VI. ECOLOGICAL AND SUSTAINABLE AGRICULTURE

LAND CAPABILITY EVALUATION FOR THE EFFECTIVE LAND USE AND SOIL PROTECTION MEASURES IN DOBRICH REGION

Vihra Stoinova, Diyana Nekova

Abstract: An assessment of the suitability of the arable land in the Dobrich region for its effective agricultural use has been prepared using an eight rate classification where the land valuation strategy guarantees the conservation of natural resources, with particular attention to erosion as a limiting factor. Maps of the area with Land Capability evaluation classes for effective agricultural and erosion control land use and the actual risk of water erosion have been developed. This allows the use of an integrated approach to the definition of soil protection measures - taking into account both soil constraints (labeled with subclass land) and the need for prevention against erosion processes.

A set of different soil protection practices is recommended, each determined according to the specific soil, topographical and climatic features of the studied area, determined by the class and subclass of the land and depending on the degree of erosion risk and the way of land use (defined by Physical Blocks, 2016).

The agronomic assessments according to the soil and climate conditions of the main agricultural crops are linked to the detailed large-scale database created in the GIS format and the most suitable places for their cultivation on the territory of the Dobrich region have been identified. The agronomic fitness of arable land for the cultivation of wheat, maize, peaches and vines is assessed. Maps for the degree of their agronomic fitness were prepared. It is clear that almost all of the entire territory has a very good and good land for cultivation of these crops.

Keywords: Land capability evaluation – classes, subclasses and blocks (units), soil erosion, soil protection measures, agronomic assessment, mapping.

INTRODUCTION

Modern agriculture imposes various models of relative assessment of farmland – using and comparable to rapidly changing high technology. For our country, where soil resources are limited and the relief is varied, the land valuation strategy must first ensure the conservation of natural resources.

In view of the great diversity of the soil cover of Bulgaria, and the great differences in altitude, we selected the 8-grades classification for the aims of this project. This classification is similar to that developed by USDA [9] and the Long-Term Erosion Control Programme in Bulgaria [3]. This is the best way of taking into consideration the specific topographic, soil and climatic conditions of the country while the GIS methods enable better processing of the huge amount of information hold by the database developed so far. This classification is focusing on the requirements for soil protection from erosion.

The system has three levels of categorization of land use:

- Land Capability **classes** – give an indication of the overall extent of restrictions on land use;
- Land Capability **subclasses** – indicate the type of restrictions which exist in the class;
- Land Capability **blocks** (units) – cartographic units with similar soil types require the same type of management and the conservation suitable for growing the same crop species with

similar potential yields, i.e. account the capability of land for cultivation of different crops.

The system can be used and implemented on a variety of scales by categorizing subclass and block level, depending on the purpose of the survey. For this study, M 1:10 000 was used. It allows the use of an integrated approach in determining soil protection measures – taking into account simultaneously the soil constraints (indicated by the land subclass) and the need to prevent erosion processes (according to the degree of erosion risk).

THE PURPOSE OF THE STUDY IS:

- to evaluate the land suitability classes for effective and anti-erosion land use in the Dobrich region by analyzing the existing natural and economic preconditions, the erosion factors and the actual quantities of eroded soil;
- to recommend optimal protective practices to limit erosion processes and increase soil productivity.

MATERIALS AND METHODS

For Land Capability Evaluation of arable land in the area, is used information from:

- GIS of Land Capability Evaluation (classes and subclasses of land) for the effective agricultural and erosion control land use for the territory of the Republic of Bulgaria [6];

doi.org/10.32006/eeep.2020.1.6372

This article is distributed under the terms of the Creative Commons Attribution License

- GIS of water and wind erosion for the Republic of Bulgaria with detailed reflection of the gradients at each degree of erosion risk, way of using the land – fields, perennial crops or mixed land use and actual amounts of eroded soil [2,5];

- A digital elevation model DEM 50 is used to reflect the relief and reporting the slope;

- Information from Physical Blocks (defined in the Land Parcel Identification System) obtained by decrypting (reading) the digital orthophoto map of the country by airplane and satellite capture from 2016 is used to reflect the way of land use in Dobrich region.

Optimal measures for protection against erosion and improvement of soil fertility are proposed for each class and subclass, taking into account all the above indicators.

