DESIGNING OF AN INFORMATION ADVISORY SYSTEM FOR ASSESSMENT OF MEASURESAGAINST WATER POLLUTION FROM MINING ACTIVITIES

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ABSTRACT. The report presents designing of information advisory system forassessment of measures against water pollution from mining activities.The system is based on economic model for benefit-cost assessment thatis consistent with the European Water Framework Directive. It is necessary for the system to be adaptive and to develop information on different water bodies in order to helpmanagers in effective decision makingrelated to the water pollution reduction in mining regions. An information, functional and programme model of the system has been created. The proposed and analysed models will be used in the future implementation of the system.

Keywords: information advisory systems, cost-benefit analysis, software design

ПРОЕКТИРАНЕ НА ИНФОРМАЦИОННО СЪВЕТВАЩА СИСТЕМА ЗА ОЦЕНКА НА МЕРКИТЕ ПРИ ЗАМЪРСЯВАНЕ НА ВОДИ ОТ МИННА ДЕЙНОСТ

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РЕЗЮМЕ. Разглежда се проектиране на информационно съветваща система за оценка на мерките при замърсяване на води от минната дейност. Системата се базира на разработе никономически модел за оценка съобразен с рамковата директива за водите. Необходимо е системата да бъде адаптивна и да доразвива информацията за различни водни тела с цел подпомагане ръководни кадри, при вземане на ефективни решения, свързани с намаляването на замърсяването на водите в миннодобивните региони. Създадени са информационен, функционален и програмен модел на системата. Предложените и анализирани модели ще бъдат използвани при бъдеща реализация на системата.

Ключови думи: информационно съветващи системи, анализ разходи-ползи, софтуерен дизайн

Introduction

The administration of water bodies in the Republic of Bulgaria takes place at the national and the basin level. In 2012 a National Strategy for Water Sector Management and Development (DV, No. 97, 2012) was adopted, setting out the main development goals, milestones and methods till2037. This strategy is based on the Water Framework Directive (WFD) 2000/60 of the European Union. Four directorates for the management of the water sectoroperate on the territory of Bulgaria: Danube, Black Sea, West-Aegean and East-Aegean regions.The Ministry of Environment and Waters has developed a River Basin Management Plan (RBMP), which includes an approved national catalogue of measures with appropriate standardsfor their cost. The Basin Directorates develop water management planning papers in their area, which are updated every six months. On an operational level, they prepare programmes for water protection areas and set of measures to achieve good status of water bodies.Experts from the basin directorates monitor the implementation of these measures. Actually,the measures are implemented by different stakeholders − municipalities, water users, industrial enterprises, etc. and depend on their activity and funding opportunities. A key point in water management policy is the reduction of pollution of water bodies.

One of the main tasks of RBMP is to determine surface and groundwater status through continuous data collection (monitoring). Currently, these data as well as the national catalogue of measures are in the form of MS Excel tables.

The aim of the present study is, on the basis of the developed economic model, to design and to implement in future an information advisory system, which will support the assessment of the adopted measures for the water protection and purification from mining activities.

Data from the East-Aegean region is used to design and develop the system. However, other basin directorates could applythe developed system. Analyses for the East-Aegean region under Programme BG02 *"Integrated Marine and Inland Water Management",* Project EARBDMINING (Financial Mechanism of the European Economic Area 2009-2014) show that mines and tailing ponds are significant sources of pollution. They account for 20% of point sources and 8% of diffuse sources of pollution.

Economic model for assessing water pollution

In terms of economic theory, the model developed (Radev, 2015; Radev et al., 2019) can be described as follows: the cost-effectiveness analysis selects the optimal (cost minimising) combination of measures, which then is integrated into the cost-benefit analysis to assess the economic effectiveness of the proposed measures for individual water bodies, river basins and the area as a whole.

The main idea of the model is to analyse the complexity of the interrelations between different water bodies, as well as cross-correlations between measures and pressures (the pollution effects). Each water body has to be evaluated individually and in combination with other related water bodies, i.e., as part of a larger aggregate.

