APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN THE AGRO-ECOLOGICAL REGION OF VINEYARDS AND APPLE ORCHARDS IN BULGARIA

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ABSTRACT *- European programs are directed to suitable zoning of crops and the application of technologies that protect soil fertility. Agro-ecological zoning in the country is made on the basis of certain environmental characteristics: soil type, soil moisture and its preservation, climatic characteristics of the region (vegetation period), extreme manifestation of some factors such as altitude, relief features etc. more. Agro-ecological regions have been created, covering agriculture and forestry in Bulgaria. The development of Geographic Information Systems (GIS) provides new opportunities and challenges in the field of agriculture. Advanced software for digitization of maps has been introduced, which allows the use of digital information, visualization and interpretation of the map material. Evaluation of each agroecological farming area has been made of suitability of vineyards and apple orchards, which separates regions of "very good land," "good land", "average good land", "bad lands" and "unsuitable land". Assessment of agricultural land and forests has been carried out in "Methods for Work on Cadastre of Agricultural Land".*

Keywords: *agro-ecological region, soil, soil fertility, Geographic Information Systems (GIS)*

INTRODUCTION

Modern development of agriculture requires good organization of production, concentration and specialization of separate branches. The yields of agricultural produce depend to a great extent on subtle scientific information about particular ecological conditions and how they correspond to the grown crops and used technologies. This especially occurs in territories of complex and variously combined natural conditions. Bulgaria is characterized by a great diversity of soil cover, determined by the varied relief, soil-forming rocks and different bio-climatic influences to which its separate parts are exposed. The whole territory of the country has been mapped in M 1:25000 and 1:10000.

MATERIALS AND METHODS

The map of agro-ecological regions in Bulgaria (Fig.1.) has been made on the basis of summarized soil and climate information in M:600 000. 50 agro-ecological regions have been separated, 40 of which cover the agricultural fund and 10 – forests. This region separation has been done on the basis of qualitative and quantitative criteria, the most important of which are: prevailing soil type, moisture and heat in the region (during the vegetation period), extreme manifestation of some climatic factors such as altitude, relief features, etc.

Main soil types (FAO) are presented on the map of agro-ecological zoning into agro-ecological regions and sub-regions. Agro-ecological regions in Bulgaria were elaborated by M. Yolevski, Y. Georgieva, Asp. Hadzhiyanakiev and Iv. Kabakchiev in a map of the same name in M:1:600 000 and 1:100 000, published by, Sofia1982. It was digitalized by modern software programs and in this way provided the opportunity of entering and using digital information and its visualization. Processing data includes structuring of data in Personal Geodatabase.mdb into *shp. files in a coordinate system WGS_84 UTM 35N, ArcView 10.1, Arc GIS Spatial Analyst 10.1.

