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CONTROLLED RUN-OFF AS A METHOD OF GRASSLAND IRRIGATION AND PEATLAND PRESERVATION IN THE NOTEC RIVER VALLEY

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Summary

The paper describes the problems which are encountered in the upper Notec river catchment in agriculturally used peatlands, with hay-making as the main land use type. Economic situation in agriculture and lack of are the main reasons for the cessation of irrigation system maintaining and conservation as well as controlled water management. Decreased interest in utilization of water facilities is observed. Taking into account the present situation of agriculture in the region and the economic state of most farmers, the simple and cheap technique of controlled run-off of water from existing irrigation-drainage systems is recommended to demonstrate and implement practically as a method of irrigation and peatland protection.

Key words: Noteć river valley, peatland, subirrigation, controlled outflow

INTRODUCTION

River valleys have been utilized by agriculture for many centuries, with hay-making and grazing as the main land use types. Traditional management led to the development of many unique ecosystems changed in different degree and transformed to different habitats. Agriculturally management river valleys with peatland sites present not only the place for human life and agriculture but also the natural reserves required protection. Their protection and human economy in the harmony with nature is not a purely ecological problem but also an economic, sociological and educational challenge.

Taking the upper Notec river catchment as an example it is demonstrated which problems are encountered in agriculturally used river valleys and how far the simple method of controlling run-off from peatlands can be used for maintaining soil moisture proper for agriculturally used meadows and for peatland protection.

PRESENT STATUS OF GRASSLANDS IN THE NOTEC RIVER VALLEY

The upper Notec river catchment occupies an area of 4098 km^2. It is located in the physico-geographical region called the Wielkopolskie Lakeland, in which the number of peat deposits ranges from 10 to 25 on the area of 100 km^2 (Ilnicki 2002). Index of relative peatland occurrence in the province, where the analysed region is placed, is about 6%. The Notec river catchment is a level, in about 30-60% wooded agricultural land. The area of the upper Notec river valley is equal to 21000 ha. Peatlands cover an area of 8950 ha (42%) (Churski and Okruszko 1961, Ilnicki 2002). The region is highly differentiated in terms of natural conditions, with a corresponding diversity of its peatlands and non-peat hydrogenic sites. The heterogenity is further increased by the anthopogenic factor – ecosystems range from natural to highly transformed by human economy.

In the catchment there are peatlands of different size, including fens and transitional bogs of hydrogenic soils under grassland and woodland. Peatlands are most typically composed of reed swamp or tall sedge fen peat. The most common type are fens with reed swamp vegetation. Different soil types occur in the Notec river valley. There are hydrogenic soils: organic, mineral-organic and mineral. Among them mostly peat-moorsh soils occur in different mucking and silting stages. Mineral-moorsh soils lie on different mineral formations. At valley margins peat-moorsh soils lie on alluvial formations and alluvial and deluvial soils lie on different mineral formations.

Peatlands in the Notec river valley vary in their degree of transformation by man. Fully natural ecosystems may be encountered alongside seriously degraded ecological systems. Non-degraded ecosystems occur practically only close to a river course. The transformed natural grassland ecosystems in peatlands are located in areas used agriculturally.

Grassland have been transformed by economy to a different extent. Many areas have been drained as a result of land reclamation for many years (since the middle of the 19th century). The agricultural use of wetland areas led to their transformation into extensively managed wet and moist grasslands and the more intensively managed slightly moist and dry grasslands. Apart from extensively managed meadow and pasture-land much of the grassland area is used intensively, including full cultivation. A part of the peatlands have been cut over or

continue to be exploited for peat. Some peatlands are completely degraded and have been turned into arable land. It caused in great degree the degradation of peatlands and their natural resources comprising mainly degradation of organic matter of soil, natural plant communities and whole natural ecosystems. Some peatland sites have been indicated as being high in nature value.

The region is one of the driest in central Europe. Pedoclimatic and hydrological conditions are variable both in time and space in the Noteć river catchment. The Noteć river catchment is the area with the considerable drought hazard. It is the region with the lowest annual precipitation amount in Poland. The average annual precipitation rate for this area is about 550 mm. The average sum of precipitation in the growing season is only 270 mm. Besides the average mean daily values of air temperature are high and air humidity – low. It causes the occurrence of severe and frequent droughts and scarcity of water resources. The periods of rainfall excess also occur, especially in spring and in July.

