REGIONAL CONFERENCE ON INTERNATIONALLY IMPORTANT AZOV – BLACK SEA COASTAL WETLANDS

ODESA, UKRAINE
26 – 27 September 2018

ReedBASE is funded by the German Federal Environment Ministry's Advisory Assistance Programme (AAP) for environmental protection in the countries of Central and Eastern Europe, the Caucasus and Central Asia and other countries neighbouring the European Union. It is supervised by the Federal Agency for Nature Conservation (BfN) and the German Environment Agency (UBA).

implemented by:

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ReedBASE PROJECT PARTNERS

- Michael Succow Foundation, Germany (Lead Partner)
- Institute of Market Problems and Economic-Ecological Research (NAS), Ukraine
- Agricola NGO, Ukraine
- Agency of European Innovation, Ukraine
- Cross-Border Cooperation and European Integration Agency, Moldova
- WWF Danube Carpathian Programme, Romania

Funding
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1. INTRODUCTION

The Azov - Black Sea region contains many globally important areas of wetlands[1]. Reeds *Phragmites australis* often grow prolifically in coastal areas and the floodplains of the inflowing rivers, especially along the northern coast which is characterised by shallow limans (non-tidal estuaries). Indeed, the delta of the Danube River holds the largest extent of contiguous reedbeds (over 350,000 ha) in Europe, and one of the largest in the world. However, extensive modification of these floodplains since the 1950s (for border security, flood control, irrigated crops, forestry and fisheries)[2] has had significant impacts on wetland habitats and biodiversity, as well as wetland ecosystem services. In particular, long-standing monotonous reedbeds have become widespread, displacing species needing more dynamic habitats. In this, they counteract nature conservation targets as well as land use interests and are generally regarded as a nuisance. A further problem is that in order to clear reeds for pasture, local graziers set fires that can ignite large areas, releasing carbon dioxide and smoke that affects the environment and people's health.

Moreover, models of climate change impact on the Danube basin[3] indicate that the lower Danube River floodplain area is likely to experience lower flows, with higher intensity and frequency of floods and droughts, in future. Conservation and restoration of reedbeds including their sustainable utilisation can improve natural water storage capacity to achieve a water balance such that river flood peaks and droughts are mitigated with minimal economic cost.

In recent years, many organisations (NGOs, protected area administrations, research institutes and the private sector) have sought to address reedbed management in a way that can recover wetland ecosystem services, improve biodiversity and also generate a sustainable source of biomass for material utilisation and local energy needs (principally heating). As reeds mostly grow on land that is marginal for conventional agricultural production (due to regular flood events) they represent a substantial biomass feedstock which avoids the 'food or fuel' debate, and has the potential to establish short carbon energy cycles in local communities.

This Background Paper shows that reeds and reedbeds are a largely overlooked renewable natural resource, providing a wide range of ecosystem functions and services with minimal management requirements. The revival and modernisation of traditional reed biomass utilisation based construction materials, together with new innovative uses, can contribute to a reduction in greenhouse gas emissions by substituting fossil fuels (coal, gas, oil). In addition, sustainable reedbed management will also help absorb atmospheric carbon dioxide by fixation in the rhizome layer (eventually forming peat), and enhancement of short term carbon cycling. Where peat soils have been degraded by drainage, the restoration of the natural carbon sequestration function can be achieved by establishing rewetted reedbeds. Such strengthened utilisation of renewable reed biomass resources will also add to rural income diversification.

[1] Boris Alexandrov, Galina Minicheva and Yuvenaliy Zaitsev (2017) Black Sea Network of Marine Protected Areas: European Approaches and Adaptation to Expansion and Monitoring in Ukraine. pp. 227-246 in Goriup, P.D. (ed.) *Management of Marine Protected Areas: A Network Perspective*. Wiley-Blackwell. 312 pages. ISBN: 978-1-119-07577-6.

[2] Goriup, P. and Goriup, N. (2015) Evolution of Politics and Institutions for Conservation of the Ukrainian Danube Delta. pp 319 – 344 in Iordachi,C. and van Assche, K. (eds) *The Bio-Politics of the Danube Delta: Nature, History, Policies*. Lexington Books, London. xxx + 452 pp. ISBN 978-0-7391-9514-7

