Biomass in Biebrza National Park – waste(d) opportunity

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1. Biomass in Biebrza National Park – waste(d) opportunity

1.1. Introduction

Biomass is fuel that is developed from organic materials, it's a renewable and sustainable source of energy used to create electricity or other forms of power. Biomass is easily accessible from various industries including agriculture, forestry, fishery and livestock. Together with other renewable resources, such as solar, wind, and hydroelectric, biomass is a major future sustainable energy resource of the planet. Biomass contains energy first derived from the sun: Plants absorb the sun's energy through photosynthesis, and convert carbon dioxide and water into nutrients (carbohydrates). The energy from these organisms can be transformed into usable energy through direct and indirect means. Biomass can be burned to create heat (direct), converted into electricity (direct), or processed into biofuel (indirect).

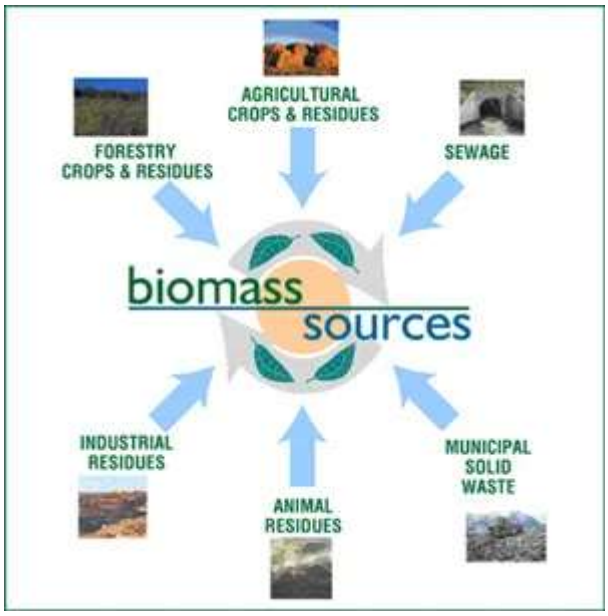

Figure 1 Potential biomass sources

1.2. Description of the area and problem to solve

1.2.1. Description of the area

Biebrza National Park (Biebrzański Park Narodowy) is a national park in northeastern Poland, situated along the Biebrza River. The Park includes 15 547 ha of forests, 18 182 ha of agricultural land, and 25 494 ha of wetlands - the most valuable habitats of the park - the famous Biebrza marshes. The area of 7 494 ha is under strict protection including the Czerwone Bagno or Red Bog at the Grzędy Forest District. Unique in Europe for its marshes and peatlands, as well as its highly diversified fauna, especially birds- the Park was designated as a wetland site of global significance and is under the protection of the RAMSAR Convention. In the richly diversified flora of the Biebrza Basin. The dominant role is played by communities of wetlands and peat bogs (sedges, rushes, moss-sedge and meadow vegetation) as well as shrub and forest (alder, oak-hornbeam, riparian, coniferous) habitats.

Figure 2 Area of the Biebrza National Park - illustrative photo (https://zpppn.pl/biebrzanski-park-narodowy-pl/park)

1.2.2. Description of the problem

As the Park covers an area of 27 699 ha under active protection, it must implement active protection measures in non-forest ecosystems. They require mowing of vegetation in conditions of low groundwater levels. Due to the large area, the park is not able to mow the entire area by itself. That is why the park announces tenders for mowing biomass.

Biomass is undoubtedly a renewable energy source, but every year the park faces the problem of the lack of a market for the produced biomass.

The following report has attempted to identify the causes of the problem which is: *Lack of using biomass from active protection in Biebrza National Park.*

Below are presented some visual tools that helped the group understand the problem more deeply.

First one is Pentagonal Problem (Fig. 3.) which help teams nail down the problem, identify its different components and details, and get to a common ground for future actions.

Second one - The Context Map (Fig. 4.) is a visual tool for system analysis, based on the well known technique PEST1 (Aguilar, 1967). The tool allowed the group to approach the problem on the Multi Level Perspective.

