strength, making a natural flood defense line. Furthermore, they have the ability to filter large particles thereby purifying the water and the ability to store nutrients, in particular phosphorus, nitrogen and nitrate, associated with sewage pollution or pollution caused by intensive agriculture. Consequently, they influence the control and mitigation of pollution. The highest vitality and the highest reed production is achieved in submerged monocultures, where it displaces all other types of helofit species. However, climate change, characterized by drought periods resulting in less flooding of the area and to the reduction of groundwater levels, as well as the negative human impact lead to compromised stability of reed beds. Maintenance of reed beds stability in space and time is of utmost importance for many species of fauna associated with this habitat, mainly for species which are always returning to the same location due to nesting and feeding, such as the *Acrocephalus scirpaceus* (Catchpole, 1972). For the protection of fauna biodiversity, marine and river reed beds are considered more valuable than terrestrial ones, furthermore those which are flooded at least a few decimeters for at least a short period of the year, and those reed beds with old stems of the last generation flattened to the ground (Ostendorp, 1993). For the biodiversity of birds in reed beds it is necessary that reed beds have parts with older, dry stems which certain bird species prefer for nessting. Generally, the edges of reed beds are more interesting for many bird species for feeding and nesting purposes than the dense inner surfaces (Kiviat, 2013). Subsequently, it is important that there is a link

between the reed bed and an aquatic body, or that there are "aquatic pools" within the reed beds, which give them structural diversity. That is of great importance for the biodiversity of aquatic invertebrates and plants. Reed beds are dynamic ecosystems in which the existence of time and spatial variation within the habitat is cruacial for maintaining a high diversity of flora and fauna. Fish biodiversity in reed beds is associated with the ecological requirements of species, therefore the fish do not live in reed beds throughout their whole lifespan, but use shallow waters for feeding or spawning, often both. Typical example would be the species of Cyprinidae taxa. Of importance for the biodiversity of fish in reed beds is the connection of reed beds with water surfaces. This is the case because many species of fish use shallow littoral parts of aquatic bodies and/or plants as a supstrate for spawning because they prefer warmer water in shallow swamp habitats. After the incubation and hatching period, the larvae of fish usually remains in the shallow coastal part among the reed stems and develops juveniles which are still active in the same area. Species of fish that feed on plants (or periphyton) can find here plant remnants, while the species of omnivores can find rich benthic fauna. When grown up, the individuals go to deeper parts of the water body, but return into reed beds for spawning. Also, favourably for fish is if there's a variety of underwater structures that ensure that microhabitaul seasonal preferences of different species are met. In addition, the submerged reed beds edges can provide an ideal shelter for hiding from some predatory birds species, especially those with a variety of edge profiles. Some of the species that have preferences to the ecological conditions provided by reed beds can be found at some part of their life cycle, due to feeding and/or spawning; these are: *Abramis sapa*, *Cyprinus carpio* L., *Carassius carassius*, *Misgurnus fossilis*, *Umbra krameri*, *Abramis brama*, *Scardinius erythrophthalmus*, *Tinca tinca*, *Alburnus alburnus* and *Blicca bjoerkna*.

### 1.2.3. Ecosystem services assessment

The concept of ecosystem services was developed to aid in assessing the natural benefits and through ecosystem services assessment it has strengthened the arguments in favour of ecosystem conservation. Ecosystem assessment is basically nature’s capital assessment based on a conservative assessment of the values of natural's ecosystem services based on gathered knowledge (Ye et al., 2016). Assessment is conducted, among other reasons, to take into account certain services which a specific ecosystem has if some kind of encroachment was to take place, and as a financial loss which could appear from losing a certain ecosystem service as a result of damage to the specific ecosystem. For market and nonmarket ecosystem services components value assessment different methods are used (market based valuation, revealed preference methods, stated preference method, benefit transfer). Nowadays, more and more attention is given to the economic ecosystem services assessment which is based on an antropogenic point of view, which states that the ecosystem has an economic value when it provides certain services to humans, but economic value is just a fraction of the value of nature, and it mustn't represent the whole value. When assessing, it's necessary to include, alongside ecosystem services which have a using value, the ones which hold bequest values, respectively the ones which have the value of being and/or some other value like symbolic, religious, heredetary etc.

## 1.3. Ecosystem accounting

Ecosystem accounting concept has been developed for integrating measures of ecosystems and the flows of their services with measures of economic and other human activity. It provides a platform for the integration of information on ecosystem assets (ecosystem extent, ecosystem condition, ecosystem services and

ecosystem capacity), and existing accounting information on economic and other human activity dependent upon ecosystems and the associated beneficiaries (households, businesses and governments).

National accounts show a complete quantitative picture of economic development based on macroeconomic indicators (revenue, production, consumption and wealth), the most commonly used macroeconomic growth measure is the Gross Domestic Product (GDP) (DZS, 2018.). The data on national accounts is based on methodological guidelines of the European System of National Accounts (EC-Eurostat, 2013). Environmental-Economic accounts are a part of the national account system which has been developed in accordance with the following regulations: Regulation (EU) No. 691/201 on the European Economic Environment Accounts and Regulation on its 2014 Amendment (Regulation (EU) No 538/2014). Modules of environmental accounts include national accounts (Eurostat, 2018): air emissions, material flows, energy accounts, environmental taxes, environmental protection accounts, and environmental sector accounts.

Ecosystem accounting is a module of Environmental-Economic Accounts. Some parts of European Environmental-Economic Accounts are still not fully implemented since the implementation of the International Standards for Environmental-Economic Accounting (SEEA) 2006 have been implemented gradually; some segments are still under development and are in the experimental phase, yet to be implemented. The System of Environmental-Economic accounting (SEEA) has emerged as a leading tool in the support of policy and analysis of the environment and its relation with economic and human activities and its particular strength is its capacity to integrate environmental information into standard measures of economic activity. The Environmental-Economic Accounting System - SEEA Experimental Ecosystem Accounts (SEEA EEA) has the following characteristics:

1. The SEEA EEA framework covers the accounting of ecosystem assets in terms of area (size), ecosystem condition and ecosystem services. Research from different disciplines includes assessment of the ecosystem condition and ecosystem services. Very few researchers have dealt in their research papers with the concept of natural assets and ecosystem services as SEEA EEA does.

2. By applying different techniques, the SEEA EEA framework encompasses the evaluation of biophysical values (expressed in physical units - eg, hectares, tons) and monetary values of ecosystem assets and services.

3. The SEEA EEA Framework is designed to ease the comparison and integration with economic indicators prepared according to the National Accounts System methodology. This has resulted in adoption of some measurement and assessment rules that are not applied in other ecosystem assessment disciplines. The application of the principles derived from the National Accounts System is easing the integration of information on ecosystems with indicators of revenue, production and wealth (used in the National Accounts System).

4. The SEEA EEA Framework provides a detailed organizational structure of data that can be used for various purposes, such as national accounts, decision making, policy setting and policy follow-up. The initial intention of establishing SEEA EEA was to provide a framework for the evaluation of ecosystem assets and ecosystem services at a regional or a national level. However, experimental application has shown that this

framework is applicable at different levels (e.g., local, basin level, etc.) depending on the purpose of the account creation and, of course, depending on the level of the detail of available data.

Given the biophysical characteristics of the ecosystem and their interconnectedness, the framework assumes the possibility of exchange and integration of information from other accounts.

# 2. METHOD OF APPROACH

## 2.1. Data collecting

In order to achieve the basic objective of this project, the assessment of reed beds ecosystem services at a national level, within the given deadline, pilot study areas where the research will be carried out were selected. The research results of pilot study areas should provide us with insights about the values that reed beds offer to people on a national level. This approach is possible because of the existence of a precise and recent map of habitats (Map of natural and seminatural non-forest and freshwater habitats of the Republic of Croatia (2016)), on this map the humid habitats are charted on a scale 1 : 25000. Reed beds are a high-value habitat type in the Republic of Croatia and are of great interest for nature protection, which is why the amount of information about this habitat type is relatively plentiful.

First phase of the activity started with the selection of suitable study areas based on the Map of natural and semi natural non-forest and freshwater habitats of the Republic of Croatia (2016). Based on this Map 8,940.549 ha of the Croatian territory is covered with reed beds (A.4.1. Common Reed, Reedmace, Galingale or large Sedges beds). In order to cover a significant number of areas and conditions, special characteristics were taken into account when choosing the locations:

- equal shares of the larger and smaller sites,

- selecting sites about which most data is available,

- including the sites in and out of the protected areas and

- including the sites close to and distant from the inhabited areas.

When selecting the pilot study areas, the following data was used:

- Map of natural and seminatural non-forest and freshwater habitats of the Republic of Croatia,
- Topographic layer in digital format,
- Habitat map at scale of 1 : 100000 scale,
- Red Lists of Croatia,
- Flora Croatica Database,
- Spatial database on wetland habitats in Croatia implemented in the project "Inventory of wetland habitats in Croatia CROWET", (2003 – 2005),

- Digital Terrain Model (DTM) with a 25 m pitch,
- Corine Land Cover (http://gis.azo.hr/services.html) and
- The national system of land parcels identification – ARKOD (http://preglednik.arkod.hr/).

According to the described methodology above, a total of 35 sites was selected for the pilot study areas throughout Croatia; 8 locations in the alpine biogeographic region, 11 in the continental and 16 in the mediterranean region; shown in Table 1 below, with the dates of field work tours. Because of the specific ecological conditions and characteristics of the alpine biogeographic region, it was not possible to select more sites with the represented habitat type A.4.1. Common Reed, Reedmace, Galingale or large Sedges beds.

Table 1: Pilot study areas by biogeographic region.

| Pilot study areas in Croatia by biogeographical region | | |
|---|---|---|
| Continental biogeograhical region | Mediterranean biogeograhical region | Alpine biogeograhical region |
| 1. Krapje Đol | 1. Blatina by Blato, Mljet | 1. Korenica |
| 2. Šoderica-Drava | 2. Torak, NP Krka | 2. Gacko polje |
| 3. Ribnjaci Dubrava | 3. Velo i Malo Blato, Pag | 3. polje Lič |
| 4. Jezero, Dobra voda | 4. Area by Jezero Desne | 4. Gorski kotar i sjeverna Lika - part |
| 5. Mihovljan | 5. Kolansko blato-Blato rogoza | 5. Dabarska dolina |
| 6. Kopački rit -part | 6. Palud | 6. Trnovac |
| 7. Ribnjaci Našice | 7. Mirna | 7. Dretulja |
| 8. Veliki Pažut | 8. Raša | 8. Mala Neteka - Una |
| 9. Crna Mlaka | 9. Area by Orepak, Pod gredom i Prud | |
| 10. Jelas polje s ribnjacima | 10. Jezero Parila i Jezero Vlaška | |
| 11. Ribnjaci Šišćani i Blatnica | 11. Jezero Njivice on island Krk | |
| | 12. Kuti | |
| | 13. Vransko jezero | |
| | 14. Vukovići | |
| | 15. Jezero Ponikve on island Krk | |
| | 16. Pantan by Trogir | |

Figure 1: 35 sites selected for the pilot study areas are shown red on the map of the Republic of Croatia.

Table 2: Pilot study areas and their basic characteristics

| Pilot study areas | Biogeographic region | CLC 2018 codes | Area (ha) | Reed bed area (ha) | Reed bed's share in the area (%) |
|---|---|---|---|---|---|
| Blatina by Blato, Mljet | Mediterranean | 411, 243, 313 | 66 | 18,6 | 28,2 |
| Jezero Njivice, Krk | | 243 311 411 512 | 77 | 41,4 | 53,8 |
| Jezero Parila and jezero Vlaška | | 112, 122, 222, 242, 243, 324, 411, 421, 511, 523, 423 | 828 | 147,47 | 17,8 |
| Jezero Ponikve, Krk | | 243 311 324 512 | 119 | 11,2 | 9,4 |
| Kolansko blato – Blato rogoza | | 142, 231, 242 221 411 | 265 | 24 | 9,1 |
| Kuti | | 112, 222, 243, 324, 411, 242, 512 | 2653 | 484,25 | 18,3 |
| Mirna | | 212 421 521 131 311 | 349 | 26,05 | 7,5 |
| Palud | | 221, 242, 311 | 227 | 15,75 | 6,9 |
| Pantan | | 411, 242, 523 | 38 | 16 | 42,1 |
| Area by jezero Desne | | 222, 223, 411, 512, 243 | 348 | 185,9 | 53,4 |
| Area by Orepak, Pod gredom i Prud | | 112, 222, 242, 243, 411, | 2047 | 1506 | 73,6 |
| Raša | | 211, 324, 523 | 350 | 157,5 | 45,0 |

| | | | | | |
|---|---|---|---|---|---|
| Torak | | 243, 311, 512 | 33 | 16,8 | 50,9 |
| Velo and Malo Blato, Pag | | 231, 411, 421, | 295 | 119,7 | 40,6 |
| Vransko jezero | | 211, 221, 311, 242, 324, 411, 333, 512, 223, 243, 313, 321, 323, 334 | 5749 | 6,99 | 0,1 |
| Vukovići | | 311, 324, 313, 133, 243, | 184 | 60 | 32,6 |
| Crna Mlaka | Continental | 512, 324, 243, 311 | 694 | 48,21 | 6,9 |
| Jelas polje s ribnjacima | | 512, 411, 324, 311, 231 | 4686 | 399,1 | 8,5 |
| Jezero, Dobra voda | | 243, 231, 242, 311 | 99 | 3,6 | 3,6 |
| Kopački rit - part | | 411, 311, 324, 231, 511, 512 | 6066 | 909,9 | 15,0 |
| Krapje Đol | | 211, 411, 311, 243, 242 | 964 | 30,6 | 3,2 |
| Mihovljan | | 242, 311 | 77 | 15 | 19,5 |
| Ribnjaci Dubrava | | 512 | 315 | 41 | 13,0 |
| Ribnjaci Našice | | 512, 411, 324 | 1409 | 391,1 | 27,8 |
| Ribnjaci Šišćani i Blatnica | | 512 | 702 | 135,95 | 19,4 |
| Šoderica | | 142, 211, 324, 512 | 310 | 13,8 | 4,5 |
| Veliki Pažut | | 242, 311, 411, 511, 211, 243, | 527 | 30,15 | 5,7 |
| Dabarska dolina | Alpine | 231, 242, 243 | 134 | 0,14 | 0,1 |
| Dretulja | | 324,112, 242, 243, 312 | 150 | 34 | 22,7 |
| Gacko polje | | 242, 231, 112, 211, | 842 | 21 | 2,5 |
| Korenica | | 112, 231, 242, 243 | 167 | 23,5 | 14,1 |
| Mala Neteka - Una | | 324, 243 | 18 | 10,9 | 60,6 |
| Trnovac | | 242, 243, 324 | 545 | 70 | 12,8 |
| Gorski kotar i sjeverna Lika-part | | 243, 312, 313 | 47 | 12,54 | 26,7 |
| Polje Lič | | 243, 112, 242, 311 | 63 | 6,392 | 10,1 |

