Ecological capacity measurements as useful tools of planning land management in a lake district: Iława Landscape Park case study

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Abstract

For tourism development an analysis of a lake and its catchment ecosystems in view of natural and anthropogenic conditions and stressors is presented. For socioeconomic reasons the research is focused on lithoral zone and its assimilation capacity for a wide range of human activities. For sustainable development reasons, a burden below the potential capacity is a necessary condition.
Keywords: lake catchment, assimilation capacity, resources management, sustainable development.

1 Introduction

In Poland one may observe among city inhabitants a growing interest in leisure and tourism, especially in lake districts. This demand meets a need of local societies, whose economics depends on natural resources, to expand their traditional products, i.e. food, timber, fish and biomass. The poor job market and decreasing income from traditional activities are the main reasons for creating exchange for tourist products and services. However, even traditional enterprises engage several environmental issues. In rural areas where spatial sources are implemented into economic activities and where products create profiled ecosystem services, inconformity to the unchangeable ecosystem functioning may not only result in media abatement [6]. It could also be an obstacle for further economic development. Agriculture and tourism are both intensive branches, so looking for a rational solution in their coexistence problem must be organized in an aspect of environmental impact [8]. In the research area,

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traditional land use, meaning agriculture, forestry and fishing, creates an inefficient income. At the same time tourism and leisure activities based on the landscape and natural hydrological resources might become a serious development branch. Among them you may observe the residential housing. However, an increasing demand for the most attractive residential areas but restricted in amount create bad conditions of environmental factors. The pressure on the environment increases and shows a conflict of interest. For that reason it is important to find a method, which could reconcile different aspects of the economy and the environment of various sectors [5].

The aim of the research conducted in Iława Landscape Park is to build a decision support system for non-conflict, sustainable use of a total range of resources. The ecosystem approach seems to be the best in a situation where all users adapt the ecosystem solutions.

2 System analysis

The method used is in a wide sense system analysis that integrates environmental and socio-economic aspects by the use of aggregated indicators in the form of links between measured components. To establish the state of a considered system a three stage analysis was conducted. The main research considered on the one hand, traditional economic sectors such as agriculture, settlement, forestry, and, on the other hand, residential housing, leisure and tourism – new ones, which are aggressive whose progress appears on the border between the land and the water. The final step is a compromise for all users; it considered the structure and flow between elements in an aspect of natural and anthropogenic processes. The calculations that represent important concepts as auxiliary variables in the model were suggested. They are used to compute rates of material transfer in the system, or to compute some end products such as a very important rate of the lake ageing.

2.1 Area - characteristic of catchments structure

The Jeziorak Lake catchment is characterised by beautiful landscape values as well as spatial resources applicable for agriculture, forestry or fishing. It belongs to the Iławka river basin, the right tributary of the upper Drwęca River. For a landscape matter it was decided to create a protection zone around the catchment area. The whole area structure is characteristic of a young glacial lowland relief with height differences over 45 m (92.0 m a.s.l. Gawda depression and 137.6 m a.s.l. in the Karpowo village area).

Jeziorak Lake itself creates multicavity, is very picturesque and so attractive for sailing. It divides into many linked reservoirs of different genesis – long subglacial channels and backwaters with lagoons. Water comes from the North out of 165 km^2 of the catchment and out of 149.9 km^2 of the rivers. Generally it is a shallow reservoir (on average 4m) with varied types of geological bed. Some parts have complicated water exchange and difficulties with oxygenation. There are two cities (fig. 1) at the north (Zalewo) and south edges of the lake (Iława).

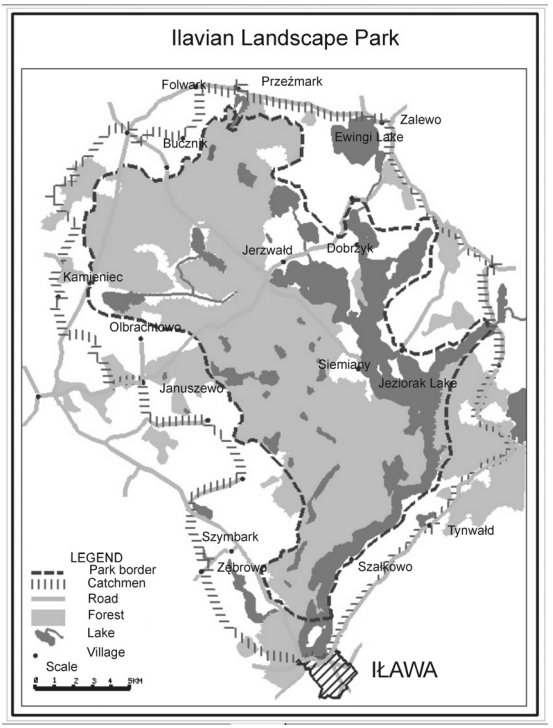

Figure 1: Land cover in Iława Landscape Park.

