The Assessment of Agroclimatic Potential and Bioclimatic Classification of Agricultural Cultures within GIS

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The quantitative interpretation of a regional climate alongside with soil bonitet is the base of natural conditions productivity estimating and the obligatory element of development of the agriculture management improved systems. If under climatic resources it is as a whole understood the potential of the sun energy, moisture supply, movement of air masses that can be used in the economical human activities, the agroclimatic resources are the climate's elements that a cultural vegetational organism at the creation of biomass uses, or the potential of a climate for agricultural production.

The receipt of climatic variable value for a given territory or, in other words, calculation of its spatial characteristics is, in essence, one forms to handle a problem of optimum spatial averaging of the climatic fields. At conventional approaches it comes usually to a search of initial data linear combination, ensuring the best approximation to average [2]. However, if the digital climatic map, or the matrix of climatic variable values in some regular grid nodes, received in GIS-environment [3], is available, the averaging of the values in the nodes, hitting in the target area, offers a good alternative method of such estimating. The procedure is close to the grid square technique [5].

As a whole, the algorithm of agroclimate spatial assessment is the following:

The contour of an area of averaging is set by the introduction of its edge list, stored in a database, to procedure;

The running over of the regular grid's nodes is done and a set of the ones, hitting in the contour of averaging, is determined; multiplication of the number of nodes on a grid step square gives the area of averaging;

Depending on the estimated meteorological element, using of one procedure, described in [3], the agroclimatic parameter values in selected nodes are calculated;

The average and other descriptive statistics of an estimated parameter in a contour of interest are found.

Two comments to the algorithm used come to the following.

1. As the long-term means do not reflect all the variability of the climate's parameters and give only smoothed characteristics, the program provides for the calculation of resources of various probability of their occurrence. For this purpose we profited by the well-known thesis of a central limiting theorem [4]: with enough large

volume of a sample ($n > 20$-30 and especially $n > 100$) the distribution of the average arithmetic values, received from the observations, belonging to the same population, approaches to the normal one, even if the individual observations are distributed arbitrarily. It gives a certain right to use the function of the normal distribution density as a model of distribution of the mean month (seasonal, annual) values of the climatic parameter, by their nature being the average of individual observations.

Mathematically this appears as follows [1].

If the random variable X has the distribution $N(a, s^2)$, an area on the left of the given value x is possible to receive by transforming X to

$$z = (x-a)/s \qquad (1)$$

Linear function Z is subjected to standard normal distribution and therefore

$$P(Z < z) = P(Z < (x-a)/s) = \hat{O}(x-a)/s, \qquad (2)$$

where $\hat{O}(\bullet)$ - the function of standard normal distribution, tabulated in most of statistic textbooks [3]. Given a field of norms (a), and knowing the standard deviation s of the described parameter long-term distribution, formula (1) easily solves the inverse task of calculating x for various probability $P(Z < z)$.

2. The task of this research did not include the proposal of any new agroclimatic division of the territory, and we provided only the description of the already existing physico-geographical systems. We have decided in favor of landscape as the most generalized form of natural-territorial complex. The table 1, as an example, describes some statistical characteristics of the agroclimatic potential of one Moldova landscape (a Tigechi hilly ridge), the table 2 - the South Moldova landscapes' agroclimatic resources of 90-% probability.

Fig. 1 shows the printer visualization of one of an agroclimatic parameter digital map.

In the same way successfully, using GIS-technologies, the tasks of agriculture bioclimatic classification are solved. Usually, for this purpose the complex of climatic parameters, expressing the particular culture demand for climate's factors and, consequently, the boundaries of its growth possible general area, is established and quantitatively evaluated. In other words, the series of "bioclimatic constants" is established and the evaluation of their conformity ("adequacy") degree to locality climate parameters is conducted. This peculiar "overlapping" leads to cartographic separation of regions, within them the culture growth is possible. The region can be considered suitable, partially suitable and unsuitable by agroclimate for the culture.

In the first case the agroclimate restrictions on growth and development of culture are absent, in the second - the restrictions are not very serious. We speak about

unfitness when the considerable climatic restrictions on economic use of culture are present, going, in the first place, from the rate-determining factor.