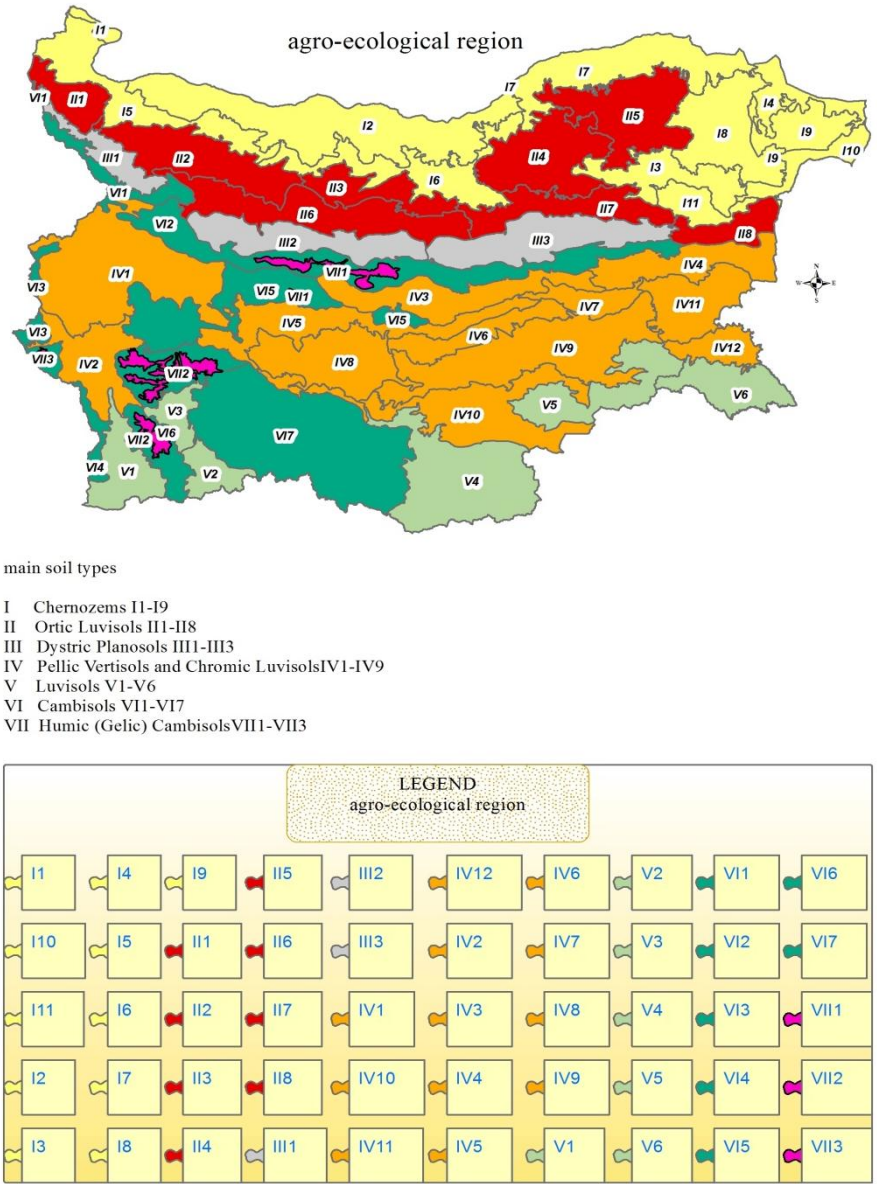

Fig.1. Map of the agro-ecological regions (M 1:600 000), according to soil type (FAO)

I. The agro-ecological region of Chernozems. 11 sub-regions, which cover the northern part of the Danube hilly plain and North-East Bulgaria are included into this group. The territory is covered by Chernozems and Fluvisols, found in a different proportion in separate sub-regions.

II. The agro-ecological region of Ortic Luvisols. 8 subregions, which cover the territory to the south of the first group in the pre-mountainous part of North Bulgaria, are included here. The basic soil cover includes Ortic Luvisols, Rankers and Litosols.

III. The agro-ecological region of Dystric Planosols. 3 sub-regions, which cover territories in the low-mountainous part of the Predbalkan and the northern slopes of the Balkan are included in this group. The soil cover consists of Dystric Planosols, in many cases moisturized too much on the surface and with a different degree of erosion.

IV. The agro-ecological region of Pellic Vertisols and Chromic Luvisols. 12 sub-regions are included in this group and they cover most of the territory of South Bulgaria with a different proportion of Pellic Vertisols and Chromic Luvisols and Fluvisols.

V. The agro-ecological region of Chromic Luvisols. 6 sub-regions are included in this group and they cover South Bulgarian transient Mediterranean zone of Chromic Luvisols. There is mainly

spreading of non-eroded and eroded Chromic Luvisols and shallow Lithosol –Alluvial and Deluvial Fluvisols. Cultivated land comprises mainly of low mountainous terrains.

VI. The agro-ecological region of Cambisols. 7 sub-regions, which totally cover the mountainous and forest zone of Cambisols, are included in this group, and it is mainly part of the forests of the country. The soil cover consists mainly of Cambisols. The arable land in this zone occupies a comparatively small area, mainly in the lower mountainous part.

