AGRO-ENVIRONMENTAL ASSESSMENT OF THE PRODUCTIVITY OF AGRICULTURAL CROPS IN THE SOUTH OFf THE REPUBLIC OF MOLDOVA WITH THE HELP OF GIS

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Рассмотрена агроэкологическая оценка продуктивности сельскохозяйственных культур на юге Республики Молдова при помощи ГИС – технологий. Произведен анализ научных исследований о пространственно-временной изменчивости агроклиматических показателей и урожая сельскохозяйственных культур, выявлены основные закономерности их распределения в рельефе.

Key words*: agro-climatic parameters, precipitation, amount of active temperatures, absolute minimum temperature, the yield of crops.*

Rezumat *În articol este reflectată evaluarea agro-ecologică a productivităţii culturilor agricole în partea de sud a Republicii Moldova, utilizând tehnologiile – SIG. Este efectuată o analiză privind variabilitatea spatio-temporală a indicilor agroclimatici şi randamentul culturilor agricole, fiind identificate principalele regularităţi ale distribuirii lor în acest spaţiu.*

Cuvinte cheie*: parametrii agro-climatici, precipitaţii, suma temperaturilor active, temperatura minimă absolută, recolta culturilor agricole.*

In the modern conditions science-based land assessment allows making the right choice of cultivars and crop management technologies, avoiding ill-considered losses and risk of damage to the plants due to adverse weather conditions - frosts, early autumn and late spring frosts, droughts, etc.

Therefore, the aim of our research is the analysis and evaluation of agroecological conditions in terms of a separate village's land use in order to optimize the agricultural crops placement. Among the indicators used to assess the agroecological resources, pedological and morphometric characteristics as well as the air and soil heat and water balance components are most commonly used [2,4,5,8]. In this case agroclimatic characteristics are expressed through various factors and indexes.

Materials and methods of the research.

The source material for this study was information about the productivity of major crops grown on the Congaz village territory. Meteorological data (heat and humidity characteristics) was provided by the State Hydrometeorological Service of

Republic of Moldova. Pedological and morphometric characteristics of the territory were provided by the Institute of Ecology and Geography, Academy of Sciences of Moldova.

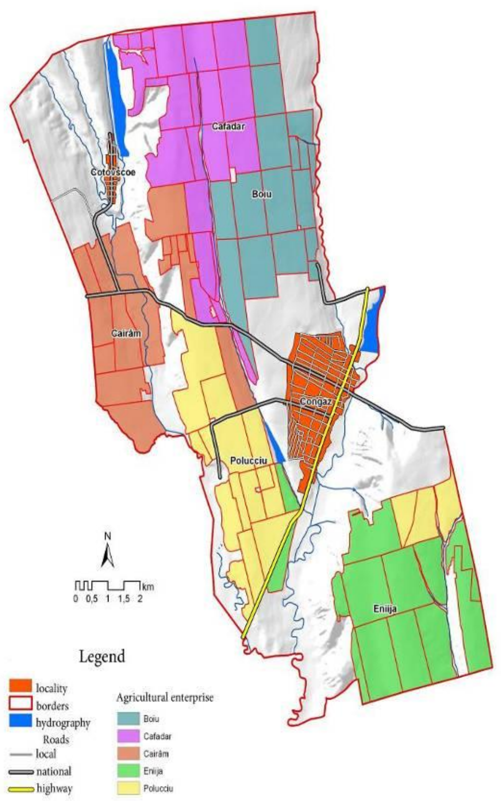

Figure 1 Location of agricultural enterprises on the land of the village Congaz

Five agricultural enterprises are currently situated on the fields of Congaz village land-utilization: Border Boiu, Cairam, Polucciu, Kafadar and Eniija, which were organized on the basis of former collective farm "Russia" (***Figure 1***).

The soil cover in the studied area mainly consists of typical weakly humeferous chernozems and calcareous chernozems.

Typical weakly humeferous chernozems are warmer and less provided with moisture compared with leached chernozem. These soils predominate in the southern plains of republic, where they occupy 32-39% of the area. They have 82 points by productivity and are the most fertile soils to the South of Codry. These soils are suitable mainly for field crops and grapes.

