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MODELING OF THE PROSPECTS FOR SUSTAINABLE DEVELOPMENT OF AGRICULTURAL TERRITORIES BY THE BAYESIAN NETWORKS

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The article gives information on the problem of sustainable development of the agricultural territories, as to provide the effective path to follow through in the future. The aim of the research is to provide a scientific basis for the need of using the modeling with the help of neural network technologies and to build a Bayesian belief network to make a decision on the sustainable development of the village council of Gladkovich and Hoteshiv in the future. It is carried out the estimation of factors and conditions influencing the sustainable development of the studied area. The results of the implementation of the Bayesian network with the help of Netica software for deciding on the sustainable development of village councils in the future based on the questionnaire data during the period of decentralization and association of territorial communities are outlined.

Key words: rural territories, stable development, social and economic problems, Bayesian belief networks, neural network technology.
JEL Codes: C11, O13, O18, Q01.

1. Introduction

In modern society, every person in their lives faces the decision-making in a given situation. In this case, we usually make an estimate of the probability of occurrence of each event in order to choose the most optimal option. Usually, we do not have enough information to make a decision, but despite these minor issues, we chose the right option with some probability. In such situations, a computational model called the Bayesian belief network comes to the aid, which allows you to significantly reduce the time to make the right decision, to get rid of errors in the process of reasoning.

Looking at the experience of foreign researchers and their progress in the development of neural network technologies, we consider that it is expedient to actualize the use of these models in modern scientific Ukrainian practice. A model called "Bayesian belief network" has the potential to become a promising tool in solving tasks and making decisions under conditions of uncertainty of a different nature. This model allows you to interconnect between the variables (factors) and divide the calculation of their values, if necessary.

This is necessary in order to stop the development of variants and consider other events to be conditionally independent. Due to this approach of building the network, we avoid labor-intensive work on building of many tables and conducting estimates of the probability of occurrence of events and in general, we reduce the volume of calculations.

The purpose of the research is to provide a scientific basis for the need for using the modeling with the help of neural network technologies and to build a Bayesian belief network to make a decision on the sustainable development of the village council of Gladkovich and Hoteshiv in the future.

The main goals were to: highlight the specifics of the use of the Bayesian belief network, to identify the main characteristics necessary for the construction and development of this model, to assess the state of the rural areas of Gladkovich and Hotechiv on the basis of the conducted questionnaires, to bring the results of the assessment to the Bayesian belief network and to identify the factors and their impact on the development of rural areas in the future. The object of the study is the process of forming the Bayesian belief network for decision-making.

The scientific emphasis on the need for the implementation of the European experience of rural development in Ukraine takes place in the works of Borodina (2016) (studied problems that influence sustainable development of rural territories), Barshchevsky (2012) (researched the mechanisms and strategic priorities of innovative development of rural territories in Ukraine) and others. The work of such foreign scientists is devoted to the study of Bayesian simulation – Cowell (1998), who reviewed several methods for representing a parameter posterior through a Bayesian sequential approach; Dempster (1958), who studied the alternative algorithmic approaches to multisensor data fusion, and others. In spite of solid scientific developments, it should be noted that some aspects of this problem remain poorly studied and are currently acute. At the present stage, the use of such neural network technologies in the literature is gaining in popularity, but it is not enough in the scientific community to apply it in practice for decision-making on sustainable development of rural areas.

Actual in modern scientific space is the use of the method of probability modeling of Bayesian belief networks for a comprehensive assessment of the occurrence of probable events or for making decisions in conditions of uncertainty of the environment. At the same time on this environment has the influence a number of exogenous and endogenous factors, which are taken into account and trained in the development of the network machine. Consider some of the definitions and characteristics that were given to scientists in the Bayesian belief network.