When collecting data on ecosystem services for each pilot study area, all of the available literature about the area was used. After a detailed review of the literature, in order to find out more about the pilot study areas, polling/interviewing method was used. 15 questions were defined for the survey and the questionnaires were prepared. During the project activities implementation period, the survey was conducted using three methods: depth interview (face to face) during field tours, field questionnaires and electronic questionnaires. Polling was conducted among the employees of Public institutions for protected areas management and the members of the local community; between local population in any way related to a particular reed bed in the area where the survey was conducted (e.g. owners of the reed beds (and the surrounding areas), visitors, tourist agencies, fishermen, Croatian waters employees).

The goal was to find the answers to the following issues:

- traditional and modern reed beds usage,
- the most valuable ecosystem service provided by reed beds according to different groups of people and
- which level of protection would reed beds deserve according to different stakeholders.

This phase of the project was named „Local community outreach". The purpose of this phase was to get as much information as possible from the local community, but also to introduce the concept of the ecosystem services to a wide spectrum of people living close to habitat of interest. This method was the most effective way of providing us with a very wide range of information on selected pilot study areas through the topic of research.

Through the phase of Stakeholder (scientists and other relevant experts) identification, CAEN organized a round table inviting all of the current and potential future stakeholders from Croatia in order to present the results of the assessment of ecosystem services provided by reed beds. After the presentation stakeholders were asked to debate about the results and ecosystem services provided by reed beds in Croatia in general. At the end of the meeting participants were invited to present their interests and possible roles in this project, or in similar future projects regarding ecosystem services assessment and valuation. Conclusions from this round table were presented at the nature conservation experts' annual meeting organized by CAEN once a year. The goal of this presentation was to popularize the concept of ecosystem services and to invite the employees from public institutions for protected areas management to plan and later conduct the ecosystem services assessment of the protected areas under their field of interest. The conclusions made at this round table are included in the chapter *5.5. Conclusions on contribution of the project*.

## 2.2. Data analysis

### 2.2.1. General ecosystem services assessment and pressures valuation

Ecosystem services supply and use, together with trade-offs inside the reed beds habitat, was assessed using different methods and considering different categories of ecosystem services. The first step in reed beds ecosystem services assessment was to determine the theoretical potential of reed beds in general. The aim was to provide ecosystem services and to provide a basic overview of reed beds ecosystem services. Then, according to the list of potential ecosystem services, ecosystem services relevant for each pilot study area were defined depending on its use, and it was evaluated how often each service is present and how significant it is in each pilot area (regarding their importance and impact). Initial ecosystem services assessment has been obtained by CAEN experts using the new Map of natural and seminatural non-forest and freshwater habitats of the Republic of Croatia (2016) and all of the data available to CAEN, including information obtained through conducting surveys as well as personal observations during field work. Questionnaire prepared for the local community and other relevant stakeholders provided information about the cultural services (recreation, tourism, cultural value etc), and at the round table specialists were asked to discuss various categories of ecosystem services, depending on their skills and field of work.

The best quantitative indicators of the presence and significance of the selected ecosystem service provided by reed beds are the following: the reed beds' surface share in the particular pilot study area, the presence of the aquatic body within the pilot study area and the existing exploitation of service products ie the existence of service users. Further, it was necessary to define the pressures that jeopardize reedbes and their services. According to the Millennium Ecosystem Assessment (2005), the ecosystems may be affected by the following pressures: land change (management change and land conversion), excessive exploitation, changes in the biological structure of the ecosystem and its functioning (invasive species), pollution, climate change and elemental disasters (fires). Excessive exploitation of reed beds ecosystem products (water, fibers, animal species, etc.) by humans negatively affects the biological structure and sustainability of the reed beds ecological integrity. Changes in land use can lead to degradation of reed bed habitats or to significant changes in the capacity of this habitat type. Furthermore, the potential pollution due to the proximity of agricultural land or urban (industrial) areas has enormous influence on the physico - chemical and/or biological quality of wetland water and soil. Invasive species have a negative impact on the reed beds biological structure and sustainability as well as the pressures of elemental disasters do, some of which are

caused by man's actions and some are caused by climate change. The pressure assessment was mainly done during field work and as for the observation of reed beds ecosystems in the field, previously mentioned pressures were selected for assessment due to their relevance concerning the condition of observed habitats and because they're easy to notice in the field during the field work.

### 2.2.2. „Using wild plants for energy production" ecosystem service assessment

Selected pilot study areas were additionally analyzed from the aspect of providing the ecosystem service "Using wild plants (land and water, including mushrooms and algae) for energy production". Due to rapid growth and re-growth of reed rhizomes after mowing, reed can be considered as a suitable raw material in energy production. Furthermore, reed does not require any technical measures in terms of maintenance and fertilization. Using reed as a resource for energy production without causing damage to the environment and nature can result in economic profits, but also represents an additional motive for reed beds protection. The literature shows that the annual yield of reed ranges from 3 to 30 tDM/ha, depending on the predominant climatic conditions (sunlight, temperature), soil salinity and water quantity, as well as the amount of nutrients available. Since mowing is not recommended during high animal activity (spring/summer), further analysis will only consider winter mowing of dry matter. Furthermore, the additional benefits of winter mowing are lower moisture content (15-20 %) and less damaging of the rhizomes. Some studies (Güsewell et al., 2000; Bresciani et al., 2009) indicate that winter mowing does not have a negative affect on reed growth. Abduloieva and Podobaylo (2014) cite sources which show that regular mowing at the end of vegetation growth (yearly or every other year) has no negative impact on reed, and in some cases the density and amount of biomass even increased during 5-6 years. Increasing biomass is a result of improved spring conditions, since dry stems can stay for a long time on the surface of water (up to 2 years) and prevent the sprouting of new stems. On the other hand, cutting reed in the summer time or autumn, biomass can be reduced in some areas by 25-30 %. It can be concluded that mowing of certain reed bed surfaces is suitable for maintaining the stability of the wetland with minimal damage to the environment and nature. Winter mowing removes the organic substance for whose decomposition oxygen from the water would have to be used. The level of nutrient removal (N, P) is low as nutrients are mostly stored in rizhomes during the winter period. To achieve all the benefits and reduce the possible negative effects of mowing on reed beds, careful planning and a well managed mowing system are required. The basic factors affecting the ability to use reed for energy production are the proportion of moisture, fuel value, percentage of ash produced and ash characteristics. Greater humidity reduces the fuel value of raw materials and the quality of combustion, causing larger fuel gas emissions (Ikonen and Hagelberg, 2007). The moisture content of reed varies during the year (15 - 60 %), and is at the lowest during the winter when it is 15 - 20 %. The higher heating value (HHV) of reed is similar to the HHV wood raw material (18 - 19 MJ / kg), while the lower heating value (LHV), with a moisture content of 15 – 20 % is 14-15 MJ/kg (Komulainen et al., 2008).

The project considers reed mowing in winter, because such raw material is more suitable for the production of briquettes or pellets, has better characteristics for energy utilization and mowing in the winter period has less impact on biodiversity. Most nitrogen and phosphorus are shifted in the rhizom during the autumn period, so winter reed mowing mostly removes carbon (Croon, 2014). The sulfur content of the reed is small (below 0.1 %), so no significant emissions of sulfur compounds occur during combustion. Also, the reed contains a small amount of chloride that causes corrosion (Komulainen et al., 2008). On the other hand, the percentage of ash produced is higher than that of woody raw material which plays an important role in selecting and managing raw material combustion. The quality of pellets or briquettes depends, primarily on the type of raw material, particle size, moisture and the temperature and pressure used in their production (Huang, 2013). The raw material used to produce pellets or briquettes must be dry (moisture content of 14 - 16 %) and cut into 2 - 3 mm lengths (COFREEN, 2013). For the production of high quality briquettes or

pellets it is also possible to use a binding compound (Komulainen et al., 2008), eg starch, rapeseed oil and molasses. On the other hand, using binding compound increases production and increases the ash content. By using simple drying techniques, the pellet / briquette moisture content can be reduced to 8 – 10 %, increasing the calorific value up to about 16.5 - 17 MJ/kg (COFREEN, 2013). Moreover, in order to improve the quality of pellets/briquettes, reed can be mixed with other raw materials, eg wood (Köbbing et al., 2013; Komulainen et al., 2008).

In order to analyze the possibility for providing the ecosystem service "Using wild plants (land and water, including mushrooms and algae) for energy production" for the selected 35 pilot study areas covered with reed bed habitat type, multi-criterion analysis (MCA) was conducted. The result of the MCA is ranking the pilot study areas according to the possibility of providing the mentioned service and selecting the pilot study area for which a case study will be carried out to evaluate the selected ecosystem service in detail.

Within the MCA, the following seven criteria were used:

- reed beds area (ha),
- raw material availability,
- the posibility of exploiting reed,
- the posibility of using the raw material for energy production,
- other raw materials (agricultural, forestal) availability,
- habitat importance in nature protection and
- change in land use.

To define the weight factor criterion, the Analytic Hierarchy Process method was used, which calculates weight factors based on a subjective estimation of the relative importance of individual criteria. The criteria are compared to each other in the scale shown in Table 3, which converts verbal responses to the grading index (Department for Communities and Local Government, 2013).

Table 3: Criteria comparison scale

| Comparative grade | Grading index | Comparative grade | Grading index |
|---|---|---|---|
| A is absolutely significant than B | 9 | | 1/2 |
| | 8 | B is slightly significant than A | 1/3 |
| A is much more significant than B | 7 | | 1/4 |
| | 6 | B is moderately significant than A | 1/5 |
| A is moderately significant than B | 5 | | 1/6 |
| | 4 | B is much more significant than A | 1/7 |
| A is slightly significant than B | 3 | | 1/8 |
| | 2 | B is absolutely significant than A | 1/9 |
| A and B are of the same significance | 1 | | |

These numerical values (grading index) are entered in a matrix that allows the calculation of weight factors. An example of a matrix with a relative comparison of importance for the three criteria (A, B and C) is shown below:

| | A | B | C |
|---|---|---|---|
| A | 1 | 5 | 9 |
| B | 1/5 | 1 | 3 |
| C | 1/9 | 1/3 | 1 |

For each criterion, the share in the total sum of the column is calculated, while the weight factors represent the arithmetic mean of the values obtained for each criterion:

| | A | B | C | TF |
|---|---|---|---|---|
| A | 0,76 | 0,79 | 0,69 | 0,75 |
| B | 0,15 | 0,16 | 0,23 | 0,18 |
| C | 0,08 | 0,05 | 0,08 | 0,07 |

Calculation of weight factors for defined criteria is given in the Excel document that is an integral part of this final report (Anex 1).

Each pilot study area is graded for each criterion from 1 to 3 or from -1 to -3 in the case of Biodiversity criteria. Criteria and related ratings are described in Table 4. The overall grade for each pilot study area represents the sum of the scores for each criterion multiplied by the corresponding weight factor.

