A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfillment of the Degree of Master of Science

The Role of Sustainable Agriculture in Increasing Export Potential of Grain in Kazakhstan with Regards to Possible Climate Change

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ABSTRACT OF THESIS submitted by:
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for the degree of Master of Science and entitled: The Role of Sustainable Agriculture in Increasing Export Potential of Grain in Kazakhstan with Regards to Possible Climate Change.

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The present research aims to describe and analyze environmental consequences of governmental plans of a rapid increase grain export of Kazakhstan. Taking into account significant environmental constrains the question of sustainable grain production arises. An attempt of qualitative evaluation of the role of sustainable grain production in governmental plans of increasing grain export has been undertaken arguing that sustainable practices can not only advance productivity and physical amount of grain, but also give opportunities to Kazakhstan's farmers because of rising market for organic production. The suggested measures to increase productivity by sustainable means are presented with consideration of natural conditions of Kazakhstan. A special attention is paid to influence of climate change in terms of decreasing area suitable for growing grain in Kazakhstan by 2050.

Keywords: Kazakhstan, grain, export potential, grain trade, sustainable agriculture, extensification, intensification, climate change

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Chapter 1: Introduction

1.1. Background information

According to the statistics of the FAO, the number of people who are endangered by food insecurity reached 1 billion in 2009 and it is projected to grow in coming decades. This factor together with surging demand on biofuel, increasing consumption in China and India, speculation on the global grain market will lead to rocketing of grain prices.

Rapidly growing global prices on grain (mainly wheat) generate growing ambitions of Kazakhstan to export more grain and play a larger role in the world grain trade as it suffices its own domestic needs for grain on 157%. Nowadays the share of grain in the agricultural export is 70% and it is planned to be increased in the State development program of agricultural sector. Evidence that Kazakhstan is going to increase significantly its export of grain is that infrastructure and facilities for grain processing and storage are being expanded and Kazakhstan also allocates significant investments in logistics for Kazakhstan's grain abroad. There are already Kazakhstan owned grain storages in Azerbaijan and Iran to ensure advancement of grain to Middle East, Northern Africa and Europe. Beside this, conditions of export to China, South-East Asia, Japan and South Korea are being negotiated.

However, such pursue for profit can cause many negative effects, most of which are environmental. This is why the grain export policy should be careful and weighted and not contravene the principles of sustainable development.

1.2. Research goal and objectives

The primary goal of the present research is to identify the alternative ways of increasing Kazakhstan's grain production while keeping environmental impacts within acceptable range with the perspectives to medium-long future.

The objectives of the present research are:

- - To analyze the state policy related to production and export of grain;
- Analyze environmental impacts and scale of them associated with the production of grain;
- To research whether the climate change scenarios are considered in the grain policy;
- To suggest alternative ways achieving the state goals related to production and export of grain.
- To identify geographical changes of the areas suitable for grain growing.

Apart from goal and objectives a qualitative research study requires research questions; therefore three research questions were formulated.

The Research questions are:

- What are advantages and disadvantages of expanding of sustainable grain production in Kazakhstan?
- What sustainable approaches can be used to improve productivity of grain production stiffed by low temperatures and moisture stress?"
- What are the geographical perspectives of grain production in Kazakhstan in coming decades bearing in mind climate change?

The logic of putting research questions in that order is that the first question can be paraphrased as "Why the sustainable grain production should be implemented in Kazakhstan at all?". This question is the fundament of the whole research. The reason for setting such question is not only that sustainable grain production in Kazakhstan has various renditions and not fixed in the legislation of the country, but also the primary reason is cumulating environmental problems associated with industrial grain production and extremely high

dependence of weather conditions can break all the plans on increasing export of grain. The second research question can be paraphrased as “How Kazakhstan is going to reach its goals of increasing grain export?”. This research question also implies the extent to which sustainable means of grain cropping can be adopted. It is clear agriculture cannot be 100% sustainable and environmentally benign, but a combination of alternative and conventional practices can even exceed results shown by each of them separately. The third research question can be paraphrased as “Where in future the grain production in Kazakhstan will be possible and what will be the conditions?”. The reason for such question is growing concern of effects of climate change in future, particularly on grain production, as it is deemed to be the most vulnerable sector of the national economy to the climate change.

1.3. Value of the study

Increasing involvement of Kazakhstan in the international grain trade, growing urbanization will require from farmers to keep up with the pace and open for them new opportunities. However, to sustain the current trend in future will require application of more environmentally friendly approaches and flexible adaptive policies and regulations from the government. Ambitious programs for development must be weighted and embrace all the aspects of it.

The value of the present research is in the critical evaluation of the grain export policy, covering many aspects of it and giving projections for the future. There might be some mistakes in the research, especially in highly uncertain projections, but I believe that the overall “direction” of the study is correct. The topicality of the present study is very high, as the last two years, 2010 and 2011, Kazakhstan endured severe droughts which threaten the results of the official plans on increasing productivity, threaten conditions of farmers, especially small-scale producers, aggravating poverty and environmental degradation.

This research might be interesting for students, professional researchers, farmers and policy makers.

1.4. Organization of the study

Chapter 2 describes the methodology of the research, process of gathering information and analysis, limitations of the research and summary of the methodology in the end of the chapter.

Chapter 3 is a literature review which is relevant to the topic. It includes the background information about natural conditions of Kazakhstan, brief historical review of the development of the grain production in Kazakhstan up to 2010, review of the State development program of the agricultural sector from 2010 to 2014, assessment of the plans to increase export of grain by foreigner researchers and organizations, environmental and social risks associated with the growing export of grain. Special attention in the section describing environmental risks is paid to possible consequences of climate change.

Chapter 4 is focused on the analysis. It is divided into three sections: 1) justification of sustainable practices and its opportunities for Kazakhstan's exported grain: 2) the methods how the sustainability can be approached; 3) the results of geographical analysis with the help of ArcGIS software.

Chapter 4 is called Conclusion which consists of summary of the results and suggestions for further research.

Chapter 2: Methodology

2.1. Introduction

The chapter presents the overall review of working process starting with identifying of problem, setting goals and objectives for the research, as well as research questions, and ending with the results and approaches by which those results were achieved.

2.2. Research process

2.2.1. Defining the problem

The topic of food security of Kazakhstan was supposed to be the theme of the [present research as it seemed to be very important issue for Kazakhstan now and getting more importance in the future. The reason for such assumption was the rising importance globally as it is often a “hot topic” on the agenda of many international forums devoted to world economy, environment, human rights and many others. After further acquaintance with the issue specifically to Kazakhstan it became clear that it is not an acute problem and the country is even increasing its export of agricultural products.

2.2.2. Narrowing the scope

Further reading and discussions of the food security and agriculture of Kazakhstan allowed finding out that the biggest share in export constitutes grain and this share is planned to increase.

After getting the grant for research trip the flight to Astana, the capital of Kazakhstan was undertaken. The purpose of the trip was gathering information relevant to the research. Some valuable and unpublished information was managed to obtain from the Ministry of Agriculture. Also a short interview was conducted with the Vice Minister of Agriculture Saktash Khassenov. The conclusion of the interview will be presented in the analysis chapter.

The second interview was conducted with the President of JSC "KazAgroInnovations" Serik Kenenbaev who was very helpful and informative. The results of the interview served a basis for the second section of the Analysis and Results chapter. It must be mentioned that 11 people were contacted with the purpose to conduct interviews, but due to various reasons only 2 interviews were obtained.

For the chapter of Literature review various previously conducted research were perused. Mainly the publications of international organizations such as FAO, IFPRI, CIMMYT, EBRD and OECD were used for describing the situation of Kazakhstan's agriculture and grain production in particular. Two main important official publications used in the chapter are the *State Development program of the agricultural sector from 2010 to 2014*, and *Report on Agricultural Sector* made by state-owned consultancy company of RCFA Ratings. Besides these publications many other Kazakhstani and foreign publications were used.

For the chapter of Analysis and Results also some literature about sustainable agriculture was used for the first section, the second section is based mainly in the interview with Serik Kenenbaev mentioned above, and the third section is based on the result obtained in the ArcGIS software.

2.2.3. Using ArcGIS

The ArcGIS software was used to generate 11 maps relevant to the research. The layers of climate constraints, length of growing period, soils were taken from the web-database of FAO (www.fao.org/geonetwork). As there were no such layers for Kazakhstan, the global layers were taken from the source and then with function of "Extract by Mask" the territory of Kazakhstan covered with those layers were obtained. The Figures 1 and 2 were created only by Extracting by Mask of the whole territory, but to create the Figure 3 ("Soils suitable for growing grain") the additional function "Select by attributes" was used. In the Figure 3

the soils suitable for grain cropping (chernozems and kastanozems) were selected and presented. The layers of mean temperature and monthly precipitation for the present and future (projections for 2050) were downloaded from the web-datasets of www.worldclim.org. Then for the mean temperature and monthly precipitation the territory of Kazakhstan was extracted by Mask. After that the conditions suitable for growing grain were identified by superimposing the extracted layers with maps showing currently grown crops downloaded from the FAO database. Then the results of analysis were verified by reading literature and finding precise temperature and precipitation ranges within which the grain cropping is possible without high inputs of agro-chemicals. After creating maps of mean temperature and monthly precipitation (Figures 5 and 8 respectively) they were compared with their projections for 2050 (Figures 6 and 9) respectively). To create the maps which would show the difference between the present conditions and the projections the following path was used in ArcGIS: Toolbox – 3D Analyst – Raster – Minus. Such operation allowed calculating the differences and presenting them on the maps.

For creating the maps of areas suitable for growing grain (Figure 11) the layers of suitable soils, extracted suitable precipitation and temperature were superimposed by the same pathway described before: Toolbox – 3D Analyst – Raster - Minus. The same approach was used to create the map of suitable areas for growing grain by 2050, but using the layers of precipitation and temperature projected by 2050 (Figure 12). Then to calculate them different approaches were tried. The first approach was converting raster files to shapefiles, and then to calculate areas of polygons, but such approach caused difficulties with projection of maps. After trying such approach another method was found: knowing the cellsize of raster, obtained from metadata of the layers, to multiply it on the number of cells. Such approach allowed calculating the final results of mapping, which are the areas suitable for growing grain in present and in 2050.

To create such maps significant investments of time were made, because many different techniques and approaches were done and analyzed.

The main assumption made to create the final map (Figure 12) is that the level of inputs of agro-chemicals was presumed to remain the same, so that they were not taken into consideration. Probably, the level of scientific and technical progress will allow to grain growing expand to the less auspicious areas.

Uncertainties in the maps depend on the quality of input data and interpolation methods used to create the layers (Hijmans *et al* 2005). Also the precision of the data depends on density of meteorological stations which collect and analyze data for creating digitized layers. In Europe and Northern America the density of meteorological stations is high, but in Kazakhstan it is visually 2-3 times lower. Strictly speaking, none of the climate change projections is precise.

Besides the advantages the final maps (Figure 11 and 12) have some flaws as they do not include urban areas, protected areas, roads, rivers, and pastures. This flaw changes the results of calculations. The second flaw is that they do not show the differences of conditions for growing grain in different parts. The advantage of such maps that they give the idea to which extent the grain growing areas can potentially expand or reduce.

Relevance of the final maps to the topic is that they show where the grain areas can be expanded without heavy environmental damage if the management of agriculture is appropriate. The projection for 2050 shows that in order to keep the pace of grain production significant investments in intensification and innovations will be needed as the opportunities for extensification will be limited.

2.3. Limitations

Lack of time to conduct a sterling research is the main limitation. During the research trip the time was also a constraint raking into account that it coincided with national holidays and

changes in the government so many connected people were leaving their positions and refused to have an interview.