[3] Michail Nesterenko, Oleg Dyakov, Dumitru Drumea and Mihai Doroftei (2014) Adapting to Change: Climate change adaptation strategy and action plan for the Danube Delta region, Romania - Ukraine - Moldova. Report for the project on "Climate proofing Danube Delta through integrated land and water management" co-financed by European Commission and implemented by WWF Danube Carpathian Programme Romania, Danube Biosphere Reserve Ukraine, Center for Regional Studies Ukraine, NGO Ecospectr Moldova.
http://d2ouvy59p0dg6k.cloudfront.net/downloads/2_danube_delta_adaptation_strategy.pdf

2. REEDS IN NATURE

2.1 ECOLOGICAL CHARACTERISTICS

2.1.1 Botanical features

The Common Reed *Phragmites australis* is a large perennial species of grass. Reeds normally grow to about 2 m high, but much of the plant biomass is contained below ground in a dense mass of roots and rhizomes that can penetrate the soil to a depth more than 2 m. In summer, reeds have flat grey-green leaves about 5 cm wide and 16 to 30 cm long that alternate along the stem. Reeds produce a distinctive feathery purple-brown seed head by mid to late summer. In the autumn, most of the leaves drop off, leaving only the characteristic straw-like stalk and brown seed head commonly seen throughout winter.

Each mature plant can produce as many as 2,000 seeds annually. However, reproduction occurs mainly by vegetative spreading of shoots and rhizomes; long-distance dispersal of seeds eaten by birds or blown by the wind also takes place but colonising new areas by this means can be a slow process.

Reeds favour damp to moderately flooded conditions (normally about 1.5 m water depth, exceptionally to 2.5 m) where it usually grows as the dominant plant species and forms extensive continuous patches known as reedbeds. It occupies a wide range of mineral to organic soil types, as well as fresh to brackish waters varying in nutrient status from oligotrophic to highly eutrophic. It is capable of persisting for many years in sites which have ceased to be wetlands, for example where the source of water to a wetland has been diverted, but does eventually die out.

Reed has a very high level of genetic variability[4], which may or may not be expressed in physical differences. In Eastern Europe, the predominant form of reed has four sets of chromosomes, but a larger form (sometimes called *gigantaea*) with eight sets of chromosomes occurs in the lower Danube region which is taller (up to 4 m high), has broader somewhat darker leaves and has thicker, cane-like stems[5].

2.1.2 Distribution

Reed has a sub-cosmopolitan distribution from sea level up to 2,200 m in altitude. It occurs naturally from north-west Europe south through central and southern Europe to North Africa and south through Southern Africa to the Cape; it also occurs east through Russia and the Middle East to the Far East and south through South-east Asia to Australia, as well as throughout much of Canada south throughout the United States and Mexico as far south as Chile and Argentina. Its global population status appears to be more or less stable[6].

2.1.3 Invasive properties

Reed is capable of colonizing and becoming a serious weed in some types of irrigated agriculture such as rice paddies, fish ponds and waterways. Abandoned arable land in the lower Danube floodplains tends to revert to reedbed within five to ten years. In North America, the introduction of non-native European genotypes during the early 20th century (from packing materials and ballast containing peat) has over the last 150 years resulted in extensive "cryptic" invasion of reeds where the introduced type has displaced native types as well as

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[4] Luciana Achenbach, Carla Lambertini, Hans Brix; Phenotypic traits of *Phragmites australis* clones are not related to ploidy level and distribution range, *AoB PLANTS*, Volume 2012, 1 January 2012, pls017, https://doi.org/10.1093/aobpla/pls017

[5] Hanganu, J., Mihail, G., Coops, H. Responses of ecotypes of *Phragmites australis* to increased seawater influence: a field study in the Danube Delta, Romania. Aquatic Botany, 1999, vol. 64 (pg. 351-358)

[6] http://www.iucnredlist.org/details/164494/0

expanding to regions previously not known to have reeds[7]. The invasive variety of reeds creates tall, dense stands which degrade wetlands and coastal areas by crowding out native plants and animals, blocking shoreline views, reducing access for swimming, fishing, and hunting and can create fire hazards from dry plant material[8].

2.2 ECOSYSTEM FUNCTIONS

2.2.1 Hydrological amelioration

Reedbeds, depending on their size and location, can play important roles in ameliorating local hydrological conditions[9,8]. These include:

- providing buffer zones between farmland and waterbodies where nutrient run-off can be trapped;
- accumulating heavy metals from water and sediments;
- preventing erosion of channel banks;
- acting as sedimentation basins;
- reducing the energy and flow of water during flood events;
- influencing local climates, especially rainfall patterns.

