Land Evaluation and Application of Geographic Information Systems in the Zoning of Main Agricultural Crops in Southern Bulgaria

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Abstract

This paper presents data on the main ecological elements in the land of the village of Tsalapitsa, Plovdiv region - soils and climate. By applying the methodology approved in Bulgaria, an agro-ecological assessment of agricultural lands was made, calculating the Field Ratings (FR) for certain crops under non-irrigated and irrigated conditions. The values of the FR indicate the suitability of the land for growing the specified crop. The Average Agronomic Rating (AAR) of the lands were also calculated, which also determine the final value classification (grouping and categorization) under non-irrigated and irrigated conditions. The results obtained (without irrigated) determine 99,6 % of agricultural lands as good and medium-good lands, respectively the 3rd, 4th, 5th and 6th categories. Only a small part of 0,4 % is unsuitable land. When irrigation is applied, the suitability of the land and the possibilities for growing certain crops change in a positive direction, so 62,5 % of agricultural lands fall into the group of very good lands or 1st and 2nd categories, and 37,1 % are good and average lands or 3rd and 4th categories. The final land quality classification is also harmonized with the recommendations of the FAO. The data from the land evaluation are analyzed in a GIS environment and are visually and spatially interpreted in the form of maps and graphs. A zoning of the most suitable crops for growing has been made - wheat from cereals, tobacco from technical crops, apples, peaches, plums, pears, cherries and vineyards from perennial crops, and with mandatory irrigation - tomatoes and rice.

Keywords: land evaluation, soil, climate, agricultural crops, geographic information system, mapping

Introduction

In the modern market economy environment, with a view to planning, organizing, sustainable and effective management of agricultural activities to achieve the best results in terms of costs and efficiency, one of the most important conditions is the correct choice of crops in relation to the soil and climatic characteristics of the area. This implies making evaluations of the agro-ecological potential of the studied territory and zoning of the main agricultural crops. In connection with the realization and implementation of the above, the use

of GIS as a powerful modern tool (platform) for collecting, storing, analyzing, modeling and visualizing spatial data is of essential importance.

A number of studies, as in Bulgaria so globally, have shown that the use of GIS is an effective and innovative method for data analysis and management in agriculture, and in particular in the analysis and assessment of the agro-ecological potential of a given territory for the cultivation of different crops (land suitability assessment). In turn, this is a prerequisite for land use planning and development.

Akanci, H. et al., 2013 used GIS to analyze the suitability of agricultural lands in Yusufeli district of Artvin city (Turkey). The authors note the importance of preparing land use plans that allow the transfer of natural resources to future generations and that allow for the planned and sustainable use of these resources in a manner appropriate to their potential.

Bera, S. et al., 2017 analyzed land suitability for agricultural crops using remote sensing and GIS in Purulia district, West Bengal, India. The final suitability map discovered five classes of land: Not Suitable zone, Low Suitable zone, Moderate Suitable zone, High suitable zone and Very high suitable zone.

Nabati, J. et al., 2020 present GIS-based agro-ecological zoning of chickpea in semi-arid regions of Iran.

A GIS-based analysis of land suitability for sustainable almond cultivation in Lebanon was conducted by Elbared et al., 2025. Climatic, soil and topographic conditions, as well as existing biophysical constraints, were assessed using multi-criteria spatial analysis. The result is a map showing suitable locations for almond trees, "which will be an essential indicator for decision-makers, providing them with strategic aspects of land use planning and land loss mitigation, thus leading to the development of a safer and more resilient future livelihood."

Yang, X., et al., 2025 also used GIS to assess the suitability of agricultural lands in the Guder River Basin, Ethiopia. Based on several thematic maps, the authors generate a detailed suitability map of the study area in a GIS environment. "The study underscores the importance of using GIS in agricultural land suitability analysis, providing crucial insights for sustainable land use planning. These findings guide policymakers and stakeholders in optimizing agricultural practices, ensuring efficient and sustainable use of land resources, and promoting long-term environmental and economic sustainability in the region. The analysis serves as a foundation for informed decision-making and strategic interventions in agricultural development."

Vegetable production is widespread in Bulgaria. Arnaudova et al., 2014, after the degradation of agricultural production, conducted a GIS-based analysis and assessment of tomato and pepper areas and yields in Bulgaria for the period 2008-2012. Based on the assessment of the information, they identified the South-Central Planning Region as the main region for vegetable cultivation. In conclusion, they note that the GIS-based analysis will be useful for agricultural users in making appropriate decisions on management practices. As a result, higher yields and better quality production will be obtained.

Arnaudova et al., 2020 used GIS to map the habitats of grasslands and oilseed rapes in Bulgaria, and in 2022 they assessed the suitability of the lands in the area of the village of Katunitsa, Plavdiv region for growing pepper (Arnaudova et al., 2022).

The paper aims to assess the agro-ecological potential of the land of the village of Tsalapitsa, Plovdiv region. Using geographic information technologies, to make a zoning and to present the most suitable crops for cultivation in the area.

Materials and Methods

The object of the present study is the land of the village of Tsalapitsa, Rhodope Municipality, Plovdiv District – South-Central Planning Region (SCPR - NSI, 2011). It occupies a key location in the heart of the Upper Thracian Plain, just 9 km west of the city of Plovdiv between the Trakia motorway and the main road Plovdiv – Pazardzhik. The strategic location of the land is complemented by the favorable soil and agroclimatic conditions suitable for growing fruits and vegetables and from an economic point of view, by the numerous investments in the processing and manufacturing industry. The village is home to the largest and only nursery in the country for certified fruit, rose and poplar material.

The primary soil, climatic and agro-ecological data used in the land evaluation are from the soil and land evaluation archives of the ISSAPP "N. Poushkarov", as well as from officially published climate reference books (Hershkovich, 1970; 1984; Koleva and Peneva, 1990; Kyuchukova, 1979; 1983). The land evaluation by crops was carried out following the algorithms in the "Methodology for the Relative Assessment of Agricultural Lands in Bulgaria" (Petrov et al., 1988) and the Georgiev equation (Georgiev, 2006).

The software ArcGIS for Desktop (ArcMap 10.8.2) was used for the geospatial data interpretation. The soil differences in the land of the village of Tsalapitsa were determined and isolated from a digital soil map of the Plovdiv region (1: 10000 scale) from the digital archive of the ISSAPP "N. Poushkarov".

Results and Discussion

The land of Tsalapitsa is located in the climatic region of Eastern Central Bulgaria. Winter is relatively mild - the average temperature in January is about 0°C, soil temperatures at a depth of 2 and 5 cm in January are distinguished by relatively high values – 1,5 – 1,8°C. Precipitation in winter is on average 115 mm, but only about 30-35 % of them are from snow. Spring begins early due to the rapid rise in temperatures at the end of the mild winter. The average starting date with stable retention of temperatures above 5°C occurs around 5. III., and above 10°C - on 4. IV. Soil temperatures at a depth of 10 cm in March reach 7.3°C, and in April they are already 13,5°C. The average date of the last frost is 4. IV. Sowing of spring crops in this region can begin at the end of the first ten days of April.

Summer is warm, with the average July temperature being 23,2°C, and the number of days with average daily air temperature above 25°C being more than twenty. The temperature sum for the period with average daily temperatures above 10°C is 3795°C – sufficient for the development of crops with a longer growing season. The annual precipitation is small – 515 mm, with 240 mm of precipitation falling in the period April-August, and the deficit in the balance of atmospheric humidification is 200-250 mm (Hershkovich, 1970, 1984; Koleva and Peneva, 1990; Kyuchukova, 1979, 1983).

In a GIS environment, based on the large-scale soil survey - 1:10000 scale (soil and digital archive of ISSAPP "N Pushkarov"), a soil map of the land of the village of Tsalapitsa

was prepared, in which the following soil types were localized: Smolnitsi (Vertisols, WRBSR, 2014), Cinnamon Forest sols (Luvisols) and Alluvial (Fluvisols) (figure 1.). According to the prepared soil map and the geospatial and statistical analysis, the total area of the land of the village of Tsalapitsa is 7255,11 ha, of which 690,18 ha are non-agricultural areas, including the settlement, rivers, swamps, reservoirs, sands and gravels. Agricultural lands are 6564,93 ha. The most widespread are the Cinnamon Forest soils – 4218,186 ha or 64,3 % of the total area of agricultural lands (Legendary No. 2, 3, 4a, 4b, 5, 6a, 6b). Alluvial and alluvial-delluvial soils occupy 1773,795 ha or 27 %, with a very small part of them (27,453 ha) being saline (Solonetz). The Vertisols are 572,948 ha or 8,7 %.