Calcareous chernozems - a distinctive soil subtype containing carbonates from the surface, the least humeferous and most lightly-colored - is notable for the most moisture deficit. Especially prevalent in the southern plains, where they reach 36% from the whole. By productivity they have 71 point, for viniculture- the highest score (100 points).

Here is a brief overview of soil cover in the research area: Typical weakly humeferous chernozems and calcareous (mainly moderately humeferous clayey-loamy ones) chernozems are common on the territory of ***Eniija enterprise***. In percentage: 30% - weakly eroded calcareous chernozems, 20-30% - moderately eroded calcareous chernozems and strongly eroded loamy and clayey-loamy, under the vineyards. Typical weakly humeferous chernozems constitute 40% of all soils and are under annual crops.

Pulucciu Enterprise - here prevail (40%) alluvial mollic soil, moderately loamy or clayey-loamy, weakly eroded in some places. Nearly 40% of the territory are occupied by weakly eroded typical weakly humeferous chernozems , and only 20% of the territory – with weakly and moderately eroded calcareous chernozems.

Kairam Enterprise - this area is dominated (50%) by calcareous chernozems, clayey-loamy and sandy-loamy varieties, weakly eroded. 30% of the territory is occupied by the typical weakly humeferous chernozems, strongly humeferous clayey-loamy chernozems, weakly humeferous clayey-loamy and sandy-loamy chernozems. About 25% of the territory is occupied by strongly eroded and deformed soils, rugged by ravines and destroyed by landslides.

Kafadar Enterprise is characterized from pedological point of view by calcareous clayey-loamy chernozems (60%), 25% of the territory is occupied by weakly eroded typical weakly humeferous chernozems and 15% of enterprise area is occupied by deformed and eroded soils.

On the ***Border Boiu enterprise*** territory the largest area (65%) is occupied by flat areas of weakly eroded typical weakly humeferous chernozems. Calcareous chernozems here occupy about 30% of the area, humic gley soils also can be met on nearly 5% of the territory.

Currently, the data obtained by the network of weather stations and posts is commonly used to estimate the agroclimatic resources of the territories [1,6]. This usually does not take into account the fact that the weather stations and posts are placed in different locations. For example, the Moldova's weather stations and agrometeorological posts' altitude varies from 26 m on Vulcanesti post till 232 m at Cornesti weather station. In addition to that, many of them are located on various forms of relief.

Given that the studied area is located on complex relief, and, consequently, agricultural fields are located in different agroecological conditions, we tried to identify microclimatic features of the territory and sites of natural, most favorable microclimate for agricultural crops cultivation. For this purpose, microclimatic data from Agroclimatology Laboratory, Institute of Geography, Academy of Sciences of Moldova was used, field studies of which were made on Baurci village fields - adjacent to Congaz village's land-use territory.

Agroecological estimation of crops growing conditions in the areas that are not covered by instrumental observations is performed using computational methods, involving long-term agroclimatic data of Comrat weather station. It should be noted that microclimatic patterns of distribution of several meteorological parameters - radiational, heat, humidity and other characteristics for complex relief areas have been investigated by present due to field studies and computational methods, as well as informational technology features. Patterns are often presented in the form of microclimatic maps. [2,4,5,9]. In order to elaborate microclimatic maps, traditional methods of inter- and extrapolation of meteorological values are commonly used to establish the statistical relationship between relief characteristics and meteorological values. [2,8,9]. In this case, the real picture is not always reflected objectively.

GIS technologies were used for elaboration of agrometeorological indexes distribution maps in this paper. Characteristics of the air thermal regime was expressed as an average of the absolute minima and the sum of active temperatures above 10°. The amount of precipitation per year was adopted as moisture. As a basic characteristic of plants heat supply, the sum of air temperatures depends on the values of latitude and altitude above sea level, which determine the degree of its variability.

