Journal of Geography and Earth Sciences
December 2019, Vol. 7, No. 2, pp. 1-14
ISSN 2334-2447 (Print) 2334-2455 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jges.v7n2a1
URL: https://doi.org/10.15640/jges.v7n2a1

Structuring and Evaluation of the Factors Affecting the Efficiency of Decision Making Regarding the Use of Water Bodies

Olga Petrakovska[1] & Marharyta Dubnytska[2]

Abstract

The article describes the results of the research of structuring and evaluation of the factors affecting the efficiency of decision making regarding the use of water bodies. The authors define seven aggregated thematic groups of factors: information, technology, environmental, economic, legal, institutional and social. For estimation of demonstration and qualitative factors, conventional 5-point scales have been developed. In order to determine the significance of each factor, three categories of the subjects involved in decision making have been identified: subjects that justify and influence decision making; subjects that make final decisions; subjects that experience the consequences of decision making. According to the survey results of the representatives of the first two categories, the ranking of expert evaluations was carried out and the significance of the factors was determined. It was proved that information factors are the most significant, among which geospatial information is of particular importance. An algorithm based on the Cobb-Douglas logarithmic function is proposed for integral estimation of the efficiency of decision making regarding the use of water bodies. This approach allows to evaluate the efficiency of the decisions implemented and to forecast the results of the future ones.

Keywords: Water bodies, expert evaluation, efficiency of decision making, ranking, integral estimation.

1. Introduction

Environmental management, in particular the use of water bodies, is an interdisciplinary task (Thompson, 1998). The accounts and evaluation of water bodies were made in two-dimensional information systems for a long time. However, under conditions of today's urbanized areas with significant anthropogenic environmental load, these two-dimensional systems are not sufficient to ensure natural resource management. Western scientists have concluded that water body accounts should be kept in a three-dimensional environment. Strictly in the availability of three-dimensional information the accounting of water bodies can be complete and adequate (Stoter, 2004).

To solve the task of water body management, it is necessary to structure and evaluate the significance of the factors that affect the efficiency of decision making regarding their use. For said purpose, the authors have analyzed a set of factors and structured them on the disciplinary principle.

The research was conducted in the following sequence:
1) identification of a set of the factors and their analysis;
2) determination of the most significant factors necessary for consideration;
3) structuring of the factors and clustering them in qualitatively homogeneous groups;
4) factor evaluation and ranking;
5) integral estimation of the efficiency of decision making(Charnes, A., Cooper, W. W., Rhodes, E., 1978).

[1]Head of Land Management and Cadastre Department, National University of Architecture and Construction, Povitroflotsky avenue 31, Kyiv, Ukraine, 03037; petrakovskaolga@gmail.com, ORCID: 0000-0002-9437-9730
[2]Assistant of Land Management and Cadastre Department, National University of Architecture and Construction, Povitroflotsky avenue 31, Kyiv, Ukraine, 03037; dubnytskamv@gmail.com, ORCID: 0000-0002-1907-1496

2. Analysis of a set of factors

The analysis of a set of the factors affecting the efficiency of decision making regarding the use of water bodies was conducted through a combination of literary source studies and practical experience. This has made it possible to identify the factors that are obligatory for consideration when managing the use of water bodies, which were clustered into seven thematic groups: information, technology, environmental, economic, legal, institutional and social. (Fig. 1).

