Information system for assessing environmental-economic regional development based on factor analysis and expert evaluations

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Abstract. This paper presents the results of the development of an information system for assessing environmental-economic regional development based on the joint using the factor analysis and expert evaluations. As tools for the implementation of the Web-application were selected: database MySQL and the software part Microsoft Silverlight. Software implementation of the method of calculating integrated indicators of environmental-economic development is carried out in the C# programming language. The Web-application is designed to work with three groups of users (administrators, data editors and regular users) and provides access to controls depending on the level of access of a particular user. The developed information system allows analyzing regional development, identifying the causes of positive and negative trends, determining the list of the most important environmental and economic indicators to focus on and build regional development strategies.

1. Introduction

The economy today is functioning in a competitive environment that is undergoing continuous change because of dynamic development of advanced technologies and their influence on the environment and economic activity [1]. Modern world conditions, economic globalization, acceleration of market development processes, information technologies, environmental-economic factors require public administration new approaches to the formation of regional strategies, development of new models, method, and tools in the field of regional governance, especially it concerns to management of ecological and economic regional development [2-4].

Using modern information technologies and new communication tools significantly increases the social activity and efficiency of business, and the new possibilities allow re-designing environmental-economic development strategy at any time [5]. In connection with the globalization and the processes of post-industrial economy development, the effect of unpredictability appears in the change of environmental-economic systems state due to the increasing influence of economic crises, suddenly emerging threats and risks [6-11]. One of the urgent problems in the analysis of environmental-economic systems is the construction of adequate models. This is due to the multidimensionality of environmental-economic systems, the stochasticity of their behavior, as well as the complex interaction between the elements of the systems [8, 10].

The main problem that arises in environmental-economic studies is reliable conclusions [12]. In statistical calculations, the importance of specific indicators for the environmental-economic system is
not taken into account. In this case [12], only the weighted average of such indicators is considered, but this problem is solved by expert evaluation. Knowledge and experience of experts make it possible to rank the indicators in terms of their importance for ensuring the effective functioning of the environmental-economic system [12]. At the same time, however, expert evaluation fails to establish the correlation between environmental-economic indicators. This task is successfully managed by factor analysis. It is an expert-statistical option that is most suitable, since taking into account knowledge and experience of experts in the calculations significantly increases the reliability of the conclusions obtained in the study [12]. At the same time, it gives a chance to perform an extensive environmental-economic analysis by establishing correlations between indicators and to determine the influence of the change of a particular indicator (indicators) on the state of the system [12]. Thus, the problem of assessment formalization for regional environmental-economic development is being solved. The studies performed in the work [12] describe computation method for determination of the regional development integral indicator based on the methods of factor analysis and expert evaluations which is used for automated computation of integral indicators of environmental-economic development in presented information system. Due to the above-said, the purpose of this work is to develop an information system for assessing environmental-economic regional development based on the joint using the factor analysis and expert evaluations.

2. Results and discussion

The software implementation of the information system for the assessment of environmental-economic regional development is carried out on the basis of the calculation algorithm proposed in [12] using factor analysis and expert evaluation. The method of automated determination of integrated indicators of regional development presented in [12] is the basis of the information Web-system functioning created for the purpose of providing access to the functions of assessing the level of environmental-economic development and use in the system of regional management.

Important aspects of the developed Web-system are automation of all calculation procedures and support of work in the computer network Internet which provides access to all its resources of territorially distributed users. The developed Web-application includes the following functional blocks:

- user authentication module;
- database designed to store indicators and results of the subject area calculations, as well as the information content of the Web-application interface elements;
- unit that implements the method of automated determination of integrated indicators;
- gateway to ensure interaction between the Web-application and the database;
- interface that provides the access to the Web-application functions.

The user authentication module provides functional delimitation of access to the Web-application controls and its resources, according to the user's role, and also verifies the correctness of the user data entered by the user. To access the functions of the application need to enter the E-mail and password issued by the administrator of the application. It is also possible to access the basic functions of the application in demo mode. This module checks the compliance of the user-entered data with the records stored in the database. In the case of correct data entry, the module provides access to the functionality and resources of the Web-application according to the user access level specified by the administrator.

Database: when developing a conceptual model of the subject area, its essence and relationships between them were determined. Each entity in database development is converted into a table; each attribute of the entity corresponds to a field in the database table. Fig. 1 presents a database model used to determine integrated indicators of environmental-economic development of regions. The following essences of the database are used in the development of the model: regions of Ukraine, districts of regions of Ukraine, environmental-economic indicators, factors, experts – evaluation by experts of the subject area of influence of one or another indicator on the change of environmental-economic conditions of the region, integrated indicators.
Designing data sets involves determining their composition, content, structure and the choice of a rational way of their presentation. The database was developed using MySQL database [13, 14]. The database contains the following tables:

- table “state” is used to store information about the regions of Ukraine and contains the following fields: key; names in two languages; descriptions;
- table “district” is used to store information about the regions of Ukraine and contains the following fields: key; the key of the area to which the district belongs; names; descriptions;
- table “parameters” is used to store the names of indicators of the subject area and contains the following fields: key; names; dimension; auxiliary fields that specify the characteristics of the indicator (the indicator that is calculated, the indicator that is used in the calculations);
- table “parameter in district” is used to store the values of indicators of a particular area and contains the following fields: indicator key; district key; the value of the indicator within a particular area;
- table “results” is used to store the results of the calculation of integrated indicators and contains the following fields: indicator key; district key; the value of the integrated indicator within a particular area;
- table “users” is used to store the information about users of the Web-application and contains the following fields: key; E-mail; password; user access level;
- table “contents” is used to store the auxiliary information of the Web-application and contains the following fields: key; text in two languages.

