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Ecosystem services and water resource management in a small scale river basin characterized by ponds and wetlands: Fizeş River (Romania)

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Abstract. Water resource management can prove to be a very difficult task. It is not an easy job trying to fulfill the current requirements of the Water Framework Directive[1] (WFD 2000/60/EC) especially because it is difficult to estimate what really "good status" means according with WFD. In order to reach the "good status" in a particular river basin the water manager needs to propose a so called Program of Measures, which identifies and proposes measures to be taken in order to lower the impact generated by human activities. All these measures are based on an evaluation of the supposed natural status and current status in the river basin. What we try to propose here is a model for an integrated management plan approach based both on the natural functionality of the river but also on the ecosystem services and social functionalities generated by man made ponds in the river basin.
Key Words: management plan, ecosystem services, ponds, program of measures.

Zusammenfassung. Wasservorkommenmanagement kann eine sehr schwierige Aufgabe sein. Es ist nicht ein einfacher Job, der versucht, die gegenwärtigen Anforderungen der Wasser-Rahmenanweisung (WFD 2000/60/EC) zu erfüllen, besonders weil es schwierig zu schätzen ist, was wirklich ein „guter Status" in Übereinstimmung mit der WFD bedeutet. Um den „guten Status" in einem bestimmten Flussbassin zu erreichen, muss der Wassermanager ein so genanntes Programm von Messen vorschlagen, das Masse identifizierent und vorschlägt, dessen Auftrag das Senken der Auswirkung die durch menschliche Aktivitäten erzeugt wird ist. All diese Messungen haben als Basis die Auswertung des angenommenen natürlichen Status und des gegenwertigen Status im Flussbassin. Unser Vorschalg da, wäre ein Modell für eine integrierte Abfallwirtschaft zu gründen, die sowohl auf der natürlichen Funktionalität des Flusses, als auch auf den Ökosystemdienstleistungen und den Sozialfunktionalitäten, die von den Menschen erzeugten Teiche im Flussbassin aufgebaut wird.
Schlüsselwörter: Verwaltungsplan, Oekosystemdienstleistungen, Teiche, Programm von Messen.

Rezumat. Activitatea de gestionare a resurselor de apa se poate dovedi ca fiind extrem de dificilă. Conformarea cu cerinţele Directivei Cadru Apă (DCA 2000/60/EC) este o muncă complexă în special datorită faptului că este dificil de estimat ce înseamnă de fapt „starea bună" a apelor conform DCA. Pentru a atinge această „stare bună", expertul în gestionarea resurselor de apă trebuie să propună un aşa numit Program de Măsuri, prin care sunt identificate măsurile de întreprins pentru a diminua impactul datorat activităţilor umane. Toate aceste măsuri sunt bazate pe evaluarea stării naturale şi a stării curente a corpului de apă. Acest articol încercă să propună un model pentru un plan de management integrat al resurselor de apa, bazat atât pe funcţionalităţile naturale ale râului cât şi pe serviciile ecosistemice şi funcţionalităţile sociale generate de prezenţa iazurilor piscicole în bazin.
Cuvinte cheie: plan de management, servicii ecosistemice, iazuri, program de măsuri.

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[1] Directive2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal of the European Communities, L 327/1, 22.12.2000.

Introduction. Our society benefits from a multitude of resources and processes supplied by natural ecosystems, called "ecosystem services". Under this name could be included a large number of products like clean air, water and processes like decomposition of waste, soil generation, photosynthesis and many more. All of these are very important because there is a certain human need for them.

Services can be subdivided into five major categories: *provisioning services* such as the production of water and air; *regulating services*, such as the control of climate; *supporting*, such as natural cycles (nutrient cycle, energetic cycles); *cultural*, such as spiritual and recreational benefits; and *preserving*, including here guarding against uncertainty be maintaining diversity (Daily 1997, 2000).

Regarding Fizeş river and services offered by ecosystems in this small scale basin can be stated that these are very much related with the presence of natural and man made ponds.