VII The agro-ecological region of Humic (Gelic) Cambisols. 3 sub-regions, which cover the highest ridge non-forest parts of Bulgarian mountains at an altitude of 1700-1800 m, are included in this group. The basic soil cover consists of Humic (Gelic) Cambisols. There is no arable land. The terrains are used mainly as high-land pastures.

The bonity assessment of vine and apple was accomplished in "Methods of Work on the Cadastre of Agricultural Land in Bulgaria" and was calculated by the equation:

$$FR_x = \frac{R_{TX} + R_{THH} + R_{TSP} + R_{CCR} + R_{pH} + R_{HC} + R_{GWT}}{n^R} k_{EA}\, k_{SA}\, k_{ST}\, k_{FL}\, k_{CL}$$

where FR x –is Field Bonity Number for the particular crops.

Bonity assessment for R TX –mechanical composition of the soil; R THH-power of the humus horizon; R TSP-power of the soil profile; R CCR-texture differentiation of profile; R pH- reaction of soil; R HC – content of organic substance (humus); R GWT-level of underground water.

Correction coefficient for: k EA erosion or accumulation of soil; k SA salinity/alkalescency of soil; k ST – availability of stones in the arable soil layer; k FL – swamping; k CL – climate; R – number of included characteristics (R……)

The assessment of climatic conditions for apples is presented by the indicator "possibility (%)of having temperatures below -2 degrees C in April. The evaluation of climate for this culture varies from bonity 90 (most suitable climatic conditions) to bonity 0 in which places of altitude of 800, 900 and 1000 m are assessed. Assessments of climate conditions are formed on the basis of heat and the temperature regime during the blooming period. The sum of temperatures over 10 degrees C in most regions in Bulgaria is between 3000 and 4000 degrees C. Winter varieties cannot ripen at a temperature sum below 2500 degrees C. For the blossoms of apple temperatures from -1.6 degrees C to 2.2 degrees C are accepted as critical while temperatures between -1.1 degrees C and 2.2 degrees C are critical for phase fruit set of plants. [2], [3], [4], [8]. At the evaluation of soil conditions for apples indicators are used which have an influence on the development of the culture. Apple plantations develop on deep soils with a powerful and rich in organic substance humus horizon, with an average to heavy sand-clay mechanical composition (physical clay particles < 0.01 mm) 45-60%, providing good moisturizing ability with a neutral to slightly acid reaction (pH in H_2O 5.0-6.5) They do not develop on soils with an alkaline reaction, high level of underground water and too much moisture. The evaluation of climatic conditions for vineyards was made with the indicator "general temperature sum from durable presence of an average 24-hour temperature over 10 degrees C in spring to durable presence of this temperature in autumn. Level of climatic are developed on the basis of percentage availability by using the following scale: availability over 90% - assessment 100; availability over 70% - assessment 90; availability over 50 % - assessment 70; availability over 30 % - assessment 40, availability over 10 % - assessment 20; availability under 5 % - assessment 0 .

At the bonity evaluation of soil indicators the requirements for basic varieties of wine grapes and table grapes are taken into consideration.

For growing vineyards and production of red table wines we take as most suitable moderately wet, well-aired soils with a good temperature regime, average to high sand and clay mechanical composition (content of physical clay particle < 0.01 mm – 35-45 %) and slightly to average

calcareous soils. The must have a moderate amount of humus and enough phosphorus, iron and potassium. For growing white varieties of vine the most suitable are soils, characterized by a light mechanical composition, a high percentage of skeleton grains, loose structure, good airing and low content of nitrogen. [5].

DISCUSSIONS AND CONCLUSIONS

There are maps of suitability for growing apples and vines in Bulgaria. Regions of "very good land", "good land", "averagely good land", "bad land" and "unsuitable land" have been separated. For the bonity assessment data has been entered concerning:

1.Climate, precipitation, temperature, balance of atmospheric moisturizing, risky meteorological conditions and other parameters, characterizing the region under consideration.