Table 4: Described criteria and related ratings

| Criterion | Description | Grade | Data used |
|---|---|---|---|
| Reed beds area (ha) | The criterion refers to the size of the reed bed habitat within the pilot study area in hectares. The surface represents a substitute criterion for the quantity of available raw materials in the pilot study areas because the data about quantity is not available. Larger reed bed surfaces have a positive impact on the project due to increased raw material supply, greater profitability of the project, and the ability to exploit reed only in certain parts of reed bed (eg rotating surfaces for mowing every 2-3 years), thereby reducing the negative impact on biodiversity. | 3 - > 100 ha<br>2 - 50-100 ha<br>1 - < 50 ha | Field data obtained from HAOP |
| Raw material availability | The criterion indicates the ability to access the location and the technical possibility of mowing reed at the location itself. The final grade represents the mean value of these two criteria.<br>When considering access to the site, it was observed how distant the location was from traffic routes which could be used for the delivery of the mechanization and the shipment of reed. Better ratings were given to locations located near major traffic routes (local, county roads), where access to the site itself is enabled. The middle grades were given locations close to traffic directions but with poorer quality access like macadam roads or forest dirt roads. The lowest rating has been given to locations that can be accessed, but access is difficult because of the distance from traffic routes or the quality of the access roads.<br>Another factor is the possibility of mowing reed beds by standard mechanization, ie the relationship between land and surface water area on the site. Generally, reed beds on land can easily be mowed with already available mechanization, while those which are mostly in the water require special vehicles that can move on water surfaces, such as an amphibian vehicle. If that's the case, many complications could occur with the implementation of the project. | 3 - Easily available<br>2 - Available<br>1 – Hardly available<br>3 - Mainly land area<br>2 – Land area dominates over the water area<br>1 – Water area dominates over the land area | DOF, Topographic maps |
| The posibility of exploiting reed | The criterion covers information about the degree of protection and ownership structure of the pilot site location. Areas included in the category of a National Park or a Special Reserve, where the use of natural resources is prohibited or restricted, are eliminated from further analysis. Regarding ownership, it is assumed that project implementation would be easier if parcels were state owned. | 3 - Mostly publicly owned location<br>2 - Bigger private-owned parcels dominate<br>1 - Mostly small, private parcels<br>0 - Pilot area located within NP or special reserve | The national system of land parcels identification („ARKOD"), Bioportal - Nature Protection Information System |
| The posibility of using the raw material for energy production | The criterion evaluates the possibility of using pellets / briquettes near the pilot study area. It is assumed that the possibility of using it will be greater if larger settlements are located near the site, thus increasing the possibility of using raw materials within public buildings, such as schools, public administration buildings and the like. | 3 – Bigger settlements by the location<br>2 – Smaller settlements by the location<br>1 - Village or just several houses near | DOF, Topographic maps |

| | | | |
|---|---|---|---|
| | | the location | |
| Other raw materials (agricultural, forestal) availability | The criterion takes into consideration the possibility of using another raw material within a 5 km "buffer" zone from the reed bed for pellet/briquette production. Together with the reed, it is also possible to use additional agricultural (eg straw) or forest materials in pellet/briquette production. For the evaluation of this criterion, information on available agricultural and forest areas within the buffer zones was used. It is assumed that the availability of additional raw materials near the pilot study area has a positive impact on the project due to the higher amount of available raw materials, increased project profitability and increased raw material for garanteed supply. Also, by adding other raw materials, primarily wood raw materials, the quality of pellets / briquettes is increased. | 3 – Area with lots of agricultural or forest areas<br>2 – Location near smaller agricultural or forest areas<br>1 – Scarce agricultural areas in location proximity, degraded forests | DOF |
| Habitat importance in nature protection | The criterion assesses the importance of reed bed habitat within pilot study areas in nature protection. Information on protected areas and the NATURA 2000 ecological network were considered. Significant negative impact on the exploitation of reed is assumed for pilot areas located within SPAs of importance for wintering birds according to the Ordinance on conservation objectives and basic conservation measures for bids in the NATURA 2000 ecological network area (NN 15/14). This is because the production of pellets/briquettes is carried out during the winter when the raw material is the driest. Less negative impacts are assumed for pilot areas located within other SPAs, protected areas, or surface areas superposition with SCIs. | -3 - The area within SCI of great importance for wintering birds<br>-2 – The location within protected area or SCI area or SAC area<br>-1 – Remaining reed beds | Bioportal - Nature Protection Information System, Ordinance on conservation objectives and basic conservation measures for bids in the NATURA 2000 ecological network area (NN 15/14). |
| Change in land use | The criterion takes into account land cover and changes in land cover in the pilot study area based on the CORINE Land Cover digital database, ie data on the change of land cover since 1980. It is assumed that the reed bed area is acceptable for exploitation if it is not largely used intensively (for agriculture, fisheries, forestry) and if there has been no changes indicating that the area is more intensively used than before. CLC categories that do not indicate the intensive use of reed beds (if there are no changes in use over a number of years) are eg 512 Water bodies, 411 Land swamps. Less safe categories: 242 Agricultural land mosaic, 243 Predominantly agricultural land with a significant share of natural vegetation, 324 Forest succession (healing land), for which the coverage and direction of changes over the years are checked using available satellite images (eg Google Earth). | 3 – Area under reed beds has a growth tendency<br>2 – Area under reed beds is stable<br>1 – Pilot study area is mostly intensively used, surface under reed beds has a decline tendency | CORINE Land Cover base, Google Earth |

# 3. RESULTS - key findings

## 3.1. Reed beds ecosystem services overview

Since ancient times, reed was used for paper production and to feed cattle. Moreover, dry reed stems were used for making mats, screens and various compartments, as well as eaves, arbors and roofs. Getting to know the new materials, the reed was no longer in frequent use, but the traditional crafts, which use reed can still be found in some places. In addition, reed was and remained an inspiration to artists, painters, photographers, poets, and as a part of legends and myths. Reed was the motiv of one of the legends about the emergence of Pan's musicl instruments (Source: http://www.hgu.hr/status/20/pan.htm), the song "Labud" A.G. Matoš, The instrumental piece "Schilflieder - Song of the Reeds" and „The Reed-Cutter Returning Home" song by Lewis Charles Powles. Moreover, Blaise Pascal's saying is well known: "Man is only a reed, the weakest in nature, but it's the reed who thinks" (Source: http://www.udrugapopulus.hr/). Recently, reed is used as an element in wastewater treatment facilities.

Providing of the entire spectrum of ecosystem services depends on reed bed's habitat type, size and location. Kiviat (2013) divides reed bed ecosystem services to non-habitat and habitat services. Habitat services refer to biodiversity support, while non-habitat functions depend on biomass production. Non-habitat functions include processes such as photosynthesis, transpiration and nutrition intake; and non-habitat services are: carbon sequestration, local climate regulation (environment cooling and solar reflection, evapotranspiration, high albedo), soil erosion protection, water regulation (water retention and flood control), soil formation and nutrient retention (eg heavy metals), biological water purification, recreation, tourism, aesthetic value, education, research, raw materials (energy biomass, building materials), food, medicines. Habitat services are: food or shelter for various animal species, source of genetic resources, bird breeding grounds (nesting area and source of nest material), fish hatchery, habitat for plant species. Considering CICES classification, reed beds have the potential to provide all the services related to genetic material, production of cultivated and non-cultivated plant species, and production of wild and reared animal species (including aquaculture species). Reed can be used for nutrition and as a material or source of energy. According to CICES v5.1., reed beds provide all services from the biomass department and genetic material of all living creatures (including seed production, spores and gametes). Regarding the biotic regulatory and supporting services of reed bed ecosystems, the most relevant are the following:

- Maintaining nursery populations and habitats (Including gene pool protection) (code 2.2.2.3.),
- Hydrological cycle and water flow regulation (Including flood control, and coastal protection) (code 2.2.1.3.),
- Regulation of chemical composition of atmosphere and oceans – carbon sequestration (code 2.2.6.1.),
- Regulation of temperature and humidity, including ventilation and transpiration (code 2.2.6.2),
- Regulation of the chemical condition of salt waters and freshwaters by living processes (code 2.2.5.1 i 2.2.5.2.),
- Decomposition and fixing processes and their effect on soil quality ( code 2.2.4.2),
- Pest control (including invasive species) (code 2.2.3.1),
- Control of erosion rates (code 2.2.1.1),

- Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals (code 2.1.1.2) and
- Bio-remediation by micro-organisms, algae, plants, and animals (code 2.1.1.1).

In addition, reed beds have a potential to provide all cultural services from the following groups: physical and experiential interactions with ecosystems and landscapes, intellectual and representative interactions with ecosystems and landscapes, spiritual, symbolic and other interactions with ecosystems and landscapes, and biotic characteristics of ecosystems and landscapes without value. It is also important to mention their role in providing recreational opportunities, primarily for birdwatching and relaxation in nature.

## 3.2. Reed beds ecosystem services of pilot study areas

Despite a wide range of potential ecosystem services provided by reed beds, it was hard identifying them in selected pilot study areas. Biotic regulatory and supporting services were difficult for identification and valorization, because there are no implemented systematic measurements in the territory of the Republic of Croatia which would confirm the existence of these services. Furthermore, a large number of pilot study areas with relatively small areas of reed beds within them made identifying these services even more difficult. Given that the assessment of reed beds ecosystem services was manly based on local population surveys, biotic regulatory and supporting services remained largely unrecognized in the field. In addition, these services are the ones that local residents find more difficult and harder to recognize when they hear about ecosystem services the first time. The local population across Croatia has recognized little or no benefits from the reed bed habitat type, but confirmed that reed was used in the past, as material for the construction of roofs (Figure 2), canopies, as an insulation material (Figure 3), material for making baskets, various types of fish traps and pots, arbors, and even as a material for scraping and fixing the barrels. The use of young reed stems as cattle feed is also pointed out.

Figure 2: Roof made out of reed at the entrance to Nature Park Kopački rit

(Source: CAEN; Author: Tamara Kirin)

Figure 3: Example of using reed as an insulation material in old houses in Zlatar

(Source: CAEN; Author: Tamara Kirin)

Nowadays, the Neretva river area is one of the few remaining places, or one can even say, the only place in Croatia where people still make traditional reed products, such as „reed knit" (Figure 4) which is used as a protection from the sun (Figure 5), or litter for drying figs (Figure 6). According to our knowledge aquired during field work, there are small family companies in this area who are engaged in this activity and still manage to „survive" on the market.

Figure 4: „Reed knit" for protection from the sun made out of reed from the Delta Neretva area

(Source: CAEN; Author: Irina Žeger Pleše)

Figure 5: „Reed knit" for sun blocking on the terrace of the house in the village Desne

(Source: CAEN; Author: Irina Žeger Pleše)

Figure 6: Litter for drying figs made out of reed from the Delta Neretva area

(Source: CAEN; Author: Irina Žeger Pleše)

The cultural reed beds ecosystem services are differently perceived by the local population. A conclusion can be made that their value is recognized by the local population only in the vicinity of the protected areas visited by tourists, whereas traditionally, this habitat is less widely recognized as a cultural value.

## 3.3. Ecosystem services ranking results

During field work, surveys have been conducted among the potential users of ecosystem services (people from local community) and in total 187 people were interviewed. Participants in the survey were supposed to recognize the reed beds ecosystem services which they consider to be the most important for the local community and themselves. The overall results are shown in the Figure 7 below.

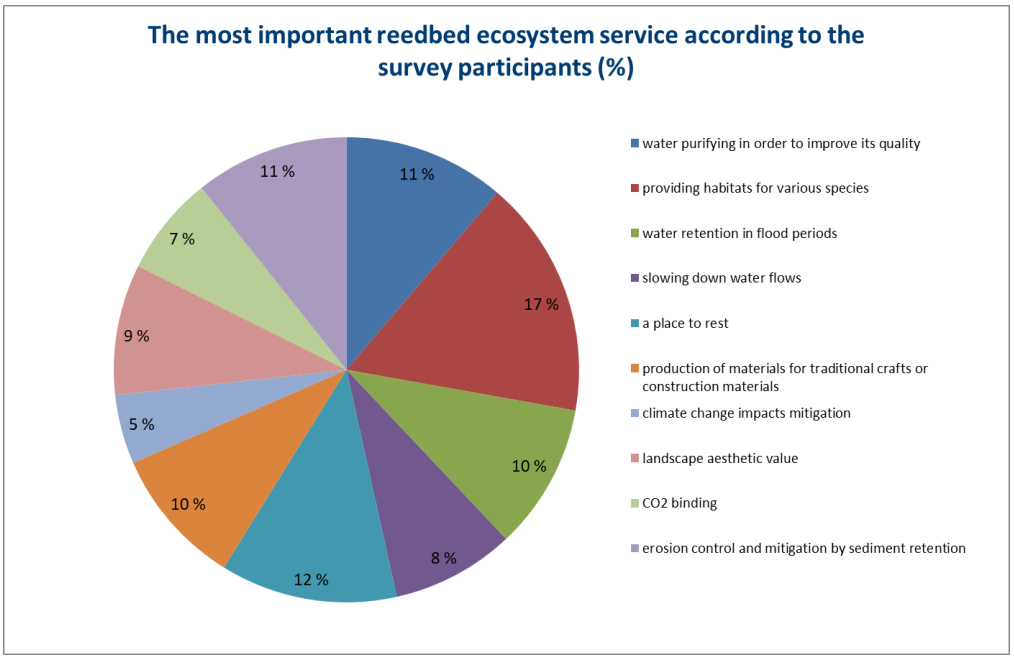


Figure 7: Survey results about which ecosystem service is the most important one according to respondents

The local population recognizes the following reed beds ecosystem services as the most important ones: „Maintaining nursery populations and habitats", service of refining water for the purpose of improving its quality ("Regulation of the chemical condition of freshwaters by living processes or Regulation of the chemical condition of salt waters by living processes"), slowing down the flow of rivers („Hydrological cycle and water flow regulation (Including flood control, and coastal protection)") and consider reed beds as an ideal place for rest in the nature (services "Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions" and "Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions"). It can be noticed that the local population is well aware of these 10 reed bed's ecological functions and recognizes them as reed beds' ecosystem services, and as for other services they may not be familiar with them, or don't automatically associate them with reed bed habitats.

## 3.4. Pilot study areas ecosystem services assessment results

Ecosystem services assessment is based on the antropocentric approach according to which ecosystem is considered more economically valuable when it provides benefits to people. During the ecosystem services assessment, ecosystem services of each pilot study area were graded. The grade 0 indicates that the pilot study area is not currently able to provide a specific ecosystem service, while grade 1 indicates that the pilot

study area has the potential and the ability to provide the service but benefits of this service aren't being used. Grade 2 indicates that the service is being used and the benefits are being exploited, but to a small extent. Grade 3 indicates that the service is being used and it's of great importance in the particular pilot study area. Surveys and the reed bed areas' surface in hectares were also taken into account. Assessment results are shown in the Table 5 (in the Annex 2).