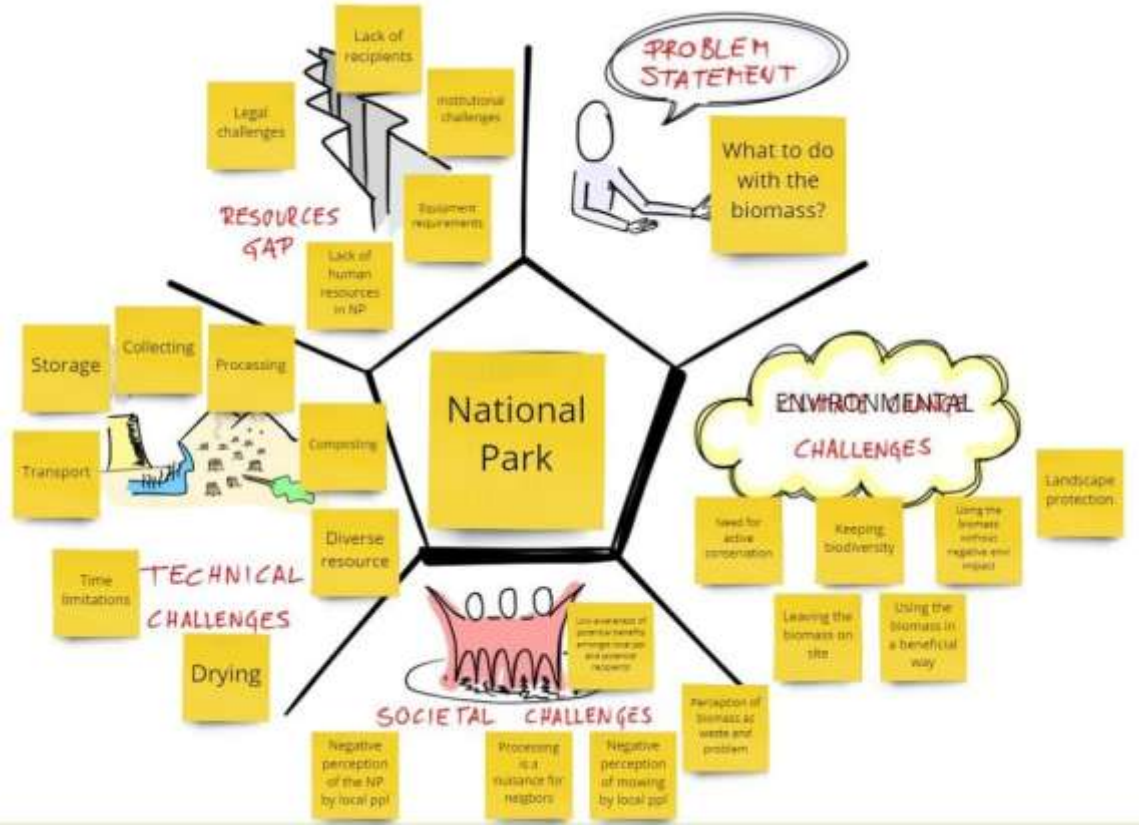

Figure 3 Pentagonal problem

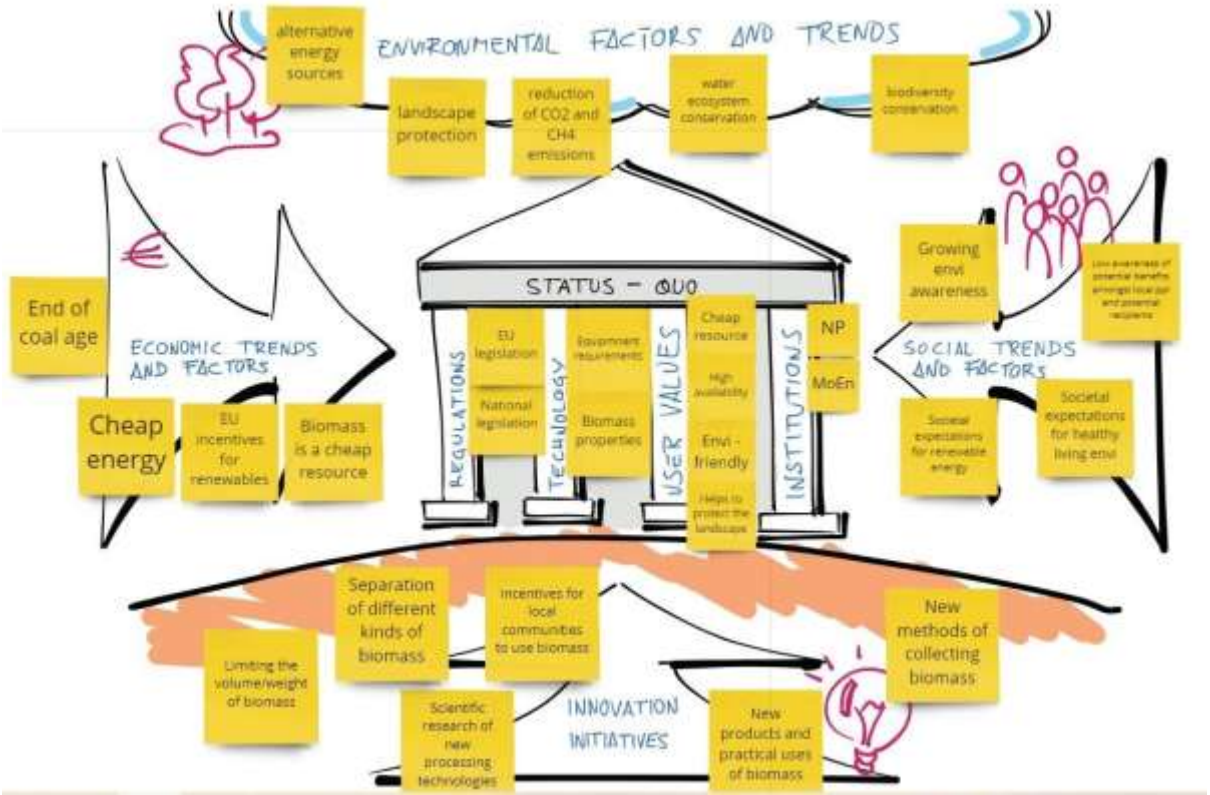

Figure 4 The Context Map

2. From bog to boiler: processing, products and uses of biomass

2.1. Processing and products

Worldwide energy consumption is on a moderate increase, especially in fast developing countries. The overall size of the global energy market almost doubled in 1971–2003. This is due to the rapid increase in energy consumption in developing countries, where population and energy activity have increased [1]. In 2019, bioenergy power generation increased an estimated 5%, falling below average yearly growth since 2011. According to IEA [2], electricity generation from bioenergy increases 6% annually through 2030 (Figure 5).The energy of biomass includes energy crops, agricultural and forest residues, animal manure, wood processing, food consumption waste and other waste. Additionally, bioeconomy is seen as a solution for reducing environmental impacts (carbon intensity and global warming). Therefore, several political measures have been taken to promote bioeconomy and a number of national bioeconomy strategies have increased [3]. Energy requirements for biomass processing is one key element that should be discussed. In case of fuel production, biomass have lower energy intensity compared to fossil resources indicating that required amount of biomass is remarkably higher [4]. Unfortunately, fossil fuels are needed for the cultivation and harvesting of biomass raw materials, transport of raw materials and products, and processing, which is often energy intensive. To reduce the value of energy consumption, all stages should be optimized, including biomass location and raw material production, as well as the potential end users.

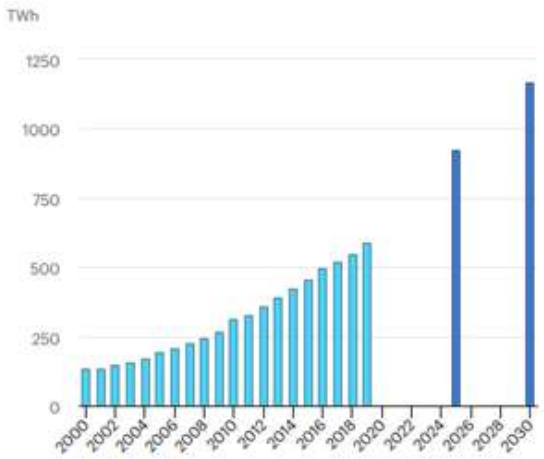

Figure 5 Bioenergy power generation in the Sustainable Development Scenario, 2000-2030 [2]

2.1.1. Processing biomass into biogas

The most important application of agricultural biomass for energy is the production of biofuels, typically sugar and starch crops for bio-ethanol and oil crops for biodiesel. In some regions straw is used for the production of heat and/or electricity . There are also agricultural digesters producing biogas from energy crops(predominantly maize) and manure [5].

Biogas is one of the products that can be obtained by converting biomass into energy and it is a renewable resource. It consists mainly of methane and carbon dioxide and it is produced during anaerobic micro bacterial degradation processes of organic material. For the production of biogas all microbiological degradable substrates can be used including biomass [6].

A detailed study of the worldwide availability for biogas and biomethane, shows that the technical potential to produce these gases is huge and largely untapped. These raw materials include, among others crop residues, animal manure, and forest residues. Biogas and biomethane production in 2018 was around 35 million tonnes of oil equivalent, only a fraction of the estimated overall potential. Full use of the sustainable potential could cover around 20% of today's global gas demand. It is noted that the number of biogas plants is systematically growing. France is the leader, but other countries are not far behind [7,8].