Table 1: Main characteristics of catchment, natural and human components.

Components	Park	Protection zone	Total
Total area [ha]	25279	17804	43083
Catchment area [ha]			31495
Lake area [ha]			5006
Forest area [ha]			8879
Population	1500	9300	10800
Tourists (daily average)	4600	7000	11600
sailors yachts		800-2000 700	

2.2 State of system and development tendencies

The Jeziorak Lake catchment system consists mostly of lake water, an agricultural area, a forest area and a wetlands area. It is a part of a water route from the Baltic Sea down south to the Drwęca River. 90 m of altitude difference was overcome by a lifting system hauled by the water movement. The water transport of timber and food was a driving force for the trade development of the area. As time passed by the system changed but the human impact on the system

in each period added up. The trade used to be combined with land improvement for agriculture in the north and forest management in the south and the central part of the catchment. Nowadays, the extensive husbandry along with the human impact causes water cloudiness and pollution [3]. Local society tries hard to decrease the stress on the water ecosystem, e.g. by creating a commonwealth of municipalities. They built waste dumps and sewage disposals and then the polluted water could avoid the lake. However, the income of most people is rather low, the unemployment rate is high and most people live rather out of farming than tourism. All these aspects are a part of socioeconomic and environmental problems. Tourism may be a solution as there is a high demand for this type of services and the catchment characterizes great potential. The lake is a delicate system of low environmental capacity because of a well-developed coastline and a low amount of water. Recently, a high demand for the lake coast areas for residential housing has been observed. New landowners also create a leisure offer in the form of bars or sailing boat hires. There is a real danger of intensification of environmental problems that could threaten the sustainable development.

2.3 System functioning – characteristics and variables

2.3.1 Lithology and relief

The Jeziorak Lake catchment covers three regions varied by relief and geological structure. The northeast part belongs to a hummock moraine plateau with many cavities and subglacial channels filled by organic and lacustrine deposits. The other one built of similar material lies along the eastern part of the lake, between Iława, Tynwałd and Jeziorzyce. The central and west parts cover the Iława sandur built of sands and gravels and filled in cavities by organic, lacustrine and mineral sediments. Moreover, two sandur levels, the lower and younger one over 2-5 m and the higher one 10-15 m, differentiate the Ilavian sandur relief.

2.3.2 Land use and land cover

A great majority of the area is covered by pine forests and along the high and steep coast (around Szałkowo village) broadleaved forests occur with a high percentage of beech. The north areas are agriculturally exploited and meadows, pastures, arable lands, fallowed lands and wetlands cover only a minority of the area.

Only 13% of the park is covered by cattle stations (100 farms) and in the protection zone 70% of the area (550 farms of total 7500 ha and average of 13ha for a farm). A domination of growing pigs over cows is common in farms. The scale of some of them is big – 400 pigs in Olbrachtowo, or 100 cows, 300 calf and 600 pigs in Rudniki or 130 cows, 500 pigs and 200 sheep in Kamieniec. In Iława area there are 70 chicken farms of 6000 pieces each.

2.4 Ecosystem

In the catchment area we can distinguish three types of biota and ecosystems: lake, land and wetlands. On the land area, forests have generated seminatural

ecosystems and are managed extensively. Crop fields build a high-developed input-output ecosystem, which in part cause an increase of matter by erosion acceleration and further on an input to the lake. This created a threat for the lake ecosystem. A lack of ways to counteract erosion is also a threat for sustainable farming.

The lake ecosystem is close to a natural one, however wide spreading wetlands are an intermediate stage along the transformation into land. Bad management of ecosystems can accelerate ageing of the Jeziorak Lake [2]. This process is visible mostly in the lithoral zone where interference occurs between land and water. Protection activities must be activated in that part of the lake to stop degradation if the lake is going to be an attractive resource for tourism and leisure activities. The lithoral zone characterizes a great dynamic of physicochemical conditions as well as processes of mass plants exchange and mobility. Two epilithoral sub-zones can be discerned there – the highest level above water and the lithoral level where water plants communities are under the water. Along the lake coast, epilithoral on sandur is covered by forest and on the moraine surface by meadows and tree stripes. Small patches of pits with alder and willow shrubs and wet meadows may be found in Gardno. Reeds cover some places exposed to the wind and waves. The opposite ones – places sheltered from the wind are covered by trees or a rich composition of water plants and the lack of waves has caused an accumulation of organic and inorganic deposits resulting from the processes of water shallowing.