The presence of these ponds is very much related with the specific geology (sand stone, sand, argyles and tuffs), which in fact influences the land forms in the basin, creating a landscape where steep slopes alternate with low angle slopes. Because of this specific geology and also flow variations, the valleys tend to present callow plains with low slopes bordered by steep hillsides (Mihăiescu 2004). These natural settings copped with flow variations are the ideal settings for the apparition of both natural and man made ponds and wetlands.

Fizeş river basin is part of Someş river basin, one of the main tributaries of Tisa river. It is located in the northern part of Romania and covers a surface of approximately 562 km^2, with an average altitude of approximately 400 m .The general water flow is directed west from the hilly region of the Transylvania Plain. Yearly average precipitation is approx. 600 mm. The main land use is agricultural, and due to terrain structure the step slopes are subjected to erosion processes (Mihăiescu et al 2005). The area is characterized by a mosaic of broad interfluves generally occupied by grass and occasionally forests, step hillsides with agricultural land and forests and broad stream corridors occupied by arable land and marshes (see Figure 1 for a general map of the river basin).

The specificity given by the large number of ponds in the basin has also promoted the development of a network of protected areas, including here Special Protection Areas (SPA) for the protection of birds (under Birds Directive[2]) and Sites of Community Importance (SCI) for the protections of species and habitats (under Habitats Directive[3]). There are also several national level protected areas related with the specific valuable wetlands and mezo-xeric habitats most of them being protected as natural reserves.

Ecosystem services in Fizeş river basin. Natural and man made ponds in the basin, copped with the natural and cultural landscape (villages and small scale agriculture), provide ecosystem services not only for locals but also for a large number of people coming from the neighboring urban areas.

As always the capability to provide services depends on the ecological state which should be preserved together with the local specific features in the context of economic growth and development of the area (Naiman et al 1995).

The ponds are the main distinctive feature in the landscape, acting as a focal point for both economic and social activities (just to be noticed but the most important settlements are the ones located near the ponds, which promoted their development and growth). Of course that the "reverse of the coin" means that actually the most polluted and endangered areas are also centered near the localities and consequently near the ponds.

[2] Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds, Official Journal L 103 , 25/04/1979 P. 0001 – 0018.
[3] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7–50.