Biomass from national parks, where wetlands occupy a significant area, has been considered many times as a raw material for biogas production. There is a study provided by Bialystok University of Technology concerning the potential of reed and sedge biomass to create self-sustaining energetic system for a household based on a methane production. Considering the “average” composition of reed and sedge species, they proved it’s possible to provide 2.3 MWh of energy from each hectare of wetlands which would be sufficient to power 1.2 of household [9]. They also emphasize that the system based on such biomass composition can provide significant amount of nutrients which would basically go back to the environment with the waste from biogas plant as the loss of nitrogen and phosphorus is rather small.

Advantages:

- Provides non-polluting and renewable source
- Biogas Generation Reduces Soil and Water Pollution
- It’s A Simple and Low-Cost Technology
- Efficient way of energy conversion (saves fuelwood)

Disadvantages:

- Difficult to enhance efficiency of biogas systems
- Contains some impurities and gas that are harmful
- It is somewhat unstable make it prone to combustion if methane comes in contact with oxygen
- The optimal temperature bacteria need to digest waste is around 37°C

2.1.1.1. Material for biogas plants

Biofuels are classified according to the type of biomass from which they come from. We can distinguish the first-, second-, and third-generation biofuels (Fig. 6). First-generation biofuels come from edible plants. Second-generation biofuels are those that come from agricultural waste and non-edible plants. Finally, third generation biofuels are biofuels derived from algae biomass. Second and third generation biofuels are also called advanced biofuels, because their production does not compete with food supply, and in many cases is produced from biomass resulting from reclamation processes [10].

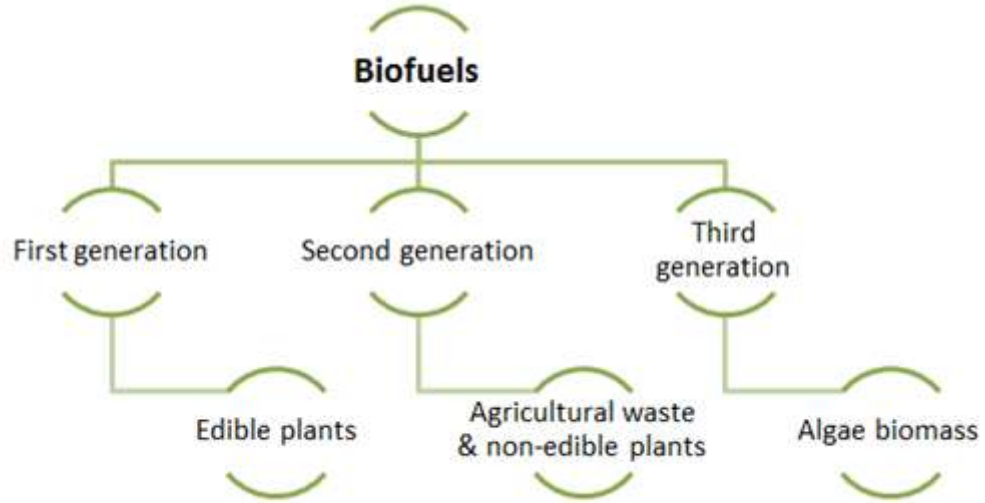

Figure 6 Biofuel classification

Each plant can be used as a material for biogas plants, especially if it is earlier dried. From grasses and plants it is required that they have a relatively high calorific value compared to conventional fuels. Even with a low grass yield of 4-5 t/ha, the purchase equivalent of 3 t hard coal can be obtained. A biomass of 20 t/ha gives the equivalent of 12 t coal. In the coming years, biomass will be one of the most important renewable energy source.

The use of biomass for energy purposes has been described in recent years by numerous authors: Czyż et al. [11] , Dradrach et al. [12] , Grzelak [13] , Grzelak et al. [14], Harkot et al. [15], Księżak and Faber [16] , Rogalski et al. [17] and Winkler et al. [18] . Based on the conducted research, they described the energy value of meadow communities, grass species, sedges, as well as various crop species from the Poaceae family and other species from different phytosociological classes.

The biomass obtained from meadows is characterized by low nutritional value due to the late mowing period and lack of fertilization.

One of the parameters characterizing biofuels is the energy value expressed in MJ/kg (megajoules per kilogram). It depends on the next parameter, moisture, which has a negative impact on the calorific value, and thus also energy. Biomass with 50–60% moisture can provide energy within 6–8 MJ/kg, pre-dried to 10-20%, 15–17 MJ/kg, while completely dried up to 19 MJ/kg [19] . However, the energy value that can be obtained from biomass is lower than that obtained from coal or natural gas. Therefore it is necessary to dry some types of biomass in order to obtain the desired combustion parameters and a specific energy value [20]. According to Grzybek et al. [21] the heating installations allows different biomass moisture (between 18 and 25%). The humidity of the biomass has a direct impact on its transport and storage.

Sedge meadows are close to the natural environment. Their useful meaning is limited, primarily due to too much moisture content, variability of atmospheric conditions and specific nature of sedge vegetation [22] .

2.1.2. Biowaste briquetting

Most of the plant habitats in Biebrza National Park are forestless [23]. Sedges and reeds, which are cut off as part of the active protection of swamp habitats, contain a great amount of moisture content. That is why combusting of biomass made of them may be not effective. However, the physical and chemical properties of this biomass can vary depending on the mowing time. The moisture content of biomass from summer mowing can reach 75%, while biomass from winter mowing contains only 25% of water [24] .

Biomass from late mowing can be used as a material for briquette production. This particular type of biowaste is characterized by a higher content of substances such as lignin, cellulose and hemicellulose compared to biomass from summer mowing. Lignin makes the raw material more suitable for the compaction process [25]. However, biowaste made of sedges and reeds may be resistant to compression due to the large amount of cellulose fibers like in case of agricultural waste.

Stages of briquette production from agricultural waste are:

1) chopping or grinding
2) crumbling and drying (15-17% of moisture is required)
3) grinding
4) granulating
5) pressing
6) cooling

2.1.3. Composting

In general, composting is a common way of biomass transformation. The process of composting is quite complicated and depends on a wide variety of parameters like: dry matter content, humidity, organic matter content, carbon-nitrogen ratio, oxygen access. It is not easy to treat sedge and reed biomass as a main or even significant compound of compost because it's parameters are not stable and they vary during the year. For example, during the winter season it could be treated only as a structural element for dumps stabilization – especially when organic matter would come mainly from sewer treatment plant waste. Still this option is worthy of considering.

Composting is one of the most common methods of biological transformation of municipal refuse or "green" waste. The process relies on mineralization of organic matter into stable components under aerobic conditions [26]. The product of composting can be safely stored and used in the environment. Composting has several significant advantages. First of all, during the process pathogens are removed from the waste. Secondly, the mass and volume of bio-waste is reduced, which is very important when it comes to transport and storage. The final product is biologically stable and aesthetically acceptable. It can be used to improve the soil structure quality as well as a fertilizer [26].