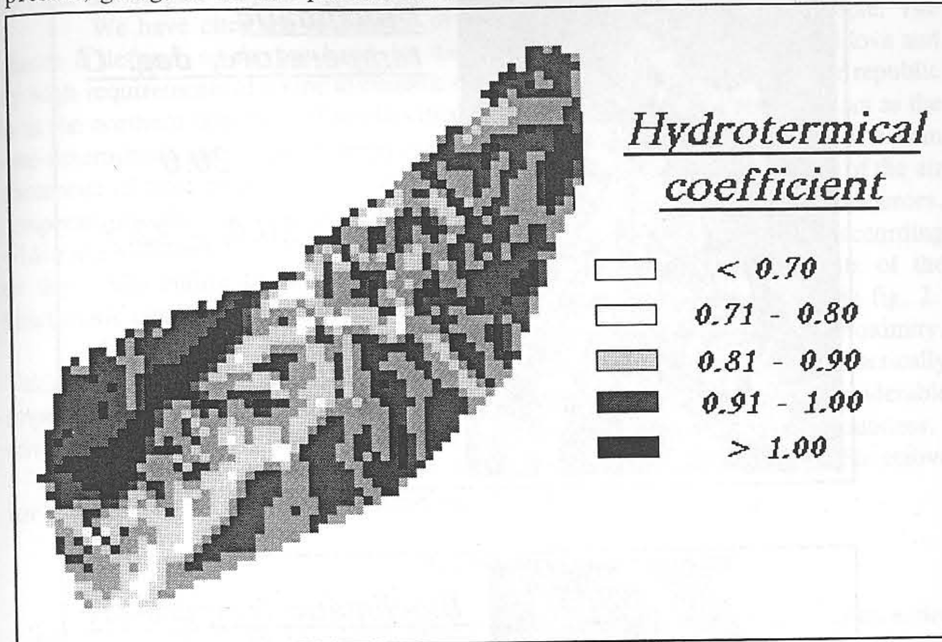
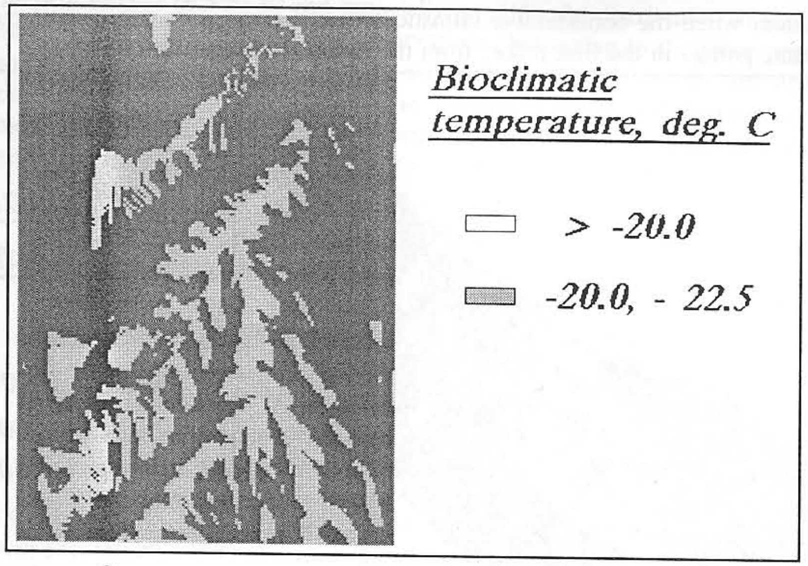


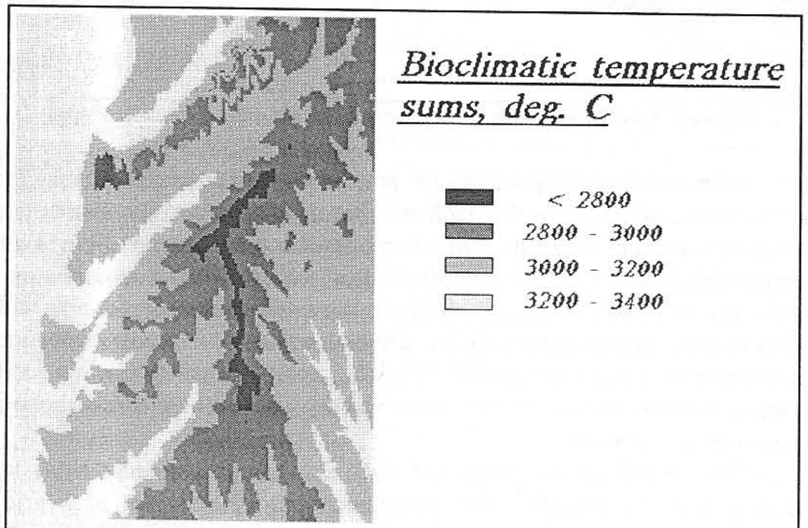
Figure 1. Spatial distribution of hydrotermical coefficient (a Tigechi hilly ridge)

With traditional approaches the process of such agroclimatic map preparation comes to consecutive transferring izolines, meeting the bioclimatic constants of crops, from appropriate climatic maps. For a homogeneous flat country it is enough to have the equivalent material of the meteorological station network observation for this. Nevertheless, if a territory has complicated orographical structure, the map with izolines is not more than simple generalization, presenting some qualitative evaluation of areas that are possible for culture growth. The complexity of the following calculation of these areas' dimensions, i.e., the transition to quantitative assessment is the considerable restriction of the method too.

The shortcomings mentioned are eliminated "automatically" with GIS-technology use. To calculate the agroclimate parameter value in a grid node is practically the acquisition of its estimating for a sort of an operating territorial unit, here the grid cell acts as such. The selection of the nodes with climatic characteristics, adequate to bioclimatic constants of the culture, permits to pass easily both to the detailed classification, with the opportunity of subsequent visualization, and to the



a



b

Figure 2. Bioclimatic classification of the territory for vine: **a.** by frost danger; **b.** by heat ressources.

evaluation of an area.

To handle a problem, the computer interactive procedure has been developed. The inputs of the procedure are the threshold values of biological constants of a culture; the outputs are the digital maps of its classification.

We have cited the realization of this software for vine as an example. The choice is defined, on the one hand, by the importance of viticulture for Moldova and by high requirements of a vine to climatic conditions, one the other hand. The republic is at the northern boundary of world viticulture, where the thermal resources act as the rate-determining factor of normal development and high-quality yield forming. The main parameter of frost-danger conformably to vineyard frost-killing is the average of the air temperature's absolute minima. The classification of the territory as to heat resources, which are necessary to different groups of a vine for normal growth, is made according to the distribution of active (>10°C) temperature sums. The fragments of the bioclimatic classification map of a territory by these two indices are shown in fig. 2.

Undoubtedly, the procedures described contain the element of proximity. Taking all the agroclimatic nuances of the studied territory into account is practically impossible. Therefore, the final decision remains for an expert. However, considerable advantages of a such approach in comparison with a conventional one are doubtless.

In summary the author express deep gratitude to S. Novac and N.Shvetzova for the software realization of a described algorithm.

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