Irrigation in the Notec river valley plays an important role in mitigating the effects of drought on crop production. In recent years the role of irrigation in supplying water to maintain proper moisture conditions in grassland ecosystems has been stressed. Under climatic, soil and economic conditions occurring in the region, systems of gravitational irrigation on permanent grasslands in low-lying river plain areas, situated in the direct vicinity of the river and its tributaries, on vast reclaimed lowland post-swampy territories, are applied. Such systems consist of a network of ditches and control structures, supplemented with a network of drain pipes in some irrigation units.

Gravitational irrigations on permanent grasslands, being developed or improved on reclaimed (dewatered) organic peat soils, have the longest tradition in the upper Notec river valley. At present subirrigation systems are installed on the area of about 4200 ha, but only 20-50% are in use every year. Introduction and performing of gravitational irrigation on these lands has been caused by the need of restoring water-humidity equilibrium of earlier dried post-swampy areas which were threatened with a serious natural degradation (oxidation of organic mass and its decomposition) as well as by the economic one (decrease and high variability in yielding in the particular growing seasons as well as in the particular years due to irregular distribution of precipitation and its frequent deficits). The techniques with controlled drainage (controlled run-off) and with a constant water level are commonly used for maintaining groundwater level in the drainage-subirrigation systems. Subirrigation with a constant water level assumes drainage during spring to the optimal groundwater level, which assures the volumetric air content of 10% in the root zone. Then the groundwater table depth is kept close to this optimal value. This guarantees the required air content in the root zone during periods of excess rainfall (drainage) and sufficient capillary rise during periods of drought (subirrigation) (Brandyk et al. 1993).

MAIN THREATS TO PEATLANDS

The river valley peatlands apart from natural values are important for economy. For many years they have been a source of fodder (meadows and pastures). To intensify agriculture in the region, systems of drainage and irrigation-drainage ditches were set up. These projects led to the lowering of the groundwater table, making favourable conditions for agriculture, but at the same time resulting in unfavourable changes in peatland ecosystems, in degradation of peat soils, in mineralization of organic matter, in declining biodiversity. One of the main dangers for peatland sites being used agriculturally is overdrying of the soil. Apart from this anthropogenic reason of overdrying of peat soils, frequent atmospheric, hydrologic and soil droughts in the region have their share in the degradation of peatlands.

The effects of subirrigation of permanent grassland in peatlands with the subirrigation systems for maintaining required soil moisture are associated with the quality of operation and maintenance (exploitation) of these systems. Where exploitation of facilities is proper and water uptake is provided, one may avoid the negative effects of droughts and even obtain higher productivity. Subirrigation systems are largely degraded and used only to a small extent if at all. It can be estimated that about 20% of irrigation network and facilities are degraded and decapitalized. From the remaining 80% only about 20% of existing and competent subirrigation systems are in use every year.

Economic situation in agriculture and lack of funds by farmers, farmer associations and local government units responsible for amelioration in the catchment, are the main reasons for the cessation of irrigation system maintaining and conservation as well as controlled water management. Decreased interest in utilization of water facilities is observed. A large area of grassland are abandoned due to less interest in fodder production and its market prices. Additionally land ownership and land structure (small farms, conflicts of interest in exploitation of water systems involving the area of several farms) are unfavorable as regard to proper water management in the river valley.

ACTIONS AND METHODS FOR COUNTERACTING DRYING ORGANIC SOILS AND FOR PROTECTION OF PEATLANDS

The adverse processes mentioned above should be counteracted through active protection of the natural and anthropogenically changed environment. This includes protection of surviving peatlands which have not been used for agriculture, peatlands extensively agriculturally-used as well as those transformed to a large extent due to intensive use and existing drainage-irrigation systems.

It is worth to consider the need and the possibility of restoring grassland sites which have been abandoned in recent years.

Water conditions should be improved in order to stop the negative effects of overdrying. This involves the creation of conditions and undertaking actions to maintain high levels of ground and surface water and thus a high level of moisture in hydrogenic sites.

Studies and implementation work have been directed at protection of peatland resources paying special focus on countering their further degradation. Protection of peatlands and organic soils in the Notec river valley calls for different measures appropriate for amelioration of the environmental impact of agriculture and drainage-irrigation operation. Among them the most important are: water management principles and actions aiming at conserving existing nature peatlands or restoring lost; improving of operation and development of proper exploitation processes of drainage-irrigation systems; development and usage of the technology of groundwater irrigation using regulated (controlled) run-off.

In order to be used more effectively, it is necessary to reconstruct and modernize these systems. To achieve a high efficiency of these systems, systematic conservation of the network of ditches and facilities is necessary. A lack of modernization and improper exploitation of the systems and facilities restrict competent water management and result in overdrying grasslands and peatland sites. The proper use of the systems and facilities allows effective water management in the river valley and greater stability in grassland ecosystems.