To determine the agronomic suitability of the main agricultural crops (22 main crops for the country), a methodology for assessment of the productivity of the land, which was developed at the N. Pushkarov Institute of Soil Science, was used [1].

RESULTS AND DISCUSSION

Dobrich district consists of eight municipalities: Dobrich-town, Dobrich-rural, Balchik, Shabla, Kavarna, Tervel, General Toshevo and Krushari.

It is situated in the eastern part of the Danube Hilly Plain and occupies most of Southern Dobrudzha

on the Dobrudzha plateau. The relief is distinguished by its diverse character - from flat to plateau-hilly. Low plateaus (up to 150–200 m high) are very indicative of the region. About 75% of the agricultural lands have a slope of less than 3°, the land with a slope of 3°–6° and 6°–9° occupy a considerable part of the area of the municipalities Tervel, Krushari and Dobrich-village. In the Dobrich region there are also lands with a slope above 9° [4]. A view of the character of the relief can be seen on Fig. 1. In climatic terms, two climatic influences interweave in the territory of Dobrich region – the continent of Europe (northwest and northeast) and the Mediterranean from the southwest. The climate is characterized by hot summers – at the beginning there are large amounts of rainfall, whereas towards the end of summer there is a typical drought. Winter in the region is cold with strong winds. The annual rainfall is lower (480–580 mm), with more rainfall is falling during the autumn-winter half than in the rest of the year. Regarding the rainfall erosivity, the majority of the area (about 72%) has an average erosion – 601–800 MJmm/ha h. This implies the occurrence of flat water erosion at risk higher than the average for the country [Rousseva et al., 2010]. Typical for Dobrich region are medium and medium to high intensity winds, which is a prerequisite for a potential risk of wind erosion over three and a half times higher than in the country [4, 5].

Fig. 1

The soil cover is quite varied, with a specific mosaic character. The most common are chernozems – carbonates, typical and leached to varying degrees. There are also the dark gray and gray forest soils, in complex with their eroded species, part of which are shallow and skeletal. Meadow soils are distributed in the river valleys (Fig.2). 51% of the soils in the area have medium and medium to strong susceptibility to erosion. These soils occupy the greater part of the area of 3 of the Dobrich municipalities: General Toshevo (89%), Dobrich (67%) and Shabla (61%). The projected intensity of the potential planar water erosion in the territory of Dobrich region is about 5.5

million tons per year, with the share of individual municipalities varying within very wide limits [2; 4].

In this study, a digital soil map in M1: 10,000 was used, with attached soil profiles with detailed information on the morphological, physical and chemical properties of soils. 225 kinds of soil differences are differentiated and coded by name, soil power or degree of erosion, mechanical composition, stony and soil-forming rock (Fig.2). 1553 soil profiles have been used for which the agronomic suitability (crop bonus rating) of the main crops was determined. The calculated crop bonity assessments from soil profiles are attached to the soil map in GIS format.

Fig. 2

The broken ground relief with the typical low plateau (150-200 m above sea level) and the diversity of the soil cover are the main factors determining the choice of an eight-grade classification where the land valuation strategy guarantees first of all the conservation of natural resources, with particular attention being paid to erosion as a limiting factor in the classification of arable land by suitability [3; 6]. Under this classification, depending on the extent of land use constraints, the latter are divided into 3 main groups [3, 8, 9]:

1. Land suitable for different uses - include I, II and III class;
2. Lands with restricted use - IV class;
3. Lands with very limited use - V, VI, VII and VIII class.

A map of the area with Land Capability classes for the effective agricultural and erosion control land use is also developed. The subclasses are also mapped as an index that defines the type of constraints (e - erosion, k - stony, s - shallow soils, etc.), (Fig.3).

This map, marked with the Land Capability classes and an index indicating the type of restrictions, are the places clearly visible where the application of anti-erosion agrotechnics or other soil protection measures. The summary graph with the area performance of the specified classes of land gives an idea of the arable land status in the area and the prevailing classes of lands according to suitability (Fig.4).