2.2.2 Habitat provision

Reed is an important habitat former, often being the first coloniser of open water margins by forming a thin fringe around ponds, lakes and coastal areas. Reeds provide food, shelter and breeding areas for a high diversity of other plants, fish, insects, amphibians, birds and mammals. Indeed, the vast reedbeds of the Danube delta are recognised as a global hot spot for their biodiversity and most are protected by national and/or international designations[10]. Both the native and invasive reeds in North America are considered to provide significant ecosystem services[11].

As the reeds grow and form a layer of rhizomes, as well as trapping sediments, they can expand further into the water. Sometimes, during rough weather, parts of the reedbed may breakaway and form a floating island which serves as a safe place for birds such as pelicans to breed. If the whole lake is shallow, reedbed expansion can continue until the entire water surface has been covered. As the reedbed rises in height other plants can also colonise, including shrubs and trees such as willow *Salix*, alder *Alnus* and poplar *Populus,* which will eventually shade out the reeds. Ultimately, this process of succession leads to new wet woodland habitats.

2.2.3 Carbon sequestration

Reedbeds form on waterlogged soils in which the availability of oxygen is low and microbial decomposition processes that assist nutrient uptake by roots are inhibited. Reed has adaptations to cope with these conditions such as hollow stems that permit gaseous exchange with the extensive rhizome system that lies at or below ground level. However, the decomposition of organic materials such as leaf litter is retarded and incomplete, which results in the accumulation of these materials in the form of peat. Peat soils are the only type with a persistent storage process of carbon and therefore they are among the most important carbon-accumulating ecosystems of the world[12]. About 2–16% of the plant biomass produced per year is accumulated in peat soil.

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[7] Kristin Saltonstall. Cryptic invasion by a non-native genotype of the common reed, *Phragmites australis*, into North America. Proceedings of the National Academy of Sciences Feb 2002, 99 (4) 2445-2449; DOI: 10.1073/pnas.032477999

[8] https://www.watershedcouncil.org/uploads/7/2/5/1/7251350/deq-ogl-guide-phragmites_204659_7.pdf

[9] Wolfgang Ostendorp. reedbed characteristics and significance of reeds in landscape ecology. Seeuferzerstörung und Seeuferrenaturierung in Mitteleuropa (Limnologie aktuell ; 5). Stuttgart: Schweizerbart, 1993, pp. 149-160.

[10] Paul Goriup, Grigore Baboianu and. Joseph Chernichko. The Danube Delta: Europe's remarkable wetland. British Birds 100, April 2007, 194–213.

[11] Kiviat E. Ecosystem services of *Phragmites* in North America with emphasis on habitat functions. *AoB Plants*. 2013;5:plt008. doi:10.1093/aobpla/plt008.

[12] Maja Richert, Sanna Saarnio, Sari Juutinen, Jouko Silvola, Jürgen Augustin,and Wolfgang Merbach. Distribution of assimilated carbon in the system *Phragmites australis*-waterlogged peat soil after carbon-14 pulse labelling. Biol Fertil Soils (2000) 32:1–7.

3. REEDS AS A RENEWABLE RESOURCE

The utilisation of reed as a renewable resource for human benefit has been subject to a recent review[13]. This section reprises this work, together with some further information and updates.

3.1 TRADITIONAL USES

3.1.1 Fodder

The roots, stems, seed and leaves of reed have been and are still used for both human and livestock consumption. Reed has a high polysaccharide content giving it a sweetish flavour. One of the main reasons for late winter burning of reedbeds in Ukraine and Romania is to provide a fresh flush of shoots for cattle and horse grazing: although young reed is a good source of nitrogen, potassium and manganese, when mature it has a rather low nutrient value and is mainly a source of fibre[14].

3.1.2 Fuel and horticulture

The cutting and drying of peat from reedbeds for use as fuel and for horticulture has been extensively practised for thousands of years. Unfortunately, in many areas peat abstraction has had negative environmental effects through loss of productive soils, reduced surface water retention and regulation, lowered water tables, air pollution, release of stored carbon and loss of biodiversity[15].

Green shoots of reed can be composted[16] or used to generate methane (one kilogram of green reed biomass yields 0.4–0.5 m^3 of biogas with a maximum methane content of 55–60 %[17]). However, large-scale harvesting of live reed should be done only after ensuring that the status of biodiversity associated with reeds will not be negatively affected.

3.1.3 Construction

Reeds also have a long history of use for covering roofs (thatch), making wall panels, fencing and shades, weaving into mats, and adding stabilisation for small boats. At the present time, cutting reed for thatch is by far the main use of the material in the lower Danube region. Recent research shows that Europe is the largest market for thatching material worldwide, with a total annual consumption of some 29,400 tons of reed, about half of which is harvested in Romania and Ukraine[18]. However, it is notable that imports from China have increased significantly from about 2007, for reasons of price and durability. There is concern that the export and domestic demand for European reed will be further replaced by imports from China, and steps are needed to improve competitiveness and quality.