The most commonly used methods of economic evaluation of large investment projects for environmental protection are:

- **Cost effectiveness analysis (CEA)**. This analysis compares monetary values of the costs and the physical benefits of the measures taken (i.e. the costs are compared with the reduced level of pollution).
- **Cost-benefit analysis (CBA)**. Avoiding contradictions with the valuation of some intangible assets, such as the environment, this analysis a preferred tool in the comparison of alternative measures.

The CBA compares monetary values of costs and benefits (costs are compared to the direct and indirect benefits of improved environmental status). Assessing not only costs but also tangible and intangible assets, the CBA method is appropriate for an overall assessment of the economic effectiveness of the adoptedmeasures or a combination of measures.

The choice of benchmarks and thresholds of pressures and measuresis associated also with the selection of CBA and/or CEA methods.

According to CEA method,the costs that are required to achieve good environmental status, are effective when they are lower than the relevant thresholds. Exceeding the thresholds means that it is necessary either to reformulate the time horizon and/or to recommend measures with less ambitious environmental objectives.

When we combine the indicators from both CEA and CBA assessment methods, it is important to allocate the measures to places with the most correct estimates according to thetwo methods.

The meaning of the model can be summarised as follows: assessment of the effectiveness of WFD measures is done in terms of target water statusthroughpre-selection of the actions with which this status can be achieved in the most effective way. They should be done by two parallel analyses – on the costs and on the benefits, respectively. The cost estimates are obtained after selecting the set of measures and calculating their unit and total value.Thereafter, the measures are revised until the minimum level of costs is achieved,i.e. the level at which no more economies are possible. The values of benefits are assessed on the basis of a pre-prepared classification of the positive effects of achieving the target status. When assessing the benefits and costs of the individual water body, aggregation is undertaken, and at each level through CEA and CBA methods, the efficiency is determined (Fig. 1).