So, the researcher Tulupev (2009) in his work considers the transformation of acyclic Bayesian belief networks into algebraic Bayesian networks. The transformation is carried out by sequential calculation of common probability tensors on the basis of conditional probability tensors stored in the nodes of the Bayesian belief network. The process is completed by the transition from the common probability tensors to the probability which estimates for the conjuncture ideals.

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Bidyuk, Kozhukhivsky and Kozhukhivskaya (2013) in their scientific article proposed the procedure for building a decision support system based on the network by Bayes, which provides an opportunity to evaluate and forecast the state of the enterprise under the influence of perturbations of arbitrary types and different nature. In the work of Bychkova, Saginov and Narutta (2013) is reaserched the usage of the apparatus of fuzzy Bayesian belief networks for assessing the quality status of telecommunication services. In his article Sirotkin (2009) described the algorithms for constructing an algebraic Bayesian network, semantically equivalent to a multinetwork Bayesian belief network. Pokotilova and Pokotilov (2012) considered the use of Bayesian belief networks for the formation of a competitive rationale of food industry enterprises with the help of Hugin software. Yakovlev and Sinyova (2017) studied the process of detecting web-robots using Bayesian networks. In the work of Rosmaninoy and Bazhenov (2012), the decision-making process was implemented with the help of Bayesian belief networks in the Hugin system.

Among the foreign scientists, these models attract a lot of attention on the decision making and are widely used in scientific practice. From this point, Hsu, Moradkhani and Sorooshian (2009). used a sequential Bayesian approach for hydrologic model selection and prediction. By such authors as Phan, Smart, Capon, Hadwen and Sahin (2016) were conducted a systematic review in the field of water management using Bayesian networks. Zare, Zare and Fallahnezhad (2016) implemented a system for evaluating software development projects based on optimal Bayesian networks. Underwood, Parkes and Swasey (2016) built a Bayesian network to study the reaction of economic measures to fishing. Mkrtchyan, Podofillini and Dang (2016) demonstrated the methods of constructing probability table in the Bayesian belief network.

2. Methodology

The research is based on the results of a sociological survey of the residents of the village councils of Gladkovichi and Khoteshiv in 2017–2018. The questionnaire contains 30 questions, grouped by sections: living standards of the rural population; existing problems; vision of the village by the eyes of inhabitants, factors of economic, social and ecological development of the community, satisfaction of inhabitants with the existing conditions regarding the efficiency of conducting private peasant farms. As a result of stratified sampling 414 inhabitants of the area were interviewed.

Theoretical and methodological basis served as the fundamental provisions of modern economic science, scientific works of domestic and foreign scientists on the research problem.

The article uses the following research methods, such as: a systematic approach – for the organization of selection and creation of interrelations between factors that will be used in the model; theoretical generalization and abstract-logical methods – to systematize and generalize the main features of the formation and application of Bayesian belief networks in decision-making; graphic method – to illustrate

the main results of the survey and visual representation of the Bayesian belief network, which was created to solve the problem.

This study is the implementation of decision-making with Bayesian belief networks in the Netica system for the vision of sustainable development of rural areas in the present results of the survey of inhabitants and the prevailing system of factors that affect this problem.

Before the beginning of completing the task, we will reconsider the program Netica. Netica is a universal, fast and convenient program that you can use to find patterns in data, create charts, encode knowledge, create expert systems and more. It is suitable for use in such areas as diagnostics, forecasting, decision analysis, distribution of all simulations, risk management, expert system construction, stability analysis, some other types of statistical analysis and data acquisition. The development of Netica began in 1992 as the executive director of Norsys Software Corp. B. Borlej, in 1995 became available for purchase and is now widely used.

Netica – is a program that is quite convenient to work with graph-based probabilistic models. It has an intuitive user interface for data entry. To perform many operations, it's enough to use a few clicks to make it easier for the user to work on the system. The program has a commercial and free version. To use the free version, you need to download the application at the official website http://www.norsys.com/, leave the dialog for entering the password blank and click 'Limited Mode'. The free demo version is full-featured, but limits the size of the created model (Toropova, 2015).

