

Geoinformatics and methods of studying natural systems in agriculture

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Abstract. The development of information systems has led to interdisciplinary approaches in the field of studying the agricultural crops cultivation. The author analyzes the role of such an interdisciplinary field as geoinformatics in the field of agricultural cultivation and, in particular, viticulture. The author points out the systematic nature of this field study, its applied nature, the need to train high-quality specialists. The author presents a number of geoinformatics methods and tools that can be applied in viticulture. Geoinformatics methods allow to perform soil and climate analysis, develop measures to protect vineyards from weather conditions. The author comes to the conclusion that geoinformatics methods can be used to optimize various viticulture processes, from growing and caring for vines to harvesting, marketing, and resource management at the level of modern agricultural product quality requirements.

1 Introduction

The informatization of modern society has led to significant changes in the field of interaction and application of computer science methods in various sciences. These changes were also reflected in geography. The result of this interaction was the emergence of a fairly young interdisciplinary science – geoinformatics, the fields of research and methods of which are of key importance for the development of agriculture, cultivation of agricultural crops, viticulture. First of all, geoinformatics and its methods can be used in the field of monitoring and forecasting of human agricultural activity [1]. This is necessary to ensure the sustainable development of not only the agricultural sector, but also the country as a whole. Of course, the development of geoinformatics should include high-quality training of specialists in this field [2].

The development of geoinformatics was inspired by achievements in the field of such widespread information technologies as sensors of the global navigation satellite system (GNSS), broadband networks, cloud computing, as well as service-oriented and distributed data processing architectures [3].

Geoinformatics is a term that was introduced in 2000 and refers to the words "geo" (i.e. "earth") and "informatics" [4]. The main attention in this branch of scientific knowledge is paid to the use of modern information technologies (for example, databases, decision support systems, the Internet), communication technologies (for example, wireless

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networks, cell phones) and solutions for inter-network interaction (for example, protocols, standards for conducting information activities) for the study of various geographical objects and data.

Geoinformatics became widespread after the introduction of the "Digital Earth" concept [5] and the evolution of the use of geographical content by the technology sector and society as a whole. The proliferation of digital browsers with geodata (for example, NASA World Wind, Google Earth, and Microsoft Bing Maps), together with the increasing availability of satellite data, mobile devices and navigation systems, have become part of the digital revolution in geography.

Currently, geographical and Earth sciences increasingly rely on digital spatial data obtained from smartphones, software interfaces of social network applications, and remote sensing images analyzed using geographic information systems (GIS) or cloud applications and distributed through complex infrastructures to target an ever-growing number of users. Technologies supporting these processes are especially relevant for the development of geoinformatics. On the one hand, all of the above changes and related technologies have made citizens familiar with geographical information, and on the other hand, they have changed their role from ordinary consumers to specialists in the field of geoinformatics studies.

2 Materials and Methods

The successes of geoinformatics are associated with the development of such sciences as geography and ecology. Therefore, at the empirical level, geographical systems have become the subject of study. A special role in our research is played by viticulture and the cultivation of agricultural crops on the territory of various climatic regions and zones, the development of which cannot be studied outside of geographical, environmental, economic, and other factors. A number of studies are devoted to this area, on which this study is based [6-8].

To analyze the methods used in geoinformatics, which are important for the development of agriculture and viticulture, especially in the study, an interdisciplinary approach was used, a method of system analysis, which allowed to consider geographical systems as part of a more general global earth ecosystem. Moreover, a comparative method was used, which made it possible to identify a number of tools that can be used in viticulture.

Among these tools, the following can be distinguished:

1. Soil analysis: geoinformatics methods can be used to analyze soil, its chemical composition, water supply and other factors that affect the grape growth and quality. Data analysis will help to determine the optimal locations for growing grapes, the optimal choice of varieties and the optimal spatial distribution of grape seedlings.

2. Geoinformatics methods can help in the analysis of climatic conditions on various parts of the earth. Data on temperature, precipitation, solar radiation, and wind can be used to determine the best conditions for grape growth and development.

3. Health and yield monitoring can be provided by geoinformatics methods. In particular, remote sensing allows to monitor the health of vines, detect diseases, stressful conditions or nutritional deficiencies. This allows growers to take measures to combat diseases, optimize the use of fertilizers and increase yields.

4. Data analysis in the field of information systems allows to determine the water needs in different areas of the vineyard and develop an irrigation plan that ensures optimal use of water resources and prevents the risk of over-irrigation or lack of moisture.

5. The methods also have economic consequences: the results of their application can be used for market analysis and planning of grape sales. Data on the location of potential

markets, competition, and consumer preferences can be used to develop an effective sales and product distribution strategy.

