IMPLEMENTATION OF A SYSTEM BASED ON THE "BENEFITS-COSTS" ECONOMIC METHODOLOGY FOR SURFACE WATER BODIES FROM THE EAST AEGEAN REGION

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ABSTRACT. When planning an event or activity through the "benefits-costs" economic methodology, the monetary equivalent of benefits and costs is calculated and an evaluation of the effectiveness of measures is made. Based on this approach, an information advisory system has been developed for achieving economic efficiency of the ecological measures in the river basins of the surface water bodies from the East Aegean region of Bulgaria. The system is developed in the VBA language in the Microsoft Excel environment. It carries out combinations of measures taken from a pre-classified catalogue and develops action scenarios from these combinations. The effectiveness of the scenarios is calculated based on the "benefits-costs" methodology. The user is offered possibilities to choose from among the best scenarios. This system could be employed by experts from the Ministry of Environment and Water, environmental organisations and municipalities.

Key words: Information advisory systems, software implementation, evaluation of the effectiveness of measures

РЕАЛИЗАЦИЯ НА СИСТЕМА, БАЗИРАНА НА ИКОНОМИЧЕСКАТА МЕТОДИКА „ПОЛЗИ–РАЗХОДИ“ ЗА ПОВЪРХНОСТНИ ВОДНИ ТЕЛА ОТ ИЗТОЧНО БЕЛОМОРСКИЯ РЕГИОН

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РЕЗЮМЕ. При планиране на дадено мероприятие или дейност чрез икономическата методика „ползи-разходи“ се изчислява паричния еквивалент на ползите и на разходите от предприетите мерки и се прави оценка за ефективност. Базирана на този подход, е разработена информационно съветваща система за постигане на икономическа ефективност на екологичните мерки в речните басейни на повърхностните водни тела от източнобеломорския регион на България. Системата е разработена на езика VBA в среда на Microsoft Excel. Тя извършва комбинации от мерки, взети от предварително класифициран каталог, и изработва сценарии за действие от тези комбинации. Ефективноста на сценариите се изчислява на базата на методиката „ползи-разходи“. Дава се възможност на потребителя да направи избор от най-добрите сценарии. Тази система би могла да се използва от експерти на МОСВ, екологически организации и общини.

Ключови думи: Информационно съветваща система, софтуерна реализация, оценка за ефективност на мерки.

Introduction

The management of water resources in the Republic of Bulgaria is carried out at the national and the basin level. The State Water Management Policy follows the National Strategy for Water Sector Management and Development, which defines the main goals, stages and methods for development. The strategy was adopted on 21.11.2012, with a period of validity until 2037. A key point in the water management policy is the reduction of the pollution indicators of water bodies.

Catalogues of measures have been developed in the Ministry of Environment and Water (MOEW) and in the basin directorates on the basis of European Union directives for measures to improve the ecological status of waters. When deciding on measures to improve the ecological status of specific water bodies, experts need to work with these catalogues, which is rather time consuming and subjective. A solution to this problem would be decision support systems through which experts can quickly and efficiently find the necessary measures. For this purpose, an information advisory system has been developed and tested, using a methodology for the economic evaluation of benefits-costs.

In articles (Radev 2015; Radev et al. 2019), the economic benefit-cost method applied to measures for improving the ecological status of water bodies is presented. An article (Simeonova et al. 2019), presents a project of an information advisory system for the assessment of measures for water pollution from mining activities.

Functional model of the advisory system

The input data in the system are divided into four tables:

The “Water Bodies” table provides information on the water bodies from the East Aegean region with which the system works.

The "Pollutant groups" table defines the combination of chemical elements for the respective pollutant group.

The "Measures" table includes measures to improve the ecological status of water bodies, and for each measure, the following data are provided:

• the code of water bodies,
• the group of pollutants,
• the discounted value of the measure.

The "Population" table includes information about the settlements and their inhabitant number around the water bodies in the region.