The second limitation was the lack of literature devoted to sustainable or organic agriculture in Kazakhstan.

The third limitation was the fact that there is only one NGO in Kazakhstan dealing with organic agriculture and which is situated in Almaty (the former capital of Kazakhstan).

The fourth limitation is rather dire infrastructure in the Akmola oblast and bad conncetion between the capital and farms situated in the oblast, which hinder accessibility of farm to interview farmers and get their position towards sustainable agriculture in increasing grain export of Kazakhstan.

Chapter 3: Literature Review

3.1. Introduction

The literature review of the present work pursued the following goals:

1) To present the current situation of grain production in Kazakhstan;

2) To present the vision of the officials on the development of grain production and export;

3) To find out if the sustainable means of development are considered;

4) To present the results of research on expanding erxport of Kazakhstan's grain;

5) To present the experience of growing grain in Kazakhstan and its environmental, economic and social lessons.

The main official document which was used in the literature review is the State development program of agricultural sector from 2010 to 2014. The importance of this document for the literature review is that it represents the position of the government on the direction of agricultural development, its priorities, goals and time needed for implementing them. Other officials documents used in the chapter were different projects of the Ministry of Environmental Protection such as "Project of management of arid lands". Also the Ministry of Agriculture provided information requested during the research trip which is referenced as "Materials from the Ministry of Agriculture". Besides, the official governmental information the report of RCFA Ratings was widely used in this chapter. This is an analytical and rating agency which claims to be independent, but which was established by the government in 2007 for making analysis and critique for state projects.

The chapter was based on different research conducted by Kazakhstani and international scientists and organizations. The foreign research literatures used in the present chapter were mainly works of such organizations as FAO, IFPRI, EBRD, OECD, and CIMMYT.

The chapter gives brief summary of natural conditions of Kazakhstan and the historical development of its agricultural activities, describes and identifies some flaws of the State development program of the agricultural sector, presents existing research on increasing grain export of Kazakhstan and points out associated with it environmental and social risks.

3.2. General data about the climate and natural conditions of the Republic of Kazakhstan

The Republic of Kazakhstan is situated in the geographical center of Eurasia. The remoteness from ocean stipulates arid continental climate. The territory of the country occupies 2,724.9 square kilometers and it is the 9th largest country in the world. The population of Kazakhstan is around 16 million people. Such proportion of population and territory creates situation when many lands are being idle, i.e. not used for any purposes, but can be potentially used for agriculture as it is stated in the official documents taken from the Ministry of Agriculture. According to RCFA Ratings (2010), the lands of reserve make 43%, pastures – 35%, arable lands – 9%, haymaking – 1%. Overall agricultural lands constitute 89% of the whole land fund of the country.

Generally there are four climate zones in Kazakhstan: forest-steppe, steppe, semi-desert and desert. In Northern Kazakhstan where steppes and forest-steppes are situated there are mostly chestnut and chernozem (molisoils) soils suitable for growing grain, in Southern Kazakhstan semi-deserts and deserts can be used for growing only if sufficient irrigation is provided (National Atlas of the Republic of Kazakhstan 2006). Fertile chernozems occupy around 11% of the territory (Funakawa *et al* 2004)

Climatic conditions of the country are different in different parts of it due to spread of Kazakhstan from West to Easr and from North to South. According to the National Atlas of the Republic of Kazakhstan, average annual precipitation in the Northern Kazakhstan is 200-400 mm, in the South it is 150-250 mm, except for mountainous areas where precipitation can reach up to 500 mm. Arid lands occupy 86,2% of the territory and more than 70% of arable and abandoned agricultural lands are subject to land degradation to some extent or another (Ministry of Environment 2003). The length of period with temperature over 10°C is from 120 to 160 days in Northern Kazakhstan while in the South it can be up to 210 days. The last frosts in year in Northern Kazakhstan can occur even in the middle of May in some parts, in the South it is usually in the beginning of April. The snow layer usually remains untill the Middle of April in the North and till the first decade of March in the South (National Atlas of the Republic of Kazakhstan 2006).

Such combination of climate conditions and soils makes possible growing high valued spring wheat which is superior to that produced in Europe or Asia due to high gluten content (Meng *et al* 2000; Hilkmann 2006).

3.3. Brief historical review of Kazakhstan grain production from Soviet times to 2010

Growing grain in Kazakhstan was known from the ancient times as archeologists often find remnants of cropping in the ancient settlements. Natural climatic fluctuations always affected the lifestyle and economic activity of the inhabitants of Eurasian steppe zone. Historically the Kazakhs have always led the nomadic lifestyle, which has accounted more than three thousand years of history on the territory of Kazakhstan, but always with some spots where the grain was grown. More intensive grain cropping started to develop with the first Russian settlements during the Russian Empire times, but dramatic intensification and involvement of huge areas into the grain cropping occurred in the Soviet times. During the Khrushev's

campaign of mastering of virgin lands in 1954 and later more than 25 million hectares of non-arable lands were ploughed up in Kazakhstan (RCFA ratings 2010). Among those 25 million ha 21,9 million ha were used to grow cereals, including the acreage for wheat which took 18 millions of ha (82.5%). The productivity has increased from 1.8 millions of tons of grain in 1949-1953 to 18.8 millions of tons of grain in 1956-1960 (RCFA ratings 2010). Consequently, due to the mastering of the virgin lands Kazakhstan has turned into the grain-basket of the USSR, but it had many environmental (substantial loss of fertility due to unsustainable practices, triggering desertification, ploughing very marginal lands) and social (displacement of traditional livestock breeding and associated with it Kazakh population, change of demographic structure) costs. The main agricultural specializations of Soviet Kazakhstan were productions of grain (mainly wheat) and meat. As Spoor (1999) put it, there was "one-sided inter-republican division of labor" between the Republics of the USSR.

After the collapse of the USSR the inter-republican division of labor has broken down and the newly independent states, particularly in Central Asia, declared the policy of food self-sufficiency. Some of the researchers think that the policy of self-sufficiency caused more harm than benefit, asserting that such policy has not led to food security but even induced drop of outputs of many crops and livestock because in some countries such fields as development of agro-chemistry and technologies had to be developed from scratch (Babu, Rhoe 2001).

The collapse of the USSR also has led to the change of the economic regime and switching from state ownership of farms to private. An estimated number of state and collective farms in Kazakhstan in 1991 were 2500 (Baydildina *et al* 2010). Then most of them were privatized and divided among many small farmers, but due to new farmer's inability to pay for new agricultural machines, technologies, fertilizers, seeds, there was a significant decrease in productivity (Meng *et al* 2000, RCFA Ratings 2010). As a result, a variety of different

agricultural commercial organizations have emerged such as joint-stock companies, co-operatives, partnerships, peasant associations (Spoor 1999). Compared to the other republics of Central Asia the process of privatization was rather gradual and deregulating of the marketing and agro-industrial processing in Kazakhstan took more time. Finally the dominant form of ownership became private (Baydildina *et al* 2010).

Such structural and economic changes have led to an abandonment of many arable lands. In 1991 there were 35,2 million ha under crops in Kazakhstan (Baydildina *et al* 2000), but it has to be admitted that abandonment took place only with unproductive risky lands. After 1991 in three main grain producing countries of the former USSR (Russia, Ukraine and Kazakhstan) overall around 23 million ha were left idle 90% of which were used for growing grain (FAOSTAT 2008). In Kazakhstan an average pace of dereliction of the arable area was 2 million ha per year (Lioubimitseva 2010?).

Economic crisis has led not only to abandonment of arable lands but also to a dramatic decrease of productivity. While the productivity and efficiency in developed countries were growing, former Soviet Union countries faced a harsh lowering of yields. Kazakhstan and Ukraine still have not reached the productivity level of 1990. During the first 10 years of independence the fall of production in Kazakhstan is estimated to be 35% (Osborne and Trueblood 2002), particularly wheat production has fallen from 24 million tons to 11,8 million tons (Hilkmann 2006). The spring wheat production has approximately halved since 1960s and declined by about 4 million hectares from 1990 to 1998 (Meng *et al* 2000). The government has established a threshold of productivity. If an arable area consistently failed to meet the threshold it was converted to a pasture or included in lands of reserve. Another reason for reducing the size of arable lands was the decline in livestock. Thus, unproductive lands were left to recover (Lioubimitseva 2010?).

The decrease of grain production and overall decline in agriculture affected the nutrition of the population. For example, Baydildina *et al* (2000) note, that hunger and malnutrition were observed in the 90s among the poorest strata of the population. They also remark on average statistical figures of food consumption per capita, saying that there was a huge inequality behind those figures. However, poverty in rural areas still remains an issue which affects productivity and sustainability. According to Kourmanova *et al* (2008), 19% of the population of Kazakhstan is below the poverty line, mainly in rural areas. In such cases agricultural development is estimated to be twice as efficient in fighting poverty (Jensen *et al* 2007), so agricultural development is important not only in terms of providing food security but also in cushioning social tension due to the growing disparity of incomes between different strata of the population.

The change of the trend of agricultural development of Kazakhstan occurred in 2000 and coincided with the overall growth of the economy (Lioubimitseva 2010?; State development program of agricultural sector of Kazakhstan from 2010 to 2014). From then on a consistent growth of the agricultural sector is observed, but to that growth also advantageous weather conditions has contributed (RCFA Ratings 2010). The biggest increase in production was observed in 2009 when the income from agriculture grew by 13% compared to the previous year, which became possible due to state subsidies which were equal to 43% during that year. Another reason is the rise of manufacturing industry which is increasing a share of products with high added value. For example, in 2009 the share of flour in the grain equivalent of the grain export was 47% and it is still increasing. By exporting 2.2 million tons of flour, Kazakhstan has become the leading exporter of the flour worldwide (State development program of agricultural sector of Kazakhstan from 2010 to 2014).

The growth of the agricultural sector has led to self-sufficiency of the inner market with own grain which is 157%. Such balance of the production and consumption resulted an increase of

grain export the pace of which sometimes outstripped the pace of the grain production. The average annual growth of agricultural production for the past five years was 9%, but the growth of the export of grain and flour in 2009 increased by 28% comparing to the previous year. These factors allowed the Kazakhstan's grain to conquer 14% of the global grain market (State development program on agricultural sector of Kazakhstan from 2010 till 2014). In Kazakhstan's GDP the share of agriculture constituted 8,6% in 2008 (compared to 34% in 1990) and it is planned to be increased, mainly due to expansion of cropping (RCFA Ratings 2010), which already makes 56% of agricultural output (Kourmanova *et al* 2008). However, notwithstanding the development of agriculture in Kazakhstan, rural poverty still remains an issue especially in remote areas which was observed by the author personally.

In the official documents the increase of grain export means increase of wheat export, since the structure of grain production is oriented for producing wheat due to high and still rising demand on this item on the world market. In 2010 wheat constituted 86% of the grain production (RCFA Ratings 2010), which allowed Kazakhstan to become the first country in the world in terms of amount of wheat per capita. However, the share of rye, oat and legumes makes only 3.4% against 10% in 1990. That means that despite the advantageous climatic and soil conditions the needs of the republic in rye bread, buckwheat, groats, and millet are not met by own production which should be considered by the policy-makers in the mentioned above State development program as indicators of food security.