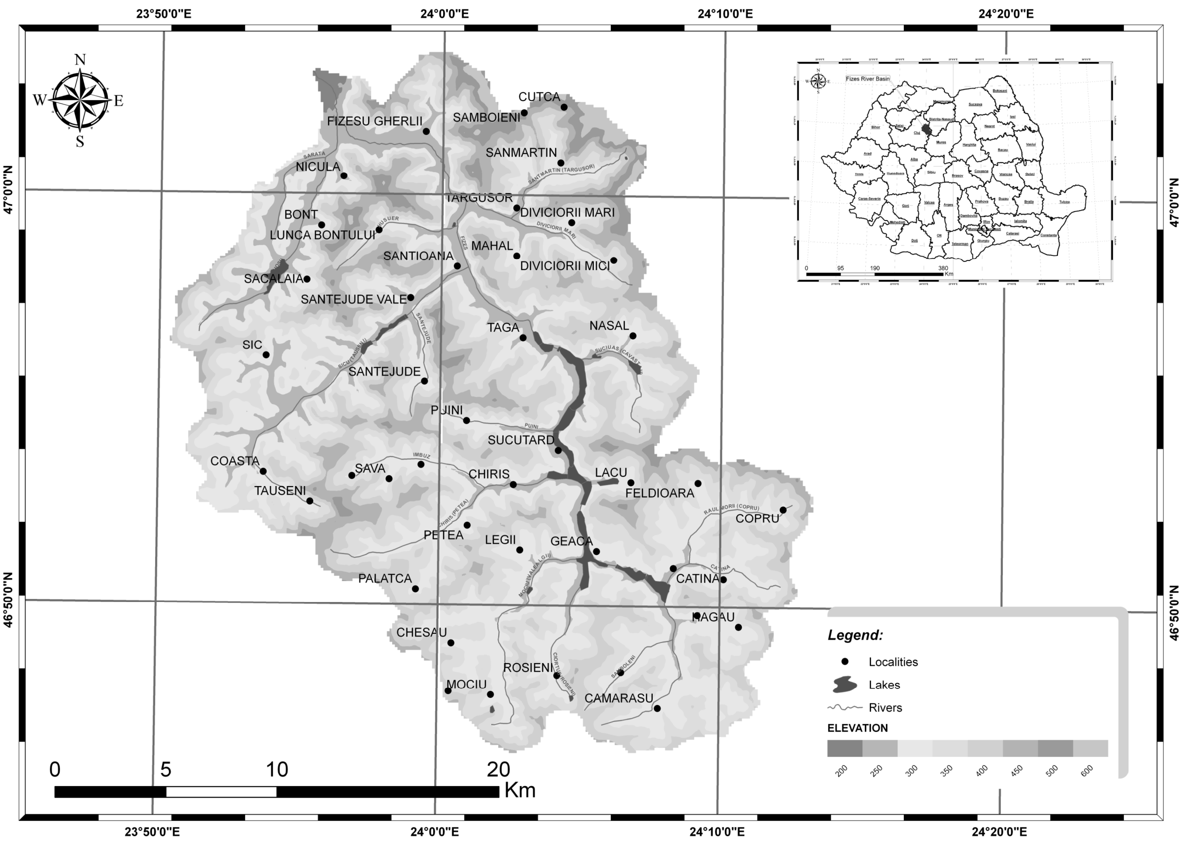

Fig. 1. General map of Fizeş river basin.

The history of pressures on the environment in the basin is mainly related with the practices in land use, which in fact was influenced by two major factors: the type and accessibility of natural resources and dynamics of demographic processes. These factors are interconnected in a network of economic, ecologic, social and cultural relations (Mihăiescu et al 2003).

The main deficiencies in the natural and socio-economic systems are generated by irrational usage of natural resources, which in fact generate an impact both on the quality and quantity of water resources. Alterations in the natural balance of ecosystems and their functionality will for sure generate effects on the services offered by these ecosystems thus leading to deterioration in the quality of human life and environment (Heikkila 2004).

Figure 2 presents the main natural and artificial ponds in the basin and also the network of protected areas (to be noticed the ecological corridor functionality of the network system).

Based on the classification mentioned before we identified some important ecosystem services offered by ecosystems in the Fizeş river basin, as follows:

- Provisioning services
    - drinking water
    - food in the form of fish (both from fisheries and natural lakes)
    - energy (hydropower and conversion of biomass)
- Regulating services
    - local climate regulation
    - water balance in the area
- Supporting services
    - purification of water and waste
- Cultural and recreational services
    - ecotourism

- sports fishing (angling)

- Conservation services
  - genetic, species and habitats diversity for future use (trough implementation of a functional NATURA2000 network).