3. Results of research

It is the process of calculating probabilities that is the basis for making decisions under uncertainty on the basis of Bayesian belief networks. Depending on what variables the variable nodes are represented, there are four types of BBNs: discrete, dynamic, continuous, hybrid.

In this research work, discrete BBN is considered – a network in which node variables are represented by discrete values. It is a directed acyclic graph, which has the following properties (Bidjuk, 2013):

- each vertex is an event that is described by a random variable that can have several states;
- all vertices associated with ancestors are defined by a table or conditional probability function;
- for vertices without ancestors, the probabilities of their states are marginal.

Thus, for the purpose of conducting a methodological study of the nature of the influence of heterogeneous factors on the choice of the decision on the probability of sustainable development of analyzed rural areas in the future, Bayesian belief networks (BTN) are considered. The research is based on the results of a sociological survey of the residents of the village councils of Gladkovichi and Khoteshiv in 2017–

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2018. Among the participants in the questionnaire, men made up 42%, and women – 58%. By age, the distribution of respondents is as follows:

- up to 35 years – 96 people (23%);
- from 35 to 55 years old – 191 persons (46%);
- over 55 years – 127 people (31%).

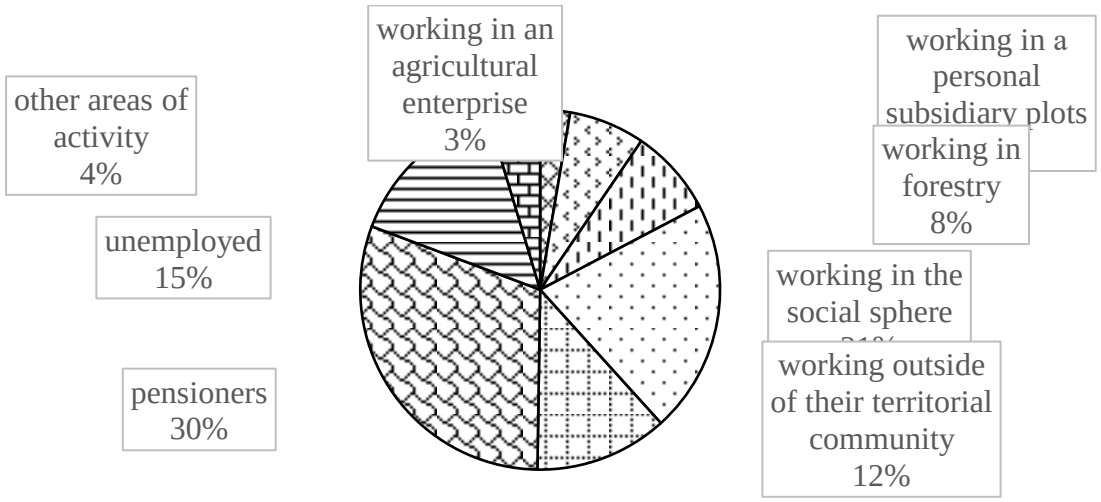

Fig. 1. Results for answering question "Your social status" by the residents

1. Of the total number of respondents, 16.0% of respondents have higher education; unfinished higher – 3.5%; secondary specialty – 32.5%; secondary – 46.0%. According to social status, respondents were distributed as shown in fig. 1 According to the results of the poll on the sources of income of the inhabitants of the village councils of Gladkovichi and Hoteshiv, the main source was the receipt of salaries – this is 38.2% of respondents. From the statistical aggregate, we also see that a large proportion of pensioners lives in rural areas, which logically sees pensions as income – which is 27.1% of the population. In addition, a significant component in the peasant's life is the management of private peasant farms, which also shows the results we get – 16.8% of inhabitants receive income from the sale of berries, vegetables, milk, etc.