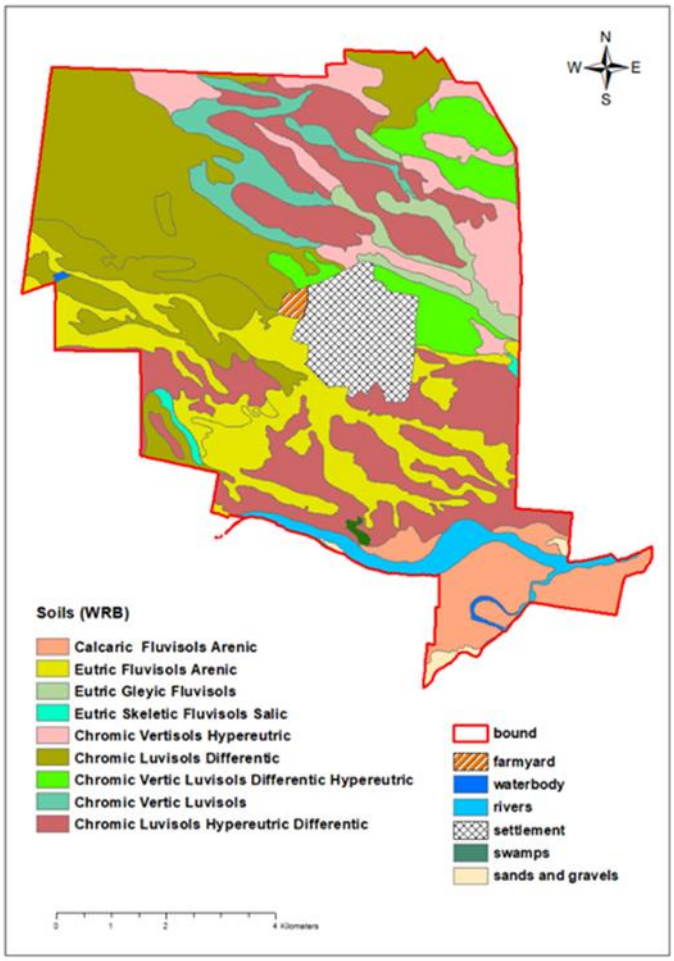


Figure 1. *Soil map of Tzalapitsa village land*

The main physicochemical indicators of the soils relevant to the land evaluation are presented in table 1. The Field Ratings for the crops included in the methodology were calculated, as well as the Average Agronomic Rating (AAR) of the lands, which determine the final quality classification (grouping and categorization) under non-irrigated and irrigated conditions. The results are visually and area-wise interpreted in the form of maps and graphs.

According to the quality assessment under non-irrigated conditions - the agricultural lands of the land were assessed as good lands (60 - 80 points or 3 and 4 categories) and average good lands (40 - 60 points or 5 and 6 categories). Unsuitable lands (< 20 points) occupy a negligible area and fall into category 10 (table 2; figures 2 and 3). The quality

category gives an idea of the production qualities of the land. The higher the category, the larger the range of crops that can be grown (cereals, technical, fruit, fodder, vegetable and vineyards).

Table 1. *Physico-chemical indicators of the soils, distributed in Tsalapitsa village land*

№	Soil name	<0,01 mm in plowed horizon (%)	<0,01 mm in area under plowed horizon (%)	Humus horizon depth (cm)	Soil profile depth (cm)	Texture Coeffic ient	pH /KCl/	Humus %
1a	Chromic Vertisol, (heavy Loamic)	52	56	60	100	1,2	6,5	1,8
1b	Chromic Vertisol, (slightly clayic)	68	70	60	105	1,2	6,0	1,6
2	Vertic Luvisols, (heavy Loamic)	47	60	30	90	1,4	6,1	1,2
3	Vertic Luvisols, (moderately loamy)	43	55	30	100	1,6	6,1	1,3
4a	Chromic Luvisols (Cleyic), (slightly loamy)	22	36	25	115	2,0	6,2	1,0
4b	Chromic Luvisols (Cleyic), (slightly and moderately loamy)	31	35	25	115	1.4	5,7	1,1
5	Chromic Luvisols, (sandy loamy)	18	31	20	100	2,2	5,6	0,8
6a	Albic Luvisols, (sandy loamy)	26	45	28	120	3,0	5,6	0,9
6b	Albic Luvisols, (slightly loamy)	37	49	30	110	2,7	6,3	1,3
7a	Dystric Fluvisols, Aluvial (FLdy), sandy	8	10	20	140	1,2	5,9	0,6
7b	Dystric Fluvisols, Aluvial (FLdy), sandy loamy	14	16	29	130	1,3	5,8	0,5
8	Calcaric Fluvisols, Aluvial (FLca), sandy loamy	15	10	20	120	1,0	7,9	0,8
9	Gleyic Fluvisols,Aluvial-Deluvial (FLgl)	35	32	70	105	2,0	5,8	1,4
10	Solonetz (SN), slightly loamy	24	46	55	100	3,7	6,7	1,2

Table 2. *Average agronomic ratings (AAR), land suitable group and land category, FAO suitability class of agricultural lands in Tsalapitsa village*

№	Soil name	Average agronomic ratings	Land suitability group	Land category	Class FAO
1a	Chromic Vertisol (VRcr), heavy loamy	74*/103**	Good lands* Very good lands**	3*/1**	S2
1b	Chromic Vertisol (VRcr), slightly clayey	67/90	Good lands* Very good lands**	4/1	S2
2	Vertic-haplic Luvisols (L V vr-ha), heavy loamy	68/94	Good lands* Very good lands**	4/1	S2
3	Vertic-haplic Luvisols (L V vr-ha), moderately loamy	67/90	Good lands* Very good lands**	4/1	S2
4a	Cleyic-Chromic Luvisols (L V gl-ch), slightly loamy	65/93	Good lands* Very good lands**	4/1	S2
4b	Cleyic-Chromic Luvisols (L V gl-ch), slightly and moderately loamy	67/93	Good lands* Very good lands**	4/1	S2
5	Chromic Luvisols (L Vch), sandy loamy	48/69	Medium good lands* Good lands**	6/4	S3
6a	Albic Luvisols (L Vab), sandy loamy	55/80	Medium good lands* Very good lands**	5/2	S2
6b	Albic Luvisols (L Vab), slightly loamy	57/79	Medium good lands* Good lands**	5/3	S2
7a	Dystric Fluvisols, Aluvial (FLdy), sandy	48/65	Medium good lands* Good lands**	6/4	S3
7b	Dystric Fluvisols, Aluvial (FLdy), sandy loamy	61/87	Good lands* Very good lands**	4/2	S2
8	Calcaric Fluvisols, Aluvial (FLca), sandy loamy	43/59	Medium good lands* Medium good lands**	6/5	S3
9	Gleyic Fluvisols,Aluvial-Deluvial (FLgl)	64/90	Good lands* Very good lands**	4/1	S2
10	Solonetz (SN), slightly loamy	4/10	Unsuitable lands* Unsuitable lands**	10/10	N2