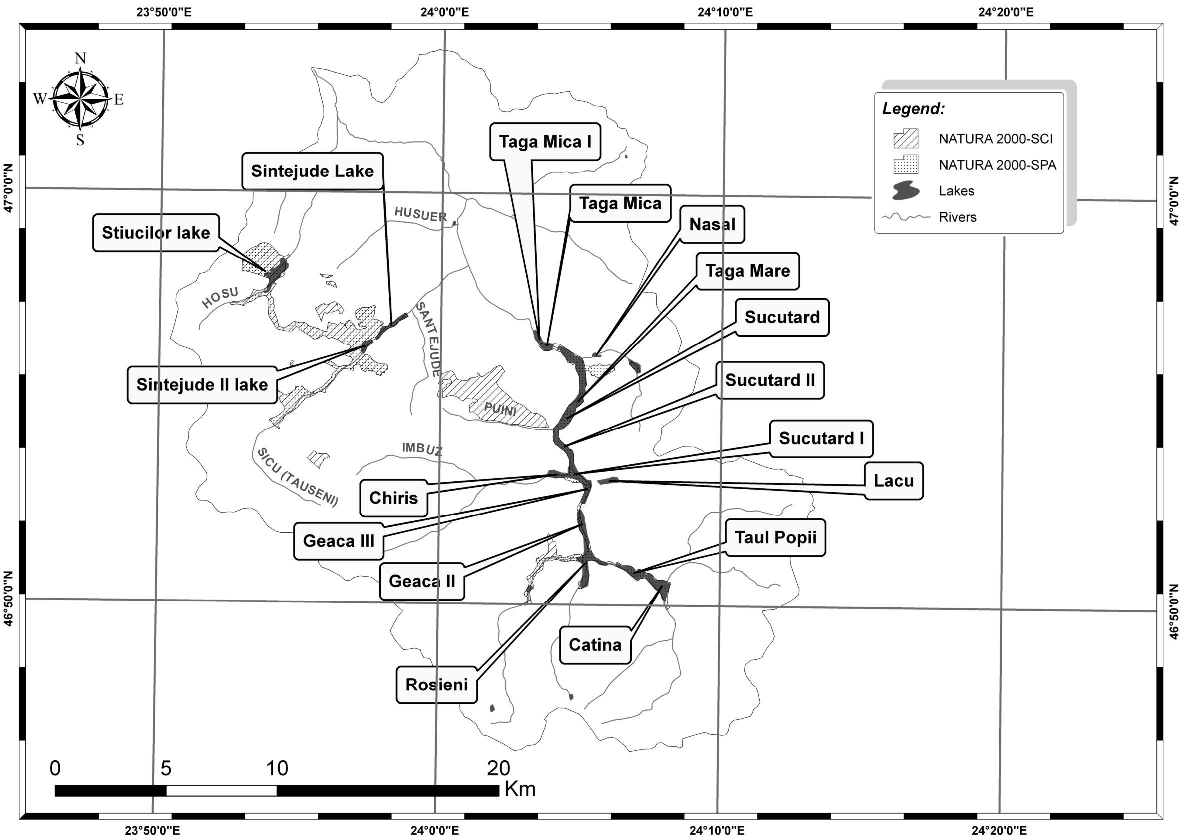

Figure 2. "Sources" of ecosystem services in the basin: ponds, lakes and natural protected areas.

Some of these services offer benefits taken for granted till recent times and which are not considerate have a direct income value (water sources, local climate regulation), but others like cultural, recreational and conservation services can be a major source of income for the local communities in the same time being important also for the general society (in is the case for ecotourism, bird watching, sports fishing) (Kremen 2005)

Ecosystem services should be always taken into consideration in all the stages of the implementation of a management plan, no matter if it is a general development plan, a water management plan or any other planning scheme.

River Basin Management Plan. The new approach of the Water Framework Directive (WFD) proposes and imposes a series of revolutionary concepts in the field of water resource management. The most important and revolutionary concept refers to the evaluation of water quality relaying more on ecological parameters instead of chemical parameters. Ecology should make the difference in the process of evaluating water quality, because aquatic ecosystems are the ones to be conserved and maintained. The characterization based on chemical parameters does not show anything, or al least does not show a lot, about the natural ecosystems of the river.

Other important concepts refer to the implementation of a unitary river typology trough out entire Europe and the establishment of a network of monitoring sites in order to define reference conditions (natural, undisturbed conditions for a specific river type).

The River Basin Management Plan is the most important planning instrument in a river basin. It should comprise all that is known about the river system and based on that, propose a set of measures (Program of Measures-PoM) in order to reach the "good status" as defined by WFD. In order to better understand the importance of the planning process see Figure 3.