In the continental region, most pilot study areas were selected near fish ponds, artificial lakes or along the agricultural areas, and a small number of them was selected near the "natural reed beds", along rivers or lakes. Thanks to the choice of pilot study areas, the most recognized services in the continental biogeographic region were „providing services" and the service "Animals reared by in-situ aquaculture for nutritional purposes" dominated. Most pilot study areas selected in the Alpine biogeographic region were recorded on neglected agricultural land. In addition, in this region the least ecosystem services were recognized, most often „providing services" and „regulatory and supporting services" were mentioned. Cultural services were rarely mentioned in this region by services users. The reason for this could be the fact that there are not many users of such services in selected areas in the alpine region and that there is no management for those areas present. Nevertheless, the most recognized services of these pilot study areas were the following ones: Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes, Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition and Fibres and other materials from wild plants for direct use or processing (excluding genetic materials). In the pilot study areas of the Mediterranean region, the most ecosystem services were recorded and recognized, including providing, regulatory and supporting and cultural services. In the pilot study areas situated within protected areas, the most cultural services have been recorded, from which the "Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions" and "Characteristics of living systems that enable education and training" because many people who visit protected areas visit them to observe and learn about beautiful landscapes and species they find within them. What makes providing of this service possible, are extremely valuable species of flora and fauna, ie the following services: "Characteristics or features of living systems that have an existence value" and „Maintaining nursery populations and habitats (Including gene pool protection)". Furthermore, management plans in protected areas were defined and developed in order to protect them long term, so the reed beds in these areas are also in good condition. If there is a water body, river, lake, etc. within the pilot study area, the pilot study area provided more ecosystem services, especially those related to water. From the aspect of providing ecosystem services, services that are generally most commonly recognized in the majority of pilot study areas by the local community are the following: „Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals", which reminds people of reed beds because of their water purification ability, „Maintaining nursery populations and habitats (Including gene pool protection)" – because of the reed bed's species biodiversity and cultural services, „Characteristics of living systems that enable aesthetic experiences", „Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions" and „Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions".

### 3.4.1. Reed bed habitat influence on the ecosystem services providing within the pilot study areas

Reed bed habitat, as a part of pilot study area, can have a positive, negative or a neutral influence on the provision of the ecosystem services identified in the pilot study areas. Ecological functions which characterize the reed bed's habitat type can enhance or disable the provision of a specific ecosystem service in the pilot study area. Some pilot study area's services may endanger the reed bed habitats within the pilot study area.

In Table 5 ecosystem services that have a negative impact on the reed bed habitats are shown in red and those which have a positive influence on the reed bed habitats and services are shown in green. The presence of reed is negatively evaluated in relation to the following ecosystem services in pilot study areas: Cultivated terrestrial plants grown for nutritional purposes, Animals reared by in-situ aquaculture for nutritional purposes, Fire protection, Freshwater surface water used as an energy source and Coastal and marine water used as energy source. Reed beds are mostly dense and monodominant habitats in which *Phragmites australis* displaces all other plant types, thus negatively affecting the service „Cultivated terrestrial plants grown for nutritional purposes". Because of the same traits, they're rated negative in relation to the service „Animals reared by in-situ aquaculture for nutritional purposes". This service is largely recognized in the production fish ponds where fishermen recognize reed as a plant species that expands rapidly, thus occupying the space used in fish ponds by reared fish. Some users of fish ponds point out the other negative side of reed in fish ponds, which is to provide habitat for fish feeding birds. Furthermore, reed beds have no potential for fire protection and do not enhance the provision of this service in pilot study areas. That is why in some pilot study areas, local population burns reed beds, making damage to the wider ecosystem. Moreover, reed beds do not enhance the provision of the service „Freshwater surface water used as an energy source" because they slow down river water flow. Contrary, in the pilot study area reed makes a base for providing the following ecosystem services: Fibres and other materials from wild plants for direct use or processing, Wild plants used as a source of energy, Wild animals used for nutritional purposes, Seeds, spores and other plant materials collected for maintaining or establishing a population, Animal material collected for the purposes of maintaining or establishing a population, Filtration/sequestration/storage/ accumulation by micro-organisms, algae, plants, and animals, Bio-remediation by micro-organisms, algae, plants, and animals, Control of erosion rates, Maintaining nursery populations and habitats, Pest control (including invasive species), Decomposition and fixing processes and their effect on soil quality, Regulation of the chemical condition of freshwaters by living processes, Regulation of chemical composition of atmosphere and oceans, Regulation of temperature and humidity, including ventilation and transpiration, Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions, Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions, Characteristics of living systems that enable education and training, Characteristics of living systems that enable aesthetic experiences, Elements of living systems used for entertainment or representation, Characteristics or features of living systems that have an existence value, Surface water for drinking, Dilution by freshwater and marine ecosystems, Dilution by atmosphere, Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation), Maintenance and regulation by inorganic natural chemical and physical processes and Liquid flows. All of the above-mentioned ecosystem services in pilot study areas have been enhanced or possible thanks to the presence of reed bed habitats in the area, ie thanks to the ecological functions of reed beds.

### 3.4.2. A typology of pilot study areas and their ecosystem services

Pilot study areas were selected according to the explained aforementioned criteria. Nevertheless, the potential of pilot study areas for the provision of ecosystem services was dependent on particular pilot study area land use patterns and on its origin. Although the initial way of land use was determined on the basis of existing CLC maps, this approach was abandoned since the pilot study areas were partially small and planned maps didn't provide enough satisfactory data. For these reasons, selected pilot study areas were assigned to arbitrarily defined groups. We tried to describe the pilot study areas as simply and accurately as possible from the point of view of land use, making sure that the position of reed beds remained clear within a particular group.

The group Wetland habitats with significant percentage of reed beds included natural wetland habitats with a large share of reed bed habitats. These are pilot study areas in the Continental and Mediterranean biogeographic regions where the natural reed beds occupy significantly large areas and represent a dominant habitat. Also, the use of these areas is "subordinated" to the reed beds.

Pilot study areas called Complex of wetland habitats and agricultural areas are the ones where natural reed beds occupy significant areas and are habitats of great importance for the pilot study area but are not necessarily the dominant habitat at the site. In these pilot study areas, around and near the reed beds, there are agricultural lands, some of which are still regularly taken care off.

The group Agricultural lands in succession included pilot study areas with relatively recently appeared reed beds as a repercussion of neglecting agricultural land. Within such pilot study areas, the reed beds are most often isolated and situated far away from settlements. If there are settlements close to such reed beds, these settlements are usually small, rural and with a small number of residents.

Pilot study areas whose main and most important part is the water body, ie natural or artificial lake, are included in the group Water bodies with reed belt. Those areas are characterized by the water body, which determines their use, but there is also a significant reed bed belt in the area along the waterbody. In such areas often if reed beds are not maintained, they're starting to spread towards the center of the water body, potentially filling it.

The group Fish ponds includes continental carp fish ponds for commercial fish rearing. Fish ponds covered by the research are mannaged extensively or semi-intensively according to the standardized methodology. In this kind of fish ponds, reed usually develops along the pond edges and stabilizes the shore. From pond edges reed naturally spreads into the fish pools. While reed expanses, the square footage of water in which the fish is reared decreases, which is usually the main reason why owners of fish ponds remove it.

Table 6: The main types of pilot study areas assigned to arbitrarily defined groups considering land use patterns and pilot study areas' origin. [In the right column of the table, pilot study areas are shown in colour by biogeographic regions: pilot study areas in the continental region are shown in green, those in the alpine region are shown in red and those in the mediterranean region are shown in blue.]

| Pilot study area type | Pilot study area name |
|---|---|
| Wetland habitats with significant percentage of reed beds | Jezero Parila and Vlaška |
| | Kuti |
| | Palud |
| | Pantan |
| | Area by Jezero Desne |
| | Area byOrepak, Pod gredom and Prud site |
| | Torak |
| | Kopački rit - part |
| | Veliki Pažut |
| Wetland habitat and agricultural surface complexes | Blatina by Blato, Island of Mljet |
| | Kolansko blato – Blato rogoza |
| | Mirna |
| | Raša |
| | Krapje Đol |
| Agricultural lands in succession | Dabarska dolina |
| | Dretulja |
| | Gacko polje |
| | Korenica |
| | Mala Neteka – Una |
| | Trnovac |
| | Gorski kotar i sjeverna Lika - part |
| | Polje Lič |
| | Mihovljan |
| | Jezero, Dobra voda |
| | Vukovići |
| Water bodies with reed belt | Jezero Njivice, Island of Krk |
| | Jezero Ponikve, Island of Krk |
| | Velo i Malo Blato, Island of Pag |
| | Vransko jezero |
| | Šoderica |
| Fish ponds | Ribnjaci Dubrava |
| | Ribnjaci Našice |
| | Ribnjaci Šišćani i Blatnica |
| | Crna Mlaka |
| | Jelas polje s ribnjacima |

Ecosystem services which specific pilot study areas have the potential of providing were defined. These ecosystem services are most relevant for such types of pilot study areas, that is, each pilot study areas belonging to one of the above mentioned types, has the greatest potential to provide ecosystem services listed in *Table 7. The main types of pilot study areas with indicated ecosystem services* below. This does not mean that some pilot study area, if it belongs to a particular type, can't provide more or less ecosystem

servicest than the above mentioned ones; it means that these ecosystem services are most commonly associated with the particular pilot study area type.

Tale 7: The main types of pilot study areas with indicated ecosystem services

| Pilot study area type | Reed beds' ecosystem services by type of pilot study area |
|---|---|
| Agricultural lands in succession | Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes |
| | Cultivated plants (including fungi, algae) grown as a source of energy |
| | Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition |
| | Fibres and other materials from wild plants for direct use or processing (excluding genetic materials) |
| | Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy |
| | Higher and lower plants (whole organisms) used to breed new strains or varieties |
| | Seeds, spores and other plant materials collected for maintaining or establishing a population |
| | Pest control (including invasive species) |
| | Maintaining nursery populations and habitats (Including gene pool protection) |
| Wetland habitat and agricultural surface complexes | Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes |
| | Cultivated plants (including fungi, algae) grown as a source of energy |
| | Fibres and other materials from wild plants for direct use or processing (excluding genetic materials) |
| | Decomposition and fixing processes and their effect on soil quality |
| | Wild animals (terrestrial and aquatic) used for nutritional purposes |
| | Fibres and other materials from wild plants for direct use or processing (excluding genetic materials) |
| | Animal material collected for the purposes of maintaining or establishing a population |
| | Maintaining nursery populations and habitats (Including gene pool protection) |
| | Control of erosion rates |
| | Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals |
| | Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions |
| | Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions |
| | Characteristics of living systems that enable aesthetic experiences |
| Water bodies with reed belt | Animal material collected for the purposes of maintaining or establishing a population |
| | Maintaining nursery populations and habitats (Including gene pool protection) |
| | Regulation of chemical composition of atmosphere and oceans |
| | Regulation of the chemical condition of freshwaters by living processes |
| | Fibres and other materials from wild animals for direct use or processing (excluding genetic materials) |
| | Fibres and other materials from animals for direct use or processing (excluding |

| | |
|---|---|
| | genetic materials) |
| | Wild animals (terrestrial and aquatic) used for nutritional purposes |
| | Control of erosion rates |
| | Hydrological cycle and water flow regulation (Including flood control, and coastal protection) |
| | Bio-remediation by micro-organisms, algae, plants, and animals |
| | Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals |
| | Surface water for drinking |
| | Surface water used as a material (non-drinking purposes) |
| | Freshwater surface water used as an energy source |
| | Dilution by freshwater and marine ecosystems |
| | Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation) |
| | Liquid flows |
| | Maintenance and regulation by inorganic natural chemical and physical processes |
| | Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge |
| | Characteristics of living systems that enable education and training |
| | Characteristics of living systems that are resonant in terms of culture or heritage |
| | Characteristics of living systems that enable aesthetic experiences |
| | Elements of living systems that have symbolic meaning |
| | Elements of living systems that have sacred or religious meaning |
| | Elements of living systems used for entertainment or representation |
| | Characteristics or features of living systems that have an existence value |
| | Characteristics or features of living systems that have an option or bequest value |
| | Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions |
| | Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions |
| Wetland habitats with significant percentage of reed beds | Bio-remediation by micro-organisms, algae, plants, and animals |
| | Maintaining nursery populations and habitats (Including gene pool protection) |
| | Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals |
| | Regulation of temperature and humidity, including ventilation and transpiration |
| | Wild animals (terrestrial and aquatic) used for nutritional purposes |
| | Control of erosion rates |
| | Fibres and other materials from animals for direct use or processing (excluding genetic materials) |
| | Regulation of chemical composition of atmosphere and oceans |
| | Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge |

| | |
|---|---|
| | Characteristics of living systems that enable education and training |
| | Characteristics of living systems that are resonant in terms of culture or heritage |
| | Characteristics of living systems that enable aesthetic experiences |
| | Elements of living systems that have symbolic meaning |
| | Elements of living systems that have sacred or religious meaning |
| | Elements of living systems used for entertainment or representation |
| | Characteristics or features of living systems that have an existence value |
| | Characteristics or features of living systems that have an option or bequest value |
| | Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions |
| | Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions |
| Fish ponds | Plants cultivated by in- situ aquaculture grown for nutritional purposes |
| | Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials) |
| | Plants cultivated by in- situ aquaculture grown as an energy source |
| | Bio-remediation by micro-organisms, algae, plants, and animals |
| | Animals reared by in-situ aquaculture for nutritional purposes |
| | Animals reared by in-situ aquaculture as an energy source |
| | Control of erosion rates |
| | Maintaining nursery populations and habitats (Including gene pool protection) |
| | Liquid flows |
| | Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions |
| | Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions |

### 3.4.3. Results of the pilot area analysis regarding the possibility of using reed for energy production

The analysis was carried out during the third phase of the project called "Assessment and valuation of specific ecosystem service provided by reed beds" and the result is one specific ecosystem service assessed and evaluated in detail. The results are shown in the text below.