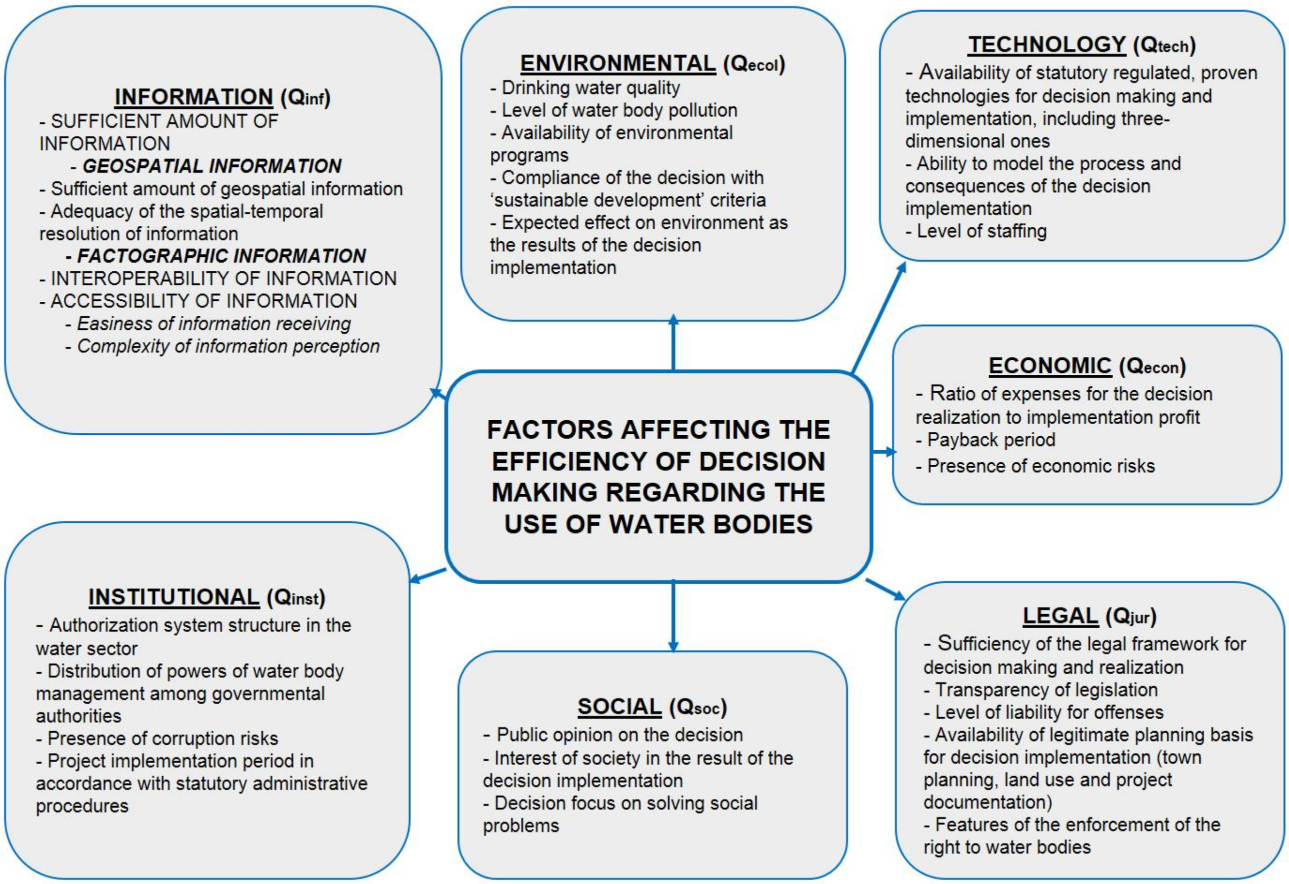

Fig. 1. Factors affecting the efficiency of decision making regarding the use of water bodies

In Ukraine, the reform of the law institute is still continuing, and decentralization has been actively implemented recently, leading to a reallocation of the functions, powers and responsibilities of all management entities. Under such conditions, <u>legal factors</u> Q_{jur} are of particular importance (Wozniak, 2019).This group of factors includes the following: the sufficiency of the legal framework for decision-making and realization, transparency of legislation, the level of liability for offenses, the availability of a legitimate planning basis for the implementation of the decision, the features of the enforcement of the right to water bodies. The availability of a legitimate planning base for implementation of the decision means the existence of approved land use, town planning and project documentation.

When making any decisions, a significant regulator is the <u>institutional factors</u> reflecting the structure of the authorization system in the field of water use, the distribution of powers of water body management among governmental authorities, the presence of corruption risks, project implementation period in accordance with statutory administrative procedures (Klovienė, 2012).

The group of <u>social factors</u> Q_{soc} is actually a reflection of the attitude and response of society to the implementation of a decision (Wozniak, 2019). This group includes public opinion on the decision, the interest of society in the end result, the focus of the decision on social needs. Under democratization of public administration, a group of social factors is of particular importance. In addition, it is one of the indispensable components of the sustainable development of society.

In today's ecologization of society, it is difficult to overestimate the significance of environmental factors Q_{ecol} when using water bodies that have water supplying and recreation functions and are the main means of production, etc. Considering the multifunctionality of water bodies, the necessity of considering the decisions on the quality of drinking water, the level of pollution of the water bodies and any other direct or indirect expected negative impactis obvious. At the same time, environmental programs aimed at implementing sustainable development principles are important levers (Pedrazzini, 2011).