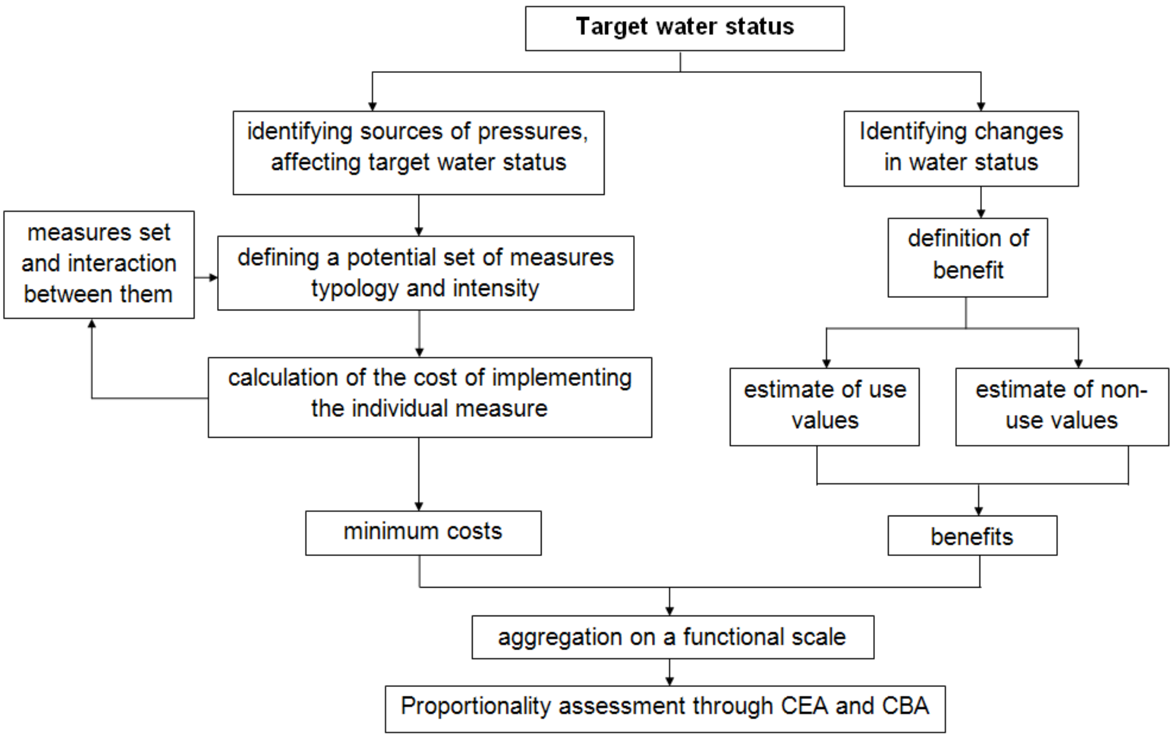

Fig. 1. Procedures for the application of AER and CBA

The choice of assessment methods and benchmarks is complemented by the choice of the most appropriate scale of economic analysis.

The final result of the cost benefit analysis is a B/C coefficient, which is determined as a ratio of benefits to costs per inhabitant of the water body area. This factor gives information about theprofitability of the investment on the basis of the takenmeasures. The investment is effective if the ratio is greater than 1, even though in some cases it is assumed to be smaller but close to 1.

Information advisory systems

The primary source of each solution is a problem. It can be classified as: structured, poorly structured or unstructured. Management decisions can be taken at operational, strategic and tactical levels.

The decision-making process goes through several stages. The sequence of these steps is illustrated in Figure 2 (Tujarov, 2007). Successful implementation of each stage requires specific information that is achieved through data processing for decision-making.

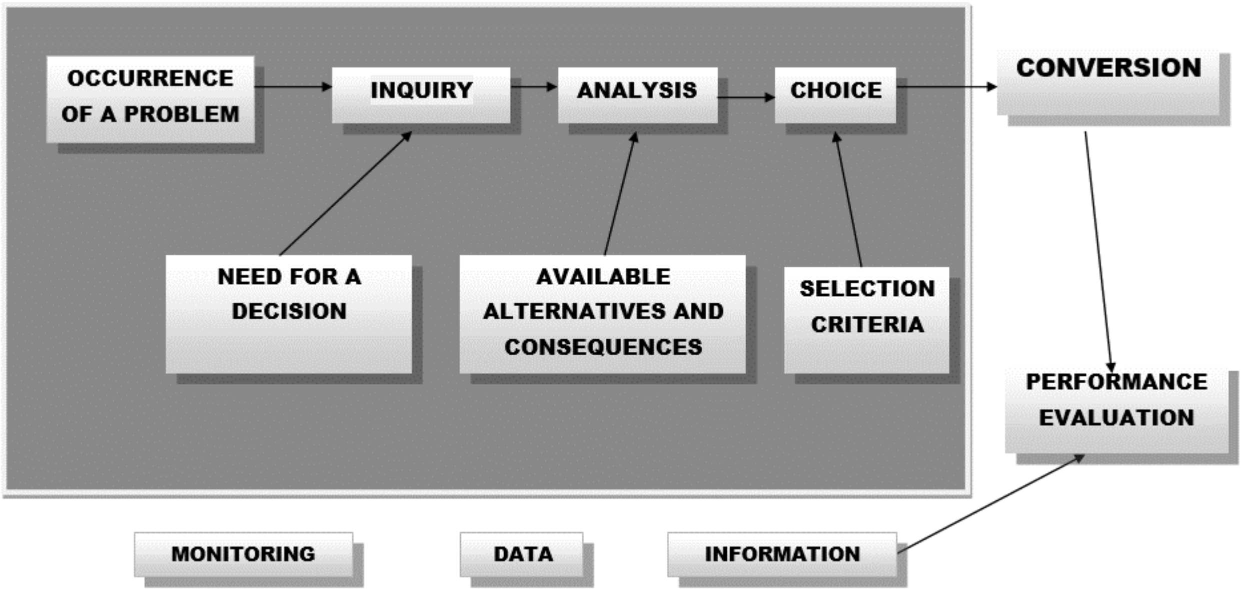

Fig. 2. Illustration of the decision making model

In order to cover the management processes, it is necessary to consider the decision-making area, the decision-makers and the way in which the information is used in the decision-making process. After problem identification, a study that generates alternatives is conducted; a variant according to certain criteria ischosen, a possible decision is selected and the resultsare evaluated.

