Use of GIS technologies to determine the light of garden plants

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SUMMARY

GIS technologies have become entrenched in modern cadastre and land management and have become a key element in zoning areas on relevant topics. The object of this research is the orchard of the Center for Studies, Science and Production (CSSP) of Uman National University of Horticulture. The subject of the research is zoning of territory of the orchard of CSSP of Uman National University of Horticulture by level of illumination depending on the relief of its territory. A Digital Relief Model (DRM) was created on the territory of the garden, for this purpose fragments of two adjacent sheets of a topographic plan of scale 1: 10000 with a relief cross-section of 1 meter were digitized with the help of SURFER package. According to this digital model, the zoning of the study area was performed according to the degree of illumination. As a result of the performed experimental research the possibility to zone the territory of the garden on illumination with the use of GIS technologies is shown.

Keywords: geographic information systems, garden, Uman National University of Horticulture, relief, digital relief model, solar radiation
Introduction

Intensive development of geographic information systems (GIS) and technologies lead not only to the expansion of their use in geodesy and land management, but also allows the use of GIS products to meet other needs, including horticulture, architecture, park design, construction. In particular, in horticulture it is often necessary to calculate the illumination of the territory, or solarization. The use of geographic information technologies for this purpose allows not only to perform the necessary calculations efficiently and quickly, but also with the help of computer technology to visualize the results and demonstrate them to customers of garden projects without significant labor and resources.

Analysis of literature sources

Analysis of reports shows that GIS technologies have become entrenched in modern cadastre and land management and have become a key element in zoning areas on relevant topics. Publications related to the subject of this article can be divided into two groups. First, these are articles concerning the lighting of gardens and other plantings. Secondly, these are works which analyze the use of GIS technologies for zoning the area by lighting. Since the first group of reports is less related to topographic and geodetic direction, we will indicate only the main works of scientists of Uman National University of Horticulture O.V. Melnyk and A.M. Chaploutskyi (Levchenko O.M., Shynkarenko H.A. 2000, 2003). In these publications, it is noted that in life process, fruit plants for their normal growth and development must be provided with light, heat, moisture and nutrients, i.e. the main mandatory environmental factors that are not interchangeable. Deficiency or excess of any of the factors adversely affects photosynthesis.

Analyzing the second group of publications, first of all it is worth paying attention to the research by Lviv scientists H.A. Shynkarenko and O.M. Levchenko. In their publications the issues of application of GIS technologies in research of relief and illumination of territories are variously covered (Levchenko O.M., Shynkarenko H.A. 2000, 2002, 2003). These reports show that the relief model in the form of a grid-grid allows to obtain exposure and illumination, which play an important role in conducting numerical studies of many issues of the national economy, economics and ecology. These works indicate that for various areas of human activity, in particular for agriculture, it is important to find the amount of solar energy that receives over time a part of the earth surface. Publications (Horlachuk V.V. 2008, Kravets O. Ya. 2021, Kravets O. 2012) also touch on these tasks. Their main content is to solve issues similar to those analyzed in the previous paragraph, namely: it is proposed to use geographic information technologies for zoning the area by steepness, exposure, solarization of slopes, to create models of erosion and hydrological processes. Such studies aim to improve the efficiency of agricultural land use, classification of sown areas taking into account the microclimate, lighting, erosion of slopes in terrain of varying complexity, and their results can be used to determine the productivity of sown areas and land values.

Thus, most of the considered publications indicate the need to develop a methodology for zoning areas by lighting. The use of GIS technologies to solve this problem will have significant practical potential in the future, as it will improve the situation with the cultivation of both fruit and other crops.

Method and Theory

Experimental studies were performed on cartographic materials provided by the Research Institute of Geodesy and Cartography. For this purpose, a garden belonging to Uman National University of Horticulture was chosen. The mentioned object is placed on two sheets of the topographic plan of scale 1: 10000 (fig. 1).

A Digital Relief Model (DRM) was created on the territory of the garden, for this purpose fragments of two adjacent sheets of a topographic plan of scale 1: 10000 with a relief cross-section of 1 meter were digitized with the help of SURFER package. The size of the grid side was 3 m.
Illumination of certain parts of territory allows to place objects (garden and park plantings, buildings, etc.) accordingly when creating projects. In particular, for gardens, geoinformation technologies allow to select appropriate places for certain species, etc.

The results of the yield of garden and agricultural lands are quite significantly affected by influence of such morphometric characteristics of the terrain as steepness and exposure of slopes. It is known that the temperature gradient is from 0.6 ° (for moist air) to 1 ° (for dry air) per 100 m, so the distribution of temperatures on the slopes contributes to the flow of cold mountain air down the slopes and its retention in the depressions. As for the gradient, it is usually larger at lows than at highs.

**Figure 1** Fragment of the topographic plan with the garden of Uman National University of Horticulture

Since the amount of light that falls on a given area depends mainly on its terrain, and for a small area is determined by its slope and orientation, using a digital terrain model (DEM) and SURFER software package, you can solve these problems.

**Examples**

As a result, a digital terrain model of this garden was created. The size of the grid of the digital model is 3 meters. Figure 2 shows a topographic plan of the territory, combined with a digital terrain model within the garden of Uman National University of Horticulture.

**Figure 2** The relief of the garden, shown horizontally and changing green depending on the height
Visualized 3D model of the terrain of the garden is shown separately in Fig. 3. This image clearly shows all the features of the terrain due to the level of insolation and lighting of the area, which is especially necessary for gardeners.

![Figure 3 3D model of the relief of the garden](image)

The distribution of solar radiation depending on the exposure of the slopes shows that the erosion of the southern slopes is 10-15% higher than the northern ones.

Figure 4-5 shows a map of the distribution of solar radiation in the garden of Uman National University of Horticulture at noon on June 22, when the height of the Sun is maximum. Blue (in Fig. 4) and red (in Fig. 5) lines outline the border of the garden. Changing the color of the filling from light yellow to dark red corresponds to an increase in the intensity of heating of certain parts of the garden. The scale in the figures characterizes the magnitude of solar radiation in fractions of the maximum value, which is equal to 1.

![Figure 4 Map of the distribution of solar radiation at noon on June 22](image)

![Figure 5 Map of the distribution of solar radiation in the territory, combined with the original topographic plan](image)
Conclusions

As a result of the performed experimental research the possibility to zone the territory of the garden on illumination with the use of GIS technologies is shown. Zoning of illumination of the territory according to the DRM allows to select places of planting of garden trees depending on their need for illumination. The proposed technique does not exclude the need for purposeful crown formation in plantations (Levchenko O., Shynkarenko H. 2000, 2002).

References