The group of economic factors Q_{econ} includes the ratio of expenses for the decision realization to implementation profit, payback period and the presence of economic risks(Visnja, Jovičić, Arsovski, Živković-Drezgić and Badjok, 2016).

In the group of technology factors Q_{tech}, the main ones are the availability of statutory regulated, proven technologies for decision making and implementation, the ability to model the process and consequences of the decision implementation, and the availability of the necessary staffing (Institute of Medicine, 2013).

Any decision can be justified only if there is verified and qualitative information (Choo, 2002). Therefore, special attention is given to the group of information factors $Q_{\inf}$,in which the authors additionally distinguished three main subgroups: sufficiency, interoperability and accessibility of information. The emphasis should be placed on the significance of different types of source information – geospatial (cartographic) and facto graphic (semantic / attribute). Such additional division of information makes it possible to structure the information layers of the 3D cadastre of water bodies and evaluate the completeness of different types of data. In assessing the quality of geospatial information, the availability of map data of different spatial-temporal dimensions and the level of their spatial-temporal resolution are important indicators. It should also be noted that the information accessibility to a decision-maker is determined by the ease of its obtaining and the complexity of its perception ('understandability').

3. Scales for factor evaluation

After determining the list of factors affecting the efficiency of decision making regarding the use of water bodies and combining them into qualitatively homogeneous groups, their evaluation and ranking have been carried out. The vast majority of the factors (all groups of factors except economic ones) are characterized by qualitative properties that cannot be numerically expressed. Thus, a qualitative scale of the ordinal type was used for their evaluation, in which the measurement results are defined as $\varphi_i(k_i)$, where φ_i is an arbitrary increasing function. The features of such scales are that they do not record the beginning of the reference, there may be different scales of measurement, even the magnitude when passing from one value to another can be different (Nogin, 2005). In view of this, each factor was rated on a qualitative 5-point scale: 1 (very bad), 2 (bad), 3 (satisfactory), 4 (good), 5 (very good). The substantive content of each graduation is determined according to the thematic groups of factors that must be considered when evaluating the efficiency of decision making (Tables 1 – 7).

Any decision can only be implemented if there is an appropriate legal mechanism. In addition to the above, the legal framework is not only necessary to ensure the justification and legitimacy of the decision, but also must be sufficient to make the decision transparent and understandable (Wozniak, 2019)(Table 1).

Table 1. Scale of evaluation of legal factors

Score	Factors				
	Sufficiency of legal framework for decision making and implementation	Transparency of legislation	Level of liability for offences	Availability of legitimate planning basis for decision implementation (town planning, land use and project documentation)	Features of enforcement of the right to water bodies
1 (very bad)	Legal framework is absent	Legislation is nontransparent, explications are blocked	Liability for offences is not prescribed	Legitimate planning basis for decision implementation is absent and cannot be developed	Water bodies cannot be used lawfully
2 (bad)	Common legal framework is available, but some its provisions block adoption and realization of individual decisions	Legislation is nontransparent, explications are provided, however, there is now certainty as to application of specific rules of law	Disciplinary, civil or administrative liability is prescribed; penalty mechanism is absent	Legitimate planning basis for decision implementation is absent, but can be developed	Possible use without water body transfer
3 (satisfactory)	Common legal framework is available only	Legislation requires further explanations	Offence provides for disciplinary, civil or administrative liability, penalty mechanism is imperfect and does not fully work	Legitimate planning basis for decision implementation is being developed	Transfer of the right to water body use is possible, however, it is difficult to implement
4 (good)	Legal framework is available, but some provisions are discretionary	Legislation is transparent, but some provisions are discretionary	Offence provides for all kinds of liabilities(includin g criminal), but penalty mechanism is imperfect and does not fully work	Legitimate planning basis for decision implementation is partly available	Transfer of the right to water body use is possible and is implemented
5 (very good)	Legal framework is available to the full extent, creates favorable conditions for decision making and implementation	Legislation is transparent, accessible and comprehensible	Liability of all kinds (including criminal) is prescribed and imposed for an offence	Legitimate planning basis for decision implementation is available to the full extent	Water bodies can be provided into the ownership, they are freely provided for use

Institutional factors demonstrate the quality of government regulation of decision making (Klovienė, 2012). The structure of the authorization system in the water sector is evaluated in terms of the complexity of obtaining the relevant permits, which is determined by the possibility of centralized or online submission of orders and terms of obtaining permits. The distribution of powers regarding the water body management among governmental authorities illustrates how rational the management structure is, whether there are discretionary issues, or whether some areas of water use remain unmanaged. When assessing corruption risks, it is necessary to note not only the probability of their occurrence, but also the estimated share of these risks in the total cost of the decision implementation, which in size can correlate to the probability in a certain way(Table 2).