2. Among the problems that accompany the rural population of the area were the most severe – the lack of employment (25.2% of respondents) and low income (24.8% of responses). In addition, a pressing problem for the countryside is the spread of drunkenness, drug addiction, theft, etc. (15.2% of respondents).

3. According to respondents, the perspective and valuable, in the living rural population is that the village is currently a promising place of residence (32.3%), characterized by a lack of social conflicts (14.2%), good transport links and assistance from local authorities' self-government (13.9% is the same for both factors).

4. The majority of rural residents are engaged in the management of private farms (75%), but only 37% of the peasants would like to go to work in this way. That suggests that personal farm labor is an additional income for them, which is influenced by a number of factors and which does not always bring profit. It also indicates that only 18.5% of the respondents want to legally transfer or transform into a farm. The reasons for this are a combination of factors that respondents noted: insufficient

funds (26.8% of responses); concerns the villagers about the problem of sales of manufactured products: low purchasing prices (16.1% of responses) and unorganized sales channels (11.9%).

5. Gladkovich and Hoteshiv village councils belong to the natural-economic zone of Polissya, where sod-podzolic and soddy soils of sandy or sub-sandy mechanical composition predominate, the land is overgrown and waterlogged, which prevents the harvesting of high crop yields. Therefore, shepherding is a traditional branch of livestock breeding, which is confirmed by the results of the survey, because 22.6% and 18.6% of respondents prefer the dairy and meat cattle industry. Among the products of plant growing, grain crops (15.0%) and potatoes (14.0%) are favored, as well as almost 6% of peasants grow vegetables on their land plots.

6. Despite the fact that the establishment of entrepreneurial activity in the countryside can become a pledge to improve the economic situation of rural areas, only 24.0% of the respondents from the village councils of Gladkovich and Hotechiv would like to become entrepreneurs. The distribution of answers to the question "In which areas of economic activity would you like to open your own business?" Shows that the majority (18.0% of the answers) prefer the agricultural sector; 20.0% – trade; 19.0% – would like to try themselves in the service sector.

Accordingly, a qualitative analysis of the causality of the binary choice can be performed using the Bayesian belief network toolkit. The answer to the question "Do you see the sustainable development of your rural territory?" Is considered as a binary, target variable (target node) – the answer "No" can be considered a negative result (y = 1), the answer "Yes" is positive (y = 0).

As a result of the statistical analysis of causal relationships in the Netica package, factors that influence the distribution in the target node and the most significant interrelationships between factors are detected (with a probability level of p-value = 0.05). The resulting network structure is presented in Fig. 2 and includes eight factors. Simulation of the researched network and the creation of a conditional probability pattern (EM-algorithm) was carried out in the Netica package. The average classification error based on the received network is 9.2%.

As a result of the analysis of the sensitivity of the target node to changes in levels of the causal units, the factors that most strongly influence the expected decision about the probability of sustainable development of the analyzed rural territories in the future were revealed. The most significant factors for the development of rural areas in the future are: association with other communities and the return of the forest fund to the property of the community.

Next we will bring the Bayesian network into action – we choose the factors that will influence the decision on sustainable development of the studied rural territories in the future and we will get a productive graph. In this case, the following factors influencing decision-making were chosen: inability to work, not to be united with other communities, housing construction, water fund conservation, agricultural aid. Therefore, subject to the fulfillment of these conditions and the influence of factors on the resultant trait with a probability of 55% in the future, the studied rural territory will

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have a steady development. For each of the Nodes (model factors in the form of questions and answers of respondents), the network has calculated the quality of impact on the resultant feature, which can be seen in Fig. 2. Each cell of the data gives numerical values about how the resultant sign can change in a positive or negative sense.

That is, each of the factors of economic development can fluctuate in the range from – 9.2 to 9.2 units of influence on the resultant trait. In addition, the program automatically calculates the standard error, median, and probability of 80% and 95%, as well as the interval sample size (IQR) that can be seen in Fig. 3.

