Practical Application Peculiarities of Geo-Information Technologies While Planning the Protective Forest Belts

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Abstract. This article considers methodological and practical aspects of applying geoinformational technologies in assessing environmental and biologic states of the protective forest-belts. The algorithm for geo-informational cartographic database compilation has been suggested to develop the projects of forest-belts restoration, functions assessment and reclamation effect. The examples of computations while planning forest-belts for the Crimean Republic are given here.

1. Introduction

The expediency of applying geoinformational technologies while designing the protective forest-belts for the territory of the Crimean Republic is stipulated by the necessity to develop a unique project (for the south of the Russian Federation) of area restoration of these forest planting system. The area of this project covers the whole Pervomaiskiy region territory in the Crimean Republic and it is 5.5% of the whole republican territory, which is considered to be an unprecedented example. In the last 40-50 years such measures were not held in the Crimea.

Such area scope brings about the necessity to use the system of remote sensing of the Earth and modern approaches to geoinformational modeling on environmental and biologic assessment stage of modern condition of the forest-belts region and on the stage of projecting restoration measures.

The aim of the work is to develop and apply the algorithm of modern geo-informational technologies in planning the protective forest-belts system on large areas for the Crimean Republic territory.
2. Methodology and methods

The object of the research is 795 land plots of the forest-belts within 16 rural settlements on the Pervomaiskiy region territory of the Crimean Republic. The total area of the plots is 900, 56 ha.

The study of presented data and geo-informational cartography show that the forest-belts, being analyzed, cover less than 1 % of the Pervomaisky region area. However, taking into account the most significant landscape and environmental role of the given object, this quantity is of average size by fact in comparison with other Crimean regions. In reference, the area of the forest-belts covers about 0, 8 % of the whole area in the Dzhankoysky region, whereas the Razdolnensky region occupies less than 0, 3 % and the Simferopolsky region covers 1, 3 % [See 2, 3, 4, and 5].

Geo-informational modeling is carried out by using modern professional computer programmes as ArcGis 10.4.2 programs and QGis 2.18 and 3.4. Cartographic project is made up in parametric wgs84 (zone 36 N) system. The GPS receivers of Garmin 64 st pro systems are used for the field researching.

The geo-informational modeling is carried out in the framework of a single cartographic project.

Thematic geo-informational cartography is implemented based on open sources cartographic data, printed charts, schemes and charts zoning presented in professional scientific editions and publications.

To conduct thematic cartography, topographically attached vector layers of soil and climatic zoning are used in different variations. The chart-scheme of natural resources is made up by deciphering the cosmic HD photo, received by applying SasPlanet thematical resource as well as vector layers, presented in the open access in Open Streetmap resource.

As a result of our research a single cartographic project is made up, as well as the database allows making an assessment of the modern forest-belts condition within the areas studied.

The following parameters are included in the contents of the database:

1. The serial number of a forest-belt;
2. Administrative forest-belt belonging;
3. The area of a forest-belt;
4. The area of a forest-belt within the area of which its structure is destroyed;
5. A percentage of a forest-belt damage;
6. The soil type within a forest-belt;
7. Forest-belt belonging to a contour of the soil zoning system proposed by Dragan N.A.;
8. The location of a forest-belt within the soil and climatic zoning of the Crimean Republic;
9. Forest-belt location within the climatic zoning in the Crimean Republic.

The magnitude of biologic forest-belt productivity in 1979 – 2018s, calculated

3. The main part

Let’s consider the results of modeling in detail.

The most important point in the project of forest-belt restoration is the expediency of a given measure. In the framework of environmental and biological assessment of forest-belt condition project the following estimations have been made:

- The condition assessment of agrophytocenosis and morphometric parameters of field-protective plantings;
- The location assessment of field-protective forest-belt with regard to the effectiveness of their functions;
- the assessment of forest-belts impact on the physical parameters of the environment;
- The assessment of forest-belts influence on micro-climate and ecological condition of the territory;
- The magnitude assessment of protective forest-belts biological productivity in modern conditions using remote sensing methods and field observations.