Table 2. Scale of evaluation of institutional factors

Score	Factors			
	Authorization system structure in the water sector	Distribution of powers regarding the water body management among governmental authorities	Presence of corruption risks	Project implementation period in accordance with statutory administrative procedures
1 (very bad)	Obtaining a permit for use of a water body is impossible	Governmental authorities responsible for water body management are absent	High level of corruption risks (over 50 %)	Over 10 years
2 (bad)	Permit term isfrom 1 to 6 months; submission of documents directly to authorization authority; clear list of documents is not defined	Powers are dispersed between a large number of different executive bodies, are discretionary, duplicated or leave certain areas unmanaged	Level of corruption risksis above average (30-50 %)	5-10 years
3 (satisfactory)	Permit term is from 10 working days to 1 month; documents are submitted through Administration Service Center; information and technology service cards are available; authorization authority may return the documents with observations several times	Powers are dispersed between several state executive bodies; some issues are discretionary, unmanaged spheres are absent	Average level of corruption risks (15-30 %)	3-5 years

4 (good)	Permit is issued within 10 working days, documents are submitted through Administration Service Center; information and technology service cards are available; the permit is issued for the first time after the compliance with observations	Powers are clearly distributed among several state executive bodies	Low probability of corruption risks (5-15 %)	1-3 years
5 (very good)	Obtaining a permit is automated, possible online	Public water body management is coordinated by one authority	Minimum probability of corruption risks (up to 5 %)	Up to 1 year

An aggregated evaluation of the decision efficiency is impossible without consideration of social and environmental factors. Social factors characterize the consequences of managerial decision for society and includes public opinion concerning the decision, the interest of the population and industry complex as the result and its focus on solving social problems (Wozniak, 2019) (Table 3).

Table 3. Scale of evaluation of social factors

Score	Factors		
	Public opinion on managerial decision	Interest of society in the result of the decision implementation	Decision focus on solving social problems
1 (very bad)	The community is strongly opposed to the decision	Society is not interested in the result of the decision implementation	The decision leads to new social problems
2 (bad)	Some members of the community are not satisfied with the decision	Individual interest is present	The decision aggravates the current social problems
3 (satisfactory)	The community is indifferent to the decision	Interest of society at the local level is present	The decision does not affect social problems
4 (good)	Some members of the community support the decision	Interest of society at the regional level is present	The decision may have a beneficial effect on social problems
5 (very good)	The community fully support the decision	Interest of society at the state level is present	The purpose of the decision is to solve social problems

Environmental factors directly or indirectly reflect the quality of the environment (Pedrazzini, 2011). Direct indicators include the quality of drinking water that varies depending on the means of pretreatment and the level of water body pollution, which is characterized by the level of hazardous substance concentration in it. Mediating factors are the availability and performance of environmental programs, compliance of the decision with 'sustainable development' objectives and expected consequences for environment as the results of the decision implementation (Table 4).

Table 4. Scale of evaluation of environmental factors

Score	Factors				
	Drinking water quality	Level of water body pollution	Availability of environmental programs	Compliance of the decision with ‘sustainable development’ criteria	Expected effect on environment as the results of the decision implementation
1 (very bad)	Water is unpotable	Radiation and chemical pollution is present – MAC*of hazardous substances far exceeds the norm	Environmental programs are absent	The decision does not consider ‘sustainable development’ criteria and aims	The result of the decision implementation can significantly aggravate the state of the environment
2 (bad)	Water is suitable for use after filtration and chemical treatment	Chemical pollution is present – MACof hazardous substances exceeds the norm	Environmental programs are available at the state level; their measures are not implemented	The decision will allow to improve the efficiency of water use, but does not affect the quality of management and protection	The result of the decision implementation may lead to insignificant deterioration of water body ecosystem
3 (satisfactory)	Water is suitable for use after filtration and thermal treatment	Biological pollution of anthropogenic origin is present (blooming of water, overgrowing, etc.), MAC of hazardous substances is at the upper limit of normal	Environmental programs are available at the state and regional levels; their measures are partly implemented	The decision will allow to improve the efficiency of water use and management of water resources, however, it does not consider the necessity of their protection	The result of the decision implementation does not affect the state of water body ecosystem and the environment
4 (good)	Water is suitable for use after filtration	Natural mechanical pollution is present (sand, clay, tree branches, etc.), MAC of hazardous substances is normal	Environmental programs are available at the state, regional and local levels; most of their measures are implemented	The decision will allow to improve the efficiency of water use, ensure the protection of water resources and complex management	The result of the decision implementation will allow to imp-rove to some extent the state of water body ecosystem
5 (very good)	Water is suitable for use without pretreatment	Water bodies are clean	Environmental programs are available at the state, regional and local levels; their measures are fully implemented	The decision is generally focused on provision of the availability and rational use of water resources and sanitation for all of them	The result of the decision implementation will allow to significantly imp-rove the state of the environment