2.5 Processes and management (regulations)

2.5.1 Natural hydrological regime

There is an intensive water overflow through the forest from the north to the south and its surplus is caught by the Iławka River. Contribution of water to the lake differs and depends on lithology. On the sandur area the surface-run of water is reduced by an infiltration rate. The ground water inflows straight to the lake and supplies numerous wetlands filling small ground cavities. Water retention is slow. In that part of the catchment the water inflow is not enriched in inorganic compounds opposite to the water overflow through wetlands. Before the water reaches the lake it also gets organic compounds coming from mineral layers of gythia and lacustrine chalk stored there over the centuries.

The surface of the moraine plateau is built of loamy soil that overlays a clay layer and its hummocky relief enables a surface water runoff. This process is usually tied to erosion, mostly of small particles. It has caused a major cloudiness of water in channels and in the lake. Water flowing across wetlands in channels is enriched in highly polluted and eutrophicated sanitation wastes from villages.

2.5.2 Man-made regulations

The need to regulate the water flow through the catchment has always been a driving factor in creating a flow and storing system. Such a possibility occurred in the 19th century when there was a need to create a cheap way for the transportation of goods between two regions relatively close to the sea. The only

obstacle was a 90 m difference in altitude between the sea and a moraine plateau. Wetlands, pits and a well-organized drainage system collected the surplus of water. Moreover, between two lakes (Ewingi and Jeziorak) gravital water flew down and reinforced the lower part of the lakes. After the regulation arable fields with crops and a developed agricultural sector of the regional economy replaced wetlands. Also the surplus of water flew out of the forest ground and enlarged the timber production. Additional water volume that flew down the channel to move boats was obtained by lowering the level of the water in the lake as a trade off for accelerating the water run.

Table 2: Main stages of the catchment natural and socioeconomic changes.

Stage	Technical change	Socioeconomic driver	Land use/cover	Impact on water regime	Matter balance	Conflict
Before 1939	channels	trade timber, corns and bricks exchange	expansion of agriculture and forestry	level of surface water lowers	water enriched in compounds	None
To 1990	pipe drainage	growing demand for food and export	decreasing area of wetlands	accelerated flow of water	overdosed in nutrients lake pollution	Between tourism and farming
Up today	city sewage system	standards of environmental protection	residential housing	as above	change in lithoral	With nature

3 Problem definition

The condition of the lake system depends on natural and anthropogenic stressors [7]. Some of them are a trade-off by the infrastructure enhancing the growing capacity for economy, e.g. a sewage plant against the lake pollution. However, in Iława Landscape Park a new stressor has occurred – man. The residential housing built very close to the lake coast replaced natural meadows and lithoral plants with gardens or lawns. Also sailors by penetrating the shore for camping purposes and tourist services such as lake ports injure the plant communities. As a result, the balance of matter is uncontrolled and occasionally, or in some places permanently, some land masses erode to the lake. The soil particles moved towards the wind bank where the substrata for biomass production accumulate. The water is clouded and a huge dose of Ca and other minerals coming from farming pollute the water and influence the plant production.

At all historical stages of the system development the strongest stress in the lake ecosystem has always been focused on the lithoral zone. Processes that take place there influence the water quality and have an impact on the state and sustainability of the lake. The zone on the border between the land and the water functions as a biofilter that controls the land expansion. It can only work properly in a situation with the lack of waves and wind. It is very important for the future of the whole catchment system and local people, who use the resources, to recognize sufficiently the physicochemical processes.

3.1 Scientific approach

The aim of the research was to analyse the functions of the lithoral zone and its capacity against natural and anthropogenic stressors. It also assumes the establishment of the impact of assimilation capacity on the lake ecosystem and recommendations for the main uses of resource management in an aspect of a sustainable development.

Table 3: Processes caused by stressors in different sectors of the economy.

Sector	Stressor	Assimilation capacity	Recovering time	State/process
agriculture	intensive production in small farms	overcome capacity	undefined require change in system	overdose of biogens riches water
tourism	penetration of the coastal zone	20% overcome	sand - more then 1 year; clay - less then 1 year	sands shallow biogens aggregated into sediments of stagnation favour zones
residential housing	change of meadows to loan, reeds removed changed into beach	often lack of possibilities for constant or temporal assimilation	undefined required change in system	sands shallow biogens aggregated into sediments of stagnation favour zones
total effect	lowering of water level, pits drainage and canalisation	highly decreased in terms of stopping the ageing processes	changes in structure and system regulation	water shallowing and reservoir pollution

The capacity of the lake was referred to a simple conceptual model (fig. 2) where sources of matter become more mobile, that is involved by one sector and sinks within the lake along with the impact of the system of interest.