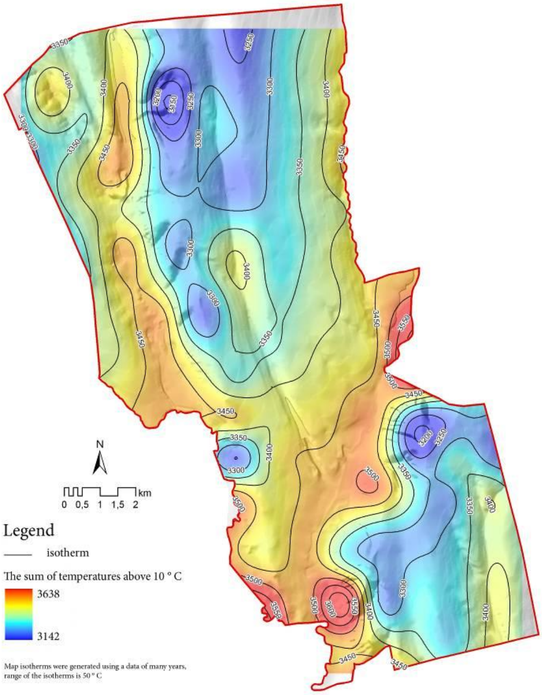

Figure 2 Microclimate variability of the amounts of active temperatures above 10 ° on the land of the village Congaz

Figure 2 shows the microclimate map of the distribution of sums of active temperatures on the Congaz village land .

The map analysis showed that the variability range in the amounts of air temperatures above 10° C at the study area is 500°, i.e. depending on the location of the plot in the relief, the amount of temperature changes from 3150 to 3600°. The smallest amount of heat enters the Eniija and Kafadar farms territory (3150 ° -3350 °), the warmer areas are located on the territory Kairam and Polucciu (3400° - 3500°). These sums of temperatures, on average, at 50-250° compared with those contained in the handbook [1] for the III-th agroclimatic region, comprising the Congaz village territory. These differences obviously can be attributed to global and regional climate warming, which is observed in recent decades and are not included in the directory, since it was published in 1982, as well as a detailed account of the topographic features.

It is known [7,9] that the minimum winter air temperatures are one of the limiting factors of overwintering perennials. According to the studies [9] not-ukryvnaya culture of grapes for the relatively hardy varieties is advisable in areas situated to the south of the contours of the average absolute minimum temperature -20° C, for half-hardy -19° C, for tender -18 ° C. Consequently, in the territory of farms the possibility of not covered grape cultivation technology is provided only in the areas where the minimum temperature does not fall below 18 ° -20 °. However, the ruggedness of terrain significantly affects the distribution of minimum air temperatures, especially in the cold and transitional periods, when this factor becomes the second most important after the latitude. With this in mind we found simulation of the field average of the absolute minima of air temperature interesting (***Figure 3***) on the Congaz village land and in this case the differences were significant in the distribution of minimum temperatures. The range of variability of the average of the absolute minimum here may vary from - 17,8 ° to 24,5 °. Less frosty areas are located in the farms Eniija and Kafadar, where the average of the absolute minima does not fall below the -22°. More severe conditions for overwintering of winter crops and perennial plants are formed on the territory of farms Polucciu and Cairam where the average of the absolute minimum is -23-24°. Lands with a minimum air temperature 18-20° occupy small areas and are located primarily in the inconvenient. Uniform deposition.

For the III-th agroclimatic region, which includes the land of the Congaz village, average of annual precipitation is 486 mm [1]. Consequently, the lack of water here is about 100-300 mm, depending on the conditions of the year.

But as it turned out, the underlying surface characteristics also affect the allocation of the precipitation amounts. ***Figure 4*** shows the distribution of average annual precipitation in the study area. According to the map the amount of precipitation varies from 490 to 530 mm in the study area. The highest precipitation amounts fall in the territory of farms Kafadar and Eniija (470-500mm), on the rest of the territories their sum varies between 450-480mm. This precipitation amount has been significantly less than optimal, and gives evidence in the terms of moisture supply to the lack of moisture resources. Consequently, this territory is at risk, requiring additional measures to ensure sustainable harvests.

This to some extent, may be facilitated by considering the agro-ecological conditions, which are one of the additional intensifying factors that determine the structure of the fields and the placement of crops based on the plants requirements to the environmental conditions and their provision. Thus, the emphasis should be placed on the greening of agriculture, in terms of crops location and the organization of field agro-based crop rotation.