Weight factors were defined as the average values that team members got by criteria comparison. According to the results, the most important criteria were *Habitat importance in nature protection* and *Reed beds area (ha)*. Criteria related to the possibility of using reed - *The posibility of exploiting reed* and *Raw material availability* and the criteria *Change in land use* had less significance, while criteria *The posibility of using the raw material for energy production* and *Other raw materials (agricultural, forestal) availability* had the least importance (Table 8, Figure 8).

Table 8: Weight factor values used in the MCA

| Criteria | TF |
|---|---|
| Reed beds biodiversity/habitat importance in nature protection | 0,26 |
| Reed beds area | 0,25 |
| Raw material availability | 0,15 |
| The posibility of exploiting reed | 0,13 |
| Change in land use | 0,13 |
| The posibility of using the raw material for energy production | 0,05 |
| Other raw materials (agricultural, forestal) availability | 0,03 |

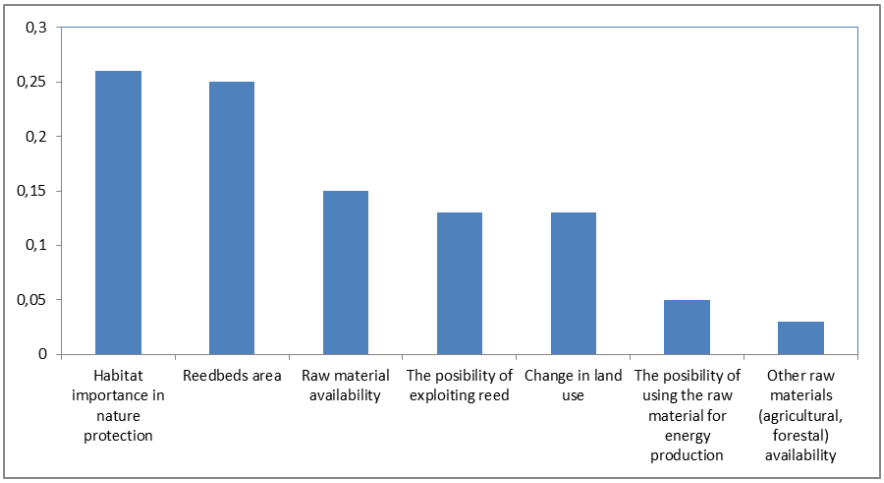


Figure 8: Weight factors

Criteria related to reed bed area and redbeed's significance for biodiversity and nature protection were estimated as the most important because they provide information on the quantities of raw material in the pilot study areas that could be exploited for energy production and they provide information about the potential negative effects that reed mowing can have on the biodiversity of the reed bed itself.

The results of the MCA - evaluation of pilot study areas from the aspect of possibility of providing the ecosystem service "Using wild plants for energy production" are shown in Table 9. Areas within National Parks and Special Reserves (Area by Orepak, Pod gredom and Prud, Veliki Pažut, Krapje Đol, Torak, Pantan, Vransko jezero, Crna Mlaka, Palud, Kopački rit reserve, Velo and Malo blato, Kolansko blato) were eliminated from further analysis as areas where mowing of reed is not recommended because of the preservation of natural and landscape values.

Table 9: Pilot study areas ranking results

| ID | Pilot study area name | Grade |
|---|---|---|
| 29 | Raša | 1.27 |
| 17 | Vukovići | 1.20 |
| 2 | Ribnjak Sišćani i Blatnica | 1.19 |
| 15 | Mala Neteka - Una | 1.16 |
| 11 | Ribnjaci Našice | 1.14 |
| 13 | Jelas polje s ribnjacima | 1.05 |
| 4 | Kuti | 1.04 |
| 6 | Jezero Parila i jezero Vlaška | 1.04 |
| 30 | Mirna | 1.02 |
| 32 | Gorski kotar i sjeverna Lika - Sušica | 0.99 |
| 19 | Dretulja | 0.98 |
| 7 | Područje uz jezero Desne | 0.98 |
| 12 | Jezero, Dobra voda | 0.97 |
| 36 | Mihovljan | 0.86 |
| 1 | Ribnjaci Dubrava | 0.83 |
| 20 | Korenica | 0.83 |
| 9 | Šoderica | 0.79 |
| 16 | Trnovac | 0.79 |
| 3 | Blatina uz Blato, Mljet | 0.78 |
| 33 | Jezero Ponikve | 0.70 |
| 35 | Jezero Njivice | 0.69 |
| 31 | Polje Lič | 0.65 |
| 22 | Gacko polje | 0.60 |
| 24 | Dabarska dolina | 0.54 |

### 3.4.4. Ecosystem service "Using wild plants for energy production" assessment on the case study results

Based on the MCA results, pilot study area „Kuti“ (Figure 9) was selected as a case study for more detailed analysis, including an economic valuation of using reed for energy production. The reed beds area in the pilot study area „Kuti“ is 479 ha. Pilot study area is mostly located within the Municipality of Zažablje, and with a smaller part in the area of Slivno, Kula Norinska and Opuzen Municipalities. Zažablje Municipality has 757 inhabitants and 60.82 $km^2$ surface. About 15 $km^2$ is occupied with wetland habitats, intersected with channals conected to the lake Kuti. Agriculture is the most significant economic branch in the municipality. Most households are engaged in agriculture as a primary activity, but there is a trend of turning to tourism, with Photo Safari being a major attraction.

Figure 9: Dense reed beds in the pilot study area Kuti

Pilot study area Kuti is located within the ecological network Natura 2000 in the Republic of Croatia:

- Delta Neretve (HR1000031) - Site of Community Importance (SCI),
- Delta Neretve (HR5000031) - Special Areas of Conservation (SAC).

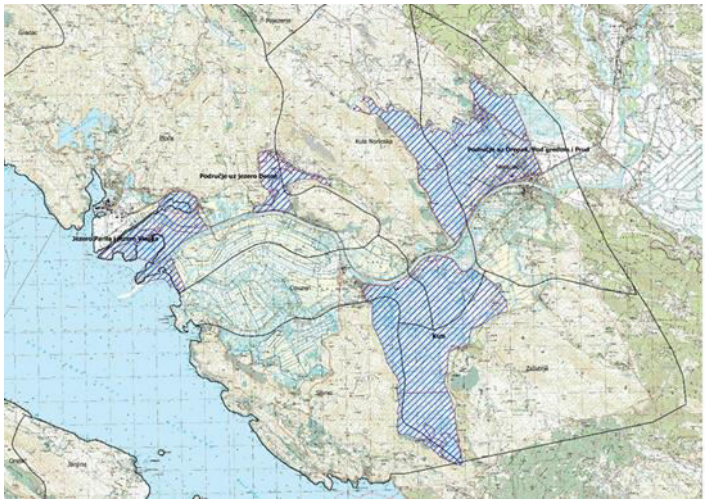

Figure 10: Pilot study area Kuti within the Natura 2000 ecological network

The Neretva Delta was included in the Ramsar List as a wetland habitat of international significance in 1993. It is one of the most valuable wetland areas on the eastern Adriatic coast and one of the few remaining wetlands with significant area covered in reed beds in the European Mediterranean, and represents an important resting place, wintering site and a breeding ground of various bird species. Although the Neretva area is recognized as an important wetland with rich biodiversity, different human activities such as intensification of agriculture, loss of habitat through melioration, ilegal hunting and setting uncontrolled fires, pose a threat to the spiecies living in the delta.

According to the cadastre data, most of the pilot study area is in the state ownership by the Republic of Croatia, while the area along the lake Kuti is defined as a public good, under the management of the Croatian waters who are responsible for maintaining the channel system in the Neretva valley.

According to the information recieved on the field, at the site of the pilot study area Kuti reed beds are spreading over the neglected agricultural land, growing into the lake Kuti water surface. That is partly caused by the reduction of the flow of water from rivers "Mislina" and "Crna rijeka". On the other hand, using satellite images, spreading of agricultural land into the northern part of the pilot study area was observed.

The maintainance of channels in the Neretva valley is carried out by the Croatian waters. Reed maintainence on the water is being carried out by mowing using boats and hand-held lawnmowers. The fallen raw material remains in the water and it makes difficult for boats to pass. On the land, reed mowing is carried out with a dredge that crushes raw material immediately. In the Kuti pilot study area, 16.67 ha are mown regually, while the Neretva valley area is about 2,000 hectares. The Public Institution for the management of Dubrovačko-neretvanska county protected areas prescribes environmental protection conditions and for the avoidance of a negative impact on bird nesting, mowing has to be done between 15 August and 31 March.

The public administration buildings in Mlinište (school, home and municipality) are using a split air conditioner for heating, while most of the Zažablje municipality population is using wood burning stoves for heating, so using stoves that run on reed pellets/briquetts would be a good and possible alternative.

#### 3.4.4.1. Economic analysis

For the service "Using wild plants for energy production" economic asessment using the Cost-Benefit Analysis (CBA) was undertaken. CBA is a procedure that evaluates benefits and costs which will arise in project realisation. The used economical model consists of items primarily divided into two groups, total revenues and expenses. All revenues and expenses used in the model do not include VAT. Total revenues represent the sum of revenues obtained by the sales of pellets/briquettes and avoided heating costs - savings generated by using free heating supplies compared to the currently used energy source. The difference between revenues and expenses is the net income that has been discounted at a 5 % rate (European Commission, 2015) during a twenty years period, the estimated operational period of the project. Taking into account net income and the discount rate, net present value (NPV) and the Internal Rate of Return (IRR) are the main economic indicators of the model.

Economic analysis was conducted for three scenarios. In all three of them, the County was taken as a potential project holder because of the greater investment potential and pellet / briquette consumption potential in its own facilities, compared to municipalities in the vicinity of the pilot study area. The reed bed area, from which collecting of the raw material and production of pellets/briquettes is foreseen, is limited to the span of the pilot study area Kuti, which is being mown as a part of the regular canal maintenance. This area covers 16.67 ha of the total pilot study area Kuti and the raw material produced by mowing it is left at the location and is not used for other purposes. In the Neretva valley about 2,000 ha are mown regullary. With increasing the area from which the raw material could be collected, the increasement the project profitability would follow subsequently.

Scenario S1a predicts production of reed pellets from reed collected at the location of the pilot study area Kuti. 50 % of the produced pellets are used for heating in publicly owned buildings that are currently using split air conditioners for heating. Assumption is made that with the available quantity of pellets (27.5 t) it's possible to cover the needs of a 1,200 $m^2$ heated surface, for which a pellet boiler with a capacity of 100 - 120 kW is needed. The remaining 50 % of pellets is foreseen/planned for sale.

Revenue from annual sales of pellets represents a multiplication of 50 % of the annual production of pellets and prices under the following assumptions:

- The surface area of the pilot study area is 16.67 ha and the raw material is estimated at 3 tDM/ha (based on information received from the Neretva basin d.o.o.). Considering the moisture content of 10 %, the amount of pellets foreseen for sale is 27.5 t/year.
- The price of pellets is 900 HRK/t.
- The total annual income from pellet production, a multiplication of 27.5 tonnes of pellets and 900 HRK/t, sums up to 24,755 HRK.

The avoided heating costs are calculated based on the following assumptions:

- Heat energy produced from 27.5 t of pellets, including 90 % boiler efficiency and 4 kWh pellet energy value, is 99 MWh.
- The electricity price per MWh is 530 HRK.
- The product of the above mentioned values is divided by the COP 3, and the annual avoided heating costs sums up to 17,493 HRK.

Total revenue represents the sum of annual sales of pellets and avoided heating costs, which brings us to the sum of 42.248 HRK/year.

Costs include investment costs:

- Construction of workshop area and pellet drying storage area of 50 $m^2$ total surface area. The cost of building the object is 1,500 HRK / $m^2$, ie a total of 75,000 HRK.
- Raw material smashing machine (11,200 HRK)
- Pellet production machine (26,000 HRK)
- Mounted pellet boiler (85,000 HRK)

The total investment cost is 197,200 HRK.

Work and maintenance costs are present throughout the whole duration of the project and include:

- Mowing costs are already included in the regular canal maintenance costs and are therefore not included in the additional costs associated with reed exploitation for energy production.
    - Transport (external service):
        - Based on the yield of 3 tDM / ha, the average moisture content of 17.5 % and the chaff density of the 76 kg/$m^3$, the volume of raw material was estimated at 46 $m^3$/ha. Assuming the truck capacity is 15 $m^3$, the raw material has to be transported 52 times total.
        - Driving cost is estimated at 220 HRK.