Fig. 3

Fig. 4

From Fig. 4, it is seen that the lands of the highest suitability, suitable for different agricultural use, that is to say class I, II and III make up 91.7% of the arable land area. However, among these, there are only 50.54% with no limiting factors and with actual erosion risk to the permissible limits. These lands do not need soil protection measures. In

classes II and III, however, there are registered soil limitations or weak to medium actual erosion risk. Mainly agro technical erosion control practices or meliorative measures according to the type of restrictions (Table 1) are needed in this case.

The limited-use (IV class) land is 7.4% of the arable land. It is suitable for growing crops primarily

with fused surface and perennial grasses. The existence of constraints or actual erosion risk greater than the allowable, almost about the entire area occupied by IV class lands, reduces the choice of plants. Shallow soils and water erosion impose the row crops cultivation to be minimized [3].

In generally, the share of Lands with very limited use (V, VI, VII and VIII class) is less than 1% (0.9%) of arable land in the area. The lands are on very steep slopes, with highly eroded and

torrentialed soils. They are suitable only for pasture and forest areas, but most often grassing and afforestation is possible only after additional soil protection measures [3].

In the present study, information from Physical Blocks on the **way of land permanently use** was used. On the territory of the Dobrich region, the arable land area is 329 965.3 ha, the Perennials occupy 1 072.4 ha, mixed land use - 5 301.5 ha, Grassland - 26 454 ha, etc., the percentage distribution of which can be seen in Fig.5.

Fig. 5

Fig. 6

A map has been developed, to illustrate the distribution of the territory according the way of to land permanently land use (Fig.6).

The parameters of relief, expressed by slope and slope length; the climate - through the rainfall and wind erosivity, and the soil – by the susceptibility of

the soil to erosion, are the main factors that determine the conditions for erosion processes.

The analysis of the arable land distribution by erosion risk and the respective soil losses in the area, as well as the data on the rainfall erosivity and susceptibility of the soil to erosion, shows that

at the different ways of land use there are real conditions for manifestation of the water erosion processes. This can also be seen from the Map for the Actual risk of water erosion for the territory of the district (Fig.7).

Fig. 7

The analysis of the data on the distribution of arable land by erosion risk in the territory of the Dobrich region shows that 65.9% are lands with low erosion risk and soil losses less than 5 t / ha / y. that is to say to the allowable losses. 18.5% are lands with low to moderate erosion risk, 7.3% with

moderate erosion risk, 7.1% with moderate to high erosion risk, 1.1% high and 0.1% with very high erosion risk risk.

The presented graph illustrate the percentage distribution of the actual erosion risk, by municipalities, for the arable land of Dobrich region.

Fig. 8

The data show that in three municipalities – Balchik, Kavarna and Shabla, arable land with a first degree of erosion risk are over 90%. The share of these lands is also high in the municipalities of

General Toshevo (72%), Dobrich-city (68%) and Dobrich-rural (56%).

The integration of Land Capability classes in the area, with the real risk of water and wind erosion in

the GIS format, makes it possible to determine complexly and precisely the type, locations and scope of the required soil protection measures.

Table 1 presents the necessary soil protection measures according to land classes, indicating the respective soil constraints and the degree of actual erosion risk. The analysis of the data shows that 50.5% are arable land of I, II and III grade by suitability and first degree of erosion risk, without the presence of other limiting factors, which does not require erosion control protection. 20.3% of the arable land of the II, III, IV Land Capability classes

according to suitability are subjected to wind erosion and for them are recommended wind protection forest shelter belts. Depending on the degree of erosion risk and the presence of other limiting factors, various erosion protection measures are recommended, such as soil protection crops rotation, soil protection treatments, grass buffer strips, belt alternation of crops and other. Arable land of VIII Land Capability class, with high and severe erosion risk and additional constraining factors such as shallow, stony and others are unsuitable for agricultural use.