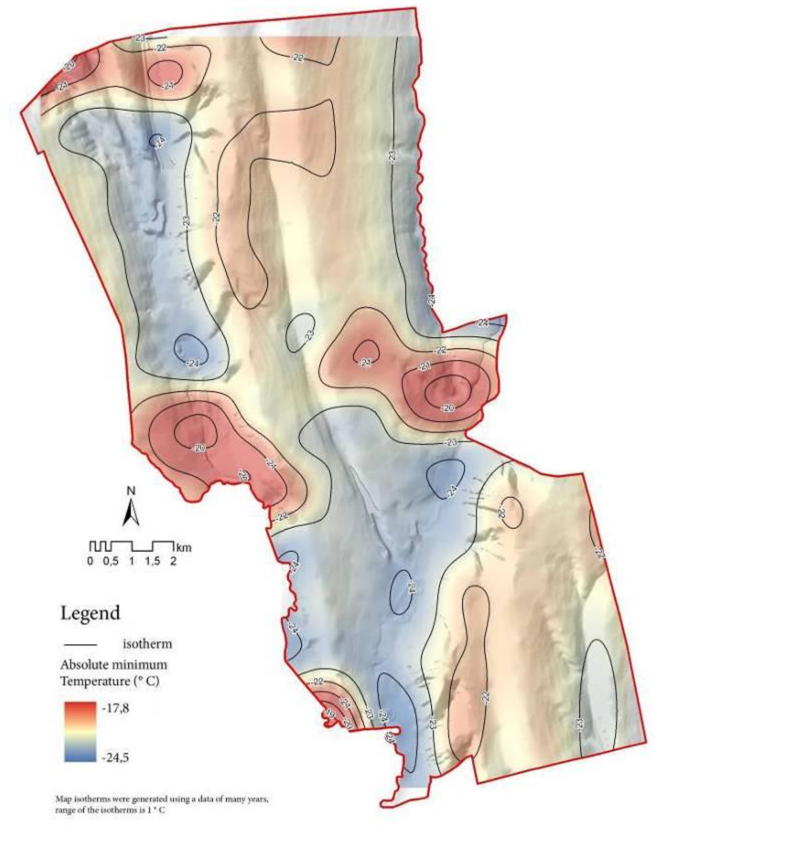

Figure 3 Microclimate variability of the average of the absolute minima of air temperature on the land of village Congaz

1. To this end, on one hand the requirements of different varieties to basic natural factors such as the orientation of slope, elevation above sea level, the slope magnitude, soil types and subtypes, their texture and degree of flushing are studied, but on the other hand, an inventory of

natural conditions within the habitats that determine the specific environmental conditions for cultivation of crops is made. An indicator of availability of crops climatic resources is their level of productivity, as well as its variability from year to year.