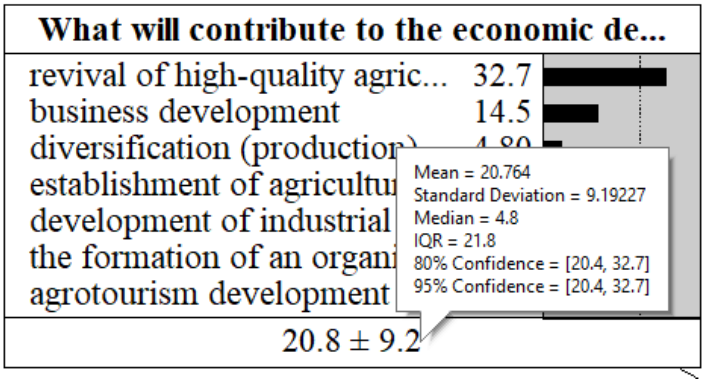
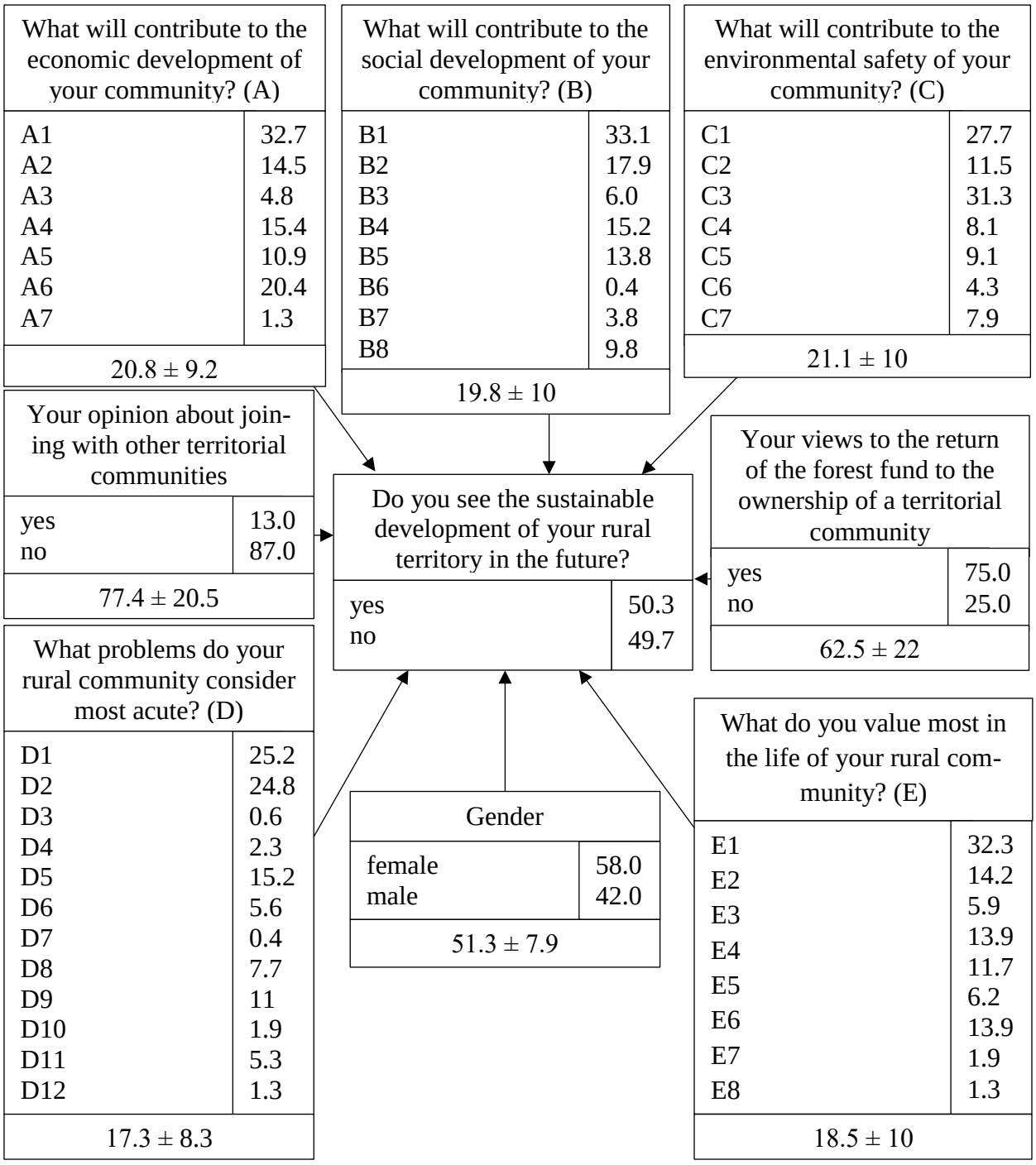