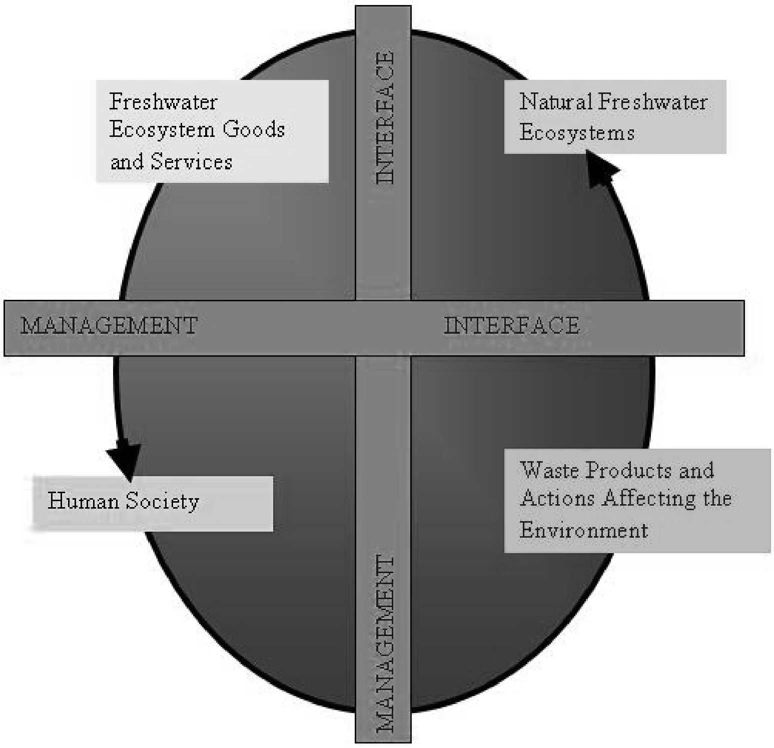

Figure 3. Provisions of goods and services by aquatic ecosystems and the role of management interface in these interactions.

So one of the most important steps in the implementation of a River Management Plan, is to define what "good status" means for that specific river (in accordance with the ecological quality objectives for that river as required by WFD) and once defined to see how our proposed measures (PoM) lead to it.

After we define the "good status", we need to evaluate the current status in the river and based on that to forecast what will be the impact of measures on the current status and what to do in order to reach the goal ("good status" equal second quality class according to WFD). This is the step in which mathematical modeling of the water quality becomes important. Together with some other methods (like the so called "expert judgment" and empirical analyses), it is a very useful tool which allows the expert to understand the complexity of the water system, propose and prioritize measures and most important to calculate the effects and impacts of the measures (Mihăiescu et al 2008).

The WFD does not state that it is mandatory to use models (however proposes a list of approved models), but the majority of water experts keen to agree that using such a model can be of real help in the process of water status evaluation.

When choosing a model we have take into consideration first the availability of data (specific models require specific data) and also the knowledge level of the expert working with the model.

The problem of choosing a model can be different from river to river and since there are several model classes we consider that a short presentation of these categories can prove to be useful. A model which suites a large river can prove to be useless for a small scale river basin because it requires a large amount of data (not available for a small basin), deal with a lot of parameters which are not relevant for the small scale river basin and also may require a high level of knowledge and training from the expert using it. A more general and not so specific model can be very useful when we need to have just a general understanding of the river system and we need to have some reliable results as fast as possible.

Water quality models can be divided based on three main criteria (according with Mihăiescu et al 2008):

- Spatial differentiation
- Temporal differentiation
- Number of water quality variables

By spatial differentiation we refer to models which are designed for different scales. General models do not take into account the length and flowing direction, instead complex models need specific geographic data like the exact position of pollution sources, discharges, intakes and so on. The most complex models can model not only processes along the length of the river but also in width and depth.

By temporal differentiation it is meant that some models take into account changes in time. A steady-state model does not take into account changes in time and uses for example yearly averages. A dynamic model does take time changes into account.

Also some models can work only with specific parameters like oxygen balance, nutrients, water flow and some complex models can deal with a large variety of parameters and the relationship between those parameters.

For the Fizeş river basin we consider that it is useful to present some results generated by using a general model focused on nutrient pollution as problems related with Nitrogen and Phosphorus are the most important issues in the basin and generate the major threats.

The model uses the current monitoring data, given by the user, to forecast the future concentrations and loads and offers the possibility to analyze these values and compare them with standards (national, international or chosen standards mainly referring to the "good status") and also to analyze the difference between pollution point pollution sources and diffuse pollution sources.