* Non-irrigated conditions; ** Irrigated conditions

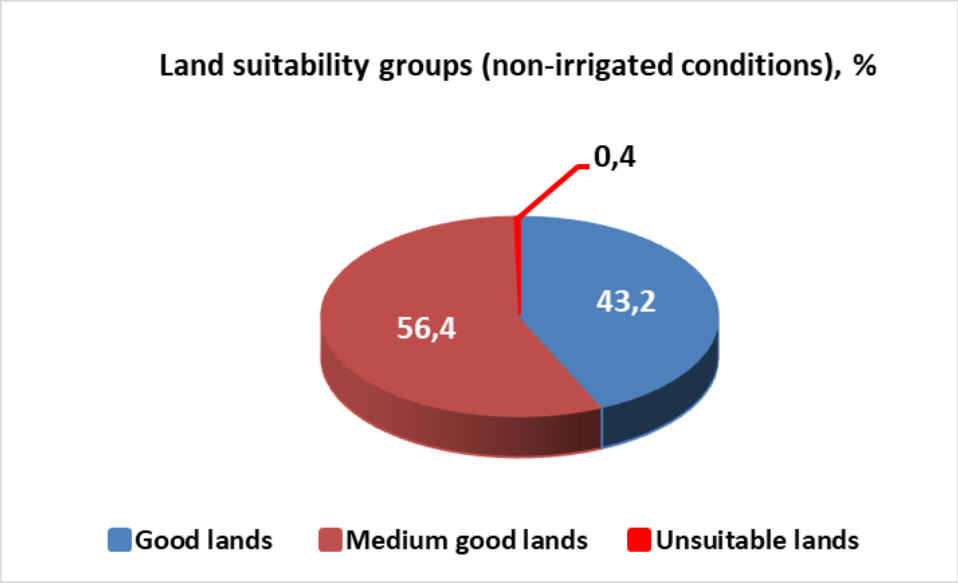


Figure 2. *Percentage distribution of agricultural land quality groups under non-irrigated conditions*

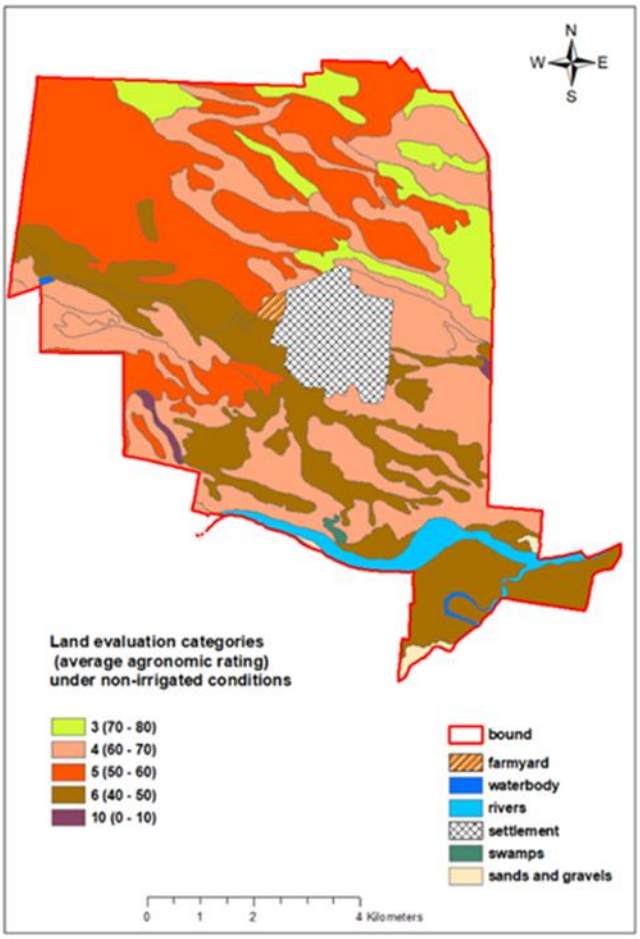


Figure 3. *Categorization of agricultural lands (average agronomic rating) under non-irrigated conditions in Tsalapitsa village land*

With ensured irrigation, the land suitability grouping and categorization changes in a positive direction, i.e. the possibilities for growing certain crops significantly improve (Table 2; Figures 4 and 5).

The results of the quality assessment of the studied agricultural lands are aligned with the FAO classification for land evaluation (FAO, 1976), (Table 2). The results are visualized in figures 6 and 7. The majority of agricultural lands – 4958,38 ha (75,5 %) belong to class S2 "moderately suitable lands". In the Bulgarian land suitability classification, they correspond to lands with AAR between 50 and 75 land suitability points or 5th, 4th and a part of the 3rd category. 1579,10 ha (24,1 %) are defined as "marginally suitable lands" or class S3. In the Bulgarian land suitability classification, they correspond to lands with an average agronomic rating of 35 to 50 land suitability points or 6th and a part of the 7th category. The unsuitable lands, according to the Bulgarian methodology (27,453 ha or 0,4 %) and in the FAO classification, are classified as class N2 "permanently not suitable", i.e. lands with AAR below 20 land suitable points. These are the 9th and 10th categories of lands in the Bulgarian land evaluation classification.

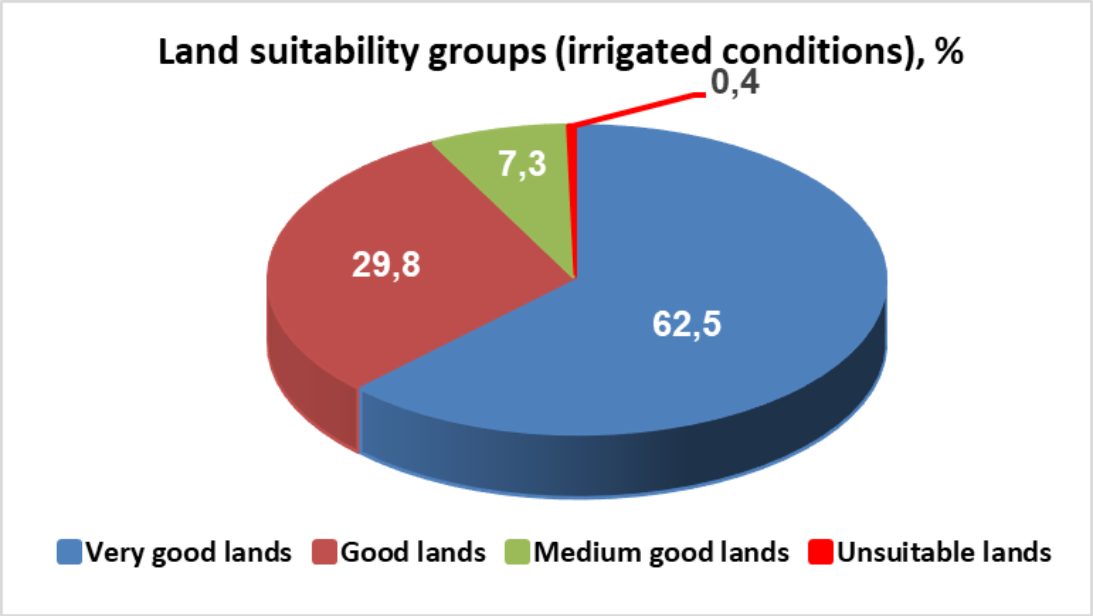


Figure 4. *Percentage distribution of land suitability groups under irrigated conditions*

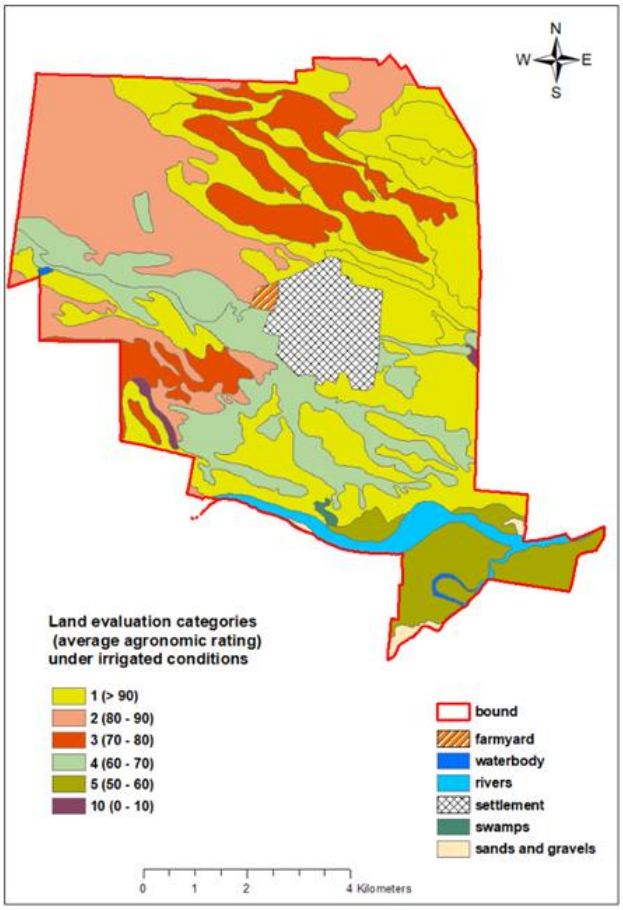


Figure 5. *Categorization of agricultural lands (average agronomic rating) under irrigated conditions in Tsalapitsa village land*