Further, according to the assessments carried out, it is possible to define the following indices to generalize the expediency of forest reclamation objects:
1. The impact of forest reclamation objects on total percentage of forest cover of the territory and its comparison with the normative and scientific indices in case of forest-belts restoration;

2. The degree of landscape clusters of the forest-belt complexes determination towards the protected lands using modern technologies of geo-informational modeling.

3. Forest reclamation effect determination in terms of its influence on the main indicators of agrophytocenosis functioning, their ecologic and economic effectiveness.

Let's consider each of the points in detail.

To determine the percent of forest cover, there can be two approaches to its computation:
- Calculating the percent of forest cover of all administrative border of the Pervomaisky region of the Crimean Republic;
- Calculating the percent of forest cover zone forest-belts location.

According to the second approach, the parameter value of forest reclamation area by default uses the area of minimal describing triangle. That was exactly done in assessing the degree of forest-belts clustering further. Unlike the first variant the minimal describing triangle may not coincide with the X and Y axis.

The calculations showed that taking into account the preserved forest-belts in the region studied, the protecting forest cover is 11.3% of total forest-belt areas, and 2.12% of them is in good condition. This enables to consider this region as a weak protected forest cover area so there is a need to restore the forest-belts.

The protection of the territory by forest plantings is a percentage ratio of the total area of reclamation influence forest plantings towards total area of the territory where they are located. Protection is considered to be complete if its magnitude is 100%, quite complete – 99-80%; not complete enough – 79-50%, incomplete – 49-20% and absent – less than 20% [see 10, 14, 15].

The total area of restored and reconstructed forest-belts is 900.5 ha. In the first calculation the area of the Pervomaisky region is 1493262534.90 sq. m (149326 ha).

In the second calculation the area is 121895,8 ha. The non-agricultural objects areas (settlements, industrial and other objects) were excluded from the given area. The area of agricultural objects was 118153826 sq. m (118153ha) for the whole Pervomaisky region and 99211ha for bounding.

The analysis shows that the result received is greatly influenced by the choice of operational and territorial unit.

So, if we take the whole territory of the Pervomaisky region of the Crimean Republic, as it may be done in forming administrative and environmental reporting, the interest increase in forest cover will be 0,61. That will provide 2,8% afforestation of the whole region that is lower than the average norm for agricultural regions [see 8, 9, 18].

Further, in detailing of operational territorial unit, there calculates only agricultural lands and only within the zone of forest-belts influence towards the peculiarities of their location, there is an increase in change of the results the index studied.

In the fourth variant of calculations, while only the agricultural lands territory in the zone of real forest-belts influence on the parameter and processes in landscapes being taken into account, the percentage of forest cover will be increased to 4,21% at the expense of the project realization. That corresponds to the average norm of 4% from the area of the territory studied.

Thus these simple calculations enable us to substantiate quantitatively the expediency of taking measures to restore the protective forest-belts.

The next step of geo-informational modeling was to define the degree of landscape clustering of forest-belts complexes towards the protected lands by using geo-informational modeling.

In fact, the main significance of the given index is to characterize how complete the planned forest-belts will ‘engird’ the lands studied from all the sides and provide ‘jointless cover’ of the forest reclamation effect carried out by these forest-belts. It will enable to exclude those parts of the fields, where this forest reclamation effect doesn’t spread spatially.

A single geo-informational project is used for this purpose, developed on the stage of environmental and biologic assessment of forest-belts condition.
Further, using ArcGis 10.4.2, module (Average Nearest Neighbor Distance) ‘Srednee blizhaishee sosedstvo’, the calculation was made. The index of Average Nearest Neighbor Distance is as a ratio of observed average distance to the expected average distance (definition of z-assessment and p-values). The expected distance is the average distance between the neighbors in hypothetical accidental distribution. If the index is less than 1, the distribution presents clustering; if the index is more than 1, there is a tendency to dispersion or disputable results.