- Total: 11.340 HRK

- Employee:
    - Production and maintenance worker with a 4,000 HRK average monthly net salary for 4 months.
    - Total: 16,000 HRK

- Production:
    - Production 7 hours/day
    - 6 kW machine capacity
    - Electricity price (0.53 HRK / kWh) multiplied with 42 kWh daily consumption during 4 months (21 work day/month)
    - Total: 1,870 HRK

Total work and maintenance costs (transport, employee costs, production costs) sum up to 29,210 HRK.

Net income represents the difference between total revenues and total costs. In the year before the production starts, costs include only investment costs; labor and maintenance costs are considered during the following years of production. Net income is -197,200 HRK before the production starts and 13,039 HRK during the twenty years production period. NPV is 34,710 HRK and IRR is 2.8 %, which shows that the projects isn't profitable under mentioned assumptions.

The sensitivity analysis was carried out for the quantity of pellets sold and the market price of pellets. IRR represents an economic indicator in the analysis. In case the IRR is higher than the 5 % discount rate, the use of reed for energy production is profitable (Table 10 - marked in green). The results show that with current market pellet prices (HRK 900) and by increasing the quantity of pellets sold on the market the project becomes profitable.

Table 10: Sensitivity analysis takes into account price of pellets (800 to 1000 HRK) and the share of pellets sold on the market (30 to 80 %). The IRR represents an economic indicator at a 5 % discount rate. The reference values used in the scenario are highlighted in yellow.

| | | Price of pellets (HRK) | | | | |
|---|---|---|---|---|---|---|
| **IRR** | **2.8%** | **800** | **850** | 900 | **950** | **1000** |
| **Share of pellets for sale (%)** | **30%** | **-1.4%** | **-0.5%** | **0.3%** | **1.0%** | **1.8%** |
| | **40%** | **-0.5%** | **0.6%** | **1.6%** | **2.5%** | **3.4%** |
| | 50% | **0.4%** | **1.7%** | **2.8%** | **3.9%** | **5.0%** |
| | **60%** | **1.2%** | **2.7%** | **4.0%** | 5.2% | 6.4% |
| | **70%** | **2.0%** | **3.6%** | 5.1% | 6.5% | 7.8% |
| | **80%** | **2.8%** | **4.5%** | 6.1% | 7.7% | 9.1% |

Scenarij S1b predicts the pellet production from reed collected at Kuti pilot study area. 50 % of the produced pellets are used for heating in public buildings which are currently using heating oil as an energy source for heating. It is assumed that, with the available quantity of pellets (27.5 t), it's possible to cover the needs of about 1,200 $m^2$ heated surface, for which a pellet boiler with the capacity of 100 - 120 kW is needed. The remaining 50 % of pellets is set to be sold.

S1b differs from the previous S1a scenarios only in the avoidable heating costs, so only the calculation of these gains is shown below.

The avoidable heating costs are calculated based on the following assumptions:

- The heating value, produced from 27.5 tons of pellets, including 90 % boiler efficiency and 4 kWh pellet energy value, is 99 MWh.
- Price of oil for heating is 528 HRK/MWh.
- The efficiency of the boiler running on oil fuel is 90%.
- A multiplicity of produced heat (heating value/ energy value/calorific value) and the price of oil fuel divided by the boiler efficiency and the annual heating cost avoidance, sums up to 58,092 HRK.

Total revenues represent the sum of pellets sold annually and avoided heating costs, which brings us to the sum of 82,847 HRK a year.

Net income represents the difference between total revenues and total costs. In the year before the production starts, costs include investment costs, while labor and maintenance costs are considered during the following years of production. Net income is -197,200 HRK before the production starts and 53,637 HRK during the twenty years production period. NPV is 471,232 HRK, and IRR is 27 %, which shows us that the project is exceptionally profitable under mentioned assumptions.

Scenarij S2 predicts the production of briquettes from the reed collected at the location of the pilot study area Kuti, which are meant entirely for sale on the market. Briquettes, among other things, can be used in wood-burning stoves as are used by the local community for heating.

Briquettes sale revenues represent a multiplication of annual production of briquettes and their prices under the following assumptions:

- The surface area of the pilot study area is 16.67 ha and the raw material is estimated at 3 tDM/ha (based on information received from the Neretva basin d.o.o.). Considering the moisture content of 10 %, the amount of pellets foreseen for sale is 55 t/year.
- The price of pellets is 750 HRK/t.

Total annual sale of briquettes, a product of multiplication 55 tons of briquettes and 750 HRK/t, sums up to 41,258 HRK.

Costs include investment costs:

- Construction of workshop area, briquetes drying room and briquetes storage room of 50 m2 total area. The cost of building the object is 1,500 HRK / $m^2$, ie a total of 75,000 HRK.
- Briquettes production machine (52,000 HRK).

The total investment costs sum up to 127,000 HRK.

Work and maintenance costs, unlike investment costs, are present throughout the whole duration of the project and include:

- Mowing costs are already included in the regular canal maintenance costs and are therefore not included in the additional costs associated with reed exploitation for energy production.
    - Transport (external service):
        - Based on the yield of 3 tDM / ha, the average moisture content of 17.5 % and the chaff density of the 76 kg/$m^3$, the volume of raw material was estimated to be 46 $m^3$/ha. Assuming the truck capacity is 15 $m^3$, the raw material has to be transported in 52 times total.
        - Driving cost was estimated to be 220 HRK.
        - Total: 11,340 HRK
    - Employee:
        - One worker for production and maintenance, with an average monthly net salary of 4,000 HRK, for 4 months.
        - Total: 16,000 HRK
- Production costs
    - Production 7 hours/day
    - 7 kW machine capacity
    - Electric energy price (0.53 HRK/kWh) multiplied with the daily consumption of 49 kWh during th 4 month period (21 work days/month)
    - Total: 2,181 HRK

Total work and maintenance costs (transport, employee and production costs) sum up to 29521 HRK.

Net income represents the difference between total revenues and total costs. In the year before the production starts, costs include investment costs, while labor and maintenance costs are considered during the following years of production. Net income is -127,000 HRK before the production starts and 11,737 HRK during the twenty years production period. NPV is 19,266 HRK and IRR is 6.7 % which shows that the projects is profitable under mentioned assumptions.

The sensitivity analysis was carried out for the quantity of briquettes sold and the market price of briquettes. IRR represents an economic indicator in the analysis. In case the IRR is higher than the discount rate of 5 %, the use of reed for energy production is profitable (shown in green in Table 11).

Table 11: The sensitivity analysis takes into account the production of briquettes (30 to 80 t) and the briquettes price on the market (600 to 900 HRK). The IRR represents an economic indicator at a 5 % discount rate. The reference values used in the scenario are highlighted in yellow.

| | | Production of briquettes (t) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **IRR** | **6.7%** | **30** | **40** | **50** | 55 | **60** | **70** | **80** |
| **Price of briquettes on the market (HRK)** | **600** | **#NUM!** | **#NUM!** | **-17.6%** | **-5.2%** | **0.2%** | 7.5% | 13.4% |
| | **650** | **#NUM!** | **#NUM!** | **-6.3%** | **-0.2%** | **4.2%** | 11.0% | 16.9% |
| | **700** | **#NUM!** | **#NUM!** | **-1.4%** | **3.6%** | 7.5% | 14.3% | 20.3% |
| | 750 | **#NUM!** | **-17.6%** | **2.3%** | 6.7% | 10.5% | 17.4% | 23.7% |
| | **800** | **#NUM!** | **-7.7%** | 5.3% | 9.6% | 13.4% | 20.3% | 26.9% |
| | **850** | **#NUM!** | **-3.1%** | 8.0% | 12.2% | 16.1% | 23.2% | 30.1% |
| | **900** | **#NUM!** | **0.2%** | 10.5% | 14.7% | 18.6% | 26.1% | 33.3% |

#### 3.4.4.2. Trade-off analysis with the ecosystem service „Maintaining nursery populations and habitats (Including gene pool protection)"

As early mentioned, pilot study area Kuti is a part of the Neretva Delta. Neretva Delta is a Natura 2000 site, significant for conservation of species and habitat types, designated both as a Special Protection Area (SPA) and a Site of Community Importance (SCI). The total area of the Neretva River Valley under ecological network protection is 23,814.31 ha, while the area Kuti occupies 2,652 ha, ie 11.1 % of the total area. According to the Regulation on the ecological network (OG 124/13 and 105/15), Standard Data Form (Nature Protection Information System - Bioportal, 2018) and the Proposal for the Natura 2000 sites management plan, in the Neretva Delta ecological network area, 33 target species and 65 target bird species are present along with 15 target habitat types, of which two are a priority habitat types. The delta represents the largest reedbeed complex in Croatia and serves as an important stopover, breeding and wintering site for almost 200 regularly occurring bird species. Neretva is a key area for migrating birds on the Adriatic migratory path. Furthermore, since 1993 the area has the status of a Ramsar Site (number 585), also known as a Wetland of International Importance under the Ramsar Convention on Wetlands. Neretva, its tributaries and delta, are also important areas for numerous fish species of which 150 freshwater and marine species were recorded. Endemic species of fish that live only in this area and therefore make Neretva especially interesting are (Šarić and Budinski, 2018): *Salmothymus obtusirostris oxyrhynchus*, *Cobitis narentana*, *Knipowitschia croatica* and *Knipowitschia radovici* (PI for protected areas of Dubrovačko-neretvanska County, in making). From other fauna in the Neretva delta, it is important to mention an otter (*Lutra lutra*), a species that resides in the Neretva Delta and it is quite rare in our coastal area. There were 22 reptile species and 11 amphibian species recorded. In the Neretva Delta, 29 species of dragonflies (Odonata) were recorded so far, for which the Neretva river stream, its tributaries and abundant vegetation make a suitable habitat (PI for protected areas of Dubrovačko-neretvanska County, in making).

The above-mentioned data points out the exceptional significance of the Neretva Delta area for biodiversity conservation. This data refers to the whole area of the Neretva Delta ecological network. Data only for the Kuti area doesn't exist, apart from certain plant species found in the Flora Croatica database, geographically

related to the area around Mislina and Badžula rivers: *Scirpus mucronatus*, *Marsilea quadrifolia*, *Cyperus serotinus*, *Carex elata*, *Potamogeton lucens*, *Cladium mariscus*.

In economic analysis scenarios, only the area of reed beds which is already mown is taken under consideration. It represents only the 3.5 % of the total pilot study area Kuti, which is 479 ha or 0.07 % of the total Neretva Delta area. It's evident that the area considered in this study is small compared to the total Kuti area and the Neretva Delta area. Since the reed is already mown, the use of reed from these areas doesn't represent additional encroachment in the ecosystem.

Depending on the reed bed's character and the environment, partial mowing can lead to habitat improvement for many species, while supporting ecosystem services by creating open spaces for species that don't prefer using dense stands such as some birds and mammals (Abduloieva and Podobaylo, 2014). Generally, large and dense reed bed areas with high reed stems can have less nesting birds than smaller and rare ones, since the edges of reed beds are more interesting to feeding and nesting birds (Kiviat, 2013). Winter mowing results in reduction of the number of hibernating insects and in an increase in the amount of light available to new stems, which can be seen as a positive effect on the one hand, while on the other hand, reduced populations of invertebrates in the reed beds could have a negative impact on birds (Ikonen and Hagelberg, 2007; Valkama et al., 2008). In general, in order to ensure the greatest biodiversity of reed beds, the diversity of structures which provides a suitable habitat, a feeding place and a shelter for large number of different organisms is needed. In order to maintain favorable ecological conditions and to avoid the negative impact that mowing can have on reed beds' invertebrates, and therefore on the birds that are primarily feeding on invertebrates, Valkama et al. (2008) recommend changing/rotating the mowing areas every 1 - 2 years.

As reed beds can often endanger other habitats and human economic activities, it is necessary to develop a management plan in order to limit their excessive spreading. Although, in Croatia they are characterized as rare and endangered habitats due to the presence of many endangered species, in some areas they spread and occupy the surface of the water bodies and smother them, or occupy land areas where agricultural production have been abandoned.

According to reasons mentioned above, the management plans for areas with reed beds should include the biodiversity conservation through protection of the most important species, in balance with ecosystem services and use by humans, and should be specific to each location based on the basic characteristics of reed beds and the surrounding area.

## 3.5. Pressures valuation

During the field work in the selected pilot study areas, negative pressures which affect the reed beds' condition and the provision of their services were recorded. In the Mediterranean biogeographical region, particularly in the Neretva delta area, although recognized for its natural values, there are various threats and activities that have negative impacts on the wildlife of the delta, such as habitat degradation, fires, agricultural intensification and poaching. Fires affect habitat and species biodiversity in the Neretva delta area, leaving degraded and unattractive wetland and aquatic landscapes. The motives for setting fires vary, from opening up hunting or fishing areas, keeping livestock to respected frequent thinking, though completely wrong one, that this "does good" (Šarić and Budinski, 2018). In the Alpine biogeographic region,

land abandonment was the most expressed pressure noticed. In continental region most of redbeds can be found by the fish ponds, so the most occurring pressure is fish exploatation. In carp fish commercial production ponds, a certain reed surface has to be regullary mown due to the production process. The pressure which appears is too much mowing which can lead to destruction of the habitat. Surveys results are quite similar; it was confirmed that land conversion isn't a strong pressure for reed bed habitats. Furthermore, invasive species also don't represent a strong pressure for the reed bed habitats because reed beds usually form dense and monodominant habitas in which other species rearly succeed.

## 3.6. Ecosystem accounting framework

Five core ecosystem accounts that make the basis of ecosystem accounting structure possess informations about the ecosystem assets and direct ecosystem services and can be shown in physical and monetary units. These are the following accounts: ecosystem extent accounts (physical terms), ecosystem condition accounts (physical terms), ecosystem services supply and use accounts (physical terms), ecosystem services supply and use accounts (monetary terms) and ecosystem monetary assets accounts (monetary terms).