* MAC is the maximum allowable concentration of hazardous substances

Economic factors are one of the most significant indicators of the decision efficiency in terms of investment attractiveness (Visnja, Jovičić, Arsovski, Živković-Drezgić and Badjok, 2016). This group of factors is formed by the ratio of expenses and profits from the implementation of the decision, the period of payback and the presence of economic risks (the ability of direct executors of the decision to fulfill their financial obligations)(Table 5).

Table 5.Scale of evaluation of economic factors

Score	Factors		
	Ratio of expenses for the decision realization to implementation profit	Payback period	Presence of economic risks
1 (very bad)	Losing project (expenses exceed profit)	Over 20 years	High probability of default
2 (bad)	Unprofitable project (expenses are equal to profit)	From 10 to 20 years	The financial state is unstable, there are signs of insolvency
3 (satisfactory)	The profitability is up to 10%, the project begins to generate a profit after its completion and realization	From 5 to 10 years	The ability to fulfill obligations is below average
4 (good)	The profitability is 10%-30%, the project begins to generate a profit after its completion and realization	From 1 to 5 years	Low probability of default
5 (very good)	The profitability is 30% and more, the project begins to generate a profit even in the process of its realization	Up to 1 year	The least probability of default

The group of technology factors determines the opportunity of the decision implementation, that is why these factors are determinant in evaluating the possibility of its realization. (Institute of Medicine, 2013).It should be noted that technologies must be characterized not only in terms of their availability and compliance with modern requirements, but also in terms of their frequency of use. An important technology factor is also the ability to model in detail the process of the decision implementing and its consequences. The use of technologies is possible only in the presence of qualified and experienced staff, so this indicator should also be evaluated (Table 6).

Table 6. Scale of evaluation of technology factors

Score	Factors		
	Availability of proven technologies for decision making and implementation, including three-dimensional ones	Ability to model the process and consequences of the decision implementing	Level of staffing
1 (very bad)	Proven technologies for decision making and implementation are absent	The process and consequences of the decision implementing are impossible to be modeled	Qualified staff are absent, training is impossible
2 (bad)	Single experimental technologies for decision making and implementation are available	The process of the decision implementation is roughly modeled, the consequences are not calculated	Thorough training of staff to achieve a sufficient qualification level is required
3 (satisfactory)	Technologies for decision making and implementation are under development and periodically tested in practice	The process and consequences of the decision implementation are roughly modeled	Some training of staff for their qualification upgrading is required
4 (good)	Technologies for decision making and implementation, including three-dimensional, are proven, but rarely used	The process of the decision implementation is modeled in stages, with an average detailing; one variant of the consequences of the decision implementation is calculated	Qualified staff without experience are available
5 (very good)	Technologies for decision making and implementation, including three-dimensional, are well-proven and actively used	The process and consequences of the decision implementation are modeled in stages, with a high time fragmentation; several variants of the consequences of implementation are calculated	Qualified staff with experience are available

Information, as a set of any findings, data, facts and characteristics regarding relevant phenomena, processes, relationships and events, collected and organized into a usable form, composes the basis of public administration. Therefore, the group of information factors is examined in more detail.