During classical composting of municipal refuse, the biochemical transformations are becoming more intense. The process progresses gradually and occurs into three phases: the mesophilic phase, the thermophilic phase and the cooling and maturation phase [26]. The composting process leads to partial mineralization and humification of organic compounds

contained in bio-waste. As a result of mineralization, temperature initially rises to 25-40°C. In this range of temperature, mesophilic bacteria, fungi and actinobacteria degrade easily reducible chemical compounds. Subsequently, temperature reaches 50-60°C and thermophilic bacteria and fungi become predominant microorganisms in the bio-waste. During the first and the second phase of the process, oxygen consumption is very high. The emission of odors and leachate takes place also. Above the temperature of 60°C spore bacteria and actinobacteria are responsible for decay processes. It is crucial to monitor the composting process during the high temperature phase and combine the biomass from time to time. High intensity of the process and quick evaporation of water can lead to spontaneous combustion of the bio-waste. After reaching the highest temperature, the bio-waste cools down. Figure 7 shows the curve of the temperature followed in a composting pile.

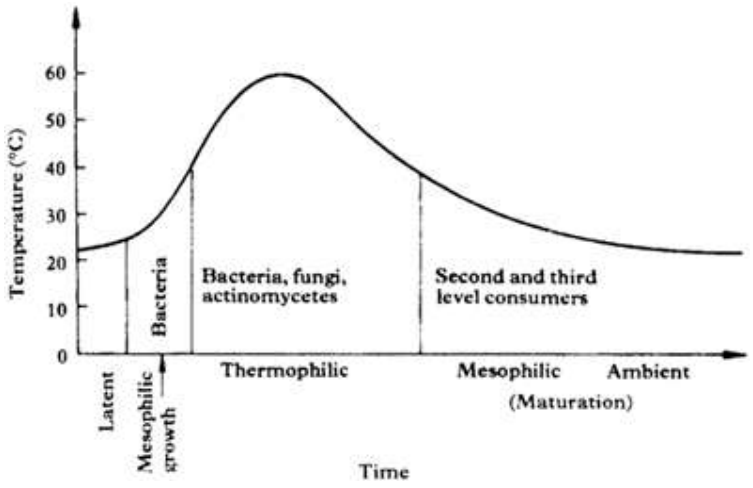

Figure 7 The curve of the temperature followed in a composting pile [27]

Composting process can be conducted in a composting pile (open system) or in a bioreactor (closed system). Intersection of the composting pile has trapezoidal shape. The prism is about 1-2 m high and about 4,5 m wide. Composting piles can be situated outside under the roof or stay open. Composting prisms are presented in figure 8. Prism aerification is a result of air diffusion and convection and biomass combining. Natural ways of combining include shovelling whereas other methods of aerification include air transport to the inside of the prism with aerators and perforated pipes (pressure methods) or suction (vacuum pressure methods). Composting in prisms lasts about 3 months. During the first 6 weeks mineralization processes dominate in the piles. This period of time can be stimulated by using special bio-stabilizers where the bio-waste is hydrated, aerified and mixed. The ambient temperature plays a significant part in the composting process. When the temperature is low, the composting process doesn't progress. When it's hot outside the water evaporates very quickly and there is a risk of spontaneous combustion of the bio-waste, whereas when it's raining, leachates from composting piles become a serious problem. In bioreactors the period of time to compost bio-waste is much shorter. The process of composting lasts about 10-14 days. During the first day temperature reaches 40°C. Then, in the next 4-5 days it rises to 40-45°C. In the second week, for 4-5 days

temperature persists on the level of about 60°C, and finally it cools down (the end of the composting process).

Figure 8 Composting prisms of "green" waste [28]

The process of composting depends on many different factors like: the bio-waste composition, porosity and size of the waste particles, C:N:P ratio, humidity, pH, temperature, quantity and species of microorganisms, oxygenation of the bio-waste and climatic conditions [29]. Composting of the "green waste" can be a challenge, because of high variability in composition which is connected with different climatic and geographic characteristics of the collection sites, different seasons etc. According to some authors, the "green waste" can be divided into two fractions: the green fraction (for example: leaves, grass clippings) and the brown fraction (for example: branches or trunks) [29]. Depending on the "green waste" composition and quality, there is a possibility to add co-substrates to improve the process of decomposition and composting [29]. The biomass from Biebrza National Park can be classified as a kind of "green waste". There are several similarities between "Biebrza biomass" and typical "green waste": composition of both types of biomass is difficult to define, but also usually both types are low in essential nutrients such as NTotal, PTotal and KTotal [29]. However, there is one basic difference between classic "green waste" and biomass from Biebrza NP: while humidity of typical "green waste" is low, sedges and reeds from the NP contain large amount of moisture. Among microorganisms that take part in the process of composting aerobic and anaerobic bacteria can be distinguished. Aerobic microorganisms degrade complicated chemical compounds to CO_2, H_2O, NH_4^+, NO_2^-, NO_3^- and humic compounds with generation of heat energy, whereas anaerobic bacteria are responsible for creating CH_4, CO_2, H_2, NH_3, H_2S, N_2, NO, NO_2 (also with heat energy production) [29]. When there are no more easily reducible organic chemical compounds in the bio-waste, cellulose bacteria start to degrade fibre to glucose. Nitrifying bacteria oxidize ammonium nitrate salts to nitrites and nitrates. Actinobacteria and fungi degrade cellulose and lignin. At the end of the composting, organisms like protozoa, springtails, mites and earthworms also participate in the process.

In Podlaskie province there are several bigger waste processing plants with a possibility of composting the biowaste. The province is divided into 3 regions (considering the waste management): central, northern and western region (Table 1).

Table 1 Enterprises with composting installations in Podlaskie province [30]

TYPE OF INSTALLATION	INSTALLATION ADDRESS	ADDRESS OF THE MANAGER / OWNER
Central region		
Installation of mechanical - biological processing of mixed municipal waste - MBP	Municipal Waste Processing Plant in Hryniewicze 16-061 Juchnowiec Kościelny	P.U.H.P. "LECH" Sp. z o.o. 4 Kombatantów Street 15-110 Białystok
Northern region		
Installation for the storage of waste generated in the mechanical-biological processing of mixed municipal waste and residues from sorting municipal waste - landfill	Municipal Waste Processing Plant in Suwałki 150a Buczka Street 16-400 Suwałki	Waste Management Enterprise in Suwałki Sp. z o.o. 82 Sejneńska Street 16-400 Suwałki
Waste Management Plant	trunk road no.65 19-200 Koszarówka	Management Office Zabiele 37, 19-124 Jaświły
Western region		
Installation of mechanical - biological processing of mixed municipal waste - MBP	Waste Processing and Neutralization Plant in Czartoria 18-413 Miastkowo	Waste Management Enterprise 22 Akademicka Street 18-400 Łomża
Installation of mechanical - biological processing of mixed municipal waste - MBP	Waste Processing and Neutralization Plant in Czerwony Bór 18-300 Zambrów	Zambrów City Hall 3 Fabryczna Street 18-300 Zambrów

As a part of the investigation of biomass usage in the composting process, several interviews with representatives of waste plants were conducted. The results are presented in Table 2.