2.Requirements of the plants – a differentiated approach has been applied depending on the plant variety, climatic conditions during the defining pheno-phases development, soil and soil-formation conditions.

3.Soils (according to FAO qualification). To assess soil conditions basic characteristics of soil and sub-soil in the investigated regions, determining its fertility and having a direct link to the productivity of agricultural land, have been used.

During assessment of soil and climatic conditions for both cultures for every soil difference there is a Field Bonity Number (FBN) with a rate of 0 to 100. The FBN represents the suitability of the region for growing the particular culture and is a result of the percentage of participating soil types in the agro-ecological region.

The assessment of suitability for every agro-ecological region for growing apples (Fig.2.) and vines (Fig. 3.), which characterizes regions as "very good land", "good land", "averagely good land", "bad land" and "unsuitable land".

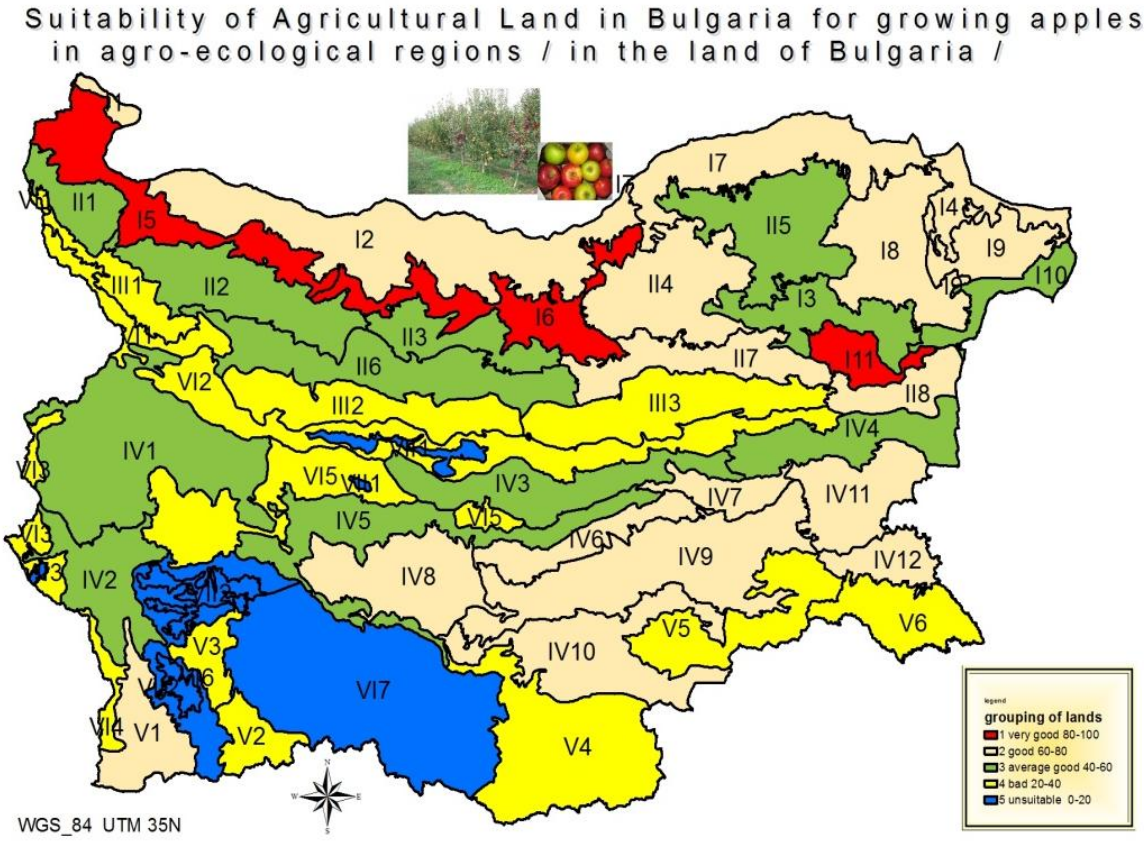

Fig.2. Map of suitability of agricultural land in Bulgaria for growing apples in agro-ecological regions (M 1:600 000).