Information is the result of data processing, so it directly depends on the quality of output parameters (Choo, 2002). The main indicators of data quality are their accuracy (or spatial resolution), reliability, representativeness and validity. The accuracy of the data indicates the size of the smallest content unit that is the object of accounting and data collection. In respect to the geospatial data, the degree of their accuracy is denoted as spatial resolution. Reliability shows how true the data is and is a measure of the reliability of the data source. Representativeness is a measure of the ability to extrapolate data on one or more objects to a set of such objects and to give an idea of the whole set of objects. Data validity is characterized by the absence of errors in the collection of data that will interfere with their processing and interpretation (Magwair et.al., 2016).

The sufficient amount of geospatial information was estimated by the following factors as: the proportion of water bodies for which such information is available; scale of geospatial information; media type - paper, electronic (raster or vector format). Similarly, the sufficient amount of fact graphic information was considered, depending on the number of objects for which it is present and its availability in digital form.

The adequacy of the spatial-temporal resolution of information depends on the number of its measurements (2D and 3D), the time slice it covers, and the frequency of its receipt.

Interoperability of information is an indicator characterizing the ability of information to interact in the environment of other geoinformation systems.

The easiness of information receiving depends on how complicated the process of information entry from organizations, which create it, is. The complexity of information perception shows how it is easy for a person making the decision to understand its content (Table 7).

Table 7. Scale of evaluation of information factors

Score	Factors					
	Sufficient amount of geospatial information	Adequacy of the spatial-temporal resolution of information	Sufficient amount of factographic information	Interoperability of information	Easiness of information receiving	Complexity of information perception
1 (very bad)	Geospatial information is absent	Information of different spatial-temporal measurements is absent	Factographic information is absent	There is no interaction of information	Information is not accessible	Information is not clear
2 (bad)	Geospatial information is available for 25% of bodies on paper,scale is 1:50000 and smaller	Only two-dimensional information for the last 2-3 years is available, non-periodic	Factographic information is available for 25% of bodies, non-digitized	Information interaction is possible after its adaptation (through its digitizing and geospatial reference, etc.)	Information is accessible for review within the organizations forming it	Information comprehension requires professional education, work experience and some time
3 (satisfactory)	Geospatial information is available for 50% of bodies, partly on paper, partly in electronic form (scanned bitmaps), scale is 1:10000	Only two-dimensional information for the last 5-10 years is available, periodic	Factographic information is available for 50% of bodies, partly digitized	Information interaction is possible after its conversion	Information is available on request	Information comprehension requires professional education and does not require additional time

4 (good)	Geospatial information is available for 75% of bodies, partly in electronic form (scanned bitmaps), partly – digital maps (GIS), scale is 1:2000	Two-dimensional information with elements of three-dimensional one (bathymetry) for the last 10-20 years is available, periodic	Factographic information is available for 75% of bodies, at least 50% of information is digitized	Information in common universal formats, can be easily integrated into other system at the national level	The most significant information for decision making is on open access	Information comprehension requires some preparation
5 (very good)	Geospatial information is available for 100% of bodies, in digital maps (GIS), scale is 1:500	Two-dimensional and three-dimensional information for the last 25-50 years is available, periodic	Factographic information is available for 100% of bodies, digitized and integrated into GIS	Information in common universal formats, can easily interact, is integrated into NSDI*	All information is on open access	Information is comprehensive without prior preparation

* NSDIis National Spatial Data Infrastructure

4. Ranking of expert evaluations of factors

Having estimated the factors on the above scales, it is necessary to obtain the value of the aggregate demonstration of factors within each group. This task requires determining the significance of each factor. To obtain the values of the ratio of the factors, the method of ranking of expert evaluations was used.

Considering the participation in decision implementation regarding the use of water bodies, all subjects involved in the process were grouped into three categories:

1) subjects that justify and influence decision making;
2) subjects that make final decisions;
3) subjects that experience the consequences of decision making (Fig. 2).