The development of agriculture described previously is possible either because of extensification or intensification of production, or combining them. According to the Program of the agricultural sector (2010), the extension of cultivated lands and technological improvement go side by side. As follows during 2009 the area of cultivated lands increased by 1429.3 thousands ha (7,1%), including the arable lands for wheat which have been increased by 1265.4 thousands ha (9,4%), and the area under moisture saving technologies

occupied 10,3 million ha which is 35% bigger than in the previous year (State development program of agricultural sector of Kazakhstan from 2010 to 2014). Thanks to such measures Kazakhstan has exceeded the level of wheat production of 1990 in 2007 (Kourmanova *et al* 2008). Theoretically there is still a high potential for increasing yields, for example the National Human Development Report (2008) provided such information that over the past 40 years an average harvest in the Northern Kazakhstan, the main grain growing region, has decreased to 58% compared to 72% in 1881-1940. I think such productivity is reachable but it will require high inputs of agro-chemicals while in 1881-1940 the production was more organic. Given the low input of agro-chemicals now, it can be concluded that significantly deteriorated impugn further increase of productivity.

Another factor which can threaten increase of productivity is high dependence on the weather condition and can notably fluctuate from year to year (RCFA Ratings 2010). This is also stipulated by inability of farmers to pay for expensive fertilizers and irrigation systems, and also by lack of scientific research.

Shortly the strengths, weaknesses, opportunities and threads are presented below in the SWOT-analysis taken from the State development program of the agricultural sector (2010).

Table 1. ***SWOT-analysis of the grain production in Kazakhstan***

Strenghts	**Weaknesses**
- low cost of grain production; - presence of the significant land resources suiting the grain production; - equipped flour industry;	- insufficient introduction of innovations; - low technical equipment of the agricultural producers; - insufficient level of implementing agro-chemical

- availability of sufficient raw materials for the production of dry wheat gluten, starch and ethanol.	treatment; - absence of the globally recognized brand of the Kazakhstan's grain; - small amount of pasta from durum wheat flour.
Opportunities	**Threats**
- opportunity to increase export of grain to China and South-East Asia; - opportunity of the diversification of the grain; - the expansion of network of pasta producing Kazakhstan companies; - expansion of the variety of the processed grain products; - presence of the demand for flour on the outer markets; - abolition of import duties on equipment and technologies used in the grain industry; - stable demand for grain and flour in Central Asia	- risks affiliated with the peculiarities of the financing (dependence on natural and climatic conditions); - remoteness of sea ports of Russia and Ukraine, high tariffs for transiting of grains across Russia; - growth of export of Ukraine and Russia - increase ending stocks of agricultural products; - the presence of trends in the milling industry in the countries of Central Asia - Kazakhstan's major importers of flour and grain; -increasing demands of buyers, stricter quality standards.

Source: The state development program of Kazakhstan's agro-industrial complex for 2010-2014

In general all the points stated in the table are correct, however the dependence on weather and threat of climate change should be considered separately, not only with risks affiliated with peculiarities of financing, because the consequences of it can be overwhelming for the whole agricultural sector. As I think, the climate change is the main threat for grain production in Kazakhstan in future, which will be discussed later.

3.4. The State development program of the agricultural sector

The main present official document of Kazakhstan's agriculture is the State development program of the agricultural sector from 2010 to 2014. The government sets ambitious plans to develop agriculture in Kazakhstan defining it as an "agro-industrial complex", explicitly expressing the role of state regulation and the priority of the big scale industrial agriculture. This approach remains from the Soviet times and has many proponents as well as critics, but given the climatic conditions and remoteness of many agricultural regions from the infrastructural network, the state support seems necessary. The flaw of such approach is that it undermines the subsistence of small scale remote farms by favoring big producers and not allocating to small farmers subsidies for different purposes: irrigation, construction of storage facilities or any other.

The Program is not the first Kazakhstan's experience in the setting goals for the agricultural sector of the economy. Before it there was a program for the development of the agro-industrial complex of the Republic for 2003-2005. Still there are a lot of problems to be solved, and as the current program identifies them they are: 1) low rates of structural and technological modernization of the sphere; 2) unsatisfactory level of development of the

market infrastructure: 3) small scale of production; 4) financial instability of the sector; 5) low level of the private investments; 6) low qualification of the cadres.

The tasks set in the current program encompass wide aspects of agricultural policy starting from production of competitive agricultural products for covering own domestic needs, occupation of strong export niches not contravening the principles of sustainable development and ending with development of the current infrastructure of the agro-industrial complex and developing own agricultural science and administrators. The first two tasks are especially interesting for my research as it is focusing, besides the covering of own needs, on the export potential of Kazakhstan's agricultural products and it is set as a paramount objective of the agro-industrial complex. It must be mentioned that it is explicitly stated in the program that the self-sufficiency with own products is always a priority and amount of exported agricultural products varies by a year depending on amount of produced grain which in turn highly depends on weather conditions

Speaking about precise figures, i.e. so called 'the target indicators' we can state that they are rather ambitious and assign a rapid increase in manufacturing of agricultural products (the gross added value of the agro-industrial complex must be not less than on 16%), increasing the export potential of the country by different means (build-up export potential of the agro-industrial complex in the total export of the country is planned to grow up from 4% in 2009 to 8% in 2014, and of the production of wheat is going to be increased on 35%), and producing of the most of imported products by the own complex (as the provision of the inner food market by the Kazakhstani production must be 80%). Such ambitious plans are backed by the growing agro-industrial complex and that Kazakhstan produces some products more than enough for own needs.

Some already achieved positive results have become possible through the implementation of major infrastructure projects of strategic importance, including construction and modernization of grain storage facilities, development of infrastructure for exporting grain and its deep processing, although they are owned by state owned enterprises or by big cooperatives. To promote its agricultural products and help farmers increase their incomes, the state will intensify efforts to implement the grain and its products through commodity exchanges. In addition, special attention will be paid on reducing the raw material orientation of grain exports through the development of processing industry. In this case, it is planned to increase the share of processed products in total exports of grain - from 32% in 2009 to 50% in 2014, which will further strengthen Kazakhstan's position as one of the world's largest grain exporters. The index of growth of the production of flour for the last 5 years is 9%. The growth of the production of flour in 2009 compared to the previous year was 24%, which allowed the country to become the biggest exporter of flour in the world and share 14% of the world balance. Further development of grain processing will allow increasing the volumes of export up to 12 million tons of grain and floor in grain equivalent. Another important aspect mentioned in the Program is the Extensification of arable lands, thus in 2014 the areas under wheat are going to be expanded up to 13.14 million ha, and all grain crops will occupy 16.7 million ha. The arable areas will be put in accordance with the scientifically proved field rotations, which, as stated in the Program, will lead to optimization them on the area equal to 16.7 million ha. Optimization mentioned in the Program means such expansion of lands to promote scientifically approved rotation of cultivated lands. It worth noticing that the area under durum wheat is going to be tripled. It would be better if the government had provided information regarding the geographical location of areas, which are going to be ploughed up in order to make a conclusion whether they are suitable for growing wheat or if they should be used as pastures to provide sustainability in the long-term. The

gross collection of wheat is supposed to make 17.7 million tons with the average yield of 13.1 cwt/ha. At the same time, due to improved cultivation technologies it is planned to increase the average annual gross grain output by 6% and raise its export capacity from 6.7 million tons to 9.2 million tons or 37%.

Given that the level of competitiveness of crop depends on seed quality, the state will continue to support the development of seed production, including those aimed at increasing the area sown by elite seeds up to 8%, and improvement of the state variety testing, seed production and the mechanisms of the state support (State development program of the agricultural sector from 2010 to 2014).

As it was mentioned above the State Program assigns the development of grain processing industry. The table representing planned development ("forecast" as it is written in the Program) of the grain and flour production in Kazakhstan is shown below.

Table 2. Forecast of the development of agricultural growing from 2010 to 2014

Measure	2009 year	2010 year	2011 year	2012 year	2013 year	2014 year
Optimization of the cultivated lands under grain, thousands ha	17,2088	16,626.4	17,000.0	16,900.0	16,800.0	16,700.0
Area of applying water saving technologies, thousands ha	10,314.6	11,246.9	11,000.0	11,400.0	11,700.0	12,000.0
Area of applying	1,600	1,800	2,000	2,200	2,400	2,400

fertilizers, thousands ha						
Recover of unused irrigated lands, thousand ha per year	-	70.0	70.0	70.0	70.0	70.0
Increase of grain production, thousands tons	20,830.5	14,072.9	17,900.0	18,600.0	19,000.0	19,200.0
Export potential of grain, thousand tons	6,788.1	7,700.0	8,200.0	8,800.0	9,000.0	9,200.0

Source: adopted from the State development program of the agricultural sector 2010

The State development program of the agro-industrial complex sets challenging tasks and objectives, but on the other hand the level of wheat production has not fully recovered after the collapse of the USSR, after the production has dropped significantly the production of wheat has been slowly approaching the level of 1991 and 1992 (RCFA Ratings 2010). Besides the advantages of the state program, it has some flaws. The first obvious flaw is the concentration on wheat production which could lead to decreasing production of other agricultural commodities and thus to decreasing export of them. Before the Program was written Kourmanova *et al* (2008) have found that while the export of grain is increasing, the export of other agricultural items is shrinking, and while the government sets plans on triple expansion of area under wheat, production of other crops (barley, rye, buckwheat etc) will shrink because there will be less land suitable for cropping. For example, since 1991 the area under rye has significantly dropped and the country had to switch from self-sufficing itself with rye for baking bread to importing it (RCFA Ratings 2010).

The second crucial flaw is not underlining the importance of preserving the environment, nothing was said about the state support of small scale farmers in the remote areas, neglecting the growing demand on certified organic production. The concept of sustainable development was mentioned only once without explaining how does the government understand the sustainable development and by what means it is going to be reached. Environmentally benign technologies such as water and soil preserving ones were mentioned in the context of increasing productivity, although it would be better if they were mentioned in the context of strategic sustaining of the environment in the long term.

3.5. Increasing export potential of Kazakhstan's grain

Kazakhstan is already playing a role in international grain trade exporting its grain to 40 countries. The main importers of Kazakhstan's grain are Russia, Azerbaijan, Turkey, Saudi Arabia and other countries of the Middle East, Northern Africa and Europe. The countries of Central Asia (Uzbekistan, Kyrgyzstan, Tajikistan and Turkmenistan) are also very important market for Kazakhstan's grain, although the grain trade in Central Asia is far less its potential, but theoretically Kazakhstan could cover all the needs in grain of the Central Asia (Kourmanova *et al* 2008). To increase efficiency of storage Kazakhstan has invested in building storage facilities in Amirabad (Islamic Republic of Iran) and Baku (Republic of Azerbaijan), but also expanded the existing one in Aktau (Republic of Kazakhstan). Also some arrangements on transit of Kazakhstan grain through the territory of China and supply of Kazakhstan wheat to China are being elaborated (Materials from the Ministry of Agriculture). In January of 2010 the first patch of Kazakhstan's exported grain in amount of 10,1 thousand tons was loaded to the Chinese People Republic. In the present time the contracts of 10 thousand tons wheat supply to China were arranged with the company of "DEN", also with the "Food Contract Corporation" in amount of 20 thousand tons. The "Grain Union of Kazakhstan" revealed its plans about monthly load of 150 thousand tons of

grain and flour in the port of Liangyungan (China, Yellow Sea) to Japan and South Korea (Materials from the Ministry of Agriculture).

In the former Soviet there are three countries with the plans on increasing agricultural export and which experienced similar problems of contraction productivity and size of arable lands. There are some research dine on this issue and many authors agree that Russia, Ukraine and Kazakhstan can potentially play much bigger role on the international grain trade market. In most of the research those three countries are considered as one region and it can be difficult to derive figures specifically for Kazakhstan, so in the coming paragraph the statistics will be presented for the whole region, not to Kazakhstan in particular. According to EBRD (2008), those three countries altogether decreased their crop acreage on 23 million ha, while 11-13 million ha of them can be ploughed up again without considerable environmental cost, but Liefert *et al* (2008) assert that the scenario of expanding the size of arable lands beyond Soviet Union level is also plausible as prices continue to rise, but that will involve isolated marginal lands and high investments in infrastructure and environment preserving technologies will be needed. Rising global demand on grain, not only for nutrition but for biofuel as well, makes the situation when even not the most productive lands can bring substantial income and pay off all the costs (EBRD 2008), but increasing competition among the exporters leads to situation when the best grain in Kazakhstan is exported abroad (RCFA Ratings 2010).