Table 2 Interviews with representatives of different waste plants in Podlaskie province

WASTE PLANT	INTERVIEW DESCRIPTION
Northern region	
Municipal Waste Processing Plant in Suwałki 150a Buczka Street 16-400 Suwałki Contact number:	The man who picked up the phone provided feedback on strict assignment of the waste plants to particular regions. Waste processing plant in Suwałki is way too far away from Biebrza National Park to transport the biomass, especially when it's wet.
Waste Management Plant trunk road no.65 19-200 Koszarówka Contact number:	The lady who picked up the phone in the office asked if I could send all the information and questions by email, so the waste plant's management could take a position on the idea of receiving the biomass from Biebrza National Park. The email has been sent, but still it remains without an answer.
Western region	
Waste Processing and Neutralization Plant in Czerwony Bór 18-300 Zambrów Contact number:	The company manager said that there is absolutely no possibility to receive biomass from the Biebrza National Park. As an explanation she pointed out the lack of stoves for drying wet biomass in the composting plant.

2.1.4. Sedge mats

Biomass can be a valuable raw material for making everyday items. Sedges and reeds are widely applied in traditional sleeping mats production in the whole region of south-east Asia [31]. Only in Mekong Delta area 180,000 people are employed in this branch of traditional craft. Production process is rather simple and consists of following steps:

1) Preparation of sedge fibres (fragmentation);
2) Dyeing;
3) First drying (traditionally solar heat);
4) Softening (soaking in water);
5) Weaving;
6) Second drying;
7) Finishing.

Biomass from Biebrza National Park which consist mostly of sedges and reeds could be a valuable material for sedge mats making. There are many companies in Poland that offer reed/sedge mats. This kind of products can be used as a cover for an existing mesh, an old fence but also as a casing for pots or trees during winter [32]. They can also be useful to protect property from wind, noise or neighbours prying eyes [33]. An example of reed mat use is presented in figure 9.

Figure 9 Reed mat used as a cover for a mesh/ fence [32]

2.1.5. Pellets

Pellet is an organic fuel made by the compression of biomass The common biomass feedstocks for pelletization are wood industry waste, agricultural and forest residues, energy crops etc. Biomass pellets are competitive against oil fuels, natural gas and electricity not only because of the low cost but also because they are ease in usage and storage [34]. Furthermore, the regular geometry and standard size allow compact storage, convenient handling, and automatic feeding in large scale unit operations. Among various types of pellets, wood pellets are commonly used biomass for modern bioenergy . Pellets can be produced from one type or mixed biomass [35]. Mixed biomass pellets (MBP) have a great potential in enlarging the use of biomass for energy conversion, particularly in central and south European countries. With the exhaustion of biomass residues for wood pellets production the production of MBP is of increasing interest for project developers and biomass producers. Hence, in this market not the availability of the biomass resource is the most critical factor, but the availability of a sales market itself. Fig. 10 shows the pellet production [34-35].

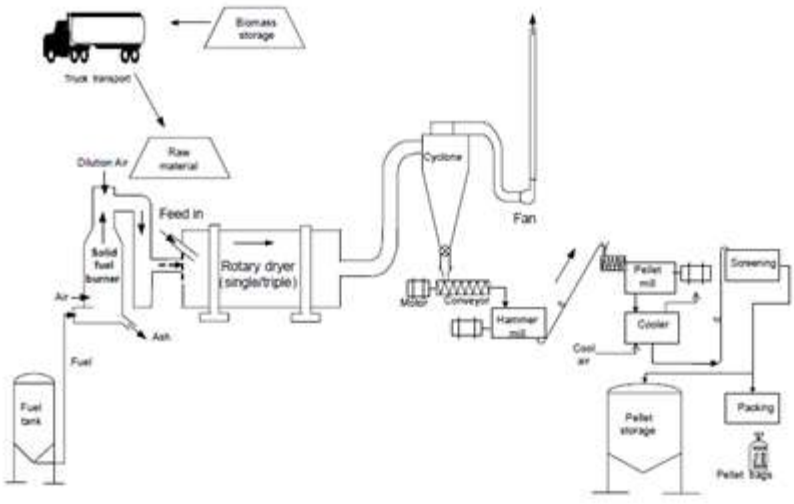

Figure 10 Pellet production [36]

2.2. Uses

As described in point 2.1 the biomass can be processed in various ways. The processing and the use of biomass depends mainly on the location of the Biebrza National Park and nearby companies. This section presents the potential use of biomass by analyzing the immediate surroundings.

2.2.1. Biogas plants

Fig. 11 shows a map of agricultural biogas plants in Poland. Almost 120 installations producing agricultural biogas are currently operating in Poland and all of them are on the first map of biogas installations on the market, prepared by the Biomass Media Group [37].

The map of agricultural biogas plants shows the current state of the sector in the country. It includes all operating installations reported to the register of agricultural biogas producers kept by the National Center for Agricultural Support and 19 micro-installations operating at farms throughout Poland.

Figure 11 Agricultural biogas plants in Poland [37]

Fig. 12 shows a map of biogas plants near the Biebrza National Park. Analyzing various literature sources, it is noted that many of the planned biogas plants were not built. Unfortunately, it is difficult to determine what was the reason for this.