Table1. Soil protection measures and erosion control practices on the different Land Capability classes

CLASS	SUBCLASS /type of constraint/	Symbol	CLASS with constraint	Actual risk / degree /	SOIL CONSERVATION MEASURES	Hectares
I				1	No erosion control measures are required	91 522,329
I				2	Agrotechnical erosion control practices	285,638
II				1	No erosion control measures are required	35 404,448
II				2	Agrotechnical erosion control practices	2 607,184
II				3	Agrotechnical erosion control practices	50,469
II				4	Runoff collectors	19,075
II				5	Channel terraces and runoff collectors	0,359
II	Wind erosion	i	II i	1	Windproof belts	59 225,564
II	Wind erosion	i	II i	2	Windproof belts	1 287,633
II	Wind erosion	i	II i	3	Windproof belts	2,903
II	Eroded	e	II e	1	Agrotechnical erosion control practices	205,816
II	Eroded	e	II e	2	Agrotechnical erosion control practices	25,981
II	Swampy	w	II w	1	Ameliorative measures	4,941
II	Stony soils	k	II k	1	Agrotechnical erosion control practices	4,009
II	Stony soils	k	II k	2	Agrotechnical erosion control practices	2,805
III				5	Anti-erosion crop rotation	39,984
III				6	Anti-erosion crop rotation	0,230
III	Wind erosion	i	III i	1	Windproof belts	6 926,662
III	Wind erosion	i	III i	2	Windproof belts	3 251,123
III	Wind erosion	i	III i	3	Windproof belts	256,116
III	Wind erosion	i	III i	4	Windproof belts	38,880
III	Wind erosion	i	III i	5	Windproof belts	0,384
III	Eroded+Wind	e+i	III e+i	1	Windproof belts	29,604
III	Swampy	w	III w	1	Ameliorative measures	0,563
III	Stony+Eroded	k+e	III k+e	1	Agrotechnical erosion control practices	48,337
III	Stony soils	k	III k	2	Agrotechnical erosion control practices	16,879
III	Stony soils	k	III k	3	Channel terraces and runoff collectors	92,832
III	Stony soils	k	III k	5	Anti-erosion crop rotation	0,164
III	acidic	b	III b	1	Ameliorative measures	2,714
.....						
VII	Shallow soils on rock	s	VII s	5	For grassing / afforestation	3,809
VIII	Stony+Shallow+Eroded+Wind	k+s+e+i	VIII k+s+e+i	2	For grassing / afforestation	81,775
VIII	Stony+Shallow+Eroded+Wind	k+s+e+i	VIII k+s+e+i	3	For grassing / afforestation	1,203
VIII	Stony+Shallow+Eroded	k+s+e	VIII k+s+e	2	For grassing / afforestation	18,596
VIII	Stony+Shallow+Eroded	k+s+e	VIII k+s+e	4	Unsuitable for all types of agricultural use	4,099
VIII	Stony+Shallow+Eroded	k+s+e	VIII k+s+e	5	Unsuitable for all types of agricultural use	16,561
VIII	Stony+Shallow+Eroded	k+s+e	VIII k+s+e	6	Unsuitable for all types of agricultural use	3,363
VIII	Shallows+Eroded	s+e	VIII s+e	5	Unsuitable for all types of agricultural use	3,441
VIII	Shallows+Eroded	s+e	VIII s+e	6	Unsuitable for all types of agricultural use	0,505
VIII	Shallow soils on rock	s	VIII s	6	Unsuitable for all types of agricultural use	1,468

Fig. 9. presents the necessary soil protection practices for the research area.

Fig. 9

The most important soil and climatic factors necessary for the development of agricultural plants and the productivity of the lands, such as: mechanical composition of the cultivated layer; power of the humus horizon; power of the soil profile; texture coefficient; soil reaction; humus content in the workable layer; groundwater level, heat, moisture and others, participate in the determination of bonity ball (from 1 to 100) with respect to the specific requirements of the crops.

The calculated bonity assessments of agricultural crops are attached to the detailed large scale database,

created in the GIS format. This makes it possible to determine the most suitable places for their cultivation on the territory of Dobrich region [Fig. 10], or to assess the degree of agronomic suitability of arable land for cultivation of a particular crop. In this study the agronomic suitability of the lands in the area is defined for cultivation of maize. In Fig. 11 is presented the prepared map for the degree of her agronomic suitability. The map show that almost the entire territory of the region has a very good and good land for cultivating these crops.

Fig. 10

Fig. 11

The linking of information on classes and subclasses of land with the calculated crop rating (bonity assessments) in the GIS format more accurately reflects the most suitable crop-growing sites and at the same time determines the need for improvement and soil protection measures while growing it.