In the coming decade the order of major grain exporters will be significantly changing. In the research of USDA made by Liefert *et al* (2009?) which was titled "Former Soviet Union region to play larger role in meeting world wheat needs" was stated that Russia, Kazakhstan and Ukraine can replace the USA as the world's "breadbasket" in 2019 with doubled export up to 50 million metric tons and share in the world grain trade equal to 33%. As it was stated in OECD-FAO Agricultural outlook released in 2007, CIS countries will increase the wheat

production and coarse grains up to 159 million tons by 2016, a 7% increase compared to 2007, and increase their export up to 14%. EBRD (2008) estimates the maximum potential for grain production of all three countries combined equal to 230 million tons, but this is possible only if all the applicable lands are ploughed up. There are different reasons for such a conclusion. One of them is that the production of wheat in the USA is shrinking due to wide switching of farmers for producing corn and soybean. The second reason is that the named three countries have substantial gap for increasing efficiency and expanding their arable lands which were abandoned because of economic crisis in the 1990s. The table representing past trends in using arable areas in the main exporters of grain is shown below.

Table 3. Past trends in use of arable land area (in million ha)

	1990-92 av	2003-05 av	Change in hectares	% change in area
China	124	142	18	15
Brazil	52	59	7	14
United States	184	175	-9	-5
Russia, Ukraine and Kazakhstan	200	177	-23	-12
Other countries	843	864	29	2
World	1,403	1,417	14	1

Source: FAOSTAT ResourceSTAT

As we can see from the table Kazakhstan, Russia and Ukraine experinced very big decrease of arable lands which backs the statements claimed by different researchers. This table also shows that there is a potential for expanding production and export.

Increasing acreage of cultivated lands is an extensive way of getting high harvests. After 2000 the strengthening intensification is being observed, when the yields rose by 25% (Liefert *et al* 2008). By 2016 Russia, Ukraine and Kazakhstan can potentially increase their yields by 11% due to improved management, plant genetics and new technologies taking into account countries with similar climate conditions but with much higher productivity (Liefert *et al* 2008). Regarding some other factors there is great gap for productivity. According to the research of EBRD (2008), Kazakhstan can approach productivity of crops already achieved in Australia. IKAR (Institure for Agricultural Market Studies, referenced as IKAR), a research institute in Russia, gave its own forecast for the development of grain production for those three countries, but here is presented only an extract for Kazakhstan.

Table 4.*Grain production potential of Kazakhstan – alternative scenarios*

	Transition period			**IKAR forecast for 2016-2018**			**Estimated maximum potential**		
	Avg 1992-1994	**Avg 2004-2006**	**Change (%)**	**IKAR forecast**	**Diff. between forecast and present**	**Change (%)**	**Max. potential**	**Diff. between max. potential and 2004-2006**	**Change (%)**
Cereals, area	21	15	-31%	17.5	3.0	21%	19	4	27%

harvested, mln ha									
Yields, tons/ha	1.06	0.98	-8%	1.27	0.3	30%	1.56	0.58	59%
Production, mln tons	23	14	-37%	22	8.0	57%	29	15	107%

Source: IKAR 2008

According to RCFA Ratings (2010), agro-industrial complex of Kazakhstan obviously gains in this situation as all the links of the production chain of it (producing, processing, distribution, and retail sales) will receive incentives for development. For example, it can develop processing industry as the existing capacities allow producing 6 million tons of flour per year (which is about the half of produced grain in grain equivalent), and the annual export rates can be brought to 2.5 million tons of flour per year, but only 30% of grain is processed to flour (RCFA Ratings 2010).

The role of big corporate farms is already enormous in the former Soviet Union countries and it will be probably strengthening with surging investments in efficiency, new technologies, seeds, better management, and research in general. In Kazakhstan they control 80% of all the agricultural output (EBRD 2008; RCFA Ratings 2010). Some of them are state owned and subsidized by the government. For example, the State Food Contract Corporation holds a sway on 10% of agricultural export (Mitra and Josling 2009).

There are different estimates of how much grain Kazakhstan can produce regarding many factors as climate change, world prices for grain, increased productivity enhanced with new technologies and fertilizers. RCFA Ratings (2010) estimated that without climate change

scenarios, only with proper management and policy Kazakhstan could increase its grain export up to 14 million tons, so theoretically it can be doubled.

It should be understood that not everything is smooth with exporting grain, and there are some possible pitfalls regarding the inner economic situation. Even if Kazakhstan suffices itself with grain on 157%, low purchasing power on the inner market and rising commodity prices worldwide could entice producers to sell more grain abroad to gain as much profit as possible. In such situation strong regulation is needed. In 2008 Kazakhstan had to ban export of grain because of bad weather conditions and consequently low harvests which led to increasing shortage of grain on the inner market and rising prices (Mitra and Josling 2009) which could possibly lead to social instability. In the end government has managed to ensure low prices but that has shaken the reputation of Kazakhstan of a reliable exporter. In response to that some countries of Central Asia started to develop their own production of wheat and processing industry and return to policy of self-sufficiency conducted in the 1990s.

One of the obstacles of rising grain export of Kazakhstan is its landlocked geographical location. Therefore, Kazakhstan has to pay taxes for transporting its grain through the territory of Russia and Ukraine, which affects Kazakhstani grain's competitiveness. The situation could possibly change in coming 10-20 years when prices are projected to decline (Rosegrant *et al* 1995), but this remains rather uncertain and will depend not only on supply and demand, but also on such factors as, for example, political stability of oil producing countries and therefore global oil prices. But anyway, such decline in prices will certainly favor Kazakhstani grain's competitiveness and policy-makers should include rising competiveness in the State Programs. Measuring competitiveness of Kazakhstan's grain is an important factor of export potential, the measure is based on how much farmers will receive for their products against the likely cost per ton (Meng *et al* 2000).

3.6. Environmental risks of increasing grain export and conservation agriculture in Kazakhstan

Intensive and badly managed agriculture were pertinent to Kazakhstan as well as to other republics during the Soviet era. With independence in 1991 Kazakhstan has received a legacy of degraded and eroded lands occupying 66% of the whole territory (RCFA Ratings 2010) and with losses of humus from 5 to 30% (Mizina *et al* 1999; Meng *et al* 2000).

The decade of economic crisis and dramatic fall of grain and livestock production has helped recover to some extent the most marginal lands, which were put to the category of land reserve. Also change of ownership helped lessen some pressure of agriculture on the environment, as agriculture became less stocked, less energy intensive, less plowing and monocropping (Hilkmann 2006).

As long as the government favors huge agroholdings, some concerns about environmental consequences remain because it seems to be contradicting to the principles of the sustainable development, because production in such farms is likely to be energy and recourse intensive. In the State development program of the agricultural sector for 2010-2014 the notion of Sustainable development was mentioned only once. It can be interpreted that the government is more concerned about getting high productivity at any cost and preserving environment is aimed on increasing productivity. To increase productivity the territories which are cultivated with moisture and soil preserving technologies (drop irrigation, zero-till, blade-plowing) are being expanded at rate around 15% annually (State development program on agricultural sector for 2010-2014). According to officials from the Ministry of Agriculture, annual losses of organic nutrient elements are equal to 2.5 million tons, which affects the productivity.

Rangelands and steppes of Northern Eurasia play important role globally as they sequester huge amount of CO_2 (Ministry of Environmental Protection 2009). Therefore poorly managed

cropping in the Northern Eurasia, and Kazakhstan in particular, can contribute to the global climate change. There is mutual influence of agriculture on climate change and of climate change on agriculture.

Since most of the cultivated lands are rainfed (Mizina *et al* 1999), there are growing concerns about climate change and its consequences among the scientists and policy-makers in Kazakhstan as grain production is considered to be vulnerable to climate change in Kazakhstan (see the table below) (National Human Development Report 2008). There are different predictions on the effects of climate change in Kazakhstan and Central Asia, but no prediction can be certain and precise. The water scarcity is the main limitation for agricultural production in Kazakhstan; in some regions harvest losses can reach 50-70% because of poor watering and precipitation (National Human Development Report 2008).

Table 5. Assessment of key sectors vulnerability to climate change effects in arid and semi arid zones of Asia

Food	Biodiversity	Water resources	Human health	Settlements
High vulnerability	Moderate vulnerability	High vulnerability	Moderate vulnerability	Moderate vulnerability

Source: National Human Development Report 2008

There is some research which concluded that Kazakhstan, especially Northern Kazakhstan, is likely to gain from climate change because of increased precipitation, warmer winters, prolonged vegetative season, expanded areas suitable for agriculture, and CO_2 fertilization effect (Parry *et al.,* 2004, Fischer *et al* 2005, Schmidhuber and Tubiello 2007; Lioubimitseva and Henebry 2009). If this scenario is right than the arid area will decrease to 38% of the whole territory of Kazakhstan and shift of climate zone to 50-100 km may occur (National

Human Development Report 2008). Yesserkepova (2010) on contrast disagrees with such statements arguing that there are three climate change scenarios: soft, medium and harsh, and even under medium scenario worsening conditions for spring wheat cultivation, decrease in crop yields by some 25-60% in the Northern Kazakhstan.

The average temperature is forecasted to grow from 2030 to 2050 by 1.5-3.5°C, the Northern Kazakhstan is predicted to receive more water, but the southern will probably have to adapt to more frequent droughts (IPCC 2007), which will increase already existing high vulnerability in that region since most of the population in the Southern Kazakhstan get their water from melting glaciers of Tien-Shan and Pamir-Alai mountains (Lioubimitseva and Henebry 2009). Lioubimitseva (2010) has mentioned that temperature increase in Central Asia is forecasted to be above world average, but such huge growth in the IPCC report in coming 20-40 years seems to be exaggerated. I assume that such changes could dramatically shift existing climate zones northward and totally alter ecosystems of Kazakhstan. Houghton *et al* (1996) give nearly the same figures (increase on 1-3.5°C), but it is global average by 2100. What is also very important in climate change predicting for agricultural purpose is the frequency of extreme events such as droughts, heavy rains, floods, and frosts the number of which is likely to be increasing globally (Lioubimitseva and Henebry 2009).

Many models also project increasing droughts in semi-arid growing zones of the Northern Kazakhstan. Rising temperature will lead to decrease of soil moisture, proliferating of insects, and spread of diseases (National Human Development Report 2008). In general, negative effect will prevail, as it is claimed in the National Human Development Report. It can boost productivity for a while because of increased concentration of CO_2, but the effect of high temperatures will overwhelm it. We can certainly state that it will have effects on population's welfare. Even now a basic subsistence of people's needs appears to be more problematic year by year (National Human Development Report 2008).

One of the long-term forecasts based on General Atmospheric and Ocean Circulation Model (AOGCM) which was taken from the National Human Development Report (2008).