According to how the necessary informationis gathered and presented, how the analysis is performed and what the resultis, the counselling systems can conditionally be divided into information advisory, decision support, and expert systems.

Information advisory systems contain mostly unstructured or poorly structured information about existing solutions in a given area. Their task is to select from the total amount, on the basis of some criteria, the necessary information and to provide it in a synthesised form to the decision makers.

Decision support systems contain mostly structured information − data in sufficiently large volumes. They contain various data about the mining methods that are used to find some characteristics of these data: classes, clusters, functional and statistical dependencies, extreme values. These characteristics determine the solutions that the system gives.

The system that is subject to design hereis at the border between these two types, because it handles poorly structured information related to assessments of good ecological water status.

Designing the information advisory system

As mentioned before, the measureswith their characteristics and the description of water bodies with their ecological status are organised in MS Excel tables.Basin Directorates prefer to work with them. This allows the system to be developed in the MS Excel environment using Visual Basic for Application. This is a programming language oriented to expand MS Excel with executable modules − macros. A similar solution is applied in the French WFD-CBA system (Termignon, Devaux, 2014).

In order to apply the cost-benefit analysis in the system of the national catalogue of measures only those measures related to the pollution from mining activities are taken. They need to be processed in a form convenient for automated analysis. Data have to include: the measure code, description, numerical criteria for its application, the cost of the measure, a numerical evaluation of its benefit. The revised measures will be in a separate table. Descriptions of water bodiesare in another table, they include their subdivisions, ecological status, number of inhabitants, possible pollutants, etc.

A functional model of the advisory system is given in Figure 3.