Starting from this point the expert can make a judgment, propose and prioritize measures targeting at first the major pollution sources and if the result are not satisfying aiming the other sources as well.

Possible measures can be divided into two main categories: basic measures (these are mandatory measures stated in the agreement of Romania with EU) and supplementary measures (measures to be taken if by applying the first set of basic measures we fail to meet the requirements).

Table 1

Model results compared with standards

Concentration and standards	*Present situation*	*Basic measures*	*Supplementary measures*
Calculated P concentrations (μg/l)	161	157	143
Objective for P concentration (μg/l)	40	40	40
Calculated N concentrations (mg/l)	2.8	2.4	2.1
Objective for N concentration (mg/l)	7.0	7.0	7.0

Some of the proposed measures (Mihăiescu et al 2008) include:

- Measures targeted on the reduction of individual pollution sources

  -building up sewage and drinking water facilities, waste water treatment plans both for human agglomerations and industrial enterprises , septic tanks etc

- Measures for conservation and restoration of ecosystem
  - -rehabilitation of natural wetlands
  - -creation of buffer zones and natural corridors
- Measures for controlling diffuse pollution
  - -measures on the main river course and banks (rehabilitation of longitudinal and lateral connectivity of the river, rehabilitation of natural riparian vegetation)
  - -measures for the flood plain (rehabilitation of wetlands, specific agricultural practices)
  - -measures for the hillside (implementing the Code for Good Agricultural Practices, building up some grass and heath strips, usage of specific local crops in order to prevent erosion)
  - -measures for the watershed (rehabilitation and restoration of natural vegetation, especially forest vegetation)

After analyzing the results of the model and in the stage where we decide about the PoM, we should consider the benefits offered by ecosystem services. If we decide to apply measures that impose strict limitations (for example we could choose to ban some traditional agricultural practices and some crops in order to lower nutrients concentrations) we could create real problems for the local community. Instead we should try to promote measures that lead to organic farming and ecotourism and avoid situations that cam prove to be disadvantageous for the local community.

One can propose a ban on fish farming in the area, and by doing so trying to lower phosphorus concentrations, but we can see that even if the Phosphorus level are high the natural balance is not affected and fish ponds play a key role in the ecosystem of the area. These ponds attract a large variety of bird species and although they are not natural but man made are a very important link in the natural, social and economic chain of the area.

Conclusions. The study revealed some threats on the environment and suggested some other management options. The effect of various development scenarios can be assessed at a preliminary stage by using mathematical models. Among the issues of concern are:

- Impairment of surface waters from suspended solids, nutrients, and pathogens
- Lack of ongoing monitoring of surface water quality and quantity conditions and trends
- Threats to groundwater supplies from nitrates, pathogens and other contaminants
- Degradation of aquatic and terrestrial habitat
- Impacts of development on agricultural land, rural character, open space and environmentally sensitive areas
- Need for a community based watershed organization
- The integrated watershed assessment highlighted the interaction of the human and natural factors in the defining of the water resources state and quality.

Mathematical modeling proved to be a useful tool in the support of watershed assessment providing supplementary data and facilitating the analysis of various development scenarios in the frame of a well designed integrated watershed management plan.

It is not feasible to analyze and develop a management plan for every small river basin but the most suitable approach to be used in this process is to start with small tributaries of the main river and after that to integrate all this tributaries into the River Management Plan of a large river.

We consider that Fizeş River Management Plan for should be focused mainly on ecosystem services (restoration and rehabilitation of wetlands-which are a distinctive feature of the basin), thus offering future benefits, both for local communities and natural ecosystems (because of the developments in tourism, other socio-economic aspects, wetland restoration, improving lateral and longitudinal connectivity of the river and so on).

Measures proposed in this Management Plan should not promote any unjustified actions that would have a negative influence on the quality of life and economic system in the area.

Increasing public awareness towards environmental problems and benefits of eco-friendly economy and ecosystem services can be seen as a major step towards the common desiderate which Sustainable Development is.

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