Ecosystem extent accounts, ecosystem condition accounts and ecosystem monetary assets accounts possess information about ecosystem assets on the area where ecosystem accounting is conducted (state, region, etc.). On the other side, ecosystem services supply and use accounts, possess information about ecosystem services flows or basket of services which one asset provides, and informations about the consumption of these services by the type of consumer/user. The described informations are recorded with the aim of monitoring the change of condition and flows over time, in the defined accounting period (eg on an annual basis). It is necessary to point out that in the ecosystem services supply and use account sum of the services provided is equal to the total consumption of these services, while the ecosystem capacity (ie the potential of an ecosystem to provide a service) is noted by a separate account.

Before making accounts within ecosystem accounting, it is necessary to define:

- The territory for which accounting will be made, eg state territory.
- Ecosystem types classification which will be the conceptual basis for accounting and integration of relevant statistics. The ecosystem type represents a set of all assets of that type on the territory for which ecosystem accounting is made. In case the ecosystem accounting service is made for the territory of the state, and the data is presented according to the type of ecosystem classified according to the CLC land cover classes, each wetland represents one asset in the wetlands category, ie the type of wetland ecosystem.

- The way information will be presented, ie the level of aggregation of information – if the information on the ecosystem's extent, condition and services will be presented at the level of ecosystem type or level of individual asset.

- Basic Spatial Unit and Spatial Access Level – shows how much information will be associated with spatial data.

When choosing how to display information and how to define a spatial approach, or basic spatial units, it should be taken into consideration that more detailed access demands more data. The data which will be entered in the accounts must ensure the traceability of the account creation, it is necessary to identify availability and the character of the required data as well as the collecting frequency. According to the SEEA

EEA technical recommendations (UNEP/UNSD/CBD, 2017), the display of information on the ecosystem type level where the ecosystem assets are classified according to the CORINE Land cover categories, has turned out to be a good approach to accounting at the national level.

Three basic accounts in the ecosystem accounting system are described bellow: ecosystem extent account, ecosystem condition account, and the supply and use account. Data in these accounts are displayed in physical units and serve as a basis for monetary ecosystem services assessment during preparation of accounts that are expressed in monetary units. Examples of these accounts structures, for wetland habitats in the territory of the Republic of Croatia have been prepared. During the preparation examples, it was assumed that these accounts are a part of the total ecosystem accounting and that they're made on the basis of the existing data and that the purpose of making accounts is to include ecosystem services in the national accounts system.

### 3.6.1. Ecosystem extent accounts

Ecosystem extent account organizes the information on the extent or area of different ecosystem types within a country during the accounting period and it gives the basis for ecosystem accounting. During the account elaboration, types of ecosystems (categories of the ecosystem assets) for which accounting is made are defined. The ecosystem type (category of the ecosystem asset) represents territories with the same ecological characteristics, ways of use and the ecosystem services they provide. When ecosystem accounting is made for a larger territory, eg the state, the ecosystem extent account contains information on types of ecosystems, ie information about certain assets of a type is aggregating. In the ecosystem accounting for the Republic of Croatia, information about wetlands' extent will represent total extent of all wetlands in the territory of the Republic of Croatia.

Table below shows the example of the ecosystem extent account, in which the initial condition, the increase and decrease of the area, the cause of the increase or decrease, the net change in the considered period and the final condition is noted for each ecosystem type. The territory for which the account is made is the Republic of Croatia, and the account refers to ecosystems which, according to the CLC 2012 classification, belong to the class „Wetlands" (AZO, 2015). Types of ecosystems are therefore determined according to the CLC classification of level 3 lands and include: land swamps, salt marshes, solanes and tidal areas.

Table 12: Ecosystem extent account - example for humid habitats on the territory of the Republic of Croatia

| | Ecosystem type - CLC Wetlands | | | | |
|---|---|---|---|---|---|
| | Land swamps | Salt marshes | Solanes | Tidal areas | Total |
| **Initial area (ha)** | 19454,95 | 546,60 | 549,42 | 48,06 | |
| Increase of the area | | | | | |
| Planned increase | | | | | |
| Natural increase | | | | | |
| | | | | | |
| Decrease of the area | | | | | |
| Planned decrease | | | | | |
| Natural decrease | | | | | |
| | | | | | |
| Net change in surface area | | | | | |
| **Final area** | | | | | |

Initial extent represents area of certain asset in the begining, and final extent represents the area in the end of the accounting period. In items of decreasing or increasing of the area, information about the causes of change is noted, depending on whether the change happened because of the planned, antropogenic activities or because of the natural ones. The mentioned data is based on monitoring of the land cover and the condition of the territory and environment. For the display of the ecosystem extent account following spatial units are used: square meter, square kilometer, hectare, or in the case of aquatic ecosystems – volume or flow. The choice of the unit will depend on the size of the total territory for accounting and the custom spatial display of the spatial data. In this case, all the data is displayed in hectares; the information about the initial state is related to the year 2012.

### 3.6.2. Ecosystem condition accounts

Ecosystem condition account contains information about the ecosystem assets quality ie about their characteristics. Indicators are used for measuring ecosystem condition and they make a basis for evaluating the quality of the individual ecosystem characteristics. Indicators which are most commonly used are the ones for evaluation of vegetation, water, soil, habitats and biodiversity condition. In addition, indicators of antropogenic pressures are also often used. Indicators should reflect the condition of ecosystem characteristics and processes of the ecosystems assets from which the ecosystem services in the supply and use account are recorded. Therefore, when selecting indicators, one should have in mind the purpose of making an ecosystem account and the availability of data necessary for calculating/displaying indicators. Table below shows the example of the ecosystem condition account for the CLC humid areas in the Republic of Croatia, with proposal of indicators for condition valuation based on indicators for habitats, water and biodiversity.

Table 13: Ecosystem condition accounts - example for humid habitats on the territory of the Republic of Croatia

| | | Ecosystem type - CLC Wetlands | | | |
|---|---|---|---|---|---|
| Condition indicators | | Land swamps | Salt marshes | Solanes | Tidal areas |
| *Habitat* | | | | | |
| Habitat index | Initial condition | | | | |
| | Final condition | | | | |
| Representation of protected habitats in an area | Initial condition | | | | |
| | Final condition | | | | |
| *Water* | | | | | |
| Water reserves | Initial condition | | | | |
| | Final condition | | | | |
| Physico - chemical quality indicators | Initial condition | | | | |
| | Final condition | | | | |
| The presence of specific pollutants | Initial condition | | | | |
| | Final condition | | | | |
| *Biodiversity* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Representation of swamp birds species in an area | Initial condition | | | | |
| | Final condition | | | | |
| Representation of protected animal species in an area | Initial condition | | | | |
| | Final condition | | | | |
| Representation of protected plant species | Initial condition | | | | |
| | Final condition | | | | |
| Total condition index | Initial condition | | | | |
| | Final condition | | | | |

Ecosystem characteristics can be described from different aspects (biological, geomorphologic, hydromorphological, physical, etc.). Grades for ecosystem characteristics condition are based on indexes or indicators and are frequently used for the display of ecosystem assets condition. In this way, it is possible to give a total, aggregated, asset valuation at the beginning and at the end of the accounting period. The grading range and the limit value of specific indicator/index can be defined when creating an ecosystem account. An equivalent approach is used to assess the condition of water bodies, based on the methodology prescribed by the Water Framework Directive. According to that methodology, total water body condition can be rated as very good, good, moderate, bad and very bad, and total condition is based on the assessment of the ecological and chemical status of the water body, which are determined by a series of indicators.

In the before given example of the ecosystem condition account, three ecosystem characteristics have been selected for the display of the humid areas assets condition: habitat, water and biodiversity. Given the availability of relevant data and environmental monitoring in the Republic of Croatia, the following indicators are suggested:

1. Habitat

    a. Habitat diversity index – the share of the natural and semi-natural habitats area in the total area of the ecosystem type multiplied by the number of different natural habitats in the area of the ecosystem type expressed as

    $$Habitat\ diversity\ index = (area\ of\ natural\ habitats)/(total\ area\ of\ the\ ecosystem\ type) \times number\ of\ natural\ and\ semi-natural\ habitats$$

    Data sources for evaluation: Map of natural and seminatural non-forest and freshwater habitats of the Republic of Croatia, DOF – digital ortho-photo, biodiversity components condition reports and other documentation and inventory data on biodiversity and environmental conditions.

    b. Representation of protected habitats - number of protected habitats in relation to the total number of habitats in the area of one ecosystem type. Source of data for the evaluation: map of habitats, ortophoto footages, reports about the environment condition monitoring.

2. Waters

    a. Water reserve indicator – average annual groundwater level in the surrounding area. Data source for assessment: measurements of groundwater levels, measurement of water levels in the area of wetland habitats.

    b. Water quality indicator – water quality in terms of physico-chemical indicators. Data source for assessment: monitoring of water bodies in accordance with the Water Framework Directive - measurement of BPK5 parameter, total nitrogen and total phosphorus.

    c. The presence of specific pollutants – the pollution condition with regard to the presence of specific pollutants in water. Data source: monitoring of water bodies according to the Water Framework Directive - Measurement of Arsenic, Copper, Zinc, Chromium, Fluoride, Adsorbable Organic Halogens (AOX) and Polychlorinated Biphenyls (PBC).

3. Biodiversity

    a. Representation of swamp birds - the number of swamp birds in relation to the total number of swamp birds recorded in the territory of the Republic of Croatia. Data source for the evaluation: bird monitoring reports.

    b. Representation of protected animal species - the number of protected species recorded in relation to the total number of protected species in the state territory. Data source for assessment: the list of protected animal species and condition monitoring reports.

    c. Representation of protected plant species - number of protected plant species recorded in relation to the total number of protected species in the state territory. Data source for the evaluation: the list of protected plant species and condition monitoring reports.

### 3.6.3. Ecosystem services supply and use accounts

The ecosystem services supply and use account contains the data on the flows of ecosystem services provided by each ecosystem type and the data about their use by different users during the accounting period. In the balance sheet, ie supply and use account, the total amount of services provided is equal to the consumption of services by all users. In other words, if some ecosystem service is not used, it is not noted in the account. To link the ecosystem accounting with national accounts, it would be well to identify links of ecosystem services with material and non-material categories that are balanced in national accounts. For example, swamp provides habitat for fish, which recreational and professional fishermen hunt, and fishing is one of the industry branches, which is balanced in national accounts.

SEEA EEA technical recommendations suggest using ecosystem services classification where ecosystem services are divided in the following groups:

1. Provisioning services – contribute to the production of material goods or are used as such directly,
2. Regulating and supporting services – contribute to ecological and physical processes, such as carbon sequestration, watercourse regulation and flood prevention,
3. Cultural services – generate intangible goods, such as recreation, education, etc.

The supply and use account of ecosystem services consists of two parts (two tables). In the first part, the services provided by each asset to users are noted, and in the second part, the total of provided services is shown considering their users.

The next table is an example of the ecosystem supply and use account - for CLC wetlands in the Republic of Croatia, with the proposal of ecosystem services that are measurable based on currently available data.

Table 14: Ecosystem services supply and use account - example for humid habitats on the territory of the Republic of Croatia

| a) Ecosystem services provision | | Ecosystem type - CLC Wetlands | | | | |
|---|---|---|---|---|---|---|
| | CICES code | Land swamps | Salt marshes | Solanes | Tidal areas | Total |
| **Provisioning services - indicator** | | | | | | |
| Wild animals used for nutrition<br>- the amount of fish caught (recreational and professional fishing) | 1.1.6.1 | | | | | |
| Groundwater for water supply<br>- the number of wells which are recharging | 4.2.2.1 | | | | | |
| Wild plants used for nutrition or as a material<br>- the amount of protected medicinal and decorative plants collected in the wetlands' area (according to issued permits) | 1.1.5.1 and 1.1.5.2 | | | | | |
| Wild plants used as an energy source<br>- the energy value of biomass used for energy | 1.1.5.2 | | | | | |
| Wild plants used for nutrition<br>- the number of grazing animals | 1.1.5.1 | | | | | |
| Wild plants used for nutrition<br>- the amount of fodder goten by mowing at the wetland area | 1.1.5.1 | | | | | |
| **Regulating services** | | | | | | |
| Hydrological cycle and flow regulation (including flood protection)<br>- the value of avoided flood damage | 2.2.1.3 | | | | | |
| Regulation of the chemical composition of atmosphere and oceans<br>- the amount of sequestered carbon in soil | 2.2.6.1 | | | | | |
| **Cultural services** | | | | | | |
| Ecosystem characteristics which enable education and training<br>- number of educational visits | 3.1.2.2 | | | | | |
| Elements of ecosystems used for entertainment or representation (Tourism) | 3.2.1.3 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| - the income of tourist objects in the area and in the vicinity of wetlands | | | | | | |
| Characteristics of ecosystems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions (Recreation)<br>- the number of recreational fishing permits issued | 3.2.1.3 | | | | | |

| b) Ecosystem services consumption | Ecosystem services users/consumers | | | | |
|---|---|---|---|---|---|
| | CICES code | households | businesses | state | Total |
| **Provisioning services** | | | | | |
| Wild animals used for nutrition<br>- the amount of fish caught (recreational and professional fishing) | 1.1.6.1 | | | | |
| Groundwater for water supply<br>- the number of wells which are recharging | 4.2.2.1 | | | | |
| Wild plants used for nutrition or as a material<br>- the amount of protected medicinal and decorative plants collected in the wetlands' area (according to issued permits) | | | | | |
| Wild plants used as an energy source<br>- the energy value of biomass used for energy | 1.1.5.2<br>ili 1.1.5.1 | | | | |
| Wild plants used for nutrition<br>- the number of grazing animals | 1.1.5.1 | | | | |
| Wild plants used for nutrition<br>- the amount of fodder goten by mowing at the wetland area | 1.1.5.1 | | | | |
| **Regulating services** | | | | | |
| Hydrological cycle and flow regulation (including flood protection)<br>- the value of avoided flood damage | 2.2.1.3 | | | | |
| Regulation of the chemical composition of atmosphere and oceans<br>- the amount of sequestered carbon in soil | 2.2.6.1 | | | | |
| **Cultural services** | | | | | |
| Ecosystem characteristics which enable education and training<br>- number of educational visits | 3.1.2.2 | | | | |
| Elements of ecosystems used for entertainment or representation (Tourism) | 3.2.1.3 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| - the income of tourist objects in the area and in the vicinity of wetlands | | | | | |
| Characteristics of ecosystems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions (Recreation)<br><br>- the number of recreational fishing permits issued | 3.2.1.3 | | | | |