Table 6. Possible climate change scenarios in general in Kazakhstan conforming to AOGCM results

Change	**Period**		
	By 2030 (2016-2045)	By 2050 (2036-2065)	By 2085 (2071-2100)
Of average annual temperature	+1,4 ℃ (+1,3 ÷ +1,9 ℃)	+2,7 ℃ (+2,3 ÷ +3,5 ℃)	+4,6 ℃ (+3,8 ÷ +5,9 ℃)
Annual precipitation	+ 2% (-2% ÷ +7%)	+ 4% (-3% ÷ +13%)	+ 5% (-5% ÷ +20%)

Source: National Human Development Report 2008

Table 7. Likely changes in seasonal precipitation (%) on average throughout according to AOGCM results

Season	**Period**		
	By 2030 (2016-2045)	By 2050 (2036-2065)	By 2085 (2071-2100)
Winter	+ 8% (+5%÷ +11%)	+ 13% (+8%÷ +18%)	+ 24% (+11%÷ +33%)

Summer	+ 5% (+1% ÷ +14%);	+ 0% (-11%÷ +18%)	– 11% (-28% ÷ +18%)

Source: National Human Development Report 2008

As we can see this model predicts significant increase of temperature and gradual lowering of precipitation during summer time, when is the growing period for grain.

To cushion possible negative effects of climate change on agriculture Mizina *et al* (1999) have elaborated a screening matrix of agricultural options which is presented below. Even it was elaborated more than 10 years ago it still remains topical and applicable.

Table 8. An evaluation of adaptation options for climate change impacts

Screening matrix for agriculture options

Adaptation	Must implement in advance	Target of opportunity	Other benefits	Low costs	Low barriers
Inform farmers about climate change	No	No	Yes	Yes	Yes
Develop forecast on snow reserving	No	No	Yes	Yes	Yes
Develop forecast on pests and diseases	Yes	No	Yes	Yes	Yes
Develop regional consultation centers	Yes	No	Yes	Yes	Yes
Provide permanent local	No	No	Yes	Yes	Yes

workshop for training on wheat growing					
Develop regional centers on genetic varieties of wheat	No	No	Yes	Yes	Yes
Make seed-banks sustainable	No	No	Yes	No	Yes
Develop long-term wheat reserves	Yes	No	Yes	No	Yes
Cultivate wheat on most fertile lands	Yes	No	No	Yes	No
Provide farmers with mid and long-term loans	Yes	No	Yes	No	No
Improve rules and laws on transition to market economy	Yes	No	Yes	Yes	Yes
Reduce soil erosion	Yes	Yes	No	Yes	Yes

Source: Mizina et al 1999

Given the increasing topicality of climate change in Kazakhstan and of conservation agriculture worldwide the author was expecting to find a research which would link conservation agriculture to combating consequences of climate change. Conservation (or organic agriculture) seems to be able to contribute to adaptation of climate change, but there

is little research done on this topic, especially on Kazakhstan. This is a substantial gap on agriculture research in Kazakhstan.

However, they were some projects introducing sustainable agriculture in Kazakhstan conducted by FAO and IFPRI. Hilmann Silke (2006) in his work "Conservation agriculture in Northern Kazakhstan and Mongolia" proposes different alternative ways to increase yields and preserve environment such as general agro-landscape management, alternative crop and pasture rotation, more timely planting and so on. All these techniques are useful because they minimize evaporation, erosion, and input of agro-chemicals, therefore they can be applied to adapt to climate change but it was not mentioned in the research.

3.7. Social consequences of increasing grain export

Development of the agricultural sector is considered to be as one of the most efficient ways of eliminating poverty or significantly reduce it. As it was mentioned above, 19% of the population is below poverty line (Kourmanova 2008). If to those people the number of people living near the poverty line is added, then we can see that there is a rather high potential for social tensions. A majority of poor population live in rural areas.

Rural poverty is connected to remoteness of roads, availability of water. RCFA Ratings states that small scale agriculture is the main flaw of productivity. State support to such small scale farmers is very difficult to deliver due to dire infrastructure, remoteness of their location. It is also difficult for them to obtain loans from banks cause there will be problems with realization of their production.

The change of ownership could change the problem, but during Soviet times the state provided more support to the peasants. The decree of the President of the Republic of Kazakhstan "About land" which has the power of law from 22nd of December 1995. The decree officially recognizes the right for private tenure for land, except for some categories of

land including agricultural. The new Land Codex from 20 June 2003 allows private owning of land for agricultural purposes.

Government and state owned companies provide considerable support to the farmers. In 2008 when the export of grain was restricted, the state bought 3 million tons of grain surpluses. An official from the Food Contract Corporation underlined importance of such action for several times during the interview. Also there was a program on improving living conditions in rural areas, so called The program of developing rural territories. The result of it alleged by the officials is that number of depressive, or in other words not perspective, villages is lowering. But there are some doubts is it lowering due to increase of wealth or because many people move from those places so that entire villages disappear. I personally observed that in 2010 during traveling in Northern and Central Kazakhstan.

However, there is still probability of social conflicts within the agricultural sector. First of it is the conflict between huge agroholdings and small scale farmers (Lioubimitseva 2010?). The second possible conflict is between cropping and animal husbandry because there are different program of developing grain industry and involving more lands in it, and there is a program on increasing export potential of meat which also will require more lands for grazing.

Chapter 4: Analysis and Results

4.1. Introduction

The present chapter is devoted to the analysis of feasibility and appropriateness of expanding practices of sustainable agriculture in Kazakhstan in order to meet the goals set by the government in the *State development program of agricultural sector in Kazakhstan from 2010 to 2014* particularly the build-up export potential of Kazakhstan's grain by increasing its production. Also in this chapter the forecast for grain production is presented in the third section answering the question where it will be possible by 2050 bearing in mind the consequences of global climate change.

In the present chapter I tried to answer the research questions stated in the introduction which are: 1) "What are advantages and disadvantages of expanding of sustainable grain production in Kazakhstan?"; 2) "What sustainable approaches can be used to improve productivity of grain production stiffed by low temperatures and moisture stress?"; 3) "What are the perspectives of grain production in Kazakhstan in coming decades bearing in mind climate change?". In other words the questions can be shortly presented as "why?", "how?", and "where in future?".

4.2. Justification of sustainable agriculture in Kazakhstan

This section of the present chapter tries to justify the appropriateness of increasing adoption of sustainable agriculture in order to advance grain production in Kazakhstan, and evaluates the costs and benefits of sustainable agriculture and its limitations in Kazakhstan. The justification of sustainable agriculture in Kazakhstan is very crucial for the further analysis because it is the bottom-line, the basis of the whole chapter. The main focus is not on the

proving that traditional agriculture is harmful in many terms, but on the advantages of sustainable agriculture.

It was mentioned in the previous chapter that the agriculture, and especially grain production, is highly dependent on weather and can fluctuate significantly from year to year. The latest example of such dependence is the present year. According to the USDA (2011), Kazakhstan's wheat production is going to experience a dramatic decrease of harvest (up to 43%) with yields 0.67t/ha compared to the previous year with yields equal 1.67 t/ha (average yields for the last 5 years are 1.07 t/ha). To mitigate such dependence on weather, different means how to make agriculture more sustainable can be implemented or expanded in their use. As the head of JSC "KazAfroInnovations", Serik Kenenbaev told in the interview that the organic agriculture (or any other type of sustainable agriculture) alone cannot solve all the problems of the agricultural sector, but combined with traditional it can give better results than traditional agriculture alone as sustainable agriculture uses a holistic approach to agriculture (Horrigan *et al* 2002) and embraces environmental soundness, economic profitability, social acceptance and political support (Reeves *et al* 2000). These mentioned four features (environmental soundness, economic profitability, social acceptance and political support) will be the basis for justification of sustainable agriculture in Kazakhstan.

One of the main concerns about sustainable agriculture is its economic profitability, but the advantages of sustainable agriculture can be seen over the long-term as it preserves the basis of production unlike industrial agriculture. However, in the short-term as well alternative agriculture can prove its viability. For example, rotation of crops can increase the yields comparing to traditional ways of growing (Reganold 1990). Case-studies from Africa show that organic agriculture can improve wealth of small communities ensuring food security (UNCTAD-UNEP 2008). Besides these opportunities, sustainably produced agricultural products have high-added value, and middle class of developed and developing economies is

willing to pay for it (Pretty and Hine 2001). For Kazakhstan it would be advantageous to grow grain sustainably and certify it as organic because the rising middle class of neighboring China can be a very profitable market for Kazakhstan's sustainably grown grain. I assume that the grain markets of China, India and rapidly growing economies of South-East Asia are not saturated with certified organic grain and flour. To estimate the opportunities of Kazakhstan's organic grain export to those countries economic and social research should be conducted.

The most notable feature of the concept of sustainable agriculture is its preserving attitude towards the environment. Taking into account that most of the soils are already deteriorated to different extent and the whole Kazakhstan is in the zone of risky agriculture, it would be sane to endorse sustainable agriculture by subsidies and other economic incentives. The main environmental concerns of grain producers in Kazakhstan are the lack and quality of water, and degradation of soil resources. Equipping small-scale producers with new water saving technologies and educating them might make a difference due to a better management of small farms.

Sustainable agriculture also has opportunities in the social terms. Public concern about health issues of traditionally grown products caused demand on organic products. The biggest social benefit of organic agriculture is improved public health since the organically grown food does not have or has less agro-chemicals in it. Second social benefit of it is the closer connection between producers and consumers which will increase accountability of producers. Absence of mediators might have effects on lowering prices. Thirdly, politically supported sustainable agriculture may reduce rural poverty in Kazakhstan which may reduce social tensions in the country.

Political supportability is the main weak point in the perspectives of the development of sustainable agriculture, especially organic agriculture. As it can be obtained from the State Development program of the agricultural sector of Kazakhstan, the government is more concerned about rapid increase of agricultural export, primarily, grain. Such situation resembles the mastering of virgin lands in 1950s which had noble intentions, but in the ended up with controversial results due to degraded environment, and therefore decreased productivity. The government should pay more attention to sustainable and small scale organic agriculture, as their products also may conquer economic niche on inner market and in the export structure. Another evidence of lack of political support of organic agriculture in Kazakhstan is that there is no organic certification in Kazakhstan and organic production is not regulated by any law. As soon as the government realizes the benefits of the organic production it might give more support to it. In fact there is no support to organic farmers from the Ministry of Agriculture, because high ranking clerks in the Ministry consider environmental issue of agriculture somehow be a subject of Ministry of Environmental Protection, but the Ministry of Environmental protection in turn consider this topic to be related to their colleagues from the Ministry of Agriculture (personal conversation with Vice Minister Saktash Khassenov)

4.3.Alternative agriculture

The main question of the present section is "What approaches can be used to improve productivity given the natural and climate conditions of Kazakhstan?", in other words it describes how the goals set by the government in the *State development program of agricultural sector from 2010 to 2014* can be reached in the specific conditions of Kazakhstan.

The basis for the present section is the interview with the president of state-owned JSC "KazAgroInnovations" Serik Kenenbaev, academician of Kazakh Academy of Agricultural Sciences, professor. He said during the interview, conducted in May, that alternative agriculture can be a real mean of achieving high productivity and keeping environmental damage within the acceptable range, but only if it is combined with the traditional agriculture. The organization he leading is involved in elaborating of new efficient approaches in agriculture.

Answering the first question about what is the likeliest scenario for grain production in Kazakhstan in coming 30-40 years, Serik Kenenbaev said that it is difficult to predict the amount of produced grain by 2050, but what is more or less certain is that climate change will aggravate the existing problems of environment. However, severe droughts of the last years should not cause radical change of land use and technologies, stated Serik Kenenbaev. Elaborated and applied technologies have proved their efficiency and adaptation to regional conditions, but further corrections are possible, for example, review of structure of cultivated crops favoring drought resistant crops and sorts, expand of minimal resources and moisture-saving technologies, and expand of aero-landscape approach to organization of land-use. The head of the company admitted possible strengthening of GMO and agro-chemical corporations such as "Monsanto" and "Syngenta" as a form of adaptation of farmers, taking into account that "Syngenta" already has its branches in Kazakhstan. The government and the society however must be careful and vigilant about GMOs, as the consequences of them are unknown. Also simple adaptive improvements in management can contribute significantly to cushion possible consequences of climate change and boost the productivity. As examples of such measures the professor mentioned snow-storage, absorbing of melting waters, preventing of expenditure of humus etc.