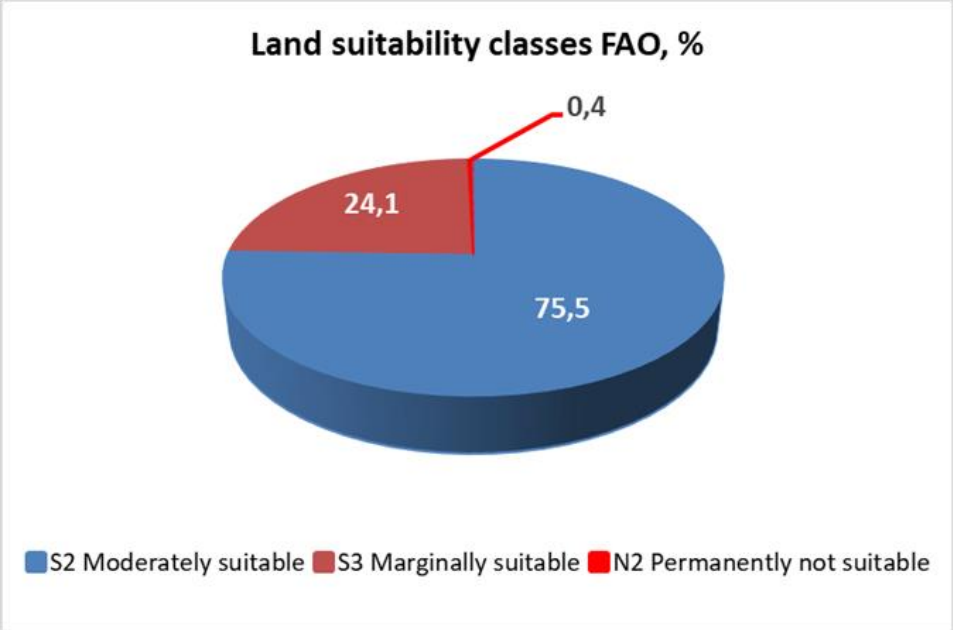


Figure 6. *Percentage distribution of FAO suitability classes*

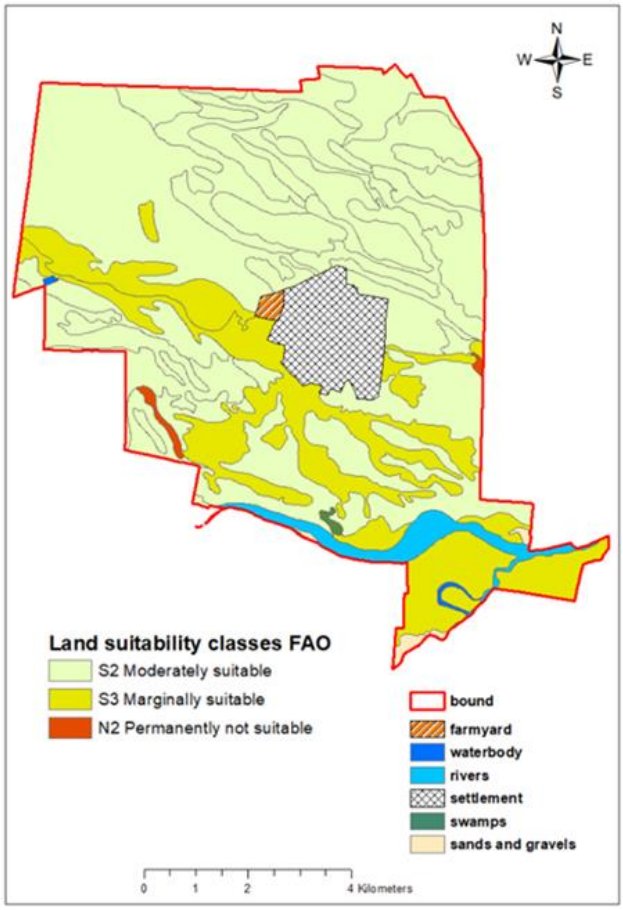


Figure 7. *Suitability classes of agricultural lands according to the FAO classification*

The average agronomic rating (AAR) is the result of the values of the field ratings obtained for unified crops, the same for the entire territory of the country: cereals, technical crops, fruit crops, fodder crops, vegetables and vineyards. The field ratings for some crops are zeroed (have a value of 0), which is the result of unfavorable soil conditions. The results of the land suitability assessments in relation to the requirements of individual crops (field ratings) are shown in table 3.

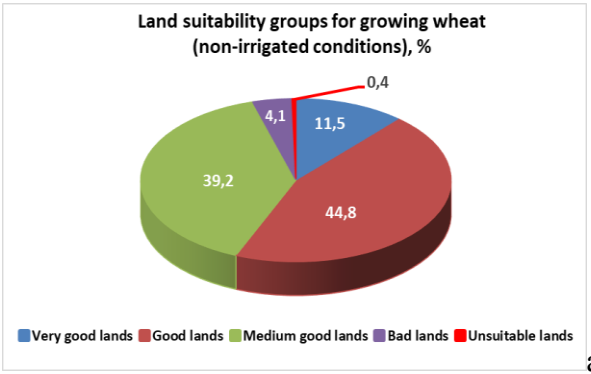
As a result of the assessment and categorization, according to the requirements of the agricultural crops included in the methodological requirements, it was established that of the cereal crops in the land of the village of Tsalapitsa, the most favorable conditions without irrigation are for growing wheat. The suitability is significantly improved, since during the critical phases in terms of humidity, irrigation is provided (table 3; figures 8 a, b; 9 a, b). Of the technical crops, the conditions in the land of Tsalapitsa are most favorable for growing tobacco, especially when providing the necessary irrigation (table 3; figures 10 a, b; 11 a, b).

With mandatory irrigation provided, very good results are obtained in the cultivation of tomatoes and rice (table 3; figures 12 a, b; 13 a, b; 14 a, b and 15 a, b) and of the perennial crops - apples, peaches, plums, pears, cherries and vineyards (table 3; figures 16 a, b; 17 a, b; 18 a, b; 19 a, b; 20 a, b and 21 a, b).

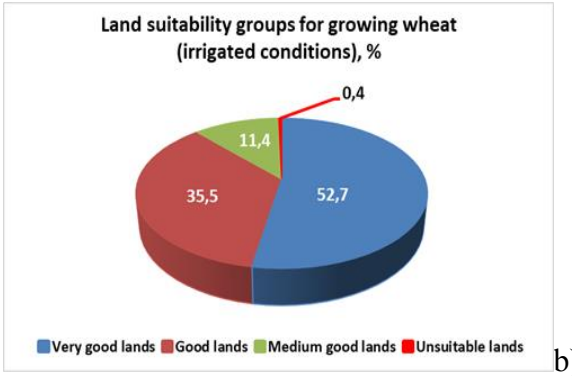
Table 3. *Field ratings (FR) of agricultural lands in Tsalapitsa village, regarding the requirements of main agricultural crops*