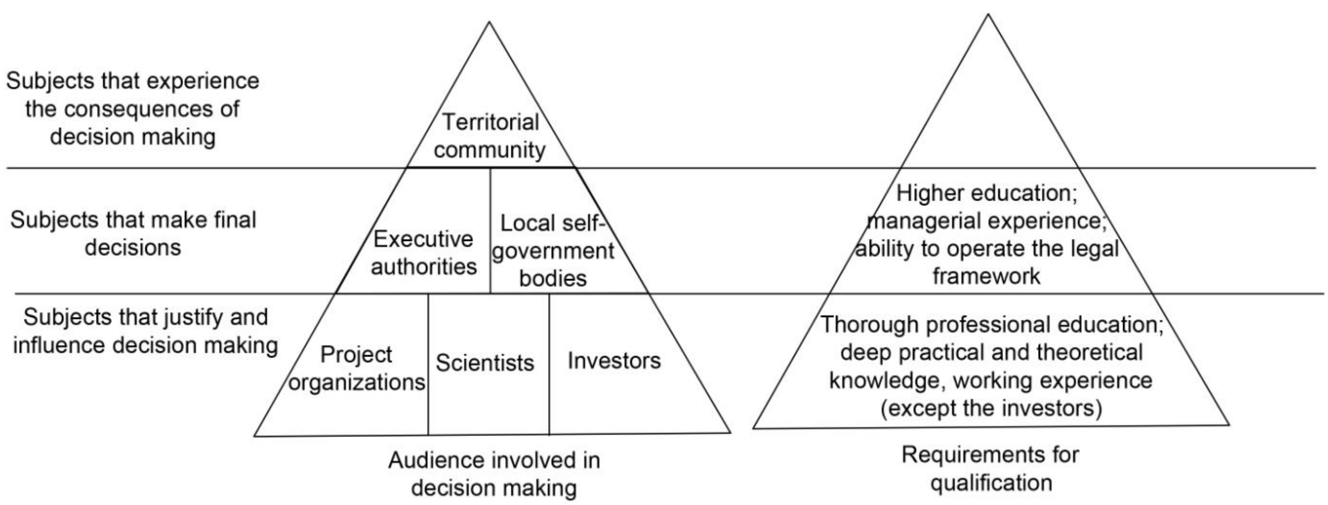

Fig. 2. Structural model of the audience involved in decision making regarding the use of water bodies

The territorial community is a direct evaluator of the end result of the decision in terms of their impact on the environment, both as a whole and within the individual areas of water body use. In recent years, decentralization reform has significantly increased the role of the community in managing water bodies. In the category of the subjects that justify and influence decision-making are united scientists, representatives of project organizations and investors. Scientists research water bodies, which are the basis for developing the documentation necessary to make justified decisions.

Thus, if the source information used for developing such documentation is insufficient and inaccurate, the decision will have negative consequences. In view of this, certain requirements for professional education and practical work experience are given to scientists and representatives of project organizations. Investors can influence decision making regarding the use of water bodies in order to improve their investment efficiency.

Executive authorities and local self-government bodies make final decisions regarding the use of water bodies based on scientific research and the measures proposed in the project documentation. In light of this, it can be argued that the basis for the decision making is the required set of factographic and geospatial information about the water body. There are also certain requirements to the representatives of this category of participants as to the experts – they must have higher education, some managerial experience and be able to operate the legal framework.

For the purpose of expert evaluation of the factors, all the mentioned categories of participants were questioned. A total of 107 experts from the executive authorities, local self-government bodies, project organizations, scientists and investors were involved. The selection of experts (except the investors) was made taking into account the requirements for their qualification, namely: higher education and experience in any field of water management, projecting or management, including water bodies for at least 5 years. The experts were tasked with estimating the factors within each group and comparing the groups with each other in terms of priority. In order to achieve homogeneity of the sample, it included survey data from 100 experts, with 20 representatives from each group. The questionnaire was drawn up considering the need for three-dimensional information for decision making regarding water bodies.

According to the survey, the most significant in decision making regarding the use of water bodies is the group of information factors. In this group, the most important is the availability of sufficient amount of geospatial information, second place is the availability of sufficient amount of fact graphic information and the ease of its obtaining. Instead, according to expert opinion, interoperability of information is the least important

5. Integral estimation of the efficiency of decision making regarding the use of water bodies

To perform integral estimation of the efficiency of decision making considering all the factors studied, an algorithm consisting of three steps is proposed:

1) evaluation of aggregate demonstration of factors within each group;
2) normalization of evaluations of aggregate demonstration of factors;
3) determination of integral estimation of the efficiency of decision making regarding the use of water bodies.

At the stage I, the aggregate demonstration of the factors within each group was estimated by calculating the ratio of the value of a particular indicator to its arithmetic mean weighted by the formula 1):

$$O_{av} = \frac{\sum O_k b_k}{\sum b_k} \quad (1)$$

where O_{av} is the average score of the k -factor;

O_k - score of the k -factor;

b_k - ratio of the k -factor.