Fig. 3. Information sampling indicator window

In the result we make work the Bayesian belief network with all the included factors used in this model. Namely, we add to the factors already included previously about the probability of a decision on the possibility of sustainable development of analyzed rural territories in the future with such factors as: diversification (diversity) of production, development of alternative energy sources, sex – woman, assistance from local governments, attitude to the return of the forest fund to the ownership of the territorial community. As a result of modeling, we see that the probability of an offensive in the future of sustainable development of analyzed rural territories increases to 100%, subject to the fulfillment of these conditions and the influence of the selected factors on the decision. Thus, in the course of the study, a fully operational Bayesian belief network was implemented, which allows to set an assessment of the decision on the possibility of sustainable development of the analyzed rural territories in the future, with the influence of all these factors on the system. It was proved that the Bayesian network is a model that can help in finding complex solutions and determining the likelihood of certain events.



Notes: A1 – revival of high-quality agricultural production, A2 – business development, A3 – diversification (production), A4 – establishment of agricultural processing enterprises, A5 – development of industrial production, A6 – the formation of an organized network of agricultural products, A7 – agrotourism development, B1 – employment creation, B2 – provision of fair remuneration for peasant labor, B3 – construction of housing, B4 – extension of the network of domestic services, B5 – repair and reconstruction of roads and rural streets, B6 – gasification, B7 – reconstruction and construction of sports facilities, B8 – organization of cultural leisure, C1 – conservation of soil fertility, C2 – anti-radiation measures, C3 – conservation and enhancement of the forest fund, C4 – conservation of the water fund, C5 – provision of quality drinking water, C6 – development of alternative energy sources, C7 – solving the problem of solid household waste, D1 – impossibility of employment, D2 – low income, D3 – impossibility to lease land shares, D4 – unresolved housing issue, D5 – the spread of drunkenness, drug addiction, theft, etc, D6 – unfavorable ecological situation, D7 – lack of gasification, D8 – poor condition and inaccessibility of health care, education and culture institutions, D9 – lack of proper domestic services, D10 – low rent, D11 – other, E1 – our village - promising place of residence, E2 – absence of social conflicts, E3 – aid from the agricultural enterprises, E4 – assistance from local self-government bodies, E5 – democracy and transparency in the work of local self-government bodies, E6 – employment opportunities in the community, E7 – good transport links and quality of roads, E8 – presence of leaders.

Fig. 2. Constructed structure of the Bayesian belief network

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4. Conclusions

1. The general analysis of the results on the survey suggests that most of the problems are related to employment in the community and low incomes. The lack of necessary information on starting a business, creating agricultural service cooperatives, high cost of loans, causes peasants to be at high risk of starting their own business and taking part in the activities of the cooperative associations. Therefore, accustomed to work on the ground inhabitants are seeking to revive high-quality agricultural production, because they believe that this will ensure their community economic growth. We believe that one of the necessary conditions for solving the identified problems is the use of the experience of developed rural communities, the formation of peoples' world outlook, the raising of their knowledge and awareness of the benefits of European integration and rural development in the European Union.