№	Field Ratings (FR)												
	Wheat	Corn	Oriental tobacco	Broadleaf tabacco	Tomatoes	Rice	Alfalfa	Apples	Plums	Peaches	Cherries	Pears	Vineyards
1a	85*/105**	63/108	42/61	70/107	96**	72**	77/119	86/132	64/99	78/127	74/114	83/128	89/114
1b	79/94	57/89	33/48	66/101	88	70	69/99	83/120	64/93	72/111	54/78	79/129	66/83
2	77/95	55/95	63/91	64/98	86	76	69/106	85/131	69/106	78/127	64/99	88/136	80/101
3	74/82	51/88	65/94	60/92	84	72	69/106	85/131	69/106	78/127	64/99	88/136	80/101
4a	65/84	44/80	87/126	52/80	78	67	66/108	81/132	63/103	84/144	68/111	85/139	82/103
4b	74/92	51/88	65/94	60/92	84	70	67/103	81/125	63/97	84/140	68/104	85/131	83/103
5	39/50	23/42	100/145	21/32	50	68	45/74	62/101	51/83	69/119	62/101	62/101	70/88
6a	56/72	35/64	87/126	42/61	66	72	55/90	63/103	52/85	69/119	62/101	63/103	72/91
6b	65/81	41/71	65/94	50/77	72	76	58/89	67/103	57/88	63/103	58/89	67/103	70/88
7a	50/65	35/64	98/142	34/52	66	47	50/82	0	0	66/114	38/62	0	66/83
7b	61/79	40/73	90/131	43/66	76	47	58/95	72/117	53/86	75/129	54/88	68/111	81/102
8	44/57	28/51	98/142	26/40	65	34	40/66	0	0	39/67	44/72	0	70/88
9	83/103	61/109	51/74	68/104	90	74	69/103	77/119	60/92	79/129	67/103	80/123	0
10	7/9	5/9	5/7	5/8	0	38	13/21	0	0	0	0	0	0

* Non-irrigated conditions; ** Irrigated conditions

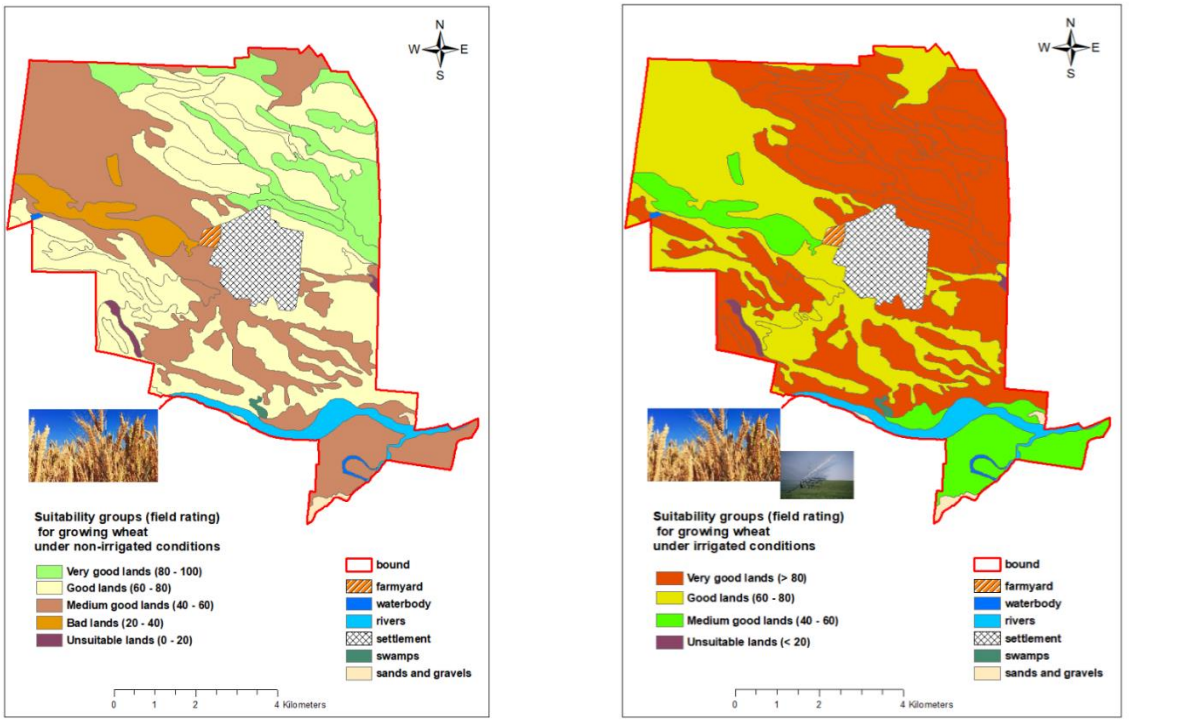


a)



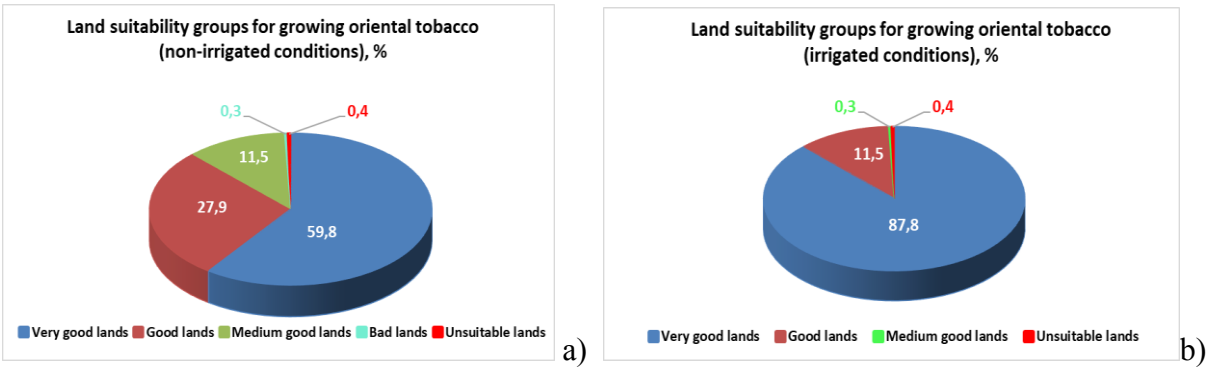
b)

Figure 8. *Percentage distribution of the land suitability groups for growing wheat – a. non-irrigated conditions; b. irrigated conditions*



a) b)

Figure 9. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing wheat – a. non-irrigated conditions; b. irrigated conditions*



a) b)

Figure 10. *Percentage distribution of the land suitability groups for growing oriental tobacco – a. non-irrigated conditions; b. irrigated conditions*

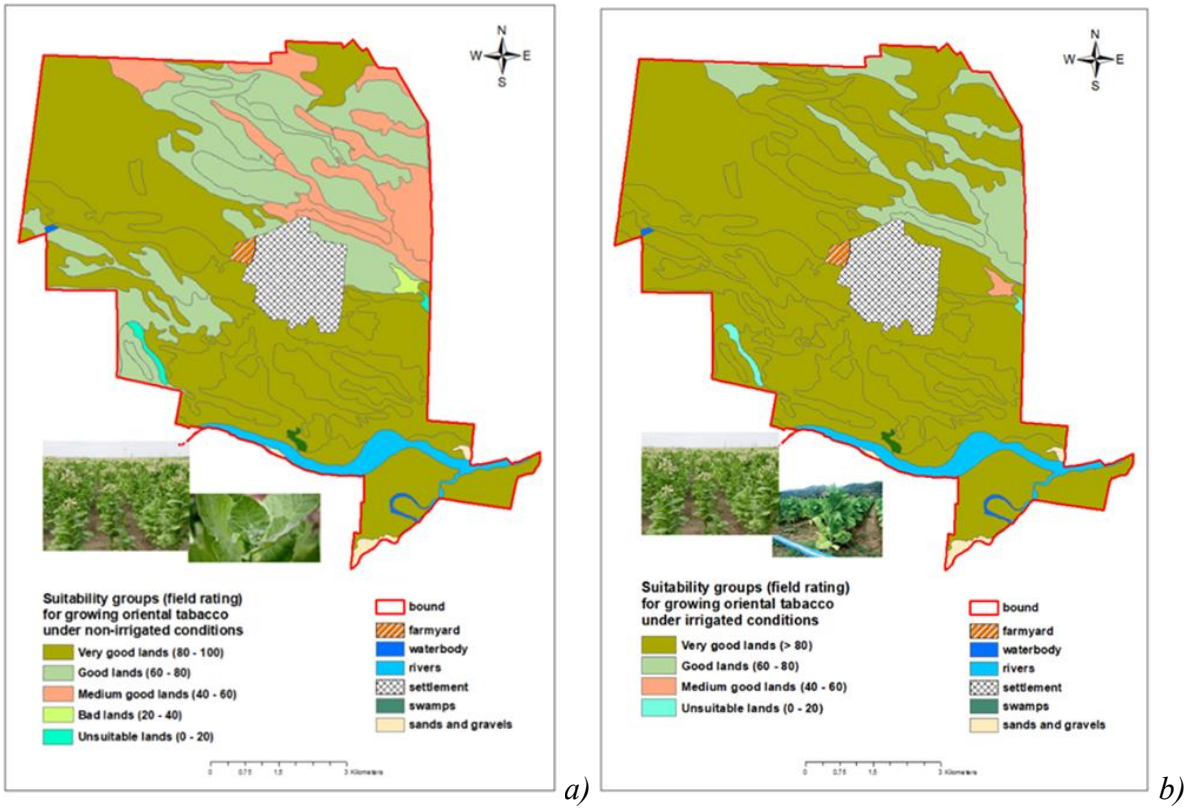


Figure 11. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing oriental tobacco – a. non-irrigated conditions; b. irrigated conditions*