CONCLUSION:

As a result of the conducted surveys, an overall assessment and classification of the agricultural lands in the area was made, and the Land Capability classes and subclasses were determined. The actual risk of erosion is determined within the class of land and soil losses are calculated according to the way of land use. An integrated approach was used to determine the necessary soil protection measures - based on the fixed soil constraints and the risk of erosion according to the calculated soil losses. As used the requirements for the development of the basic crops to the necessary soil and climatic conditions (their bonity assessment), the most suitable places for their cultivation on the territory of the region were determined and the agronomic suitability of the arable land for cultivation of wheat, maize, peaches and vineyards was evaluated.

The results obtained allow the following general conclusions to be drawn:

1. The highest representativeness, 91.7% of the arable land area in the area, have the lands with the highest degree of capability, suitable for different agronomic use, ie I, II and III class, of these,

however, with no limiting factors and an actual erosion risk up to the permissible limits are only 50.54%. Only they do not require special soil conservation practices or erosion control measures.

2. Depending on the existence of soil constraints, such as shallowness, stoniness, swampiness, etc., and of the degree of erosion risk, various meliorative measures or erosion control protection, such as wind protection belts, soil protection crops rotation and soil protection treatment, grass buffer strips, strips crop rotation and other are recommended to be used on the other lands.

3. Areas with severely limited use – V, VI, VII and VIII class with different degree of erosion risk or the presence of limiting factors which are foreseen for grassing / afforestation are 0.27% and those of VIII class with high and very high erosion risk and additional containment (limiting) factors are unsuitable for agricultural use and are 0.01%.

4. According to the defined agronomic suitability of the arable land in the region for cultivation of wheat, corn, peach and vineyards, from the drawn up maps it is visible that almost the entire territory of the district is very good and good lands for cultivation of these crops.

REFERENCES

1. Georgiev B. Land quality evaluation of agricultural lands – theoretical foundations and practical approaches to the conditions in Bulgaria. Dissertation for obtaining a doctoral degree in agricultural sciences, Sofia, Bulgaria, 2006.

2. Nikolov I., Sv. Rousseva, V. Stefanova, Consultancy Company on specifying and improving the water erosion assessment model. Project 00043507 "Capacity Building for Sustainable Land Management in Bulgaria". Contact № 2006-072-POG.2007. Report. http://www.unccd-sml.org/files/1-Water_erosion_model_EN.pdf.
3. Onchev N., Forecasting of surface water erosion in Bulgaria and optimization of erosion control measures, Agricultural Academy, Sofia., 1983, 204 p.
4. Rousseva S., Lozanova L., Nekova D., Stefanova V., Djodjov Hr., Tsvetkova E., Malinov I., Krumov V., Chehlarova-Simeonova S. Risk of soil erosion in Bulgaria and recommendations for soil protection of farmland. Part I. Northern Bulgaria. Ed. SieSet-Eco, Sofia, 2010, 304 p.
5. Rousseva St., Lozanova L., Djodjov Hr., Malinov Il, Krumov V., Stefanova V., Nikolov I., Estimates of Factors and Risk of Wind Erosion of Soils in the Administrative Areas of the Republic of Bulgaria, International Conference "100 Years of Soil Science in Bulgaria", 2011, 949-953 p.
6. Stoinova V. Land Capability Evaluation and Mapping of land in Bulgaria Supporting Erosion Preventive Landuse. PhD thesis, 2014.
7. Ozsahin E., U. Duru I. Eroglu. Land Use and Land Cover Changes (LULCC), a Key to Understand Soil Erosion Intensities in the Maritsa Basin. Journal MDPI, water, March 2018.
8. Santun R.P., Sitorus, 2010, Land Capability Classification for Land Evaluation: A Review, ISSN 1907-0799. Jurnal Sumber Daya Lahan Vol. 4 No. 2, Desember 2010.
9. USDA (2000). Summary Report: 1997 National Resources Inventory (revised December 2000), U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa, US, 2000.

**Assoc. Prof. Dr. Eng Vihra Stoinova,
Assoc. Prof. Dr. Diyana Nekova**

Institute of Soil Science, Agrotechnologies, and
Plant Protection (ISSAPP) "Nikola Pushkarov"
7, Shosse Bankya
Sofia, 1000, Bulgaria

Corresspondence address:

e-mail: vihra.stoinovava@gmail.com;
Phone: 359 882 347 874