2. The conducted modeling shows that the possibility of decision-making and solving probabilistic forecasting tasks was provided, based on subjective and expert data. The first of them is formed as a result of the questionnaire of the inhabitants of Gladkovichi and Hoteshiv village councils. Therefore, teaching the network on the basis of the data and obtaining as a result effective and most approximate conclusions.

3. The scenario analysis on the basis of a set of factors showed that by improving the condition of rural territories in the complex of all these factors will contribute to the positive sustainable development of rural territories in the future and most strongly affects only in combination with the most significant factors, increasing the likelihood of such an increase by 8.2%, with high motivation (that is, the desire to develop an economic component, to create cooperative associations, to legally start family farms, to create jobs for the worker harboring in the countryside, etc.).

4. As the research has shown, the probability of sustainable development of the surveyed rural territories will be improved with the following set of factors: diversification (diversity), development of alternative energy sources, sex – woman, assistance from local authorities, impossibility of employment, not to be united with others communities, housing construction, attitude to the return of the forest fund to the ownership of the territorial community.

5. Probabilistic estimates of the observed factors give the actual values that allow us to retrieve the confidence in the estimates of unobservable factors. From that point, the model of decision making regarding the probability of sustainable development of analyzed rural areas in the future enables:

- determine which factors have the greatest impact on the resulting sign on the degree of influence on the decision, list them and rank them according to their importance (the importance of each factor is implied in the numbers, determined by BBN and according to them most effective scenario in the future could be selected);
- identify the factors that do not give grounds for conclusions;
- to create and carry out an economic assessment of the most effective stage for improving the condition of rural territories in the future by selecting a variety of factors from the model.

References

Bidjuk, P., Kožuxivs′kyj, A., Kožuxivs′ka, O. (2013). Systema pidtrymky pryjnjattja rišen′ dlja analizu i prohnozuvannja stanu pidpryjemstva // *Radioelektronika, informatyka, upravlinnja.* No. 1: 128–136.

Borodina, O. (2016). Naukovo-prykladni zasady rekonstruktyvnogo rozvytku sil's'kogo gospodarstva ta sela v Ukrai'ni // *Ekonomika i prognozuvannja.* No. 4: 70–80.

Borshhevs'kyj, V. (2012). Social'no-ekonomichni aspekty stalogo rozvytku sil's'kyh terytorij Karpats'kogo regionu: evoljucijnyj kontekst // *Social'no-ekonomichni problemy suchasnogo periodu Ukrai'ny. Aktualni problemy rozvytku: [zb. nauk. pr.]*. No. 6 (98): 291–301.

Cowell, R. (1998). Mixture reduction via predictive scores // *Statistics and Computing.* No. 8: 97–103. – https://doi.org/10.1023/A:1008921815757.

Dempster, A. (1958). A High Dimensional Two Sample Significance Test // *Ann. Math. Statist.* No. 4: 995–1010. – https://projecteuclid.org/euclid.aoms/1177706437.

Hsu, K., Moradkhani, H., Sorooshian, S. (2009). A sequential Bayesian approach for hydrologic model selection and prediction // Water Resources Research. – https://doi.org/10.1029/2008WR006824.

Mkrtchyan, L., Podofillini, L., Dang. V. N. (2015). Bayesian belief networks for human reliability analysis: a review of applications and gaps // *Reliability Engineering & System Safety.* No. 139: 1–16. – https://doi.org/10.1016/j.ress.2015.02.006.

Phan, T. D., Smart, J. C. R., Capon, S. J., Hadwen, W. L., Sahin, O. (2016). Applications of Bayesian belief networks in water resource management: A systematic review // *Environmental Modelling & Software.* No. 85: 98–111. – https://doi.org/10.1016/j.envsoft.2016.08.006.