The functional model determines the separate stages of system implementation and is closely related to the program model. It conditionally consists of seven modules, which are executed sequentially (Fig. 1)

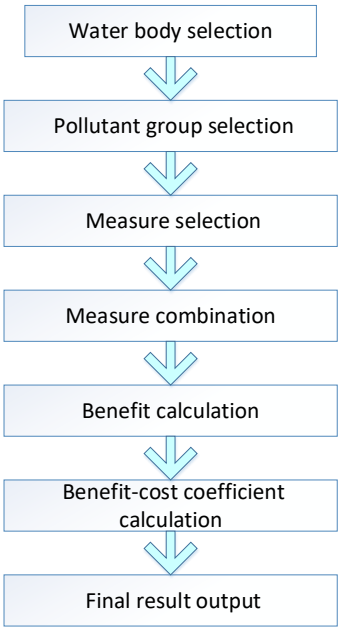


Fig. 1. Functional model of the Information advisory system

In the module "Water body selection" from the "Water bodies" table, the body or a sub-body is selected, for which a benefit-cost assessment is performed. Thus, the choice of the water body code determines: 1. its ecological status, and 2. the percentage of pollution measures in mining activities involved in the calculation of the benefits for the selected water body. Determining the combination of measures and their costs depends on the ecological status. If the object sought by the user does not exist in the table of water bodies, then the respective water body or sub-body can be added in the table.

In the "Pollutant group selection" module, from the five groups A, B, C, D and E of pollutants of water bodies, the respective group is selected for which the benefit-cost assessment is performed for the selected water body or sub-body.

From the general table of all measures, the "Measure selection" module chooses those for the selected water body and pollutant group. Accordingly, two separate tables are created with measures, whether basic or additional,. There are measures that can be both basic and additional. They are included in both tables, but the user can choose such a measure only as a basic one or only as an additional one.

The "Measure combination" module, based on the environmental status, which is good, moderate or bad, forms all possible combinations of scenarios of measures to achieve good environmental status. One scenario includes four measures, which are distributed according to the three-level scale of ecological status, as follows:

• for a good ecological status, one basic and three additional measures are envisaged,
• for a moderate ecological status, two basic and two additional measures are envisaged,
• for a bad ecological status three basic and one additional measures are envisaged.

The sum of the discounted values of the measures included in a given scenario forms the costs of applying that scenario. These are the costs in the benefits-costs model.

The resulting combinations of scenarios are sorted by cost. In some cases, these combinations are very large. The three scenarios with the lowest costs are proposed by the developed system as effective.

In the "Benefit calculation" module, from the table for settlements in the East Aegean region of the Republic of Bulgaria, according to the code of the water body, the settlements around it are selected and the number of inhabitants is summed. For each resident, the benefit of the annual costs of improving the environmental status is estimated to € 10.74. The reasons for determining this value are presented in (Radev 2015). The total benefit from the improvement of the ecological status of the selected water body is calculated from the product of: number of inhabitants, € 10.74, the exchange rate €/BGN and the percentage of pollution measures in mining activities of the respective water body. The value thus obtained for the benefits is discounted on the recommendation of the European Commission for a period of 30 years at 4% interest and thus the value of the updated benefits is calculated.

The "Cost-benefit coefficient calculation" module calculates the cost-benefit ratio for each scenario of measures. For the scenario, the benefit-cost coefficient is calculated as a ratio of the result obtained to the calculated updated benefits for the water body and the calculated costs for the respective scenario. Depending on the obtained coefficient, an assessment is made for proportion/disproportion of the benefit-cost ratio for reaching an improved water status and advice is given for taking actions through which the goals are achieved in a cost-effective way.

The calculated coefficient participates in the final result that the system offers. If for a given scenario the benefit-cost coefficient is a number greater than 0.8, the measures in this scenario are considered to be effective and the system advises to take appropriate actions. Otherwise, the scenario is considered untenable and if there are no better scenarios for this water body, a time derogation from economically acceptable measures is recommended, the implementation of which will take longer to reduce pollution to the desired levels. For Europe, it is considered that the coefficient for acceptable measures should be greater than or equal to 1, but for Bulgaria a coefficient greater than 0.8 is allowed.