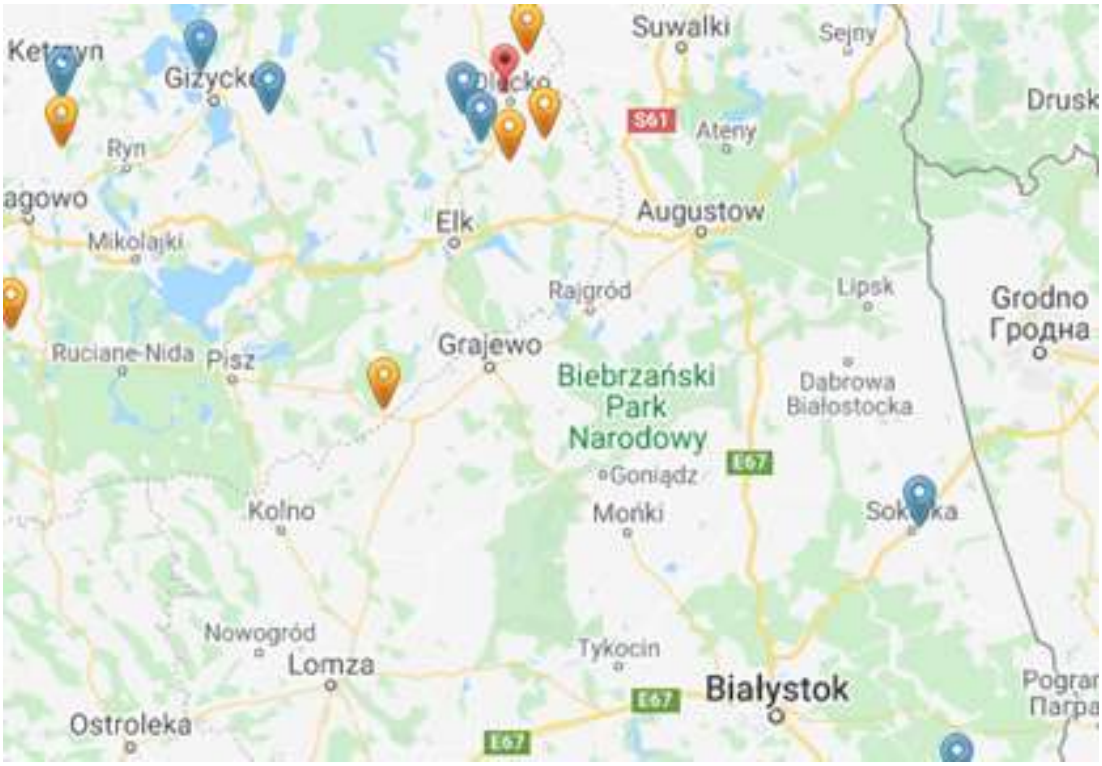

Figure 12 Biogas plants near the Biebrza National Park [37]

During the implementation of the task, interviews with selected employees of the biogas plants were conducted. It turned out that most of the biogas plants are interested in the biomass from the Biebrza National Park. An important aspect is that the wet biomass is not a problem in biogas production. In addition, it was also noted that carex should not be an additional problem. An important aspect is that none of the biogas plants can pay for the biomass, so the Park would have to give it away for free. Sometimes even pay extra for the transport. However, the topic is very interesting for the nearby biogas plants and in our opinion it would be worth arranging an interview during which all aspects would be discussed. In addition, a sample of the biomass should also be submitted for some tests at the biogas plants. A detailed description of all interviews is presented in table 3.

Table 3 The description of all interviews

	Company name	Address	Contact	Interest in biomass	Biomass parameters	Issues
1.	EKO-FERMENERGIA Sp. z o.o.	Lotników Lewoniewskich 11A 16-100 Sokółka	Michał Głuszyński tel: 695 621 113	YES	The biomass can be wet, that's not a problem at all	If the price per ton of biomass fluctuates around PLN 50, it will not be profitable
					The biogas plant is flexible when it comes to raw material, they process various things and according to them, sedges are not a problem	

	Other	-Whether the park wants to earn on this biomass or simply put it in good hands? The biogas plant usually does not pay for the raw material. -Most of it is waste and by taking it away they do someone a favor. -Moreover, this biogas plant usually charges a fee for receiving the raw material (discussion topic). -The biogas plant also thought about setting up a pellet mill and drying the wet biomass using large amounts of heat generated during the biogas production				
2.	EKO-Progress Sp. z o.o.		tel: 795 443 794	YES/NO		The biomass has too much lignin, it is difficult to process. A crust is formed from this
3.	Upałty-ROL	Upałty Małe	tel: 607 447 051	YES	The wet biomass is not a problem, the tractor will squeeze everything during prism, and this can also be used for biogas production	The transport would have to be on the park side, unfortunately the biogas plant is far away and it will not be profitable
	Other	The biomass must be delivered in a chopped form				

2.2.2. Pellet plants

According to the latest "Pellet Market Overview 2019 - Preliminary Report", issued by the European Pellet Council, worldwide global demand for pellets has experienced sustained growth, both on the industrial and heating market [38].

Unfortunately, there has also been a delay in the implementation of new investments in areas with high availability of raw materials for production, which causes general tensions in the market. As a result, it can only be concluded that the global use of solid fuel, which is pellet, is difficult to predict.

The Polish pellet industry is not lagging behind, we continue to record increases in the production of pellets, which are mainly due to new medium-sized (up to 5-10 thousand tons per year) production units [38]. Figure 13 shows a map with pellet plants in Poland.

Figure 13 Pellet plants in Poland [38]

Figure 14 shows pellet plants near the Biebrza National Park. Unfortunately, there are few of them. The analysis of the literature shows that many pellet plants have declared bankruptcy, unfortunately it is not known for what reason.

Figure 14 Pellet plants near the Biebrza National Park [38]

2.2.2.1. Pellet ash

Heating with biomass is unquestionably ecological. It has a positive effect on CO2 emissions and air quality. Of course, ash is generated in the combustion process, but due to its properties, we do not treat it as a by-product. It is a complete fertilizer that can be used in gardening or cultivation and plant care. It contains potassium, phosphorus and calcium. High pH contributes to soil deacidification like lime fertilizer, but pellet ash does it even more effectively. Unused ash can also be added to the compost, thanks to which it will be enriched with microelements and other valuable ingredients.

3. Problem or potential? Different perspectives on biomass use

3.1. NGO - Łukasz Mucha (OTOP)

Dry biomass

"Dry" biomass is understood as biomass with a moisture content of 14-20%, possibly up to 24%. Dry biomass can be easily sold to farmers. Farmers use dry biomass mainly for mulching or as feed for younger livestock. Drying of biomass takes place in the open air.

Wet biomass

Wet biomass is a problem.

Ideas for wet biomass utilization

1. Biogas plant - wet biomass from the national park gives little gas
2. Briquetting - there is no demand for briquette, it is difficult to sell it
3. Pelleting - the idea was developed, a pellet mill was established but it turned out that it is not effective
4. Composting - compost is not in demand, it is difficult to sell it

- **Pelleting problems**

Silica

SiO2 in the plants from which the biomass is made causes corrosion of pelletizing machines and installations

Humidity/drying

Due to the high humidity of the biomass, it was necessary to dry it before making pellets. The dryer located in the pellet mill was fired with dried and crushed biomass chaff. It turned out that even 100% of the biomass dried in the first run is not enough to dry another portion of biomass.

Ashes

Pellet tests have shown that its calorific value is at a "decent" level, but the ash content is so high that it causes clogging of the furnaces (probably grates).

Withdrawal of the "Green Certificates" program

Until 2014, CHP plants collected pellets as a matter of the "Green Certificates" program, which was connected with receiving donations for energy produced from renewable sources. After withdrawal of the program , power plants stopped buying pellets because it turned out to be unprofitable.