The usage of the GIS software product of ESRI – ArcView 10.1, Arc GIS Spatial Analyst 10.1, Arc Pad 10.1- Mobile GIS Software, and their control on expertise level provides the opportunities of application of new innovatory solutions and technologies on "farmer" level.

Attributive data about the objects by arithmetic and logical operations, without changing the already available data, is derived while generating of questions to the geo-database [7].

In North Bulgaria the most suitable agro-ecological conditions for growing apples are found in Vidin-Byala Slatina (I_5), Pleven-Pavlikeni (I_6) and Provadia(I_{11}) regions, where the bonity assessment for apples are between 80 and 100 and these are places of "very good land" for this culture. In these regions the soil and climatic conditions are most suitable for apple plantations.

Less suitable natural conditions characterize Zlaten Rog-Novo Selo(I_1), Lom-Svishtov (I_2), Rousse-Silistra (I_7), Kardam-Durankulak (I_4), Dobrich (I_9), Tervel (I_8), Isperih (II_5), Veliko Tarnova-Preslav (II_7), and Avren (II_8) agro-ecological regions. There the soil and climatic conditions are assessed by bonity of 60 to 80 and this land is "good" for growing this culture.

In South Bulgaria the regions Petrich-Sandanski (V_1), Pazardzhik-Plovdiv(IV_8) , the region of Sredna Gora and Rhodopes foot, Sliven-Straldzha(IV_7), Karnobat-Bourgas (IV_{11}), Grudovo-Sozopol (IV_{12}), Chirpan-Yambol (IV_9) and Haskovo(IV_{10}) are taken as "good land" for growing apples and are assessed by a bonity of 60 to 80. The remaining regions of the country belong to the groups of "averagely good", "bad" and "unsuitable" land for growing this culture and are presented in Fig. 2. The zoning by suitability of land has been made on the basis of average soil and climatic data and is valid for the territory of the defined agro-ecological regions and sub-regions. If a larger scale of assessment is used in many places where the land is defined as "unsuitable" for growing this culture there could be special terrains where the conditions are suitable.