6. Geoinformatics methods can also be actively used in modeling various systems. Geometric modeling can be used here to create three-dimensional models of vines and vineyards. This allows growers to visualize and analyze the spatial distribution of vines, optimize the placement of retaining structures and maximize the use of available space.

7. Of course, geoinformatics methods can be used in determining the optimal time of grape harvest. Analysis of data on climatic conditions, solar radiation, and other factors makes it possible to predict the moment of the highest degree of grape maturity. This helps growers make decisions about the optimal time to start harvesting to get the highest quality grapes.

8. Development of weather protection measures can also be used using geoinformatics methods to develop measures to protect vines from adverse weather conditions, such as frost, hail, or strong winds. The analysis and forecasting of weather data allows growers to take measures to protect the vines, for example, the installation of heating systems, shelters or the use of special grape varieties that better cope with adverse weather conditions.

9. Analysis of geographical availability of grape lands can be used with the help of digital information systems. Analysis of data on the distance to the sales market, road infrastructure, and transport routes allows to determine how efficiently you can deliver the crop to the market. This helps in planning delivery routes and determining the optimal locations for the wineries.

The study is based on the application of data on monitoring and analysis of the efficiency of resources use in viticulture, such as water and fertilizers. Analysis of geographical data on planting density, irrigation level, and application of fertilizers allows optimizing the use of resources, reducing excess consumption and increasing the environmental sustainability of viticulture.

3 Results and Discussions

Geoinformatics plays an important role in improving the efficiency and sustainability of agriculture. It combines the use of geographic information (GIS), remote sensing, and global positioning system (GPS) for the analysis and management of agricultural processes. One of the main applications of geoinformatics in agriculture is resource management. The results obtained with the help of geographical information can be used to create land use maps at wineries and analyze the land characteristics. Such characteristics include, for example, relief, soil moisture, the content of nutrients in it. This allows growers to optimize planting planning, choose the best places to place grapes, and make decisions about fertilizers and other agronomic interventions.

Geoinformatics methods also allow monitoring of fertile lands. Remote sensing and GPS can be used to monitor plant growth, detect diseases and pests, as well as to assess the productivity of fields. This information can become the basis for the development of innovative agrotechnical solutions and increase yields.

Another area of application of geoinformatics methods in agriculture is, as we wrote above, resource management. This area can be used to analyze climate data, including temperature, precipitation, and humidity, as well as to predict weather conditions. The result of this use is the successful determination of the optimal timing of sowing and harvesting grapes, as well as planning proper irrigation and drainage of vineyards.

In addition, geoinformatics in agriculture plays an important role in sustainable development. Its results and methods can be used to assess the impact of human agricultural activities on the environment and develop measures to minimize this impact. For example, it becomes possible to analyze the protection zones of reservoirs from pollution by

agricultural chemicals or the possibility of drawing up and implementing an optimal application scheme to prevent the leaching of nutrients into reservoirs used for irrigation.

The main methods and tools of geoinformatics in agriculture include the following:

1. Irrigation system planning. Geoinformatics methods help to analyze topography, climatic data, and the state of water resources to determine the optimal irrigation system for various land plots when growing grapes. This saves water, increases irrigation efficiency, and reduces the risk of soil salinization.

2. Support for decision-making on the choice of grape varieties. Geoinformatics methods allow analyzing and comparing various parameters, which include climatic conditions, soil type, and the demand for wine types on the market, to help winemakers decide which crops are best grown in individual regions.

3. Monitoring of soil and plant conditions. Thus, the method of remote sensing in geoinformatics is used to assess the condition of the soil and the grape growth. This helps to identify problems such as diseases or nutritional deficiencies, as well as take measures to prevent crop damage.

4. Statistical methods in geoinformatics can be used to predict yields based on various factors, such as climatic conditions, soil type, methods of grape cultivation. This can help winemakers plan production and predict possible changes in grape price and profitability of various wine varieties.

5. Definitely, geoinformatics methods are successfully used in risk management. Such risks include the following: the risk of floods, droughts, or forest fires. Information about risks helps to develop risk management strategies and make decisions about the insurance of grape lands.

6. Geoinformatics methods are used to monitor wastewater and pollution. In particular, they make it possible to identify sources of pollution, develop measures to prevent or reduce pollution, and monitor the effectiveness of such monitoring.

7. Infrastructure planning can also be carried out using geoinformatics methods. They help winemakers and viticulture development specialists plan the placement of various infrastructure for growing grapes. The analysis of geographical data makes it possible to determine the optimal location of such infrastructure objects, considering accessibility, for example, transport and other factors.