METHOD OF CONTROLLED RUN-OFF FROM DRAINED PEATLANDS AND ITS EFFECT ON WATER STATUS OF PEAT-MOORSH SOILS

Protection of the peatlands in the river valley aiming at breaking their further degradation and making possible extensive agricultural use for fodder at the same time depends to a large extent on maintaining appropriate soil moisture of peat soils and suitable water levels in the river and its tributaries as well as in canals and ditches. Proper water management in the river valley together with possible renaturalization of peatland sites is a key requirement to protect natural values of the valley ecosystems.

The evaluation of the effects of different technical water management measures on both nature and agriculture should be done to plan and perform any actions in order to improve the status of these peatland sites.

Controlled run-off as a method of counteracting of drying organic soils in a river valley is recommended for farmers as a cheap and simple measure in the Notec river valley. This technique assumes drainage during spring to a ground-

water level which assures a minimum air content in the root zone (6%), then the control structures are closed and the position of the groundwater level is determined by the actual precipitation and evapotranspiration. The advantage of this technique is the low cost because only one control structure in the ditch or small river needs to be constructed. This kind of water management control is easy to perform by farmers in the field. However this method can be efficient only when properly chosen terms of stopping of water out-flow from river valley are complied. On one hand too early flow stop causes too excessive soil moisture, on the other hand too late flow stop causes increase of probability of soil droughts during the vegetation period.

Lysimeter and field investigations (Kaca et al. 2003, Smarzyńska and Łabędzki 2007) as well as model simulations (Łabędzki 2004) showed the positive effect of controlled run-off and groundwater lowering in spring on forming soil moisture and groundwater table depths in the valley meadow sites. The results show that controlling groundwater table depth in the meadow sites with organic soils in the river valley with the method of controlled run-off ensures soil moisture in the range required for peatland protection as well as reduces frequency and duration of soil drought and delays the term of drought appearance. Not too deep drainage in spring due to controlling of run-off from grassland makes groundwater level and organic soil moisture decrease slower in the river valley, preserving organic matter and maintaining high level of moisture in the soil hydrogenic sites.

Positive effect of controlled run-off in spring by the minimum drainage on the course of soil moisture in the growing period has been shown in the model simulations of drought in the peat-moorsh soil in the Noteć river valley in 1972-2001 (Łabędzki 2004). Comparing the conditions of minimum drainage and conditions of deep groundwater table depth in spring, duration of soil drought was almost 2.5 times smaller, soil drought occurred with lower frequency (every 1.7 years vs. 1 year) and begins two weeks later (tab. 1).

Table 1. Soil droughts in a peat-moorsh soil in different variants of groundwater lowering in spring (H) in the computer experiment in the Notec river valley

Parameter	Groundwater lowering in spring		
	H = 0 cm	H = 25 cm	H = 70 cm
Mean duration of soil drought (days)	15	20	36
Return period (years)	1.7	1.4	1.0
Mean date of drought occurrence	June 5	June 1	May 27

Source: own study

Lysimeter investigations carried out in 2002-2004 (Smarzyńska and Łabędzki 2007) showed the positive effect of controlled outflow and groundwater lowering in spring on forming soil water potential and groundwater table depths in the valley meadow site in the Noteć river valley. The effect of the spring groundwater lowering on the groundwater depth and pF value was strongly significant (tab. 2). When controlling run-off so to groundwater table was at the depth of 0 cm (only water removing from the ground surface) or at 25 cm, mean soil moisture and groundwater table depth during the growing season will be in the optimal range for grass production. These results showed at the same time that differences between the sum of evapotranspiration and hay yield in the variants of spring groundwater lowering were not significant. Independently of the spring groundwater lowering one can obtain similar hay yield using the approximate amount of water for evapotranspiration.

Table 2. Groundwater table depth (h) and soil water potential (pF), mean in the growing seasons of 2002-2004, in different variants of groundwater lowering in spring (H) in the lysimeter experiment in the Notec river valley

Parameter	Groundwater table depth in spring		
	H = 0 cm	H = 25 cm	H = 70 cm
h (cm)	61	74	88
pF	2.33	3.05	3.84

Source: own study

The results of the above mentioned studies allow the formulation of the practical pro-environmental principles of water management in river valleys. The least outflow depth can be regarded as agro-environmental normative depth of controlled outflow. The drainage may consist in water removing from the ground surface. Such not to deep drainage in spring due to controlling of outflow from grasslands makes groundwater level and organic soil moisture decrease slower, preserving organic matter and maintaining high level of moisture in the soil hydrogenic sites. It can be treated as pro-environmental irrigation of agriculturally used peatlands in river valleys, where there is no other possibility of grassland irrigation.