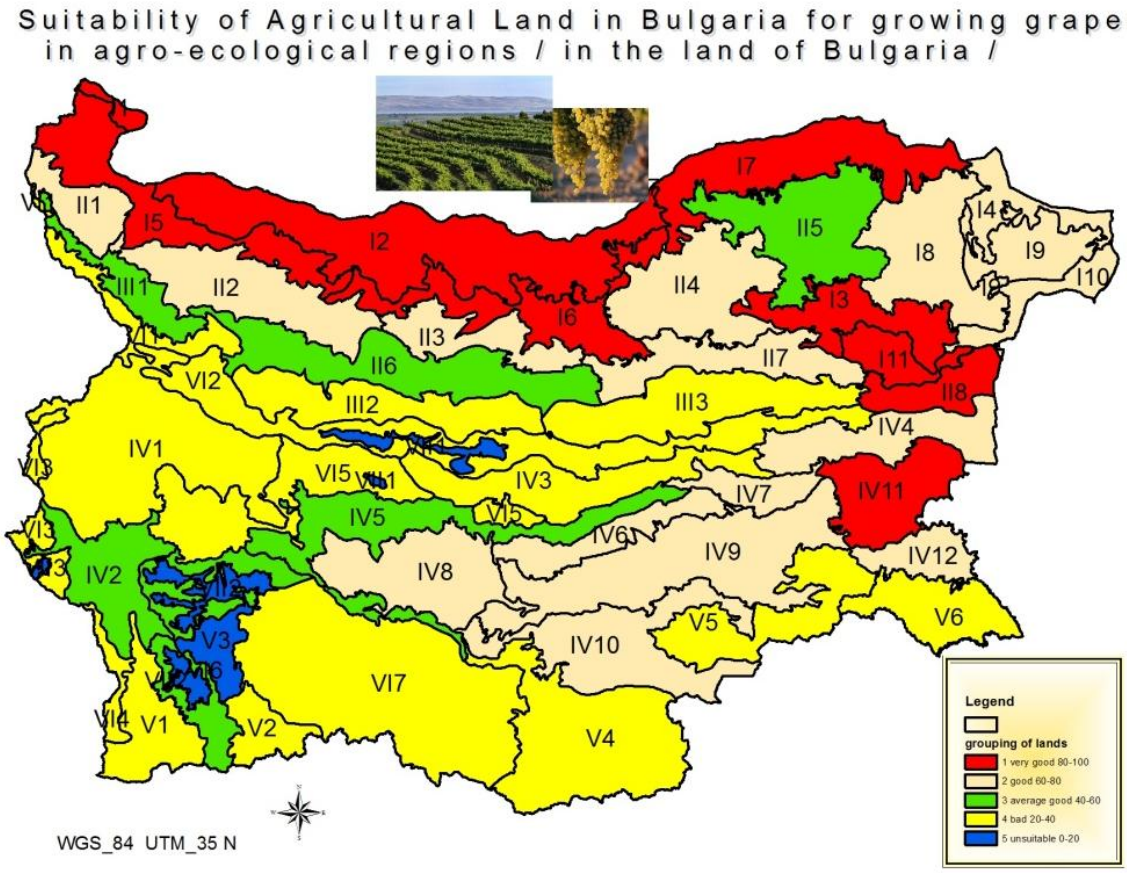

Fig.3. Map of suitability of agricultural land in Bulgaria in agro-ecological regions for growing vines. /M 1:600 000/.

Land, which is assessed as "very good" for vine plantations is found on the territory of Zlaten Rog-Novo selo(I_1) , Vidin-Byala Slatina (I_5), Lom-Svishtov (I_2), Rousse-Silistra (I_7), Pleven-Pavlikeni (I_6), Novi Pazar (I_3), Provadia(I_{11}) and Avren (II_8) regions with a bonity of 80 to 100.

Less suitable are Koula-Belfgradchik (II_1), Mihailovgrad-Lukovit (II_2), Lovech (II_3), Veliko Tarnovo-Preslav (II_7), Popovo-Razgrad (II_4), Tervel (I_8), Balchik (I_{10}), Kardam-Durankulak (I_4) and Dobrich (I_9) regions, where the bonity assessment for vineyards is between 60 and 80 and they belong to the group of "good land" for the culture (Fig.3.).

In South Bulgaria there is "very good land" in Karnobat-Bourgas region(IV_{11}). In the regions of Pazardzhik-Plovdiv(IV_8), Nova Zagora(IV_6) , Sliven-Straldzha (IV_7), Sungurlare (IV_4), Chirpan-Yambol (IV_9), Haskovo (IV_{10}) and Grudovo-Sozopol (IV_{12}) there is "good land" for vines with a bonity of 60 to 80.

The remaining regions of the country belong to the group of "average good", "bad" and "unsuitable" land for growing the culture.

Except for the whole country such maps could be presented for regions, municipalities, lands, on the level of plot grouping or a separate plot.

Data, obtained from terrain research (coordinates, prospects, altitude, stone availability, plants and a morphological description of the soil profile, way of durable use and satellite images (Fig4.) are the basis of creation of subject maps of crops on the level of land. The obtained vector data (points, lines and polygons) in field conditions are maintained in shape files and are preserved as locations (with the appropriate coordinates) and attributive information. The opportunity of overlay of raster and vector data enables us to describe soil resources.

The GIS parameters, set in the database, provide information about the identification number of the plot, the way of durable use (field, vineyard, abandoned land), area, configuration and orientation of the plot, number of the variety if soil and soil code, code for mechanical composition of the soil, code for stone availability, code for soil-forming materials, bonity assessment for apple orchards and bonity assessment for vineyards.