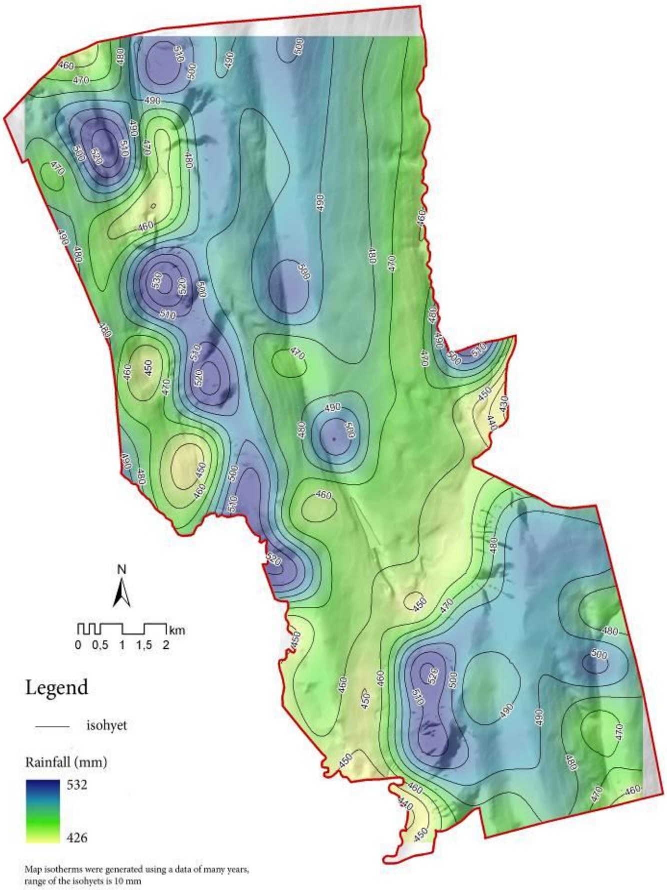

Figure 4 Microclimate variability of rainfall on the land of the village Congaz

2.***Winter wheat.*** In the south of Moldova winter wheat is the major grain crops, in this connection significant experience on the technology of its production has been gained here[1, 7,8]. However, in the years of adverse weather conditions, the yield of winter crops is markedly reduced, often significantly. Thus the maximum yield of winter wheat during the observation period (2000 and 2005) on the land of the Congaz village was 50,5 q/ha, while the minimum yield for this period amounted to 2,4 q/ha, hence the difference in yield was 48,1 q/ha.

3. Thus, the winter of 2002 - 2003 and the hot and dry summer of 2003 has turned out highly unfavorable for the winter crops. This year, the winter wheat yield was very low (5-6 q/ha) on the land of the Congaz village. The sleet in winter and the drought in summer had a severe negative impact on the harvest of winter crops. The average yield for farms this year was 5 q/ha (***Table 1***), and its value ranged from 2,4 q/ha in the Border Boiu farm to 9,5 q/ha in the Eniija cooperative.

The average yield of crops change on the Congaz village land during years 2000 - 2005

Table 1

Years of research	Winter wheat			Corn			Sunflower			Grape		
	AV farm	Δ yield	AV South	AV farm	Δ yield	AV South	AV farm	Δ yield	AV South	AV farm	Δ yield	AV South
2000	23,2	2,7	24,4	14,6	12,9	8,7	11,4	5,4	10,8	51,4	36,0	41,9
2001	41,7	14,5	37,0	20,5	9,4	15,8	11,6	7,7	13,1	30,2	25,2	26,9
2002	27,8	9,1	21,1	14,4	10,0	10,5	12,4	4,0	11,0	51,8	24,1	38
2003	5,0	7,1	5,7	19,5	10,4	17,1	8,8	9,3	9,7	48,7	27,8	37,7
2004	33,5	9,6	33,7	34,2	13,8	29,4	12,2	5,3	10,8	76,1	36,4	45,7
2005	31,6	11,2	24,7	31,1	10,5	26,0	15,1	9,0	11,7	53,1	39,8	32,8
Average	27,2	9,0	24,4	22,3	11,6	17.9	11,9	8,5	11,2	51,8	31,5	37,1

*** *Note:*** *AV farm-average yield on the farms (centner/ha);* Δ yield - *the difference in yield between farms (centner/ha); AV South - the average yield in the south of Moldova (centner/ha).*

However, under such extreme conditions on the territory of the cooperative Eniija, the harvest of winter crops was relatively good for this year and amounted to 9,5 q/ha. This can be explained by a little better temperature-humidity indices during the growing season and wintering conditions in this territory compared to other farms. Figures 2,3,4, represent microclimatic characteristics of these farms. In addition, the soil of these areas influenced the growth, development and yield formation. The difference in yield of winter wheat harvested in cooperatives in this year amounted to 7.1 q/ha, with an average harvest in the south of the country's 5.7 q/ha.

In 2001 the harvest of winter crops was generally high and varied from 36.0 q/ha in the farm Kafadar to 50,5 q/ha in Polucciu. Such a relatively high yield of winter crops is due to the amount of precipitation and their uniform distribution in time, as well as the relatively low level of temperatures. This year, the differences in yield of winter wheat in the study area amounted to 14.5 q/ha. The average yield in the south of the country this year amounted to 37 q/ha.

Table 2 presents information about the harvest of winter wheat, maize, sunflower and grapes for each farm separately, for the same period (2000 -2005). It should be noted that, in characterizing the spatio-temporal variability of the yield on the average of its value, the fact that the average number of a row evens out its value and does not reflect the full range of its variability must be taken into account. Thus, according to *Table 2*, the average yield of winter on farms totaled 27.2 q/ha, and the differences in the average yield of winter wheat between farms amounted to 3.8 q/ha.