- **Composting - a chance to solve the problem with the wet biomass?**

Current situation

· The amount of composted, wet biomass - 800t per year (1% of biomass mowed annually in the National Park)

· Composting method - wet biomass lies in the open air. Biomass is mixed (to increase oxygen access for aerobic microorganisms), but it rots anyway.

· There are plans to buy a biomass shredders and to develop the composting idea

Main problems

1. No demand for compost

* Farmers do not compost the biomass - perhaps because they do not see a potential profit in it (e.g. fashionable organic farming = healthy food without traces of artificial manures, or even selling the produced compost to larger recipients such as garden stores or wholesalers)

* People use peat soil to fertilize gardens. Perhaps that is why garden stores are not interested in purchasing ready-made compost.

2. Purchase costs of machines (e.g. shredders), the need to develop the right technology

Challenges

Development of a technology for composting biomass made of sedges / reeds, purchase of machines

Promoting the utilization of compost from NP biomass for fertilizing fields and gardens (fashionable, fully ecological, compost from NP). Encouraging farmers to set up compost piles

Development of a compost recipients network

Set up a few smaller composting plants (maybe by NP, if possible)

3.2. Biebrze NP contractors

Table 4 presents information obtained during interviews with former contractors.

Table 4 Interviews with former contractors

Entity	Biomass quantity	Biomass quality	Biomass production - who, when, how	Biomass processing - who, when, how	Biomass use - who, when, how	Possible solutions
1	approx. 5-10 K bales (1 staw bale= approx. 300 kg)	The biomass collected at the right time (before dew) is not (in his opinion) very humid. There is a lot of willow in the material that causes problems		The material was pressed without pre-treatment, it was sold in the form of bales	The biomass was sent to farmers as a bedding material.	1. Biogazownia w Krasowie – Częstkach 2. Biogazownia Dzierżki 3. Finding a place where the biomass bales would be burned (e.g. district heating)
Issues	Not every year is the same and not always the same number of farmers have dicided to buy the same amount of biomass. It is difficult to do business in an unstable market. It would be better to have a regular customer and ensure the profitability of the biomass collection. According to the biogas plant: the biomass should be delivered in a cut form. Additional: to make the biomass collecting profitable, the costs of obtaining it should be at least equal to the costs of sales. The bales are sold for around 30-35 PLN/bale. Most of the biogas plants offer 100 PLN/ton.					
2	It's hard to say. The park once allowed to collect the biomass and once not	Material of poor quality, unrepeatable, very wet and even partially frozen depending on the weather. It is necessary to dry it, which is not worth it at all	Pellets from such biomass give a lot of ash, it is not convenient. Nobody will use it at home	The biomass was collected and transferred to farmers as a bedding material, no special machines were used	Only as a litter material. Most often, the biomass landed on a heap and was not used anywhere	Nobody will be able to manage the biomass in a meaningful way, because of the lack of permanent biomass collection areas, permanent contracts and assistance from the Biebrza National Park.
Issues	The biomass is collected only because of the subsidies. Without this, most people would not decide to collect the biomass. The park has a lot of prohibitions / orders which is very burdensome during cooperation. There are many sanctions, passes, penalties and problems during the cooperation, and you have to endure a lot to persevere in this cooperation					

3	It's also hard to say, depends on the year.	Very poor quality of the biomass, in addition wet.		The biomass was collected and transferred to farmers as a bedding material, no special machines were used	The biomass was sent to farmers as a bedding material.	The production of compost does not make sense. Farmers have manure and do not need compost. Possibly for flowers, but according to him peat is better. The quality of such compost will be poor.	
Issues	Poor pellets are obtained from this biomass. Adding sawdust or something similar improves the properties, but it is still not enough. The biomass is wet, which causes problems.						
4	2-3 tons/ha, 290 ha/year	varied: wet, rotten, sometimes dry, very unreliable		The biomass was given out to local farmers for free or for a small fee.	Some of the farmers used it as fodder or bedding material. For the first 5 years the biomass was given away to OTOP's facility in Trzcianne.	Biogas plants seem to be the most sensible sollution.	
Issues	The ability to sell biomass is very unreliable, depending on the year.						
5	1 ton/ha, 10 ha	dry, homogeneus		The biomass is a by-product and not a goal of mowing.	The subcontractor of the park's contractor takes biomass in return for mowing and burns it somewhere for energy.	This biomass is not a good material for burning or feeding animals.	
Issues	Other people who mow wetter areas have difficulties with selling the biomass.						

4. How others do it: good practices from protected areas

Table 5 Good practices from other protected areas

No.	Protected area	Biomass quantity	Biomass quality	Biomass origin	Biomass collecting who, when, how	Biomass processing - who, when how	Biomass utilization - who, when, how	Issues	Possible solutions
1	Wigierski	In the Wigry National Park, as part of active protection, several actions are taken to prevent the overgrowth of non-forest habitats. Actions include: 1) mowing undesirable vegetation 2) removal of trees and shrubs in meadows and peat bogs with removal of biomass 3) restoration of Natura 2000 habitats - agrotechnical measures. Depending on the situation, it can include: mowing, removing trees and shrubs, clearing trunks, cultivating, harrowing or rolling As part of active protection, area of about 63.37 ha is mowed. The biomass is not baled, so its weight or volume cannot be determined.	In the Wigry National Park, meadow and marsh plants are mowed. Depending on plants, the quality of biomass varies. Meadow vegetation is of better quality, while marsh vegetation (reed) is of much worse quality.	Meadow vegetation, vegetation from wetlands (reeds).	Part of the land (mainly with meadow vegetation) is leased by farmers. Farmers graze animals in the meadows or mow the plants themselves. A smaller part of the active conservation area is managed by the national park. Extensive used land is mowed max 2 times a year. The most important mowing takes place after the plants finish blooming. Shrubs removal takes place cyclically - depending on the needs.	- Meadow vegetation: animals grazing or animals feed (after mowing and drying). - Vegetation from swamp habitats: biomass is removed from the mowing site and allowed to decompose naturally (it is not baled)	- Meadow vegetation: breeding animals feed. - Vegetation from marshy habitats: there was an idea to use it as a fuel in heating plants or home boiler rooms. Apparently, a power plant near Suwałki already has special boilers for burning biomass. There is a possibility that the Wigierski National Park would pursue this solution.	There is an impression that the biomass is not a big problem for the National Park. Generally, they don't give up the idea of passing the biomass to a combined heat and power plant, but probably this is not a necessity for them.	-