The "Final result output" module generates a report with the total results of the system, which includes the three best scenarios and the calculated coefficients for them. According to these coefficients, recommendations (advice) are given to the user.

Development and description of the information advisory system

The system was developed in the environment of MS Excel, because the input data, such as the national catalogue of measures, the data on the population in the East Aegean region, the data on the ecological status, are organised in such tables.

The employees of the basin directorates prefer to work with them. This gives reasons for the system to be implemented in the environment of MS Excel, using Visual Basic for Application.

Potential users of the system usually work on MS Excel and will not need to be trained to handle data in the system. An important point is that MS Excel has built-in numerous computational functions, which would facilitate the construction of the system. The system includes a basic module with a number of options and forms that allow even experts with limited computer knowledge to easily work with it. A similar solution is applied in the French WFD-CBA system (Termignon et al. 2014, pp 41-45).

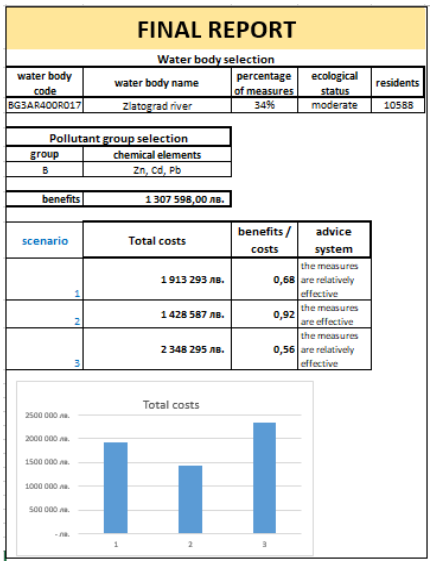
The information advisory system consists of ten worksheets the transition between which is done by buttons. Pushing a button executes a corresponding procedure from the VBA program.

Fig. 2. Home page of the system

The following results are obtained from the operation of the system:

- information about the selected water body,
- the group of pollutants,
- the calculated population and benefits for the water body,
- information on the three best scenarios found, including:
  - selected measures,
  - the costs of the scenario,
  - the calculated corresponding cost-benefit coefficient.

Figure 3 shows the page with the final report which includes tips for applying the scenarios according to the calculated coefficients.



FINAL REPORT

Water body selection

water body code	water body name	percentage of measures	ecological status	residents
BG3AR400R017	Zlatograd river	34%	moderate	10588

Pollutant group selection	
group	chemical elements
B	Zn, Cd, Pb

benefits	1 307 598,00 лв.

scenario	Total costs	benefits / costs	advice system
1	1 913 293 лв.	0,68	the measures are relatively effective
2	1 428 587 лв.	0,92	the measures are effective
3	2 348 295 лв.	0,56	the measures are relatively effective

Fig. 3. Final report of the system

Testing of the information advisory system

Two water bodies, respectively with a moderate and a poor ecological status, were selected for the information advisory system testing. The results of the testing of the system are identical to those obtained by the manual calculation of a team of researchers, which shows the correctness of the calculations of the system.

Conclusions

The implementation of an information advisory system for the selection of effective measures for improving the ecological status of water bodies from the East Aegean region, based on the economic methodology benefits-costs, is presented.

The system was developed for a single user in an MS Excel environment using the VBA programming language. The advantages of this approach are as follows:

- The users of the system usually work on MS Excel and there is no need for additional training.
- The input information about the system is located in various catalogues in the MOEW and basin directorates and is organised as MS Excel files. This allows them to be easily integrated into the system.
- The VBA language used gives access to the spreadsheet object model in MS Excel and its built-in functions.

The developed system has been tested with real data and shows the same results with previous manually performed calculations.

If there is interest in the system, it could be developed as a multi-user one in a network environment.

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