As the factors are represented by qualitative and quantitative indicators, their value were reduced to a unified qualitative scale of ordinal type. In view of this, the conditional value (estimation) of each factor $k_1, k_2, ..., k_n$, involved in the formulation of an interdisciplinary task must have natural numerical values, that is $i = 1, 2, ..., m$. In the proposed approach, the factors were evaluated from the lowest (worst) value $m_{\min} = 1$ to the highest (best) $m_{\max} = 5$.

Based on the data of expert evaluation, through ranking, the ratio of each factor b_k is calculated by the formula (2) (Petrunya I. I. et.al., 2011):

$$b_k = R_k / \sum R_k \quad (2)$$

where R_k is the value of expert evaluation of the priority level of k -factor.

The sum of the ratios for the factors of one group should be equal to 1.00, since the individual ratio of each factor characterizes the contribution of this factor to the overall (100%) value of the priority level of the whole group. Thus, formula (1) is transformed as follows (3):

$$O_{av} = \sum O_k b_k \quad (3)$$

At the stage II, the estimation of demonstration of each group of factors was subject to further normalization (4):

$$Q_N = \frac{\prod O_k}{O_{av}} \quad (4)$$

where Q_N is normalized estimate of*N*-group of factors, including $Q_{\inf}$, Q_{tech}, Q_{econ}, Q_{ecol}, Q_{jur}, Q_{inst}, Q_{soc};

$\prod O_k$ - the product of *k*-factor scores;

O_{cep} - average score of *k*-factor of the corresponding group.

At stage III, an integral estimation of the efficiency of decision making regarding the use of the water body Q was determined. For this purpose, a multi-product model of the Cobb-Douglas type function was used, which is a homogeneous first-order linear function of the aggregate estimates of each of the groups of factors (5) (Pogreschuk, Lysyuk, 2010). For our purposes, it was decided to use the Cobb-Douglas function in logarithmic form:

$$Q = \alpha \ln Q_{\inf} + \beta \ln Q_{tech} + \gamma \ln Q_{econ} + \delta \ln Q_{ecol} + \lambda \ln Q_{inst} + \varpi \ln Q_{soc} + \varphi \ln Q_{jur} \quad (5)$$

where Q is the integral estimation of the efficiency of decision making regarding the use of the water body;

$Q_{\inf}$ - normalized estimate of the group of information factors;

Q_{tech} - normalized estimate of the group of technology factors;

Q_{econ} - normalized estimate of the group of economic factors;

Q_{ecol} - normalized estimate of the group of environmental factors;

Q_{inst} - normalized estimate of the group of institutional factors;

Q_{soc} - normalized estimate of the group of social factors;

Q_{jur} - normalized estimate of the group of legal factors;

$\ln$ - natural logarithm;

$\alpha, \beta, \gamma, \delta, \lambda, \varpi, \varphi$ - the ratio of each of the groups of factors in forming an integral estimation of the efficiency of decision making; the sum of the weights should be 1.00.

Using the values of the ratio of the groups of factors obtained as a result of the questionnaire, formula (5) takes the form (6):

$$Q = 0{,}22 Q_{\inf} \times 0{,}17 Q_{tech} \times 0{,}12 Q_{econ} \times 0{,}14 Q_{ecol} \times 0{,}14 Q_{inst} \times 0{,}08 Q_{soc} \times 0{,}13 Q_{jur} \quad (6)$$

Proposed approach allows to evaluate the efficiency of the decisions already implemented and forecast the result of future ones (Petrakovska, Dubnytska, 2018).

6. Conclusions

Under the results of the research focused on structuring and evaluation of the factor significance that affect the efficiency of decision making regarding the use of water bodies, the following conclusions were made as

1. The set of factors that determine the efficiency of water body use includes seven aggregated thematic groups: information, technology, environmental, economic, legal, institutional and social.
2. In order to take adequate decisions regarding the use of water bodies, three categories of subjects should be involved depending on their participation in these decisions implementation: subjects that justify and influence decision making; subjects that make final decisions; subjects that experience the consequences of decision making.

Involving the subjects of the first and second groups to evaluate the efficiency of decision making allows to obtain reliable and objective results of ranking of factors evaluations.

3. Expert estimation of different groups of factors demonstrate that the most significant are information factors, among which the provision of geospatial information is of particular importance.
4. The algorithm of integral estimation of the efficiency of decision making regarding the use of water bodies based on the Cobb-Douglas logarithmic function allows to evaluate the efficiency of the implemented decisions and to forecast the result of future ones.

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