The interviewee told his vision on what the grain production in Kazakhstan will be like in coming decades. Firstly, he said, there will immediate processing of grain at places of its production. Secondly, the products of processing of input raw materials will either serve as products for other technologies of processing, or will be returned to soil. Thirdly, the producer will be maximal close to consumer. Fourthly, agriculture will restore the fertility of soils, not deplete it; sane processing of soils according to natural laws, sane rotation of crops according to domestic needs and outer demand, precise timing of all technological operations, the paramount object will be the work with soil, saturating it with moisture and nutrients. As it can be observed from these statements the professor implies development of small scale farmers and small scale milling factories and adoption of sustainable means of agriculture in Kazakhstan. Further the interviewee said that it will require development of agricultural sciences and nowadays trends of its development are becoming positive. The highest position in the state-owned organization allows us to say that the professor told not only his opinion, but the official point of view.

During the interview the professor underlined the importance of new technologies, but there may be difficulties with introducing them as farmers are usually very conservative and very carefully decide about using a new innovation. Furthermore, small farmers usually cannot afford it as innovations cannot be cheap or free. In this case the governmental support should be increased.

Speaking about methods of sustainable agriculture, the professor said that nowadays there are various ways and concepts of increasing productivity and at the same time decrease pressure on the environment. One of the ways of increasing efficient use of lands is *lowering of till*, which is now being widely implemented on more and more territories. Such technique allows decreasing pressure on soils, prevent erosion, reduce expenditure of fuel because traditional plowing is much more energy intensive. The latest research of the organization of

"KazAgroInnovations" have proved that in dry years the most efficient way of cultivating grain crops is direct sowing on unprepared soil, so called zero-till. Zero-till agriculture is also called "the concept of self-recovering agriculture". Passages of tractors are decreased to a minimum, but it requires an expensive aggregate where functions of pre-seeding treatment, input of fertilizers, sowing and packing are combined. On the other hand, the cost of all operations separately is roughly equal to the cost of one operations conducted by this new tractor. According to the Ministry of Agriculture, in 3 years 80% of all arable lands will be under reduced tillage and now it is more than 60%. All the plans are supported by subsidies for no-tillage wheat (up to $6 per hectare) than for traditional-tillage wheat (approximately $3 per hectare) The Ministry also plans to increase government subsidies for herbicides (USDA 2009).

Elaborated in the Research Institute of grain farming named A. Baraev *moldboardless plowing* is another technique adopted by Kazakhstan's agrarians which ensures moisture saving of seeding by 25-30%. These two techniques can be very efficient even during very dry years. According to the web-source www.agrosector.kz, the drought occurred in 2010 was one of the most drastic of the last 70 years, but nevertheless the yields were around 8 cwt/ha which is comparable to normal years. This became possible due to moardless plowing, no-till techniques and maximal preserving of stubble on the surface.

One of the efficient ways of increasing productivity of dryland farming is to convert agriculture on the biological basis. For this, new principles based on the *theory of ecosystems* which provides analysis of matter and energy flows in the chain of "soil-plant-atmosphere". Change of agro-chemical concept on agro-biological, which implies the decrease to possible minimum of anthropogenic influence on agro-ecosystem, will allow creating maximum of auspicious preconditions for sterling use of its own biopotential. In the present biological

agriculture is developing in following directions: organic, organic-biological, permaculture and so on.

The use of techniques of moardless plowing and zero-till allowed decreasing clean fallow by 20% (USDA 2010) which in turn increased output of grain. The latest research in the areas more or less sufficient precipitation (from 400 mm and more) show that clean fallow significantly reduces efficiency and it is expedient to cultivate them. This allows increasing the output of grain in 1.5-1.7 times.

At the same time the practice is showing that applying only traditional or only biological agriculture lead to some problems. For example, applying only organic fertilizers cannot recover the balance of potassium and phosphorus in the soil as well as applying only traditional ways of agriculture can lead to environmental problems. Therefore, integrated approach is needed. As an example of such approach can be landscape system of agriculture (adaptive landscape agriculture). We do not produce fertilizers and plant protecting chemicals, but these products are necessary. Kazakhstan's agricultural production is considered to be environmentally safe. In Europe on 1 ha of arable land minimum 500-600 kg of mineral fertilizers are put. In Kazakhstan the maximum of application of fertilizers occurred in 1986 when on 1 ha of arable land 29 kg of mineral fertilizers were put. Now the level of application of mineral fertilizers is around 10 kg. Using chemical means of plant protection not only harmful plants and insects, but also useful microorganisms are being killed. The adoption of bio-methods will help rebuild the balance of microflora of soils.

It must be mentioned that the agriculture in present is a saturated system, which means that further build-up of yields cost higher. Therefore, mastering of cheap means of biological agriculture is topical in our country. The crisis condition of agriculture and economy does not

allow us to do harsh intensification. We need to use alternative ways one of which is biological agriculture.

Briefly the summary of proposed techniques:

- Governmental subsidies to fertilizers, pesticides and technical equipment
- More extended reduce of zero-till.
- Introduction of rotation, especially including oilseeds and legumes.
- Expansion of the arable lands should be very careful.

4.4. The geographical analysis and the forecast to 2050

The present chapter describes and analyzes the map created by the author in ArcGIS software. The data for creating them was taken from web-sources of www.worldclim.org and www.fao.org/geonetwork. The main result of this chapter is the Figure 12 where the projection for growing grain by 2050 is given. The chapter is giving an answer on the question "Where in future the grain production in Kazakhstan will be possible?".

First what should be analyzed is the existing climatic constraints for grain cropping. As it can be seen on the Figure 1 there are three dominant types of climate constraints in Kazakhstan: severe moisture constraints, temperature constraints and wetness constraints. All the territory of Kazakhstan is under different constraints, there is no place in Kazakhstan where no constraints are present. The biggest part of the territory is under severe moisture constraints. National Atlas of Kazakhstan affirms this statement, showing that number of days with atmospheric drought can reach 100 days in the North and more than 180 in the South. Big parts of Northern and Eastern Kazakhstan are under temperature constraints. Especially in the Eastern Kazakhstan the climate is extremely continental with the average January temperature equal to -20°C and July average temperature equal to +20°C (National Atlas of Kazakhstan 2006). On the rest of territory the climate is considered to be continental, but not extremely continental. The wetness constraints are in the mountainous areas where the slopes make growing more unfavorable. This information is fundamental for planning agricultural activity. Severe climate constraints dominating in the most of the territory of Kazakhstan make cropping impossible, unless huge investments are made, but still in this case the risks are extremely huge. The case study of Saudi Arabia's grain growing promoting self-sufficiency has led to gradual increase of grain output and sudden and harsh plummeting due to depleted water recourses (Postel 1998). Of course, the climate conditions of Kazakhstan and Saudi Arabia are incomparable, but this scenario should be kept in mind if the policy-

makers would decide to expand arable lands so far in pursue of gain. In fact severe moisture constraints contribute to high gluten content of the Kazakhstan's grain, and therefore for a better quality of a better quality of it. The dryer the land, the higher is gluten content, but higher values of such grain cannot compensate the losses of yields during dry years (USDA 2009). As said the Vice Minister of Agriculture during the interview, Kazakhstan normally in 10 years has 4 years of droughts.

The Figure 2 represents the length of growing period which on the most of growing areas is 30-59 days. A thin strip of land where the length of growing period can reach 89 days coincides with more fertile soils and consequently higher yields are collected there. This is another constraint because comparing to other grain producing countries Kazakhstan has a disadvantage in it as the length of growing period, for instance, in Europe is bigger. For example, on British Isles it is 200 days, in North Scandinavia is 139 days and in Great Hungarian Lowlands is 202 days (Chmielewski 2003).

The Figure 3 shows the map of fertile soils of chernozems and kastanozems (chestnut soils). It shows an area where grain could be potentially grown if there were enough precipitation. This area is much bigger than the area where cereals are grown now. Theoretically it could be expanded to the Luvic kastanozems, but I assume that practically it is associated with very high environmental risks of soil degradation and high energy and materials inputs. Naturally, not all of the soils have the same productivity, in fact the most the more to the South the less auspicious soils are. A map taken from the National Atlas of Kazakhstan (2006), Figure 4, shows that the area of fertile soils is somewhat less, and that fertility of soils in the main grain producing regions is just average and higher than average.

The next three figures should be analyzed together. The Figure 5 shows the current mean temperature in Kazakhstan, Figure 6 shows the forecasted mean temperature by 2050 and the

Figure 7 shows the difference between two maps. The mean temperature plays a very important role in vegetation of cereals, and low temperatures can be a constraint. On the map of climate constraints we can see that the low temperatures create obstacles for grain in Northern Kazakhstan. As can be obtained from the map the grain in Kazakhstan grows on the areas with mean temperatures equal to -1.7 - 5°C. Comparing the current mean temperature and the projection for 2050 it can be stated that the range of temperatures will increase as it is from -5.9 to 14.8°C in present and projected to be from -6 to 17.6°C by 2050. It means that the Northern parts of the country and Eastern mountainous areas will experience cooling and in the Southern parts the temperature will be increasing. It also can mean that there will be more often such extreme events as droughts and frosts. In the main grain producing part of the country, the Northern, the range of temperatures will change from -1.7 to 5.0°C to -5.9 to 7.3°C. The climate conditions for agriculture are becoming more extreme. As Southern Kazakhstan is going to receive higher mean temperatures that can mean the glaciers in the Tien-Shan and Pamir mountains are going to melt causing floods at the first time, but then the water resources including for irrigation will decrease. Given that higher temperatures will increase evaporation, it is going to accelerate the problem and will require significant adaptation for the new conditions. It will also boost the conflicts as most of the rivers in Central Asia are transboundary.

The next three figures show the present monthly precipitation, the projection for 2050, and the change of it from 2010 to 2050. The precipitation is another key factor of the grain producing and the agriculture in general. By comparing the map of cereals and the mean temperature map it can be obtained that the grain production in Kazakhstan is happening where the monthly precipitation is from 25 to 56 mm/month. The range of monthly precipitation on the whole territory will be slightly changing from 9-73 mm/month to 8-77 mm/month. The conditions for grain growing in the Northern part will not change

significantly and will not affect the productivity much as the precipitation will decrease on 2.9-1 mm/month which is within the acceptable range. The main constraint in the Northern part is going to be the temperature. The decrease of precipitation will affect irrigated grain production in the South combined with increase of temperature. The decrease of precipitation will be equal to 4.9-1 mm/month, in some regions of the South no change of precipitation is projected.

For creating Figures 11 and 12 the maps showing suitable areas for grain cropping in present and by 2050. The layers were taken from the datasets of www.worldclim.org (Global Climate Data), which has predictions from IPCC 4 up to 2080. For the purposes of the present research data on 2050 is enough, because the preciseness of long-term forecasts causes many doubts. Layers of the current situation of precipitation and mean temperature of the world were taken and then the territory of Kazakhstan was extracted from them. After that the in the layers of precipitation and temperature the conditions suitable for growing grain were identified and separated from the maps. Then al the three layers of precipitation, temperature and fertile soils were superimposed which allowed identifying the areas suitable for grain growing. After that the slopes were taken out of the resulted area. The same algorithm was used to create the projection for 2050.