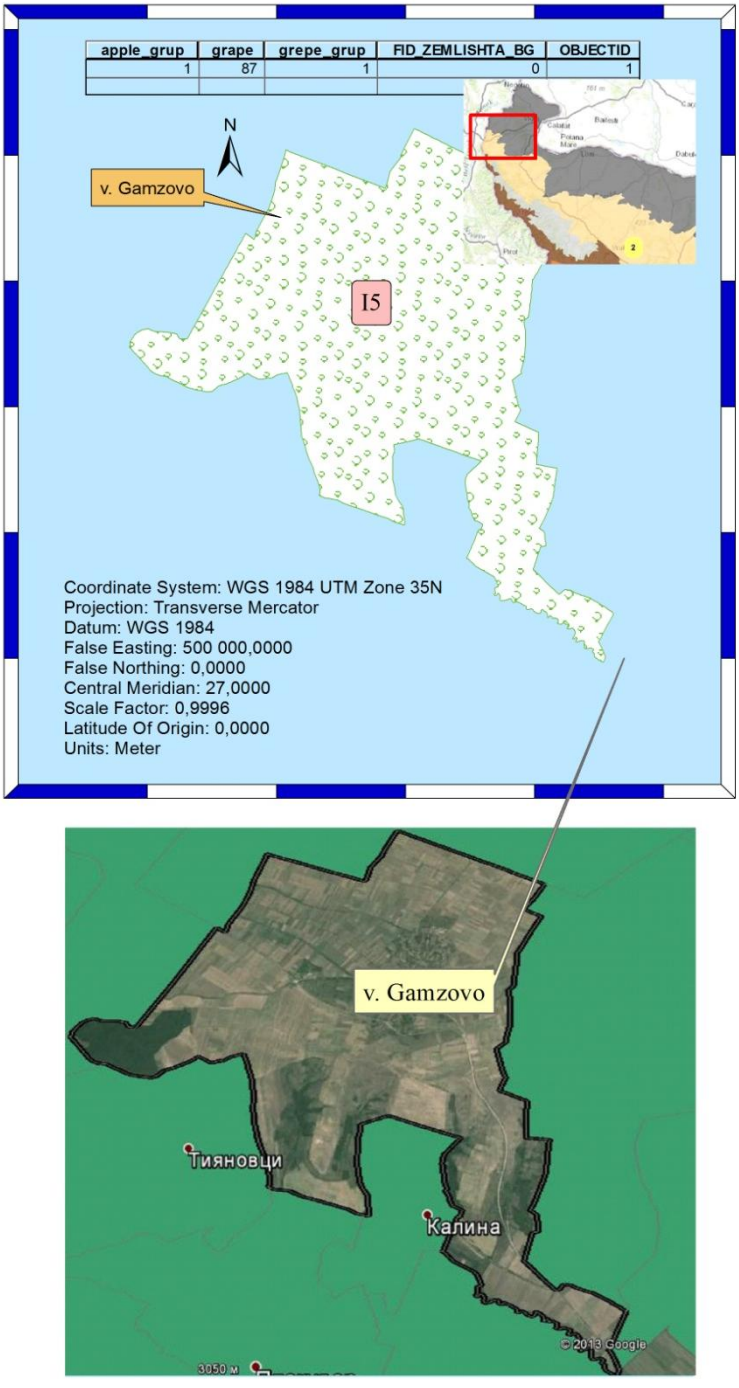

Fig.4. Satellite image of the village of Gamzovo in the region of Vidin.

ACKNOWLEDGEMENTS

Agro-ecological regions are at the basis of rational use of soil resources, in combination with climatic factors. Agro-ecological zoning is the basis of sustainable agriculture in every region.

The maintenance of digital data of the soil cover, based on various climatic, geo-morphological and physical and geographic conditions in the territory of the country provide the opportunity for structuring of the subject maps of suitability for growing agricultural crops.

Bonitation is a comparative assessment of agricultural land, which is based on their characteristics or qualities and shows their suitability for growing one or another group of crops at a certain level of agricultural machinery. The agricultural land assessment is always unique, consistent with certain requirements and subject to basic purposes linked to agricultural development.

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