The average crop change for the territory, the period of studies (years 2000 - 2005, the Congaz village). **Table 2**

Crops	Border Boiu	Kairym	Polukchu	Kafadar	Eniyzha	Average yields on the farm	The difference in yield between farms	Average yield in the south of the republic
Winter wheat	26,6	28,4	27,4	25,1	28,9	27,2	3,8	24,4
Corn	20,6	19,7	21, 6	23,3	26,7	22,3	7,0	17.9
Sunflower	9,7	13,7	12,3	11,9	10,7	11,6	4,0	11,2
Grape	43,0	67,3	55,5	54,9	38,6	51,8	28,7	37,1

Corn. It is known that corn is a very susceptible to external conditions culture [10]. The year 2000 can serve a good example of this, when due to adverse weather conditions very low yields were obtained, which ranged from 8 to 21 q/ha, thus, differences in yield in the territory amounted to 13 q/ha. In the favorable 2004 the harvest of maize was 30-44 q/ha. Differences in corn yields between farms amounted to 10-14 q/ha.

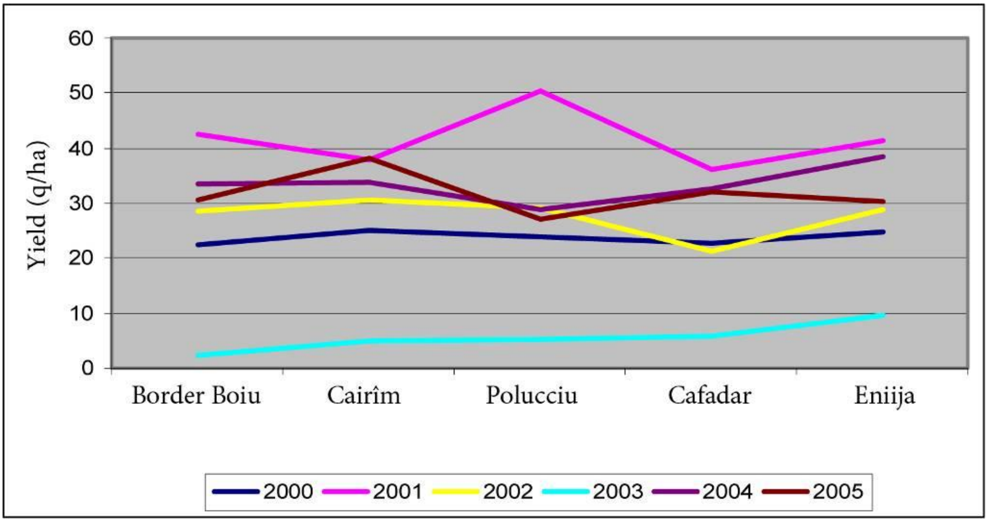

Figure 5 Spatial - temporal distribution of harvest of winter wheat on the land of the village. Congaz (2000 and 2005).

As ***Table 1*** shows, the average yield of corn during the study period varied from 14 q/ha to 34 q/ha. Differences in the average yield of maize in some years ranged from 9 to 14 q/ha. The maximum yield of maize was 43 q/ha, minimum 8.1 q/ha. The average yield in the south during this period was lower and varied between 9 to 29 q/ha. According to ***Table 2***, the average yield of maize in the studies varied from 19.7 q/ha (Kairam) to 26.7 q/ha (Eniija), which can be explained by natural conditions of these (Fig. 2, 3).

Sunflower. Although sunflower is considered drought-tolerant crops, it is very responsive to the moisture conditions [6]. Since 2003, which was characterized as arid, especially the first half of it, the average yield of sunflower in the Congaz farms this year was not high and amounted to 8.8 q/ha.

As ***Table 1*** shows the average yield of sunflower in the period 2000 to 2005 ranged from 8.8 to 15.1 q/ha. Differences in yield in individual years ranged from 4.0 to 9.5 q/ha, with an average of 8,5 q/ha. The maximum yield of sunflower was 18 q/ha, minimum 4.0 q/ha. The average yield in the south during this period was somewhat lower and varied between 10-13 q/ha.

The data presented in ***Table 2*** indicates that the best conditions for a crop of sunflower formed in the territory of Kairam with moderately warm conditions and relatively low precipitation and little washed calcareous soils.