Software implementation of the method [12] of calculating integrated indicators of regions environmental-economic development is carried out in the C# programming language [15]. It is also worth noting that the visualization of intermediate results of calculations contributes to a more objective and in-depth analysis of the specifics of environmental-economic development of regions.

Figure 1. Web-application database model
The gateway for communication with the database is a php-Interface that provides the generation of queries to the database and the formation of query results [16]. Communication of the Web-application and php-gateway is carried out according to the http-protocol [17]. Based on the parameters of the GET method of the http-protocol, the corresponding queries to the database are formed [18]. The resulting samples are serialized in the format *.JSON, for transfer to the Web-application [19]. If you need to save data in the database, the Web-application forms an object in the format *.JSON, in the php-gateway there is a deserialization of the object obtained by the POST http-protocol, as well as the formation of appropriate queries to the database (REPLACE or UPDATE) [19, 20]. The Web-application is implemented using the MVVM pattern (Model-View-ViewModel) [21].

The main elements of the Web-application are (Fig. 2):

- main window: Mainpage - view, Mainviewmodel - view model.
- admin panel: Adminpanel - view, Adminpanelviewmodel - view model.
- section for results displaying: liview - view, liviewmodel - view model.
- section for indicators editing and displaying of intermediate results: Parametereditor - view, Parametereditorviewmodel - view model.
- interactive map: Mapcontrol - view, Mapcontrolviewmodel - view model.
- context display: Context - view, Contentsviewmodel - view model.

Figure 2. Block diagram of the developed Web-system
The block diagram of the Web-application is presented in fig. 2. Application models are classes for describing database objects (User, State, District, etc.), subject area (Arraysparameter, Parameter_IN_District, Mathcalc, etc.) and auxiliary elements. The Mathcalc class describes a mathematical model of a subject area. The functions that can be performed by objects of this class are described above in the implementation of the mathematical model [12].

The interface of the Web-application is implemented on the software platform Microsoft Silverlight [22] and includes the following modules:
- controls that provide user identification, verification of input data and provide access to the Web-application functions, according to the user access level;
- control that provides language selection (Ukrainian or English);
- interactive graphical representation of the regions of Ukraine (a map) with the possibility of choosing a particular region;
- block for displaying of information about the selected region;
- module for obtaining and editing environmental and economic indicators for a specific region, as well as for activating the calculations of integrated indicators with the output of intermediate results of calculations;
- block display of the results of calculations of integrated indicators and correlations between socio-economic indicators in the form of tables and diagrams;
- administration module for adding and editing Web-application content and system user data.

The application is designed to work with three groups of users (administrators, data editors and regular users) and provides access to controls depending on the level of access of a particular user. Ordinary users have access to intermediate results and results of calculations of integrated indicators, as well as have access to information what indicators were used in the calculations. In addition to the rights of ordinary users, data editors have the ability to add and edit ecological and economic indicators for the region, perform calculations of integrated indicators and store information in the database. Administrators, in addition to the above capabilities, have access to the functions of editing the content of the Web-application and can register users of the system with the distribution of appropriate access rights. Fig. 3 shows the main window of the developed Web-system.

Figure 3. The main window of the Web-system for assessing the environmental-economic development of regions
Figure 4. Web-application for assessing the environmental-economic development of regions in the mode of access to controls

After authentication, depending on the user's level of access to system resources, a program icon with the appropriate access to the controls of the Web-application opens (Fig. 4). To enter and edit the indicators ($P_n$) values used in calculations, you need to activate the module "Calculations" in the dialog box of the application (Fig. 5).

Figure 5. Activation of the "Calculations" module
Viewing the results of calculations of integrated indicators of environmental-economic development is carried out by using the module “Results” in the dialog box of the application (Fig. 5). This module contains tables of integrated indicators and their graphical representation in the form of a diagram and a table of indicators names with visualization of their correlation dependencies in the form of diagrams (Fig. 6).

It is also worth justifying the choice of software for creating RIA (Rich Internet Application). The main requirements for the development of Web-application are: interactivity, the presence of a mathematical apparatus for the implementation of tasks, ease of use, the ability to place on free hosting platforms. As tools for the implementation of the Web-application were selected: database - MySQL [16, 18] and the software part - Microsoft Silverlight 5.0 [22]. Silverlight is a software platform that includes a browser plug-in that allows you to activate applications that contain animation, vector graphics and audio-video clips that are typical for RIA (web applications with the functionality of traditional desktop applications), using a powerful software platform * .NET Framework [23]. Silverlight-based web-applications are highly productive, cross-browser applications that use the powerful tools of modern * .NET programming languages. The C # programming language is used as the software implementation language of the Web-application [15, 23]. To ensure the operation of the Web-application on the server side the presence of: Apache 1.3 and higher or MS IIS 6.0 and higher; PHP 5.3 and higher; MySQL 5.1 and higher is required. The client machine requires a Microsoft Silverlight 5 browser plug-in, the installation of which must be confirmed the first time you access the Web-application server.

3. Conclusion
The information Web-system for assessing the environmental-economic development of the regions of Ukraine developed and implemented with the help of modern software allows you to analyze regional development, identify the causes of positive and negative trends, determine the list of the most

Figure 6. Integrated indicators $I_n$ of environmental-economic development of districts of Kyiv region.
important environmental and economic indicators to focus on and build regional development strategies. The developed information system allows you to take into account the peculiarities of regional development through the differentiation in the system of environmental and economic indicators and provides an opportunity to change the list of indicators depending on the goals and objectives of monitoring, thereby changing its focus. The application of differentiation in the system of environmental and economic indicators of regions explains unreasonable disparities in assessments of ecological and economic conditions of specific regions and increases the reliability of assessment.

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