The results of z-assessment calculation and p-values are the indices of statistical significance and one can make a decision about the deviation of NULL-hypothesis relying on them. However, statistical significance of a given method is supposed to greatly depend upon the size of the studied area. NULL-hypothesis claims that values are distributed randomly for the statistical value the Average Nearest neighbor Distance.

As a result of the assessment the following data were received:

Coefficient of nearest neighbor distance – 0,766693; z-assessment – 12,584677, p-value is 0,00.

Thus, both calculation results of z-assessment and p-value are the indices of statistical significance, so one may take a decision about the deviation of NULL-hypothesis. It means that forest-belts in case of their restoration and reconstruction will make up one single spatial cluster and that will enable to maximize their forest reclamation effect.

To summarize the results received after carrying out the assessment of environmental and biologic forest-belts condition and if this forest-belts restoration project is fulfilled, it is possible to make up an integral chart of protective belts growth (forest areas) for the territory of the Pervomaisky region area of the Crimean Republic. This integral chart is displayed on fig.1.

First of all, reclamation role of the protective forest-belts is stipulated by wind breaking effect, e.i. by the change of wind flows speed. As a result of which there are snow sediment and fine sand, changes in temperature’s regime and air and soil moisture. The increase of forest-belts areas in the region studied is sure to optimize these processes [see 20, 21, 22, 25].

Each forest-belt changing aerodynamic characteristics of the wind and hydraulic indices of water flows, creating microclimate and increasing soil fertility, exerts certain reclamation influence on protected objects [see 25].

The area, influenced by protective forest-belt impact, is called a zone of its reclamation influence [see 16]. If the project is fulfilled, the zone of reclamation forest-belts impact will increase not less than 9921 ha. This zone is considered to be rather a large one within the Pervomaisky region and even in the Republic of Crimea.

The protection of the territory by forest plantings, expressed in a ratio of the total area of the reclamation impact of forest plantings towards the total area of the territory where they are located, is also significantly increased. The protection will increase from index of incomplete and absent (less than 20% and 49-20%) till insignificantly complete – 79-50% (if the whole administrative region is used as operational and territorial unit) and till 88% – practically full protection (if the detailed scheme of agricultural lands is used).

Within the framework of this cartography block, a great number of buffers moving away from the contours of each forest-belt were built by using the standard ArcGis 10.4.2 modules. The buffer distance of 500, 550 and 600m was taken. It is stipulated by high diversity of colors of soil coating territory, mostly by black south soils and chestnut soils in the region. The first buffer diameter corresponds to the chestnut soils, the latest one – to the black south soils. Intermediate value is a certain average one.
Figure 1. Assessment of environmental effect after restoration of forest-belts system.
To assess the influence, only the forest-belts in good condition with damage degree less than 30% were considered.

To assess the zones of forest belt influence with more than 70% of its safety according to geoinformational covering, a raster layer of Euclid distance was built, with the height of 25 units of forest-belts being considered.

The comparison of these layers allows singling out the obvious zones, within which forest-belts because of its damage don't influence the environment parameters like regulation of the wind, snow retention, regulation of moisture regime. In fact, these processes are regulated only in the zone of the most effective influence. It supports the necessity of effective forest-belt restoration.

4. Conclusions
The presented cartographic data as well as the materials, received in environmental and biologic assessment of forest-belts condition, make it possible to form scientifically applied basis to carry out this project, with an obviously positive environmental effect.

The conducted analysis proves that taken into account modern unsatisfactory condition, the influence of forest-belts on the environmental physical factors is insufficient both from spatial and location outlooks. That points out another argument for the necessity of reconstruction and restoration of forest-belts.

The analysis of chart-scheme and a great number of built buffers distance from the contours of the forest-belts in all variants show that 95% of the forest-belts cases are located in such a way that the distance between them provides a complete joining of buffers within the borders of each field, so this testifies of real location effectiveness.

The carried out research concludes that the location of forest-belts is said to be effective according to scientific and methodological approaches. The given structure may be preserved to restore further the forest belts as it is stipulated by a fully developed field system on the one hand, and on the other hand it may be permissibly effective and be used in the system of on-farm structure in future.

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