# 5. DISSCUSION AND CONCLUSIONS

## 5.1. Summary of key findings

In this study, an overview of reed beds' ecosystem services was given and the most relevant ecosystem services for reed beds of the selected pilot areas were defined. Most services were identified in the pilot study areas located in the Mediterranean biogeographic region. According to the number of services, the leading pilot study area is „Pantan", where 15 ecosystem services of the 56 in total were recognized (27%), followed by „Kopački rit reserve" (25%), „Vransko jezero" (21%), „Jezero Parila i Vlaška (21 %) and Torak (20%). All listed pilot study areas, except the reserve within the „Kopački rit" Nature Park, are located in the Mediterranean region, and all areas except „Jezero Parila i Vlaška" are located within protected areas. It is worth mentioning that pilot study area „Jezero Parila i Vlaška" is a part of the Delta Neretva. Currently, it's located within the ecological network, and due to its importance in biodiversity preservation, the extension of protection of the existing special reserve is planned in the future.

Significant differences in the number of identified ecosytem services can be seen between some groups of pilot study areas. Within the group *Wetland habitats with significant percentage of reed beds*, 18 ecosystem services were identified, within the group *Complex of wetland habitats and agricultural areas* 14 ecosystem services were identified, and within the group *Water bodies with reed belt*, 12 ecosystem services were identified. Significantly less ecosystem services were identified within the groups *Agricultural lands in succession* (5 services) and *Fish ponds* (6 services). Concerning the last two mentioned groups, it should be noted that not only do they provide much less ecosystem services than other groups, but also within these groups the services identified as the most important ones (*Cultivated plants used for nutrition* and *Animals from aquaculture reared for nutrition purposes*) were the ones whose exploitation is in conflict with the reed bed habitat type preservation. This last two mentioned groups include areas of anthropogenic origin, so it can be concluded that the study confirms the thesis that natural ecosystems provide a greater number of ecosystem services than those of anthropogenic origin. Among the described groups, the majority of the ecosystem services were identified within the group *Wetland habitats with significant percentage of reed beds* and that confirms that reed beds are an essential source of ecosystem services and a significant habitat for humans.

The results have pointed out the reed beds' value and have shown that, although they generally provide many valuable ecosystem services, all types of reed beds don't provide equal number of services. According to the results obtained by analyzing local community (of selected pilot areas) members' surveys, the

following services are considered to be the most important reed beds' ecosystem services: *Maintaining nursery populations and habitats*, *Regulation of the chemical condition of freshwaters by living processes*, *Regulation of the chemical condition of salt waters by living processes*, *Hydrological cycle and water flow regulation (Including flood control, and coastal protection)*, *Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions* and *Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions*.

Through new evaluation systems, starting from the anthropocentric point of view, services that provide the most benefits to people are considered more valuable in the opinion of service users, and in this case, the before mentioned services would represent the most valuable ones. Prior to making such conclusions, it is necessary to study the significance of each particular habitat to the living world that is dependent on it. When the information given above are combined together, it's possible to realise how necessary it is to protect and preserve each individual reed bed in the territory of the Republic of Croatia. As a first step in assessing the reed beds' value, it's recommended to take its origin, stability and assessed value of how natural the habitat is into consideration. The study emphasized the value of natural habitats over the ones of anthropogenic origin. Furthermore, the results confirmed that protected areas provide a large number of ecosystem services and therefore confirmed their huge value for the Republic of Croatia. During the making/development of management plans for these areas it would be desirable to plan activities for the purpose of preserving the existing ecosystem services, exploring the potential space for their improvement or finding a way to increase of the number of ecosystem services flows.

Moreover, economic value of reed beds service „Using wild plants for energy production" was determined. Multi-criteria analysis was conducted in order to analyze reed beds' providing possibilities for this service for all 35 pilot study areas selected. As a result of ranking the pilot study areas according to the possibility of providing the forementioned service, pilot study area Kuti was selected as a case study for further analysis. Analysis was conducted for the 16.67 ha of the Kuti area, the surface which is already mown regullary as a part of canal maintainance. This way, the raw material that currently isn't use din any way, could be used for heating, which would enable the local population to enjoy its benefits. Economic analysis was conducted for thee scenarios which include the production and sale of pellets and the use of these pellets as a heat source in public buildings in the County (scenario S1a and scenario S1b) or just for their production and sale (scenario S2). Scenario S1b shown to have the highest economic profitability (NPV sums up to 471,232 HRK and IRR 27 %), then S2 (NPV sums up to 19,266 HRK and IRR 6.7 %), while S1a is not profitable under the assumptions (NPV sums up to -34,710 HRK and IRR 2.8 %). This activity was mainly conducted by a subcontracted expert who was engaged in ecosystem service assessment using an interesting and innovative method still not practiced by CAEN experts. This way, CAEN experts were introduced to a new method and overall assessment was enriched by another approach. In addition, environmental tables/bilances have been set up, ie the Ecosystem Accounting Framework has been set up, enabling scientists an easier start and a good foundation for further research.

## 5.2. Obstacles or difficulties experienced in carrying out the project

It is important to critically reflect on possible shortcomings in the research and alternative reasons which could have led to the obtained results. The first problem we encountered was during data collection. The latest map of habitats under category A.4.1. *Common Reed, Reedmace, Galingale or large Sedges beds* noted

more wetland habitats and not only reed beds made from *Phragmites australis* strands, which were at the center of our research. Because of that, once we visited the preliminarily selected areas and discovered that in these areas reed beds weren't present or that the site was in succesion, we had to eliminate some selected sites from further analysis.
Unfortunately, the chosen method of conducting surveys turned out to be a poor method for assessing reed beds' ecosystem services in areas with low population density, so in these cases we had to rely on all the available literature, our expert skill and knowledge in this field, professional experience and our subjective impressions. On the other hand, survey conducting method turned out to be an excellent method of including the local community in the project activities because of the parallel education possibillity. These activities were forseen in the phase of the project „*Local community outreach*", so by educating people about reed beds and their ecosystem services also while interviewing them, we've additionally strengthened the outreach.

Furthermore, although there is a lot of information about reed beds and about the species of flora and fauna that can be found within them, we encountered the problem were we couldn't evaluate some of the reed beds' ecosystem services, especially regulatory services, because of the lack of systematic measurements of physico – chemical parameters for reed beds in the Republic of Croatia.

Moreover, due to the problem that reed products in Croatia are non-commercial products; they are not produced in many places in Croatia and where they are produced, it is usually in small familly companies. Because of that, it was difficult to determine their market value with high accuracy, so we were forced to use all the available literature as a help to get a reference point. We compared reed material with other materials of roughly similar characteristics in order to determine the value of a ton of pellets/briquettes of reed to evaluate the "Using plants for energy production" service of reed beds.

Lastly, when setting up an ecosystem accounting frame for reed beds, ie accounting tables for Croatian wetlands, the problem was the shortness of project's duration which was inadequately defined/specified in the first place. In order to fill in all the details in the created accounting tables, we should have information of initial and final state within an accounting period and a year long period is too short to notice some significant, measurable changes.

## 5.3. Recommendations for future research

Despite the positive side of the survey as a research method, for future use in assessing and evaluating ecosystem services, we recommend supplementing this method with additional economic analyzes for all reed beds' ecosystem services in order to get the most accurate results. It is important to distinguish that ecosystems have a certain potential to provide certain ecosystem services on functioning basis (van Oudenhoveni et al., 2012), and only the demand by service users from society turns them into "real ecosystem services" ie. flows of services. Therefore, it is important to differentiate the potential of an ecosystem to provide ecosystem services and the actual flow of services. Because of the short project duration some of the methods availlable were not appropriate for use in this particular research, but for a more detailed assessment of reed beds' ecosystem services and for ecosystem accounting in future research it would be more convenient to observe this ecosystem/habitat type for a longer period of time.

Through working with numerous stakeholders on this project, we got the impression that there is a great interest in this topic, both in the Republic of Croatia and globally. We believe that there's a great potential for new research in the field of ecosystem services.

## 5.4. Recommendations for reed beds management and policy making

Natural ecosystems degradation jeopardizes provision of ecosystem services, which denies people and other organisms many benefits and reduces their quality of life. The most common and the biggest cause are we ourselves, specifically the people who with their disrespectful and irrational behavior endanger ecosystems and their potential to provide ecosystem services whose benefits we enjoy everyday either directly and indirectly. Since nature is becoming increasingly endangered by negative human activities, and ecosystems have recently been recognized as natural capital assets that support life on Earth and provide benefits for people (Turner and Daily, 2008), ecosystem services assessment is of exceptional importance for the display of values of nature. It helps to show them in a more comprehensive way, so all profiles of people can understand their value, in order to protect them, racionally manage them and keep them long-lasting.

Reed beds habitats, covering 8940,549 hectares of land in the Republic of Croatia (Bardi et al., 2016), are under great impact of human caused pressures, such as setting fires, land conversion and biological exploitation of ecosystem products. Nevertheless, it should be remembered that reed beds are transitional habitats incurred on humid abandoned agricultural areas, and in normal functioning ecosystems naturally over many years, once again, the succession process will transform them into shrubs and forests. If we want to perserve them in some areas, it is necessary to manage them in sustainable way. If areas are mown, it's necesarry to pay attention to the percentage of mowing surface, in order to maintain the most suitable conditions for most of the fauna.

Generally, assessing ecosystem services is by no means an easy process, especially if we take into account that different services demand different methodological approaches, that monetary value is not simple to display because many services do not have the market value, and the quantification of the processes and products of ecosystems is a strenuous and an expensive project. Ecosystem services assessment can play an important role in nature protection and nature conservation management plans, therefore indirectly having a considerable influence on control and mitigation of negative human impact on ecosystems and services they provide. It is important to emphasize that ecosystem services assessment can represent the basis, as well as a tool for balancing society's development along with natural values conservation. If the values of nature and the products that ecosystems provide are used by the principles of sustainable use and development, present and future generations will be able to enjoy them. That is precisely the most important thing - to ensure prosperity for future generations and to preserve biodiversity, geodiversity and landscape diversity.

## 5.5. Conclusions on contribution of the project

Despite any minor obstacles during the project implementation, the set goals of the project were accomplished. The project-team was able to assess reed beds' ecosystem services, evaluate one specific ecosystem service in detail and assess this service's exact monetary value. Furthermore, the team was able to set up an ecosystem accounting frame for the wetland habitats in the Republic of Croatia and to set up accounting tables' templates for them. Nevertheless, making assessments wasn't easy, but it was possible

due to all the data about reed bed habitat type available to the Agency. It was a challenge through which team members had build up their expertise, test new methodologies and investigate the gaps in their databases. CAEN experts implemented the results and conclusions of the general assessment of ecosystem services provided by reed beds and the results will be used in already established working processes at CAEN.

In addition, this study can be considered as the cornerstone of ecosystem services studies in Croatia because it established the first database and mailing group of ecosystem services experts (ekosustavi_i_usluge@haop.hr). This idea was brought out during a round table held by CAEN experts in February 2018. This newly formed group consisted of 19 interested experts. With their expertise, this group is surely going to help and encourage all the future studies within the sector. All of this is expected to ensure a broader use of ecosystem service assessments as a tool for evaluating our dependence on nature, eventually leading to positive changes in governance and resulting in more effective management of nature's assets.

Moreover, two phases of this project were oriented in raising public awareness on reed beds, their potential values and support for nature protection. By conducting surveys throughout the whole Croatian territory and speaking with people of all profiles (wider public) many people have heard about the concept of ecosystem services. Additionally, leaflets made as a part of the project activities have been distributed to all public institutions in the nature conservation sector, companies such as Croatian waters, Croatian forests and so on. All participants in project activities, regardless of the phase of the project in which they participated, have been informed about the project results.

As said many times, reed beds are an important habitat for many various species, especially for migrating birds. Their conservation is needed due the pressures related to them, like exploitation, setting them on fire, causing big loss for biodiversity. Pressure of fires is recorded in Croatia at its highest in the Neretva delta area. Therefore, exact value of reed beds' ecosystem service is a valuable analyses result. It’s going to serve as an input data for expert studies which are going to be used for protection of these areas, for development of standards related to management of protected areas, for preparation of the mechanisms for ecological network areas management and are going to be used in educational and promotional purposes, etc.

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