Knowing the raster cellsize it was possible to calculate the results of mapping. Total areas suitable for agriculture is given to be equal to 1,300,619,6 km^2, which is much bigger than territory currently used for the grain cropping. The limitations of this map were described in the Methodology chapter. The main result of the geographical analysis is the calculated area suitable for grain production by 2050. This area is equal to 629,044.39 km^2. As we can see, the area of suitable lands is going to decrease on 52% which is more than a halve. Kazakhstan will need to elaborate new strategies and policies to adapted to constraint conditions.

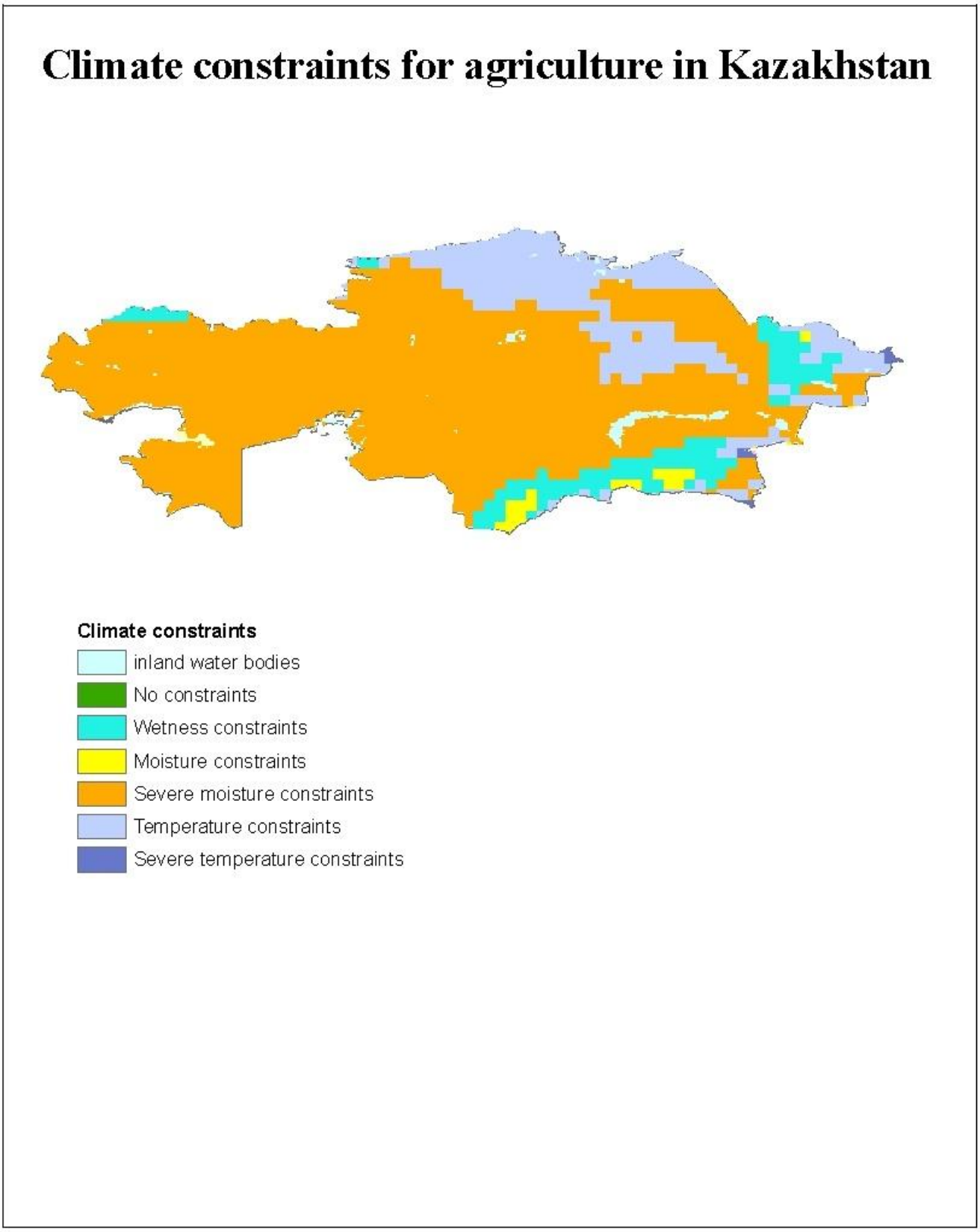

Figure 1. Climate constraints for agriculture in Kazakhstan.

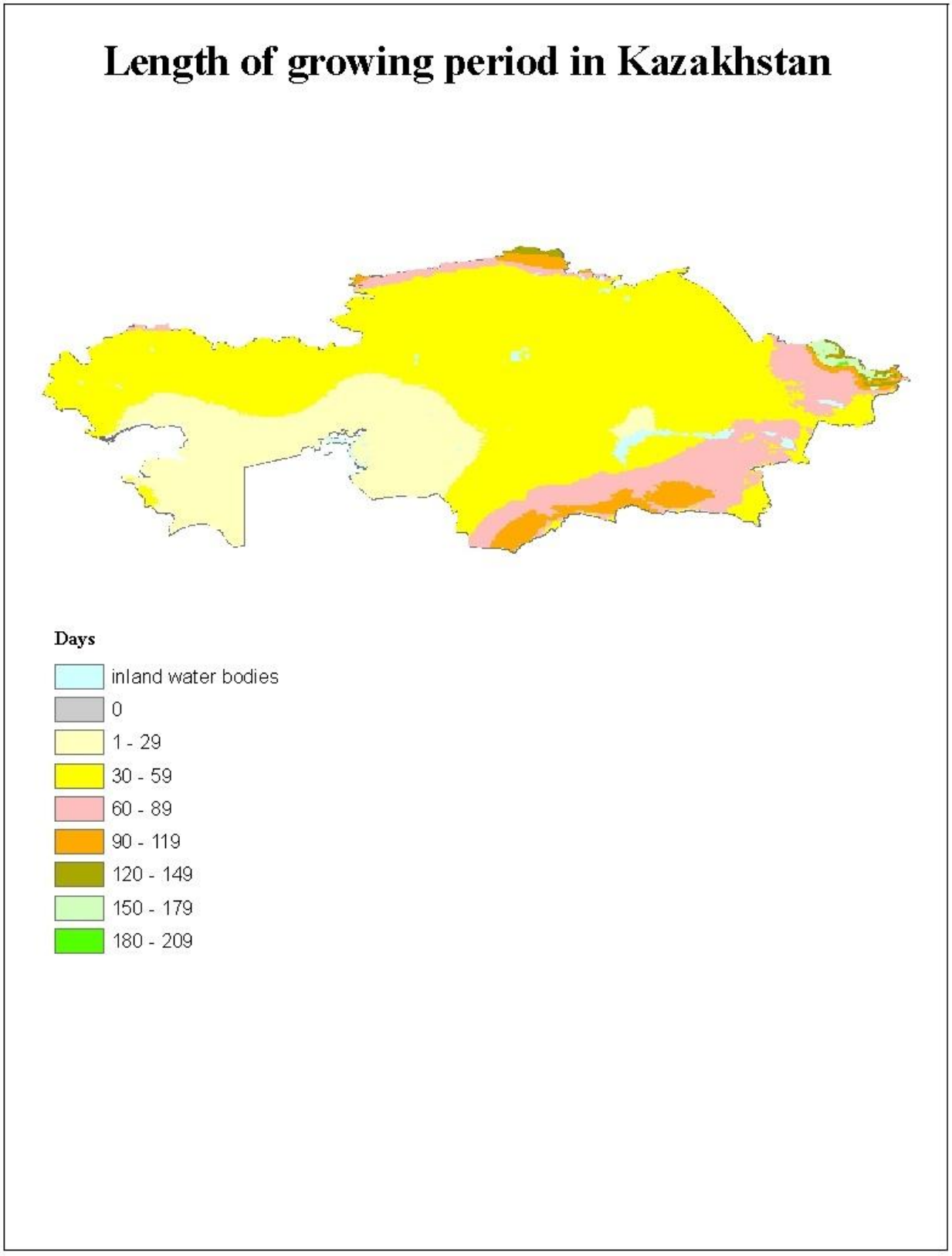

Figure 2. Length of growing period in Kazakhstan.

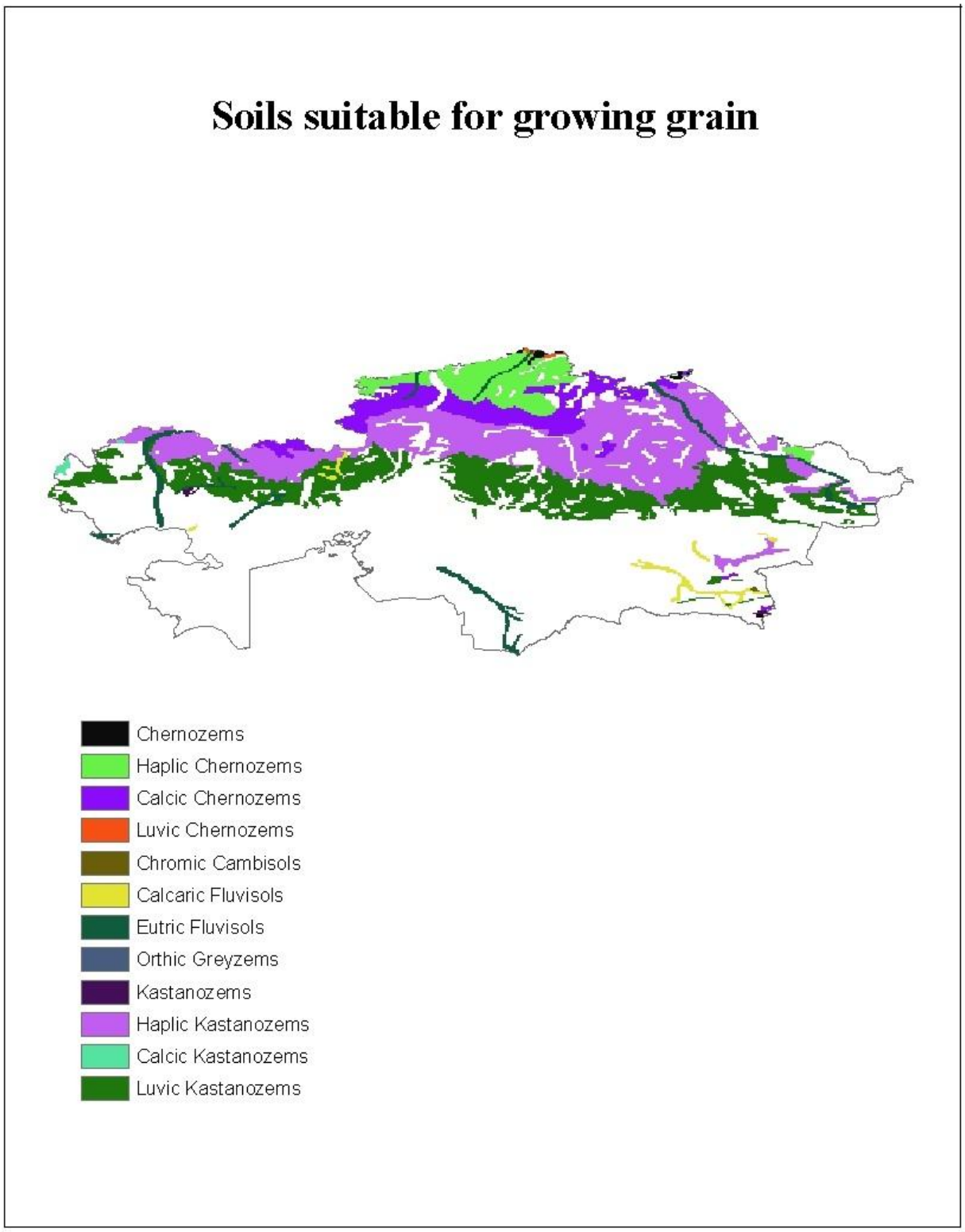

Figure 3. Soils suitable for growing grain.