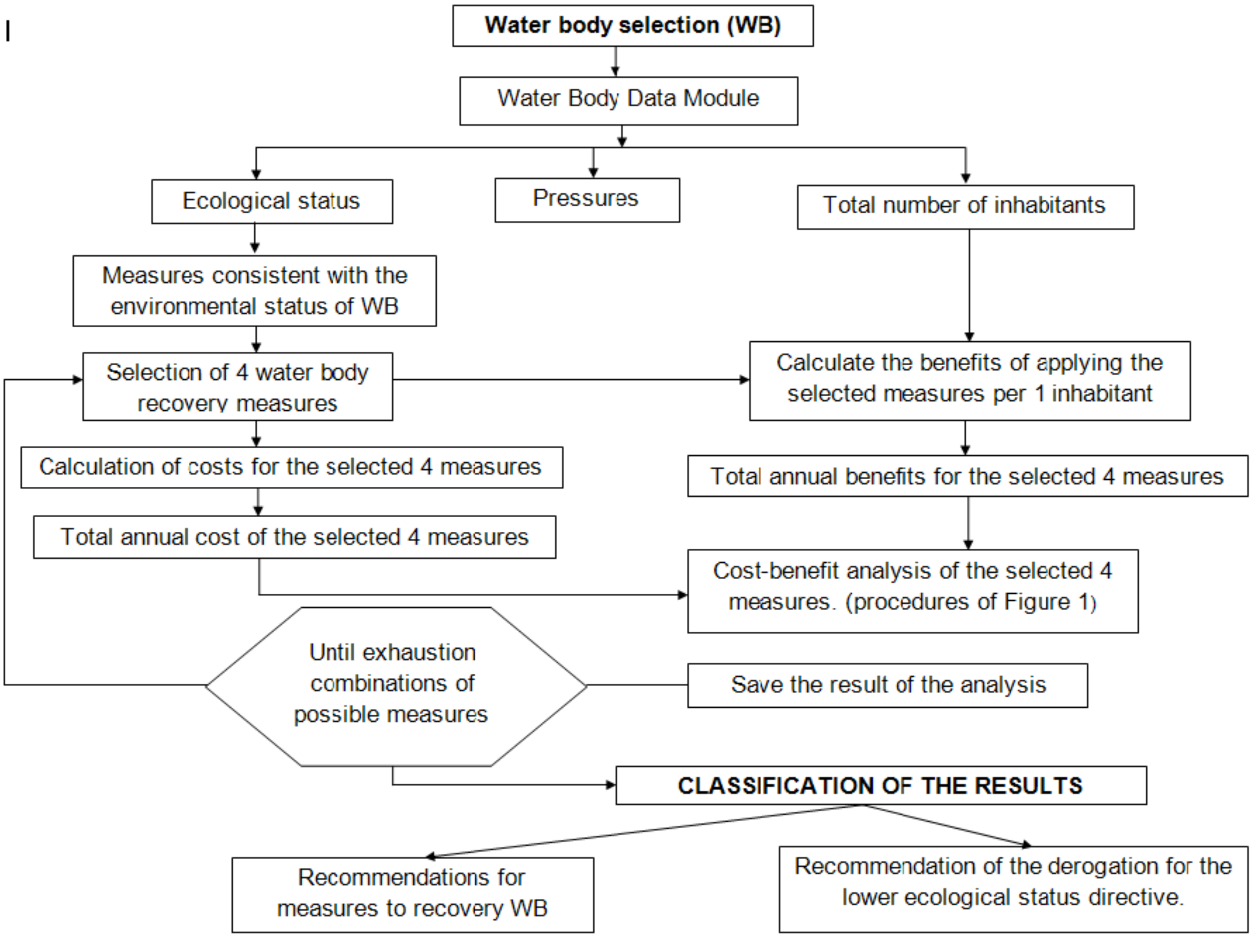

Fig. 3. Functional model of the Information Advisory System

In the "water body selection" module, the body or a section of it (sub body) for which the calculations will be performed is selected. The "Water Body Data Module" provides information to the user about the ecological status of the selected water body or sub body, possible pollutants (pressures) and the number of inhabitants living in its area.

From the table of measures, only those applicable to the respective ecological status of the selected body are separated. The measures are basic and additional. The analysis performed by the system is based on a selection of four measures. They may include one or two major measures, and the rest are additional. The system cyclically performs the cost-benefit analysis of all possible combinations of the four measures that are applicable to the status of the water body. The results are saved and sorted by the resulting cost-benefit ratio. The first few with the best ratio arepresented to the user as the result. At each step, the benefits and costs of a resident according to quadruple measures are calculated.In order to study the sustainability of the results, an option with a 10% increase in costs is also calculated.

Conclusion

The development of this information advisory system would help decision-makers from the Basin Directorates and the Ministry of Environment and Waters to select more effective measures to achieve good ecological status of the waters in certain mining areas. This means that with relatively smallercosts a better effect will be achieved.

If the system has a widespread application, it can easily be reworked as a Web based one.

References

Durzaven vestnik, 97, 12.11.2012 (in Bulgarian).

Radev, Yu. 2015. Costs and benefits of measures under the Water Framework Directive. – *Geologia i Mineralni Resursi,* 7–8, 30–35 (in Bulgarian with English abstract).

Radev, Yu., D. Simeonova, R. Barneva, K. Kanev, L. Walters. 2019. Economic Assessment of WFD Implementation Measures in the East Aegean Region. – *14th Annual BRC Conference, Innovations in Business Research and Teaching. May 27, 2019, Seneca College in Toronto, Ontario.*

Termignon, M., J. Devaux. 2014. Evaluating the benefits derived from a change in water status (update for the second WFD cycle). – In: *CGDD Service de l'économie, de l'évaluationet de l'intégration du développement durable.* Ministère de l'écologie, Paris.

Tujzarov, H. 2007. Informatsionni sistemi; *http://tuj.asenevtsi.com/Inf%20sistem/IndexIS.htm* (in Bulgarian).