Pokotilova, O., Pokotilov, I. (2012). Zastosuvannja bajjesivs′kyx merež doviry u formuvanni tovarnoho asortymentu pidpryjemstva // *Biznes Inform.* No. 9: 101–105.

Razmaxnyna, A., Baženov, R. (2017). Yssledovanye processa prynjatyja rešenyj s pomošč′ju bajesovskyx setej doveryja v systeme Hugin // *Postulat*. No. 8: 1–8.

Sirotkin, A. V. (2009). Algoritmy postroenie algebraicheskoj bajesovskoj seti, semanticheski ehkvivalentnoj mnogosvyaznoj bajesovskoj seti doveriya // *Mezhdunarodnaya konferenciya po myagkim vychisleniya i izmereniyam.* No. 1: 131–134.

Takebe, H., Kurokawa, K., Katsuyama, Y., Naoi, S. (2002) A Learning Pseudo Bayes Discriminant Method Based on Difference Distribution of Feature Vectors // *Document Analysis Systems V*. No. 2423: 134–144. – https://doi.org/10.1007/3-540-45869-7_18.

Terent'ev, A., Bidyuk, P., Korshevnyuk, L. (2009). Algoritm veroyatnostnogo vyvoda v bajesovskih setyah // *Sistemni doslidzhennya ta informacijni tekhnologii.* No. 2: 107–111.

Toropova, A. (2015). Podhody k diagnostike soglasovannosti dannyh v bajesovskih setyah doveriya // *Trudy SPIIRAN*. No. 43: 156–178.

Tulup'ev, A. (2009). Preobrazovanie aciklicheskih bajesovskih setej doveriya v algebraicheskie bajesovskie seti // *Izvestiya vysshih uchebnyh zavedenij. Priborostroenie.* No. 3: 21–23.

Underwood, F. M., Parkes, G., Swasey, J. H. (2016). Building Bayesian Belief Networks to investigate how fishery performance responds to management interventions // *Fisheries Research.* No. 182: 28–38. – https://doi.org/10.1016/j.fishres.2015.12.005.

Yakovlev, D., Sineva, I. (2017). Detektirovanie veb-robotov s pomoshch'yu bajesovskih setej // *Tekhnologii informacionnogo obshchestva.* No. 1: 292–293.

Zare, F., Zare, H. K., Fallahnezhad, M. S., Adibnia F. (2016). Software effort estimation based on the optimal Bayesian belief network // *Applied Soft Computing.* No. 49: 968–980. – https://doi.org/10.1016/j.asoc.2016.08.004.

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KAIMO VIETOVIŲ PLĖTROS MODELIAVIMAS NAUDOJANT BAJESO TINKLUS

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Gauta 2018 03 16; priimta 2018 05 16

Santrauka

Straipsnyje pateikiama informacija apie kaimo vietovių tvarios plėtros problemą, siekiant užtikrinti veiksmingą ateities situacijos sprendimą. Tyrimo tikslas – pateikti mokslinį modeliavimo pagrindimą naudojant neuroninių tinklų technologijas ir sukuriant Bajeso pasitikėjimo tinklus, siekiant priimti sprendimą dėl tvaraus vystymosi Gladkovich ir Hotešivo kaimo vietovių ateities. Atliktas veiksnių ir sąlygų, turinčių įtakos darnaus vystymosi sričiai, įvertinimas. Remiantis apklausos duomenimis decentralizacijos ir teritorinių bendruomenių asociacijos laikotarpiu, apibūdinti Bajeso tinklo įgyvendinimo rezultatai naudojant „Netica“ programinę įrangą.

Raktiniai žodžiai: kaimo vietovės, tvarus vystymasis, socialinės ir ekonominės problemos, Bajeso pasitikėjimo tinklai, neuroninių tinklų technologijos.
JEL kodai: C11, O13, O18, Q01.