8. Support for organic farming: Geoinformatics methods help winegrowers who are engaged in organic or other type of organic farming in planning and managing their lands. For example, geoinformatics data can be used to identify areas suitable for organic farming, monitor the use of fertilizers and pesticides, and evaluate the weed control effectiveness.

9. Geoinformatics methods can provide data and tools that can be useful to small grape farms and agricultural cooperatives. They can provide access to digital maps, weather forecasts, crop management tips and other information that helps optimize the production, planning, and marketing of viticulture and winemaking.

In general, geoinformatics methods and tools in agriculture provide winemakers and specialists in the field of viticulture with the opportunity to obtain accurate and timely data to make optimal decisions in the field of growing and cultivating grapes, which will certainly increase the efficiency and sustainability of agricultural production, reduce costs, and help to minimize the negative impact on the environment.

Thus, geoinformatics plays an important role in all viticulture aspects, from planning and managing production processes to monitoring the use of resources and promoting sustainable development. This is a powerful tool that helps not only winemakers, but also specialists in the field of agriculture to make decisions based on specific statistical and remote data to improve the agricultural sector efficiency.

Geoinformatics plays an important role in the process of growing grapes, which manifests in such areas as soil and climate analysis: As we have already indicated above,

geoinformatics methods help to obtain data on soil composition and climatic conditions in a certain area to determine the suitability of the latter for growing grapes. This allows breeders to choose, for example, the best places for planting vines.

Also, the field of application of geoinformatics methods is the planning and monitoring of grape fields: Geographical information systems are used to plan the placement of vines in the fields. They can help determine the optimal distance between the vines and other parameters to improve the efficiency of growing vines.

Geoinformatics methods are used in the field of plant growth and condition: Satellite monitoring and unmanned aerial vehicles can provide information about the growth and health of vines. This makes it possible to identify numerous problems such as pests, diseases, or insufficient watering, as well as take measures to prevent or treat them.

Today, people are increasingly talking about the so-called "digital" viticulture. With the help of digital sensors, a digital copy of a vineyard or vine is created, data on soil and climate are entered into the database, for example, after which programs are created that allow analyzing the further vineyard or vine development. Unmanned aerial vehicles allow to collect data on climate, soil, and other factors necessary for the successful cultivation of grapes. This allows producers and winemakers to plan production, manage inventory and make optimal and profitable pricing and marketing decisions.

With the help of models and data analysis in geoinformatics, it is possible to determine the optimal methods of watering, fertilizing, and other agrotechnical techniques to achieve the best quality of the grape harvest.

This study provides only a small number of examples of how geoinformatics can be applied in the field of grape cultivation. If we adjust this area, then it is certainly possible to get a successful result in improving the efficiency and quality of winemaking, as well as in the rational use of resources in this area.

4 Conclusion

Growing grapes in various regions today is impossible to imagine without geoinformatics methods, which are widely used in geographical and agricultural systems. They are identical because they have a single information component and play an important role in increasing the efficiency and success of winemaking. There are several methods that are based on geoinformatics methods and can be applied when growing grapes in different regions:

One of these methods is the analysis of soil and climatic conditions: Geographic information systems can be used to analyze data on soil properties and climate in different regions. This analysis allows to determine the best places for planting vines and select suitable grape varieties that can be better adapted to local conditions.

In addition, geographic information systems help in planning and monitoring fields for growing grapes. They allow to optimize the placement of vines, determine the optimal routing of grape rows, monitor and evaluate the use of land resources, as well as effectively manage agrotechnical operations.

Monitoring the growth and health of vines is important: Satellite monitoring and unmanned aerial vehicles can be used to obtain data on the growth and health of vines in various regions.

The field of forecasting is one of the main ways to develop geoinformatics today. It is especially important in viticulture. The creation of digital models of vineyards allows analyzing data on climate, soil and other factors to predict the yield of grapes in different regions. This helps gardeners and winemakers plan production and manage the development of winemaking in a particular region.

An important area is also the management of resources in the cultivation of vineyards, which include, first of all, water and fertilizers. Digital data analysis and computer modeling make it possible to determine the best irrigation methods, calculate fertilizer doses and other farming methods to achieve the best quality and yield of grapes with minimal resource expenditure.

Thus, geoinformatics helps agricultural enterprises and wineries in various regions to make more informed decisions, increase the efficiency of grape cultivation, and achieve better results in the field of winemaking and agricultural development in general. Geoinformatics methods will be intensively developed in the future, their development depends on the success of the implementation period, as well as on the development of artificial intelligence, which is a promising area of research in agriculture and the agro-industrial complex as a whole.

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