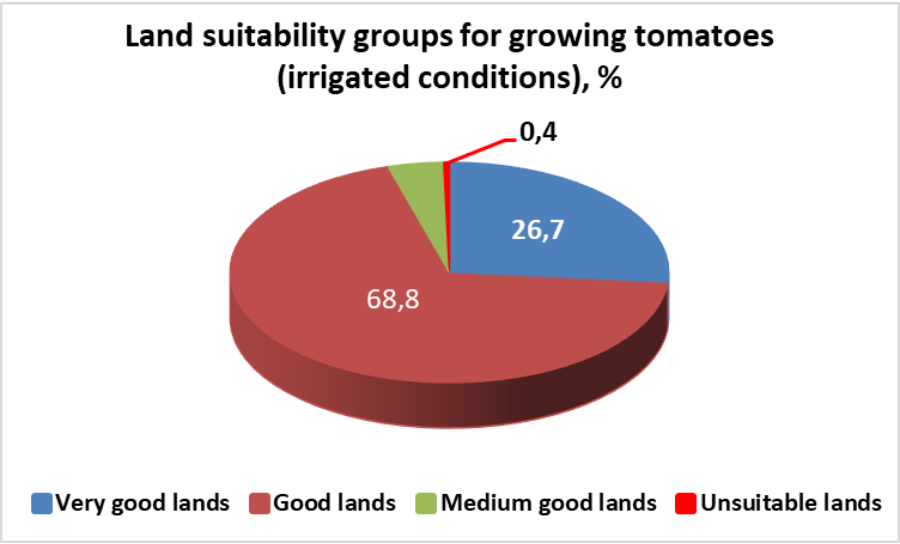


Figure 12. *Percentage distribution of the land suitability groups for growing tomatoes*

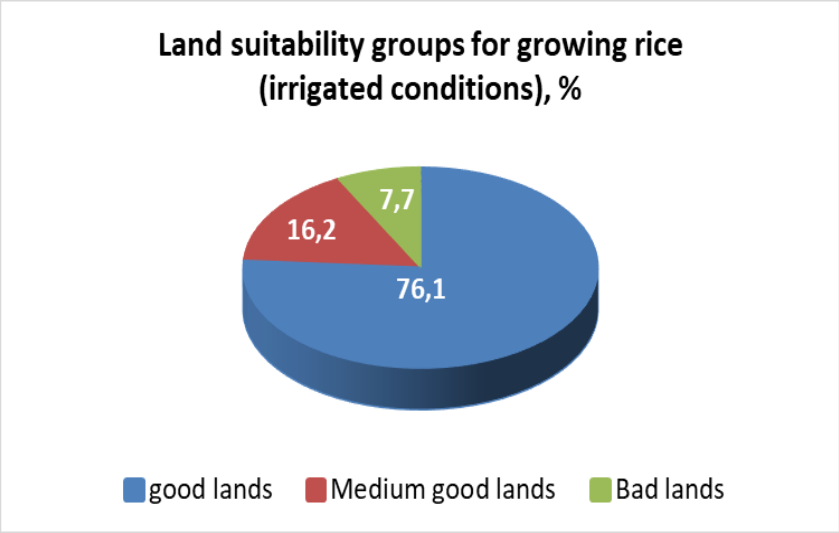


Figure 13. *Percentage distribution of the land suitability groups for growing rice*