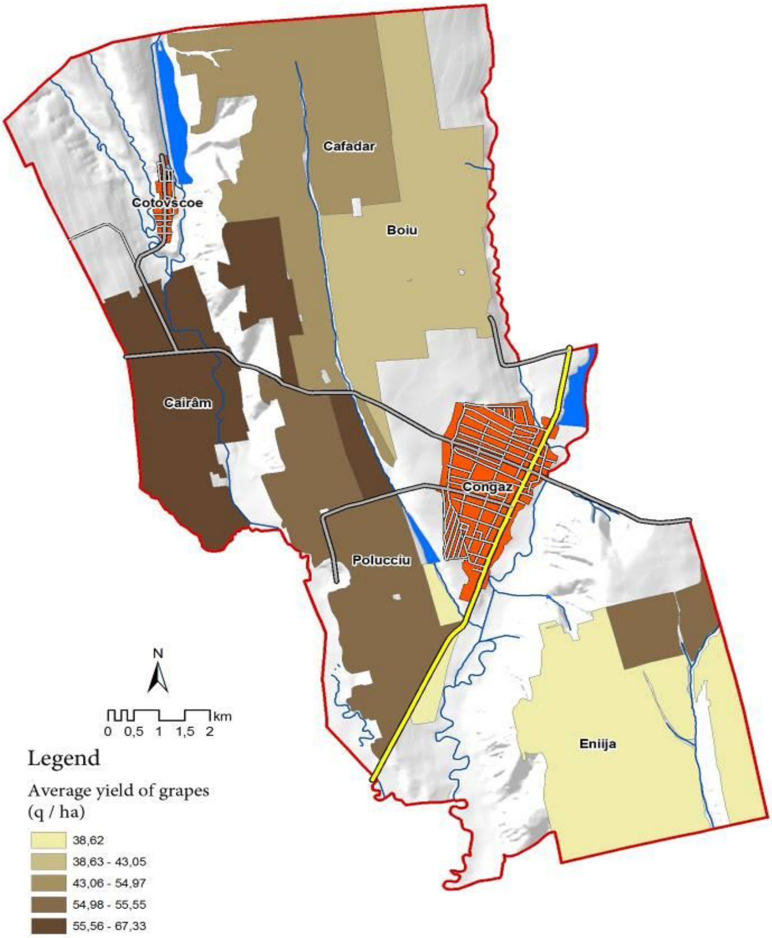

Figure 6 Variability of grapes harvest on the land of the village Congaz during 2000 -2005

Grapes. It is known that the quantity and quality of grapes depends largely on the environmental conditions of the area. In wine, as in a mirror appear particular qualities of the grapes cultivar and the place of its growth [3,9]. As ***Table 1*** shows, the average yield of grapes in the farms of Congaz during the studies period ranged from 30 q/ha to 76 q/ha. Differences in the grape harvest in some years reached 24 -

40 q/ha. The maximum yield of grapes was 96,4 q/ha, the minimum 14.8 q/ha. The average yield in the south during this period was significantly lower, it varied between 27-46 q/ha.

According to *Table 2*, the highest yields of grapes were collected at the farm Kairam with more moderate temperature regime and relatively low precipitation and little washed calcareous soils. On average of 6 years harvest here constituted 67 q/ha, this is 12 q/ha more than in the Polucciu and Kafadar farms and 29 q/ha higher than the crop harvested in Eniija.

Visually the winter wheat harvest distribution for each year of research and on individual farms is presented in *Figure 5*.

Conclusions.

1. Low yields of crops and their vast space-time variability is due largely to different levels of availability of natural conditions. The average crop grown in the fields of the Congaz village during the 2000-2005 years was higher than the average harvest in the south: in the winter crop at 3 q/ha, in maize at 2 q/ha, in sunflower at 0.7 q/ha, in grape at 15 q/ha
2. Differences in yield of crops grown in the land of the Congaz village, depending on the year, has varied considerably: in winter crops from 3 to 15 q / ha, in maize from 9 to 14 q / ha in sunflower from 4 to 9 q / ha and a grape-25-40q/ha.
3. The microclimate data of the individual farms territories allows one to correctly place the crops and crop rotations, as well as to differentiate the agricultural work that contributes to higher and stable yields and sustainable use of and. Establishment of a cartographic database for the different levels of economic organization will optimize the use of agro-ecological potential and reduce costs associated with the production of agricultural crops.

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