3.1.4 Paper and paperboard manufacture

Reed can serve as a raw material for the production of cellulosic pulps for the manufacture of paper and / or

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[13] J.F. Köbbing, N. Thevs and S. Zerbe. The utilisation of reed (Phragmites australis): a review. Mires and Peat, 2013/14, vol. 13, pp 1 – 14.

[14] Baran M., (2002) The Common Reed (*Phragmites australis*) as a Source of Roughage in Ruminant Nutrition, Acta Vet. Brno, 7 I : 445- 449

[15] Wichtman, W., Schröder, C. and Joosten, J. (Eds) (2016) Paludiculture - productive use of wet peatlands: Climate protection - biodiversity - regional economic benefits. Schweizerbart Sche Vlgsb. ISBN 978-3510652839

[16] Royal Society for the Protection of Birds (2008) Sustainable habitat management: composting for conservation. Guidance Note.

[17] Komulainen, M., Simi, P., Hagelberg, E., Ikonen, I. & Lyytinen, S. (2008) Reed Energy - Possibilities of Using the Common Reed for Energy Generation in Southern Finland. Reports from Turku University of Applied Sciences, 67, 81 pp. Online at: http://julkaisut.turkuamk.fi/isbn 9789522160355.pdf

[18] Wichmann, S. and Köbbing, J.F. (2015) Common reed for thatching – A first review of the European market. *Industrial Crops and Products*, **77**: 1063–1073

paperboard, because it has a high content of cellulose (33-36%) and hemicellulose (20-22%)[19]. However, efforts to commercialise its use in Romania during the 1950s[20] and Ukraine (in Izmail) during the 1970s failed because of the damage done by machinery to the reed rhizomes, and low bulk density of the material compared with wood that increase the costs of harvesting and transport to the processing plant.

In some coastal regions of China, however, the expansion of reed use has been driven by the paper industry since the 1950s. In the Liaohe Delta in north-eastern China, the stand of reed now covers an area of approximately 800 km^2 (the largest extent in the world) but this is down from some 1,000 km^2 in previous years. In these wetlands the annual yield of biomass for paper production is 400,000 tons, which results in a production of about 180,000 tons of paper pulp[21].

3.2 NOVEL USES

3.2.1 Wastewater treatment

As long as humans have discharged sewage into the environment, wetlands have more or less intentionally been involved in the cleaning of the wastewater. In the mid-1970s, artificial wetlands started to be constructed for the purpose of treating different kinds of wastewater, and more recently constructed wetlands have been developed into fully engineered systems[22]. Constructed wetlands are most often used as the second wastewater purification stage, meaning that before actually reaching the constructed wetland body, the wastewater is subjected to preliminary and/or primary treatment. Various biological and physical processes such as adsorption, filtration, precipitation, nitrification and decomposition take place during operation of the constructed wetland.

The role of plants in the purification of wastewater is rather secondary (as biological treatment is mostly carried out by microorganisms), but they are nevertheless an important component of constructed wetlands. Their most important task is to keep the main filtration layer permeable though the growth of roots and rhizomes. In addition, the area around plant roots is a favourable medium for the growth and development of microorganisms. Although various plants can be used in constructed wetlands, reeds are particularly favourable as they are the only marsh plants whose roots extend to more than 50 cm in depth, and they are also insensitive to change of water level and nutrient load. In addition, reed litter provides protection against freezing during winter months[23].

3.2.2 Renewable energy

The chemical characteristics of reed compared with the German pellet DIN and European wood pellet standards standard and other biomass fuels from Ukraine and Germany largely fulfil the criteria of the European wood pellet standard EN-plus as well as many parameters of the stricter German pellet DIN[24].