3.2 Materials

Agriculture as a traditional stressor is characterized by transformed information of soil and land cover in the catchment area [1]. It is associated with the land fragility as contaminants disperse on the surface and into the ground. A few groups of surveyors interviewed the farmers on management matters and the type of fertilizers used. The analysis also covered the lithoral zone in terms of its fragility for the purpose of tourism capacity assessment and the impact of a new settlement system. The soil matrix, slope angle (relief) and plant cover were considered. The data was compared with the number of sailing boats as a cause-effect system in each part of the lithoral zone.

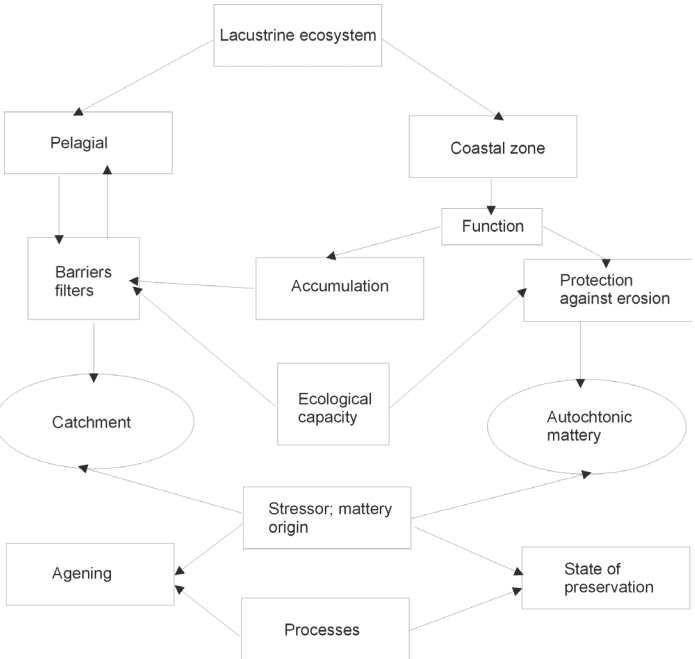

Figure 2: Conceptual diagram presenting a simple approach to analysis of the ecosystem structures and functions for management purposes.

4 Results and discussion

The analysis presented the agricultural impact as the most important burden for the lake. Assimilation capacity is overcome in the agriculture and tourism sectors as a result of the lake reaction to the water quality change. Also the tendency of wetlands to accumulate organic and inorganic deposits caused this overcome. As a result, the landscape improvement by introduction of the long-term crops seems to be the most important action in the alterations of the catchment system. The suggested type of plants is less dependent on external fertilizer support. There is also a need to run the farms according to the rules and to the change of the land cover especially in the lithoral zone destroyed by new residential housing (fig. 3) and tourism. Very intensive alterations are associated with some parts of the lithoral where the shallowing tendency is the highest. There is still a chance to protect other areas in the near future. This can be gained through system protection from the improvement of places which are invaded by tourists. Integrated land and water management would overcome the threat for further development of this district [4]. However, it does not mean stopping either tourism or the development of leisure activities.

Table 4: Suggested actions for the future effects in different sectors of the economy.

Sector	Future features	Action	Expected effect
agriculture	farm development	Landscape design Farming controlling Short Rotation Coppice Precise agriculture Agrotourism	burden of biogens below assimilation capacity
tourism	contact with coast	properly equipped ports, piers, camp sites	renaturalization of littoral
Residential houses	effectiveness of epilithoral	gardening above epilithoral	Renaturalization of epilithoral
total	development	renaturalization and protection through discrete infrastructure development	stopping the reservoir shallowing and ageing

Figure 3: Photograph of the lithoral zone destruction as a result of the processes caused by new residential housing.

5 Summary

Tourism in the form of residential housing added to other traditional activities depends on ecosystem services. To create a sustainable development all of them ought to be compatible with natural rules, while conflicts of interest are obvious. Fragility of this system depends on the type of plant communities and geomorhological features. The stress ratio results in activated natural and anthropogenic masses sinking in different lake parts. The measurements and assessments were done in relation to assimilation capacity. Finally, some simple measurements were suggested to reduce the negative impact, i.e. below the capacity threshold to restore the balance in Jeziorak Lake.

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