2	Narwiański	Poor quality biomass (reed beds) is mowed in the area of approximately 30% of the NP surface. About 700 ha of the NP surface is now leased (in "good times" it was about 70% of the area).	- In the southern part of the NP (near the town - Suraż), the quality of biomass is relatively good. - The remaining parts of NP (those that are mowed) are covered with vegetation, which - after mowing - is of low quality in terms of energy. It is very humid and contains a lot of ash.	- In the southern part of the National Park there are meadows (grass). - In the remaining mowed parts of the NP there are mainly reed beds. There are sedges in some places, but it is much less common.	- In the southern part of the National Park, farmers cut grass with mechanical devices. They have signed contracts (with the NP) to sell grass. - In the remaining parts of the park, mowing is carried out by private tenants. Most of them benefit from subsidies.	-Biomass from the southern part of PN is dried and used for agricultural purposes. -The remaining biomass is baled and transported outside of the park. There are regular inspections of tenants who benefit from the subsidies.	- Biomass from the southern part is used as feed for breeding animals. - There were many ideas on how to make use of the remaining biomass: biogas / composting / pelletization. One of the farmers had a pellet plant, but it did not pay off at all, because the biomass is of very poor quality (it is wet and contains a lot of ash).	There were a lot of ideas on how to make use of the biomass. For sure, the tenants would be interested in some profit, but the properties of the biomass limit the potential usage. Białystok University of Technology is interested in this topic and it would be worth contacting them. There is no problem with the residual biomass in the PN, because the tenants who benefit from subsidies are regularly inspected if they take the mowed biomass outside of the park.	

3	Karkonoski	Mountain meadows - area of about 70 ha	Meadow vegetation becomes hay after drying. The quality of the mowed biomass is rather good.	Meadow vegetation - fresh mountain meadows. "Fresh meadows are relatively common. In Poland, there are several types of fresh meadows. They differ from each other with regard to the floristic composition and the distribution.	First of all, sheep are grazed in the meadows under supervision according to the rules imposed for a given meadow habitat involved in the Natura 2000 program. Part of the area is mowed by farmers (as a part of the extensive agriculture). Farmers are paid by the Agency for Restructuring and Modernization of Agriculture - ARMA. The biomass is dried - the obtained hay is used by farmers as a feed for animals.	Drying (hay for feed) or direct sheep grazing. It is done by farmers.	Generally, the biomass is used as a sheep feed.	The mowed area is so small that there is not even much to talk about. There is no problem with the biomass because it is of good quality and sheep can eat it.	

4	Ujście Warty	approx. 200 ha - mowing through the park. Last year, a tender for about 350 tons, this year about 800 tons. approx. 4.5 tons from 1 ha	Diverse vegetation - meadow and wetlands. It is qualitatively suitable for animal feed	meadows, pastures, sedges and reeds	-part of the area leased by farmers; grazing cattle, mowing for animal feed or in-house storage and sale to Lootor (February) mainly mechanical / manual mowing in indicated (wet) areas; the park carries out mechanical mowing in the area of approx. 200 ha, which are not leased (strict protection, mowing after 1st July)	- farmers collect hay from leased land on their own. - the park can currently store about 400 tons of hay harvested in a short term	Cattle grazing, animal feed, sale to Germany (negligible amounts) - the nearest bridge, carrying capacity up to 3.5 tons, to carry more, transport of about 100 km to the border - is not profitable. A boiler house for willow chips was built in the area, but now the use of this material has been abandoned and it is fired with oil / gas.	Problems with tenders - no buyers, farmers who won tenders last year did not collect the hay. - the Lootor company reports a demand for fuel in February, when the park has practically nothing in stock (they have nowhere to store biomass for over half a year after mowing)	willingness to look for joint solutions with other parks
5	Magurski	approx. 600 ha per year	Good quality biomass. Suitable for animal feed and bedding.	most 95% forests; vegetation of mid-forest meadows, meadows and pastures.	Mechanical and manual mowing of meadows with biomass removal or sheep grazing. Park mechanical mowing with biomass harvesting or with the use of a mulching mower.	the biomass is mowed by the park, the park employees do it as part of their employment with machines owned by the park. Partial processing of biomass (hay bales) into pellets.	grazing animals in leased areas. farmers' use of biomass mainly for animal feed / bedding.	There is no recipient who would use biomass for heating purposes. The recipient in a nearby town (Mielec) closed the business, once biomass was sold to Slovakia, but it is not profitable - no recipients.	Project of reconstruction of a pellet-fired boiler and future extension for firing with whole hay bales.

6	Kampinoski	KPN mows 1200 ha of meadows per year, with a yield of 3600 kg/ha	most of the biomass from the meadows is of poor quality hay, with lots of sedges, from wet and wetlands. Lessees send them to an incinerator or sell them for bedding, wet for haylage, some of them are suitable for fodder.	from fresh (with dominance of grasses) to wet - large-size rushes (dominance of sedges)	about 1000 ha of meadows are mowed under leases, after August 1-15 once a year - 3-5-year contracts. Other meadows are mowed, for example, as part of projects covering an area of about 190 ha, also after August 15 - a service commissioned to external companies, on a smaller scale as contracts for the so-called grass harvesting (with local farmers) - 55 ha. Mowing and harvesting is done by machine (equipment of various sizes), less often by hand with trimmers and rakes	Part of the biomass is exported to the incinerator, part of what we know is sold for haylage or bedding, but it is difficult to determine in what proportions	local incinerator 60% (estimated), own needs of farms 40% (estimated)	especially with the management of wet biomass, not everyone has the option of sending it to incineration plants; often due to flooding of the ground there is a problem with mowing and / or later collecting this biomass; it happens that abandoned bales are found on the edges of meadows or in forests during the inspection, but it is difficult to identify the perpetrator.	

5. Conclusions

1. Plant biomass can be used in a wide range of ways, including biogas and biofuels production, composting, production of pellets, briquette, sedge mats, animal fodder and bedding.
2. In other national parks biomass is used principally as animal fodder.
3. In Biebrza National Park biomass is a by-product of conservation activities and its processing and disposal is predominantly perceived as a problem. Current uses of plant biomass from Biebrza NP are principally animal fodder and bedding. The main issues raised by Biebrza NP current and former contractors were: high variability of biomass properties depending on the time and place of collection, unreliability of demand for biomass and its products, high content of silica, high wetness, high costs of transport.
4. Pelleting of the biomass has already been attempted in Biebrza NP and failed due to biomass properties (high silica content, high yield of ash, high water content), which led to processing difficulties and low quality of the final product.
5. Due to biomass properties and low demand for compost, composting does not seem to be a promising solution.
6. Biogas plants expressed interest in receiving plant biomass from Biebrza NP. If the park or the contractors were willing to cover the transportation costs, it could be considered as viable options for more efficient and sustainable biomass management in Biebrza NP and researched further.
7. Biebrza NP could encourage the use of plant biomass in local communities to reduce the transportation costs. Further research should include: good practices in campaigns and educational projects promoting plant biomass; projects providing support to farmers who incorporate environmentally-friendly practices in their work; initiatives of local governments investing in biomass processing facilities; projects supporting local handicraft based on sedge.

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