The net calorific value of reed pellet is some 15 GJ/t, which is equivalent to about 0.5 t of coal, 395 m^3 of gas, or 405 l of crude oil. This compares quite favourably with the energy content of other agri-pellets such as wheat straw, *Miscanthus* and rice husks. In terms of chemical composition, reed has no mineral content that

[19] Maria Dolores Gomez-Sanchez1, Rafael Sanchez1, Eduardo Espinosa1, Antonio Rosal2, Alejandro Rodriguez. Production of Cellulosic Pulp from Reed (Phragmites australis) to Produce Paper and Paperboard. Bioprocess Engineering 2017; 1(3): 65-68. doi: 10.11648/j.be.20170103.11

[20] Aurel Lup, Indira Deniz Alim, Liliana Miron. 2017. Agriculture in the Danube Delta. https://mpra.ub.uni-muenchen.de/85373/1/MPRA_paper_85373.pdf

[21] Brix, Hans & Ye, Siyuan & Laws, Edward & Sun, Dechao & Li, Guosheng & Ding, Xigui & Yuan, Hongming & Zhao, Guangming & Wang, Jin & Pei, Shaofeng. (2014). Large-scale management of common reed, Phragmites australis, for paper production: A case study from the Liaohe Delta, China. Ecological Engineering. 73. 760-769. 10.1016/j.ecoleng.2014.09.099.

[22] Vymazal, Jan. (2010). Constructed Wetlands for Wastewater Treatment. Water. 25. 10.1016/j.ecoleng.2005.07.002

[23] Davor Stanković (2017) Constructed wetlands for wastewater treatment. GRAĐEVINAR 69, 8, 639-652. DOI: https://doi.org/10.14256/JCE.2062.2017

[24] ReedBASE project desk study, 2017. https://drive.google.com/open?id=1BFnTVzw_7Iw-M7ZWF08uoWCU4NsEwC7d

exceed the standards for wood pellets, whereas wheat, rape and *Miscanthus* have problems. The ash content is about the same as for other agri-pellets, but it is notable that 80% of reed ash is composed of amorphous silica that could be a useful feedstock for other industrial processes. Overall, reed pellet properties are well within the limits for commercial (but not domestic) use in biomass boilers.

3.2.3 New construction materials

Reeds are increasingly being used to produce composite building materials such as moisture-resistant MDF boards or granulate panels. The latter are made by mixing chopped winter-harvested reed (including both stems and leaves, as well as any waste from thatching) with glue or clay. Standard granulate panels are 110 cm × 60 cm × 3 cm thick and can be used as insulation or plaster base, or to construct partition walls.

The use of reed particles in composite boards provides high performance mechanical properties because the low density of reed particles causes better adhesion during hot pressing; more particles act together thereby better distributing the load exerted on them[25].

3.2.4 Chemical feedstocks

Biomass is distinguished from other renewable resources in that the energy it contains is chemical. This characteristic allows biomass to be used for several purposes apart from electricity and heat generation, such as the production of liquid fuels and chemicals[26]. Indeed, biomass is the only renewable source of useful organic carbon molecules. Nevertheless, the vast majority of biomass used now is burned to generate electricity while only a relatively small amount is converted to higher-value products, largely covered by ethanol. Yet, energy production is the sector where fossil resources can most easily be replaced by alternative sources such as wind, geothermal, or nuclear.

Although biomass is annually renewable it is still a globally limited resource, especially when produced in a sustainable manner. As the use of biomass in industry increases, it will at some point become scarce. Accordingly, research is being undertaken to convert biomass to higher-value products and used as a feedstock for the chemical industry. The amount of oil presently used in the chemical industry to produce fossil platform chemicals (methanol, ethylene, propylene, butadiene, benzene, toluene and the xylenes) is comparable in volume to the total amount of biomass harvested for non-food purposes. The potential biomass supply should therefore be sufficient to replace oil in this application, and a complete transition from petroleum to biomass feedstocks seems feasible for the production of chemicals, although this implies significant technological and economic challenges.

Furthermore, ligno-cellulosic biomass can be used more efficiently than fossil sources as a feedstock for the production of oxygen-rich chemicals such as ethylene glycol, acetic acid and acrylic acid. Since reeds have a relatively high content of lignin and cellulose (about 20% and 40% respectively, or 60% overall on a dry ash-free basis)[27], they have a high potential for future use as a biomass feedstock for conversion to high-value industrial chemicals.

It should also be noted that reed ash is a rich source of biominerals such as amorphous silica (a reason for its high resistance to water). It has been found that reed silica can used for cost-effective manufacture of anodes in lithium ion batteries[28] and has potential for improving soils and strengthening concrete.