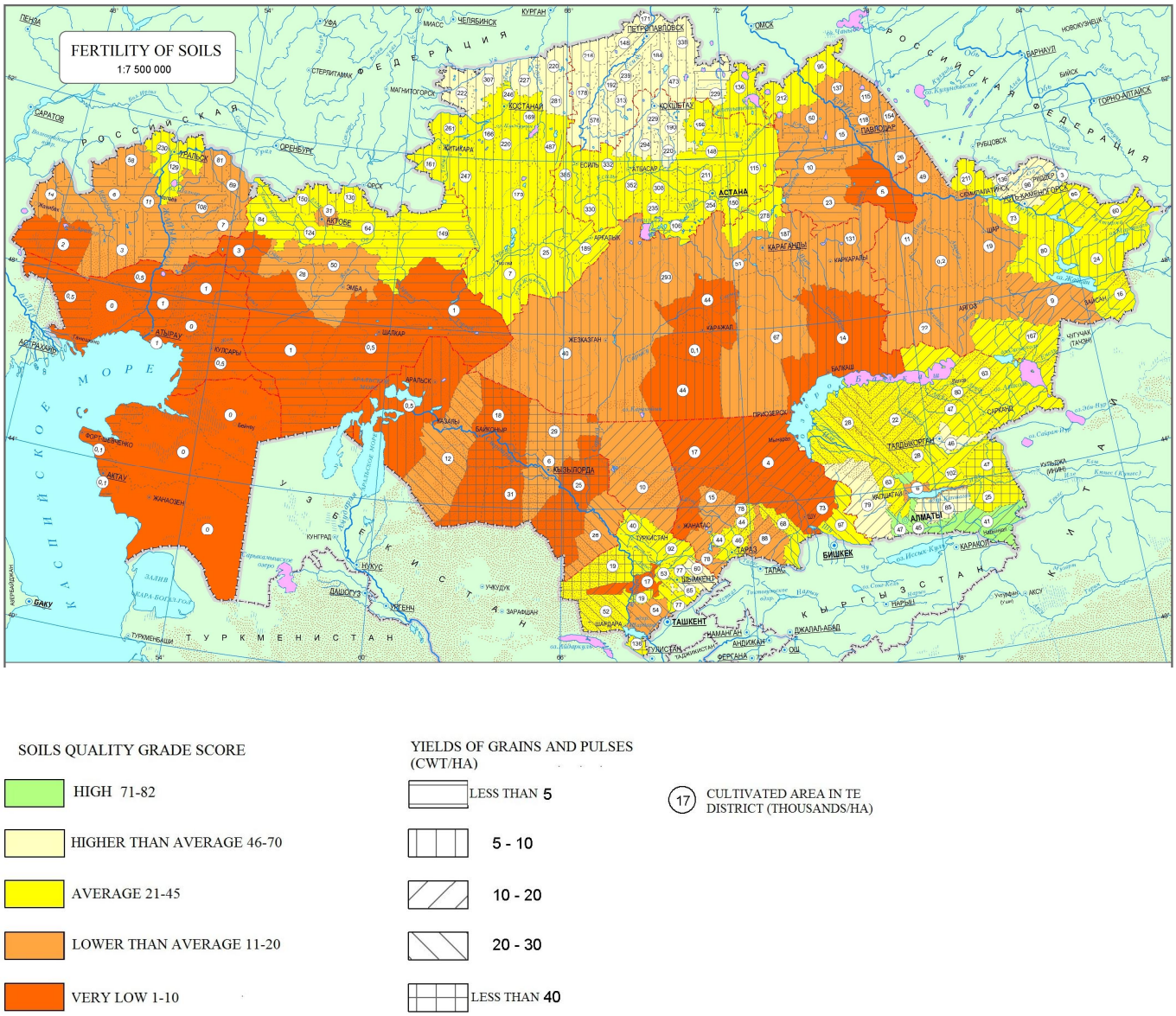

Figure 4. Fertility of soils

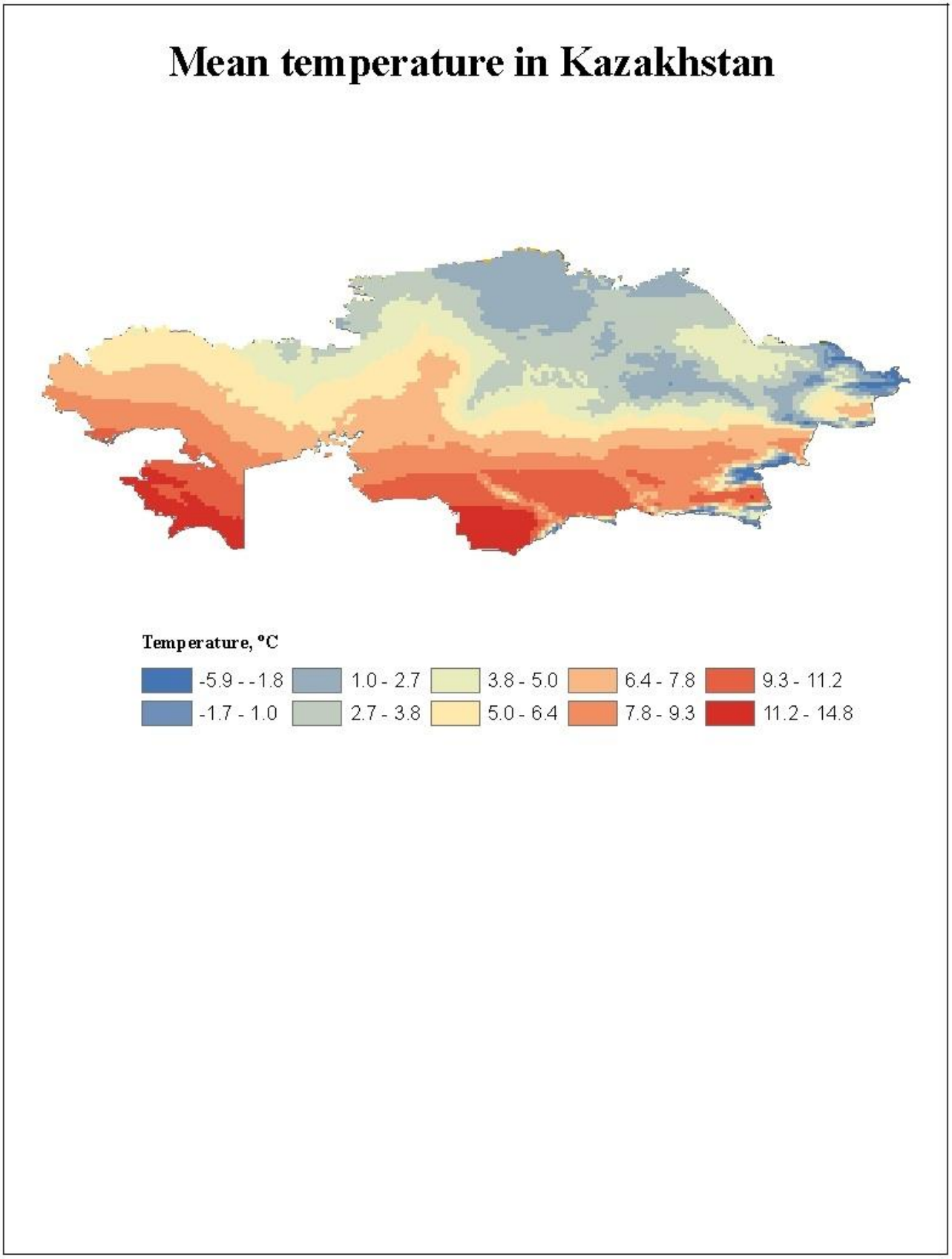

Figure 5. Mean temperature in Kazakhstan.

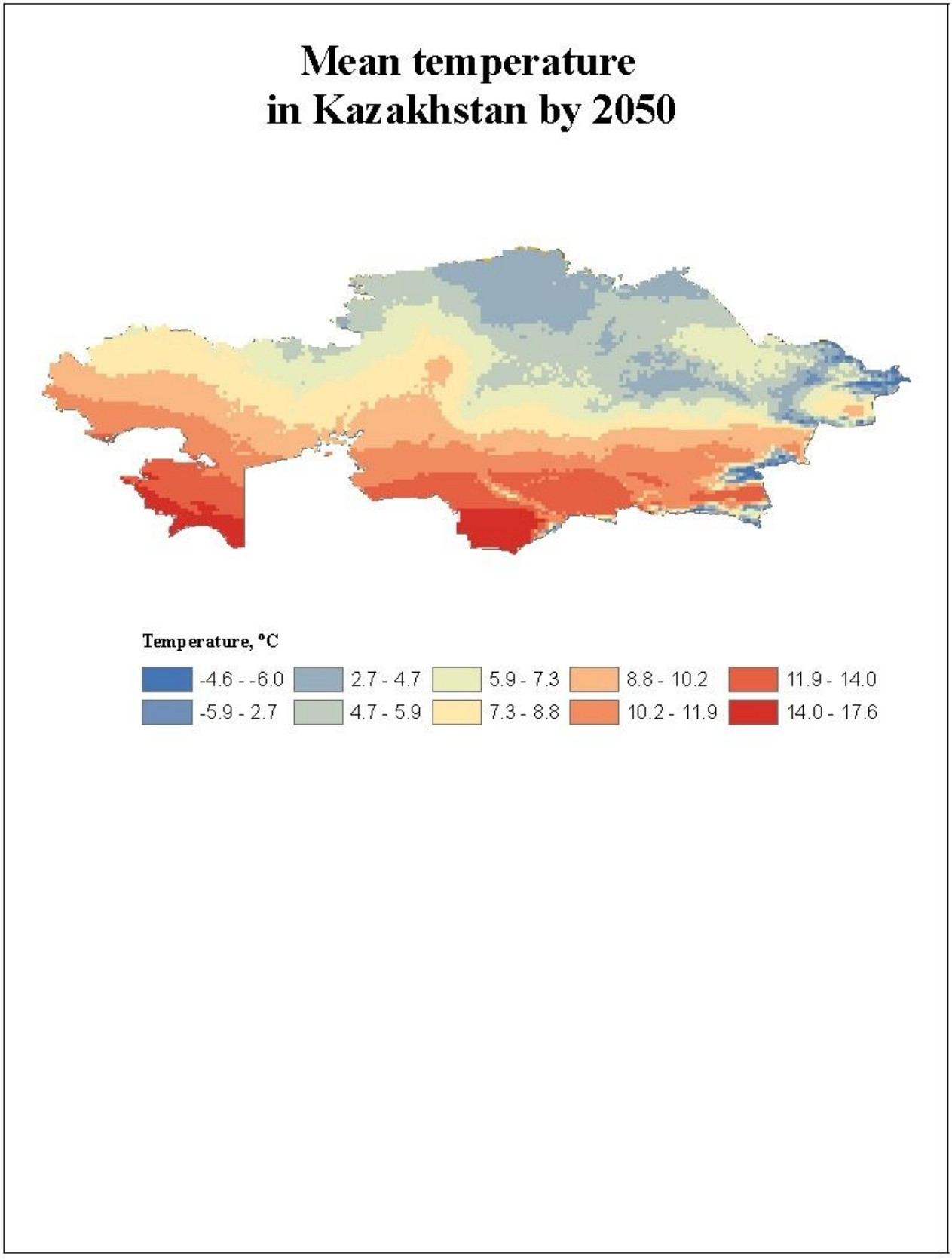

Figure 6. Mean temperature in Kazakhstan by 2050.