However, using very shallow drainage in spring, one can expect some unfavorable conditions for agricultural use of the peatlands due to high soil moisture, comprising delay of the beginning of vegetation, difficulties in agro-technique measures, fertilization and other spring measures performing in grasslands.

As it was stated above, economic situation in agriculture and lack of funds by farmers are among others the reasons for the negligence of the proper use

of the reclamation systems and facilities, grassland utilization on peatlands and decreased interest in grassland irrigation. Land ownership and land structure are unfavorable causing some problems of proper water management in the river valley.

Because of private land ownership in the valley the usage of controlled run-off depends on the farmers' interest and the farmers' awareness of the need of usage of this technique. Different actions undertaken for peatland protection are exceedingly difficult since almost the most part of the peatlands in the river valley is in private hands and acceptance and participation of the owners in various projects – elements of active protection – is indispensable.

As far as now the public awareness of the necessity of peatland preservation is rather poor. In the situation when farmers have serious problems with profitable agricultural production, they are interested in a small extend in performing any actions directing protection of natural resources in their lands. There is a lack of sense of responsibility to care for natural resources. Such attitudes ensure a short life for any project. It is important that the local population regards peatlands as their own. As they have sense of ownership and the value of peatlands as natural resources they will treat it well and insist on their preservation.

How can the present attitudes of farmers be changed? The immediate response to this question is "education and training". The role of education is to inspire everyone to be thinking about peatlands as a common value. If each farmer can be encourage to consider how they, personally, can preserve peatlands resources, how they can contribute ideas to increase the effectiveness of water management and to environmentally-sound usage of peat grasslands, then the education system may be considered to have been a success. Education to bring attitude change cannot be considered a task to be completed in the short time. A permanent, ongoing educational program is needed. Education and training on how to manage peatlands is not just needed by the scientist, managers and operators of water systems. Educational programs need to be aimed towards the farmers. Everyone need to be targeted:

- to raise their awareness of nature protection,
- to develop attitudes of care and responsibility for peatland resources,
- to foster a sense of ownership of the peatland resources,
- to foster protection and environmental management of peatlands.

Nowadays it will be hard to encourage farmers to active protection of peatlands without financial help coming from government budget, self-government budget, ecological funds and EU budget. Agro-environmental schemes and compensations give some chance and will have some importance in peatlands conservation in the Notec river valley. There need to be incentives to encourage farmers to make optimal use of peat grasslands toward their preservation.

Besides individual farmers' issues, actual determinants of various activities against degradation of peatlands and toward their protection are strictly

connected with the state of water management in agriculture, particularly with the state of amelioration and exploitation of existing drainage-irrigation systems in the valley. Basic reasons for the restricted possibilities of counteraction soil degradation on agricultural areas lie in the negligence of the proper use of the melioration systems and water facilities. Among others:

- a lack of proper conservation of running waters and ditches does not allow for planned drainage and irrigation to be carried out,
- a lack of the use instructions and control devices make the control of irrigation and drainage difficult,
- a lack of financial means to cover the costs of water uptake decreases the intensity of irrigation,
- a lack of agreements regulating water uptake for irrigation in the dry years limits the extent of irrigated areas,
- a decreased interest of farmers in grassland utilization on a farm results in agro-technical negligence and thus affects the effectiveness of management on reclaimed objects.

The group of managers, operational and maintenance personnel can have a great role in counteracting these processes. These calls for the need of education of not only farmers, but also this group to create a new thinking about agriculturally used peatlands.

CONCLUSIONS

Under the circumstances in the Notec river valley, in respect of the increase of the sub-soil irrigation areas on the valley grasslands, it is generally assumed to increase considerably the irrigated territories, mainly due to the natural reasons for protection of hydrogenic sites. The modernization, rehabilitation, proper operation and maintanance of the existing subirrigation systems are a requisite of the fulfillment of the tasks concerning required moisture conditions for peatland protection. Taking into account the present situation of agriculture in the region and the economic state of most farmers, the simple and cheap technique of controlled run-off of water from existing irrigation-drainage systems is recommended to demonstrate and implement practically.

The other tasks of local agricultural and ecological – nature protection – services are to improve social awareness of the need of sustainable usage of peatland grasslands as well as to help farmers in gaining financial resources for performing measures and carrying out proper peatland management for their preservation. Education and training are of great importance to increase the awareness of the value of the peatlands and the importance of their preservation among individual farmers as well as among managers, operational and maintenance personnel and extension services.

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