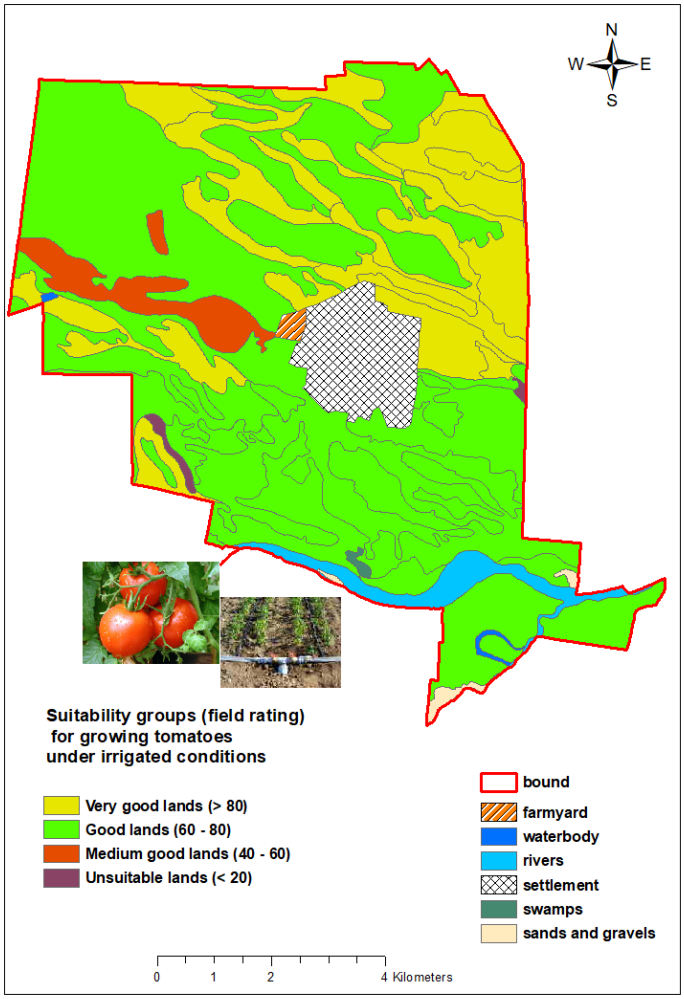


Figure 14. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing tomatoes*

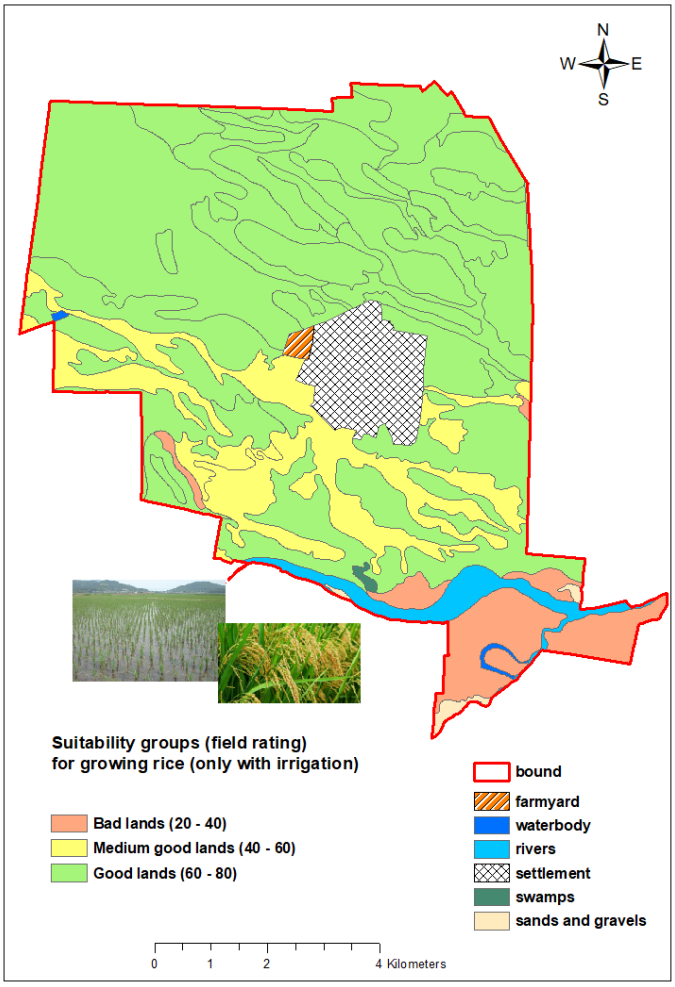


Figure 15. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing rice*

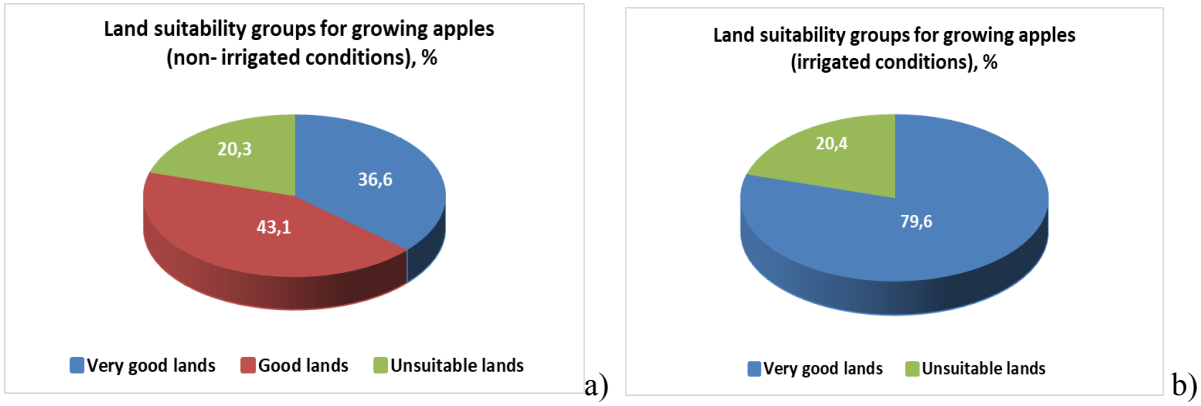
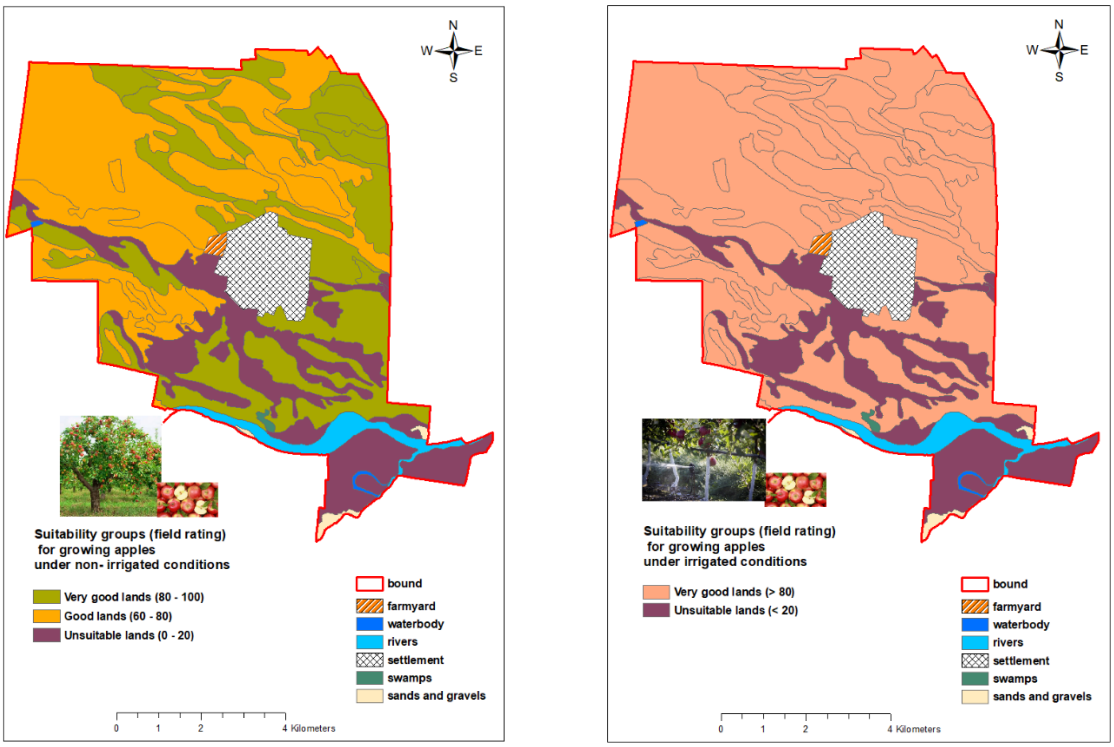
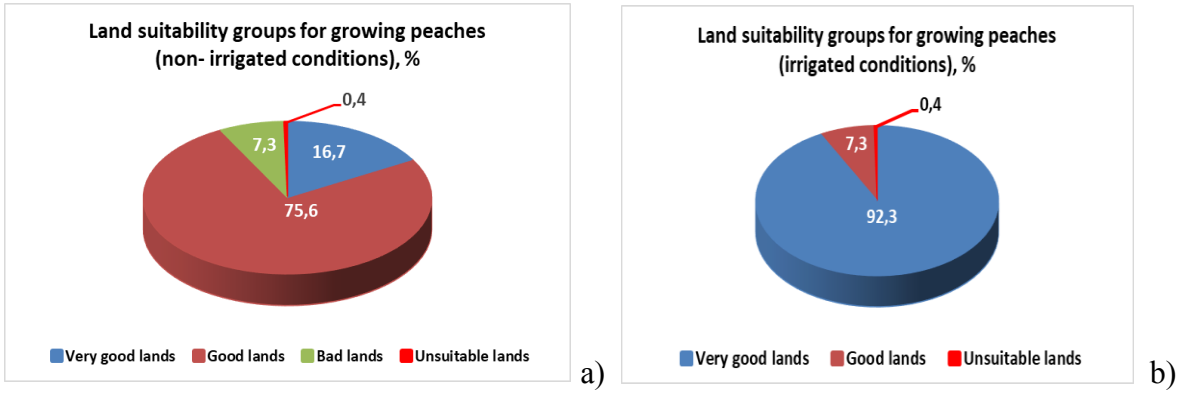


Figure 16. *Percentage distribution of the land suitability groups for growing apples – a. non-irrigated co nditions; b. irrigated conditions*



a) b)

Figure 17. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing apples – a. non-irrigated conditions; b. irrigated conditions*



a) b)

Figure 18. *Percentage distribution of the land suitability groups for growing peaches – a. non-irrigated conditions; b. irrigated conditions*