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[25] Notabo Hlabano, Lloyd N. Ndlovu, Nqobizitha R. Sibanda, Lindani K. Ncube (2018) Production and Characterization of Reed and Wood Particles/Phenol Formaldehyde Resin Composite Board. International Journal of Composite Materials 8(2): 25-31. doi:10.5923/j.cmaterials.20180802.01

[26] Vennestrøm, P. N. R., Osmundsen, C. M., Christensen, C. H., & Taarning, E. (2011). Beyond petrochemicals: The renewable chemicals industry. *Angewandte Chemie International Edition*, *50*(45), 10502-10509. DOI: 10.1002/anie.201102117

[27] Zhao H, Yan H, Zhang C, Liu X, Xue Y, Qiao Y, Tian Y, Qin S. (2011) Pyrolytic Characteristics and Kinetics of *Phragmites australis.* Evid Based Complement Alternat Med. doi: 10.1155/2011/408973

[28] Liu, Jun & Kopold, Peter & A. van Aken, Peter & Maier, Joachim & Yu, Yanlin. (2015). Energy Storage Materials from Nature through

4. THE ReedBASE PROJECT

Led by the Michael Succow Foundation[29], the Reed Biomass as a Source of Sustainable Energy (ReedBASE) project commenced in September 2016 and its first phase ended in March 2018[30]. It assessed the use of reed biomass as a source of sustainable energy as well as raw material for other products in the floodplains of the Prut, Danube and Dniester Rivers in Ukraine and Moldova, and to a limited extent Romania. ReedBASE has so far achieved the following project goals:

- Building a database comprising 118 relevant stakeholders from government, business, and research bodies, from Ukraine (82) and Moldova (36);
- Compiling and publishing an in-depth Desk Study on wetland biomass resources in the lower Prut, lower Danube, and lower Dniester floodplains;
- Conducting two stakeholder "road shows", meeting with groups of relevant stakeholders during field tours through the project region;
- Communicating the ReedBASE results on national and international scientific and policy levels;
- Establishing a ReedBASE innovation cluster based within the National Academy of Sciences of Ukraine.

The preliminary results from the first phase of the ReedBASE project concerning sustainable energy and carbon stocks are worth mentioning. Assuming that about 70% of the reedbed area is accessible (excluding areas under strict protection or unsuitable for harvest), that a two-year harvest rotation is used, that an average yield of 8 tons of dry reed per hectare cut is obtained, it is estimated that in its current state of management, the project area could in time sustainably generate some 100,000 tons of dry reed biomass per year. In energy terms, this is equivalent to almost 50,000 tons of coal, or 39.5 million cubic metres of gas. Thus, using reed biomass would not only provide a substantial amount of energy, but also avoid emitting the equivalent of some 79,000 tons of CO_2 from burning fossil fuels[31].

In addition, the extent of organic soils, which are particularly suitable for paludiculture and carbon accumulation and storage, cover significant areas in the Prut (3,873 ha) and lower Dniester (20,466 ha) study sites. Although further research is needed concerning the organic layer depth, organic bulk density and carbon content, assuming modest estimates of an average depth of 10 cm and 35 kg of carbon per cubic metre, then according to estimates in Lindsay[32], the organic soils in the study areas would contain in the order of 850,000 tons of carbon. The preservation of this stock by preventing further drainage, if not actually increasing it by rewetting already drained areas, is important for management of the region's carbon budget.

5. CHALLENGES AND FUTURE PROSPECTS

In the Azov-Black Sea wetlands, reeds are today regularly harvested on a significant scale only to produce

Nanotechnology: A Sustainable Route from Reed Plants to a Silicon Anode for Li- Ion Batteries. *Angewandte Chemie International Edition*. 54. 10.1002/anie.201503150.

[29] Other partners: Institute of Market Problems and Economic-Ecological Research (NAS), Ukraine; Agricola NGO, Ukraine; Agency of European Innovation, Ukraine; Cross-Border Cooperation and European Integration Agency, Moldova; WWF Danube Carpathian Programme, Romania

[30] The project (No. 76845) was funded by the German Federal Environment Ministry's Advisory Assistance Programme (AAP) for environmental protection in the countries of Central and Eastern Europe, the Caucasus and Central Asia and other countries neighbouring the European Union. It was supervised by the Federal Agency for Nature Conservation (BfN) and the German Environment Agency (UBA).

[31] Paul Goriup, Andreas Haberl, Oleg Rubel, Valeriu Ajder, Ivan Kulchytskyy, Anatoliy Smaliychuk, Natalia Goriup. Potential for renewable biomass use in reedbeds in the lower Prut, Danube and Dniester floodplains of Ukraine and Moldova. In press, Mires and Peat.

[32] Lindsay, R. (2010) Peatbogs and carbon: a critical synthesis to inform policy development in oceanic peat bog conservation and restoration in the context of climate change. Report to the Royal Society for the Protection of Birds, Sandy, UK. 344 pp. Available at http://ww2.rspb.org.uk/images/peatbogs_and_carbon_tcm9-255200.pdf

roof thatch that is mainly exported to Western Europe. This activity is carried out in winter between November and March, when the reed stems have died and the ground is drier, if not frozen. As a result, the thatch industry provides a source employment for local people in harvesting, processing and exporting reeds at a time when farm work is scarce.

The amount of reed harvested for any of the other purposes described above is currently negligible and represents an enormous missed opportunity for ecologically sustainable regional development. Moreover, the amount of reed being exported has declined in recent years, and the European market is turning to Chinese imports instead. Partly this is a matter of price, but there is also evidence of a decline of reed quality in the region. The causes of this are variously attributed to inappropriate water management, over-intensive harvesting, poor storage conditions and fungal disease. The future of reed harvesting is therefore in question, and exacerbates the problem of undesirable reed spread as well as reduction of employment.

As many of the reedbeds are situated on organic soils (peat) they are suitable for an emerging wet peatland management system (known as paludiculture) with reedbed cultivation, harvest of above ground reed biomass at high water tables, and a consequent biomass utilisation for a wide range of purposes[33]. Paludiculture has the potential to cut substantially greenhouse gas emissions from drained peat soils hence helping states to meet the UNFCCC global action plan to limit global warming to well below 2°C, agreed in Paris in December 2015. At the same time, paludiculture contributes to:
- Peatland and wetland restoration;
- Sustainable regional planning;
- Provision and safeguarding of ecosystem services;
- Substitution of fossil resources;
- Generation of alternative sources of income in structurally weak regions.

As much as 30% of the reed harvested for thatch is discarded during processing, and such "waste reed" amounts to several thousand tons a year; seeking additional uses for this existing by-product would already mitigate uncontrolled illegal dumping and burning and increase economic efficiency. Developing alternative uses for reed such as renewable energy would also be a way to reduce the risk of a loss of market share in thatching. Unfortunately, there remains a big gap between the current reality and the potential for new uses of reed biomass.

Unfortunately, there remains a big gap between the current reality and the potential for new uses of reed biomass, because of infrastructure and operational framework deficiencies, as well as low awareness of the benefits of switching from drainage based utilisation of marginal sites to wet reedbed management. While there are significant benefits to gain, there are also significant obstacles involved even in implementing relatively simple reed processing plants, and achieving economic viability for such small-scale initiatives is difficult. To address such obstacles, it will be necessary to draw together the various actors (research bodies, government, businesses and civil society) in a way that allows them to collaborate on innovative approaches for using wetland biomass.

5.1 RESEARCH AND INNOVATION

To date, there has been almost no scientific research dedicated to how to ensure that native reeds can be grown, harvested, processed, stored and used while maintaining ecological sustainability and high quality. Different theories have been proposed for declining quality of thatch reed (the lifetime on the roof has declined from 20 – 30 years to almost half that now). These range from too high nitrogen content (which makes the stems brittle), to overharvesting (cutting the same area too often which reduces the vigour of regrowth) and infections by

[33] Wichtmann, W., Schröder, C. and Joosten, J. (Eds) (2016) *Paludiculture – productive use of wet peatlands: Climate protection - biodiversity - regional economic benefits*. Schweizerbart Sche Vlgsb. ISBN 978-3510652839.

fungi which have been spreading in Europe in recent decades.

A broad range of microfungi are known to affect both the growth of the plant (e.g. highly pathogenic species such as *Puccinia magnusiana* and *Pythium phragmitis* that infect leaves and stems) as well as the white rot *Mycena* which causes premature decay in harvested reed used for thatch. However, there are no laboratory facilities available in the region that can identify these pathogens through standard isolation, incubation and phytopathological techniques, despite their evident impact on an important economic resource.

Universities and research institutes in the region should engage with international networks and organisations, as well as strengthen their investigations of, and train local expertise in, aspects such as:

- Evaluation of ecosystem services improved by wetland restoration and wise management
- Paludiculture opportunities on peat soils
- Assessment of carbon stocks in wetland biomass and organic soils
- Reedbed (re)creation and management especially for carbon sequestration
- Long-term monitoring of how harvesting regimes affect habitat diversity and quality
- Designing optimal biomass harvesting and processing equipment
- Control of pathogens
- Innovative construction materials from wetland biomass
- Improving the economics of wetland biomass utilisation

5.2 GOVERNMENT ROLE

The government sector in the region has a major role to play in facilitating the sustainable use of wetland biomass within its overall green energy policy. Topics to be addressed include:

- Enforcement of water protection zone management
- Seeking to rewet floodplain areas where appropriate
- Promotion of short rotation coppice for materials and energy
- Recognising reed as an energy / technical crop that can be grown on designated farmland
- Incentive schemes for research and business creation at local level to initiate ecologically sustainable economic development based on short carbon cycles
- Certification of product quality (thatch, briquettes and pellets) according to European standards
- Delivering necessary infrastructures such as electricity supply, communications and transport

5.3 BUSINESS INVESTMENT

The private sector is the main driver for the development and marketing of new products, resulting from appropriate wetland biomass policies and incorporating research results. There are opportunities in many aspects of the biomass energy supply chain, including:

- Development and sale/lease of biomass harvesting equipment
- Development and sale/lease of biomass processing equipment
- Development and sale/lease of end-use equipment (boilers and CHP units)
- Repair and servicing of biomass-related equipment
- Sale of products, locally and abroad

5.4 CIVIL SOCIETY ENGAGEMENT

Civil society organisations can play an important role by promoting awareness, increasing acceptance of and raising demand for wetland biomass products by:

- Creating awareness of wetland biomass value as a natural capital asset
- Promoting consumption of locally produced wetland biomass products
- Discouraging *ad hoc* burning of reedbeds as anti-social behaviour and wasting resources
- Promoting the role and value of ecosystem services of wet- and peat-land ecosystems especially in the climate change context

5.5 A WAY FORWARD: ReedBASE CLUSTER DEVELOPMENT

Innovation for efficient and sustainable use of renewable resources is gaining global importance and needs transboundary efforts for optimisation. The "Triple Helix" approach is one in which the potential for innovation and economic development is enhanced by close, mutual interaction between government, research bodies, and industry. For example, in 2008 the EU adopted Regulation (EC) No 294/2008 to establish the European Institute for Innovation and Technology (EIT)[34] to connect and stimulate cooperation between top-level academic and industrial research and development institutions. EIT currently administers five so-called Knowledge and Innovation Communities (KICs) from their headquarters in Budapest, Hungary.

Forming a Triple Helix cluster is a good way to promote innovation for sustainable use of wetland biomass, and obtain the inherent ecosystem benefits this approach entails. The final act of the first phase of the ReedBASE project was to convene a meeting of parties in Odessa on 25 October 2017 in order to sign a Memorandum of Understanding which formally established the ReedBASE Innovation Cluster for cooperation in the field of Innovative Utilisation of Renewable Biomass from Ecologically Sustainable Reedbed Management. The founding parties of the MoU were: the Institute of Market Problems and Economic-Ecological Research, National Academy of Science of Ukraine (MoU leader); Michael Succow Foundation, Greifswald, Germany; Cross-Border Cooperation and European Integration Agency, Cahul, Moldova; Agricola NGO, Odesa, Ukraine; Agency of European Innovation, Lviv, Ukraine; Danube Region Centre for Sustainable Development and Ecological Research, Kiliya, Ukraine; and BioTop private company, Reni, Ukraine. The MoU is open to signature by other interested organisations from European countries and currently has 11 signatories.

The central role of the ReedBASE cluster is to develop initiatives and address obstacles that impede ecologically and economically sustainable use of the considerable existing and potential wetland biomass resources available in the region. The combination of environmental research, engineering and practical implementation of sustainable wetland management and paludiculture will lead to innovations that contribute to the:

- Restoration of ecosystem services including amongst others the habitat improvement for migratory birds and waterfowl and the mitigation of greenhouse gas emissions;
- Nutrient retention and water purification in reedbeds and therefore improvement of water quality of the Black Sea;
- Development of climate change adapted land management schemes;
- Provision of renewable biomass for energy production and material use;
- Reduction of energy imports on regional scale;
- Support of regional economies and increase of local job perspectives;
- Establishment of showcase paludiculture-based enterprises.

As a result of the second phase of the ReedBASE project, the ReedBASE cluster has established a secretariat and will gain a legal identity as an association under Ukrainian law. It will identify opportunities to strengthen its membership base, and to promote good practice for reedbed management throughout Europe. In particular,

[34] https://eit.europa.eu/

ReedBASE aims to undertake activities such as:

- Screening eligibility for relevant project grants e.g. EU Transnational Danube Programme, EU Horizon 2020, EU Neighbourhood Programme, EIT and other national and bilateral schemes
- Forming consortia of members to bid for grants for research and development projects
- Joining the Triple Helix Association (https://www.triplehelixassociation.org/about-tha)
- Seeking collaboration with the European Institute of Innovation and Technology and relevant Knowledge and Innovation Communities.