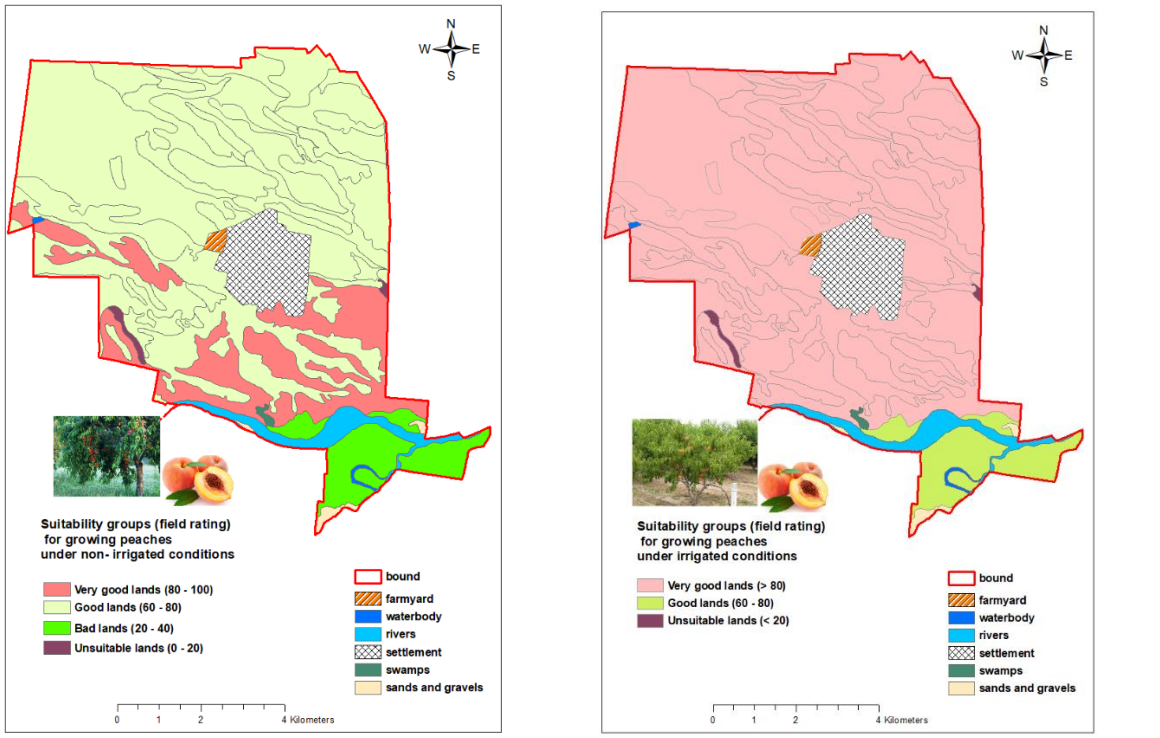


Figure 19. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing peaches – a. non-irrigated conditions; b. irrigated condition*

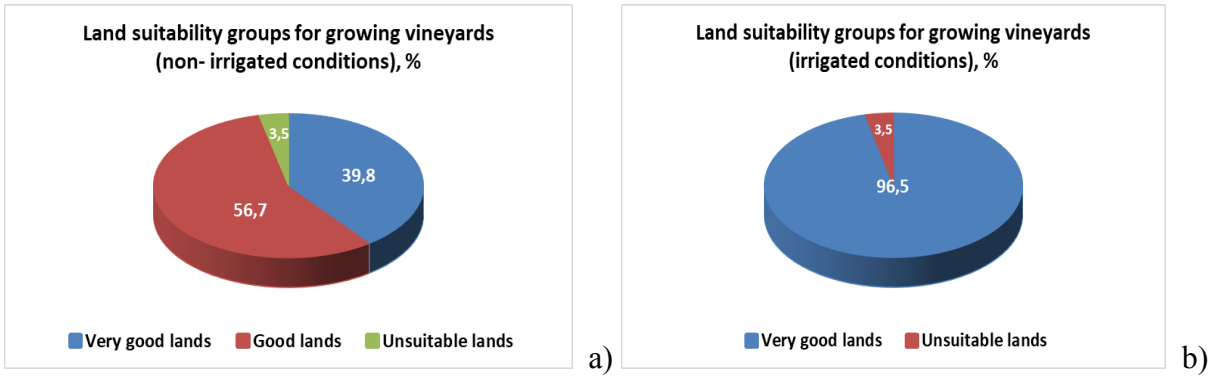
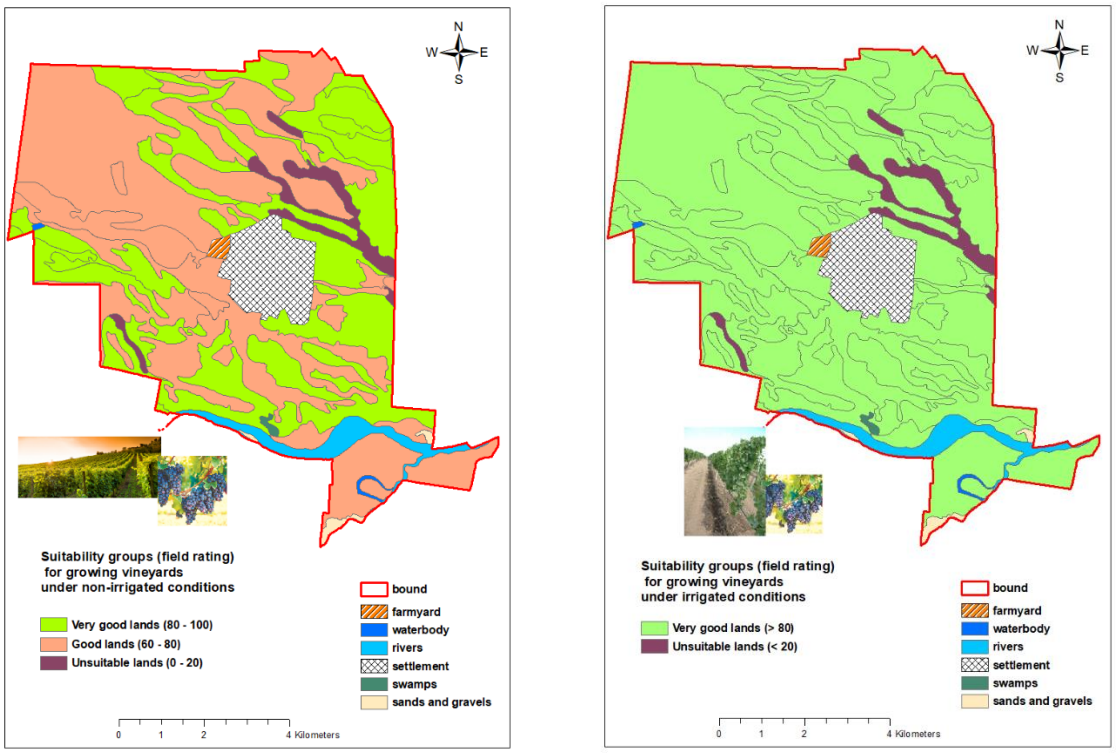


Figure 20. *Percentage distribution of the land suitability groups for growing vineyards – a. non-irrigated conditions; b. irrigated conditions*



a) b)

Figure 21. *Suitability of agricultural lands in the area of Tsalapitsa village, Plovdiv region for growing vineyards – a. non-irrigated conditions; b. irrigated condition*

Conclusion

According to the officially adopted methodology in the country, a land evaluation of the agro-ecological potential of the land of the village of Tsalapitsa was carried out at two levels: 1. Quality grouping of the lands, according to the field ratings (FR) of the crops observed by the current methodology and allowed to varying degrees for cultivation by the climatic conditions in the region 2. Quality grouping and categorization of the lands according to the Average Agronomic Ratings (AAR).

According to the land evaluation in non-irrigated conditions, almost the entire area of agricultural land in the village of Tsalapitsa – 99,6 % is defined as good and medium-good land, respectively 43,3 % are good land or 3rd and 4th category and 56,5 % are medium-good land or 5th and 6th category. Only 0,4 % are unsuitable land or 10th category. With irrigation provided, the quality grouping and categorization of the land changes significantly in a positive direction, as 92,3 % are very good and good land (1st, 2nd, 3rd and 4th category), 7,3 % are medium-good land (5th and 6th category) and the insignificant part 0,4 % are again unsuitable land.

The unsuitable lands in the studied area are occupied by saline Alluvial-delluvial meadows (Solonetz (SN), slightly loamy), where the limiting factor is salinization (the high percentage of exchangeable Na at a depth below 40 cm). This necessitates the implementation of a complex of melioration measures to improve their properties and fertility.

The final classification of the assessed agricultural lands according to the Bulgarian methodology is harmonized with the recommendations of the FAO. After the harmonization,

75,5 % of the agricultural lands belong to class S2 “moderately suitable lands”; 24,1 % to class S3 “marginally suitable lands” and 0,4 % class N 2 "permanently not suitable lands".

Of the cereal crops, the most favorable conditions are for growing wheat, of the technical crops for growing tobacco, of the perennial crops for growing apples, peaches, plums, pears, cherries and vineyards.

With mandatory irrigation provided, very good conditions exist for growing tomatoes and rice.

The results of the land evaluation of the agricultural lands in the village of Tsalapitsa have been interpreted in a GIS environment, with the zoning of the crops, area and percentage distribution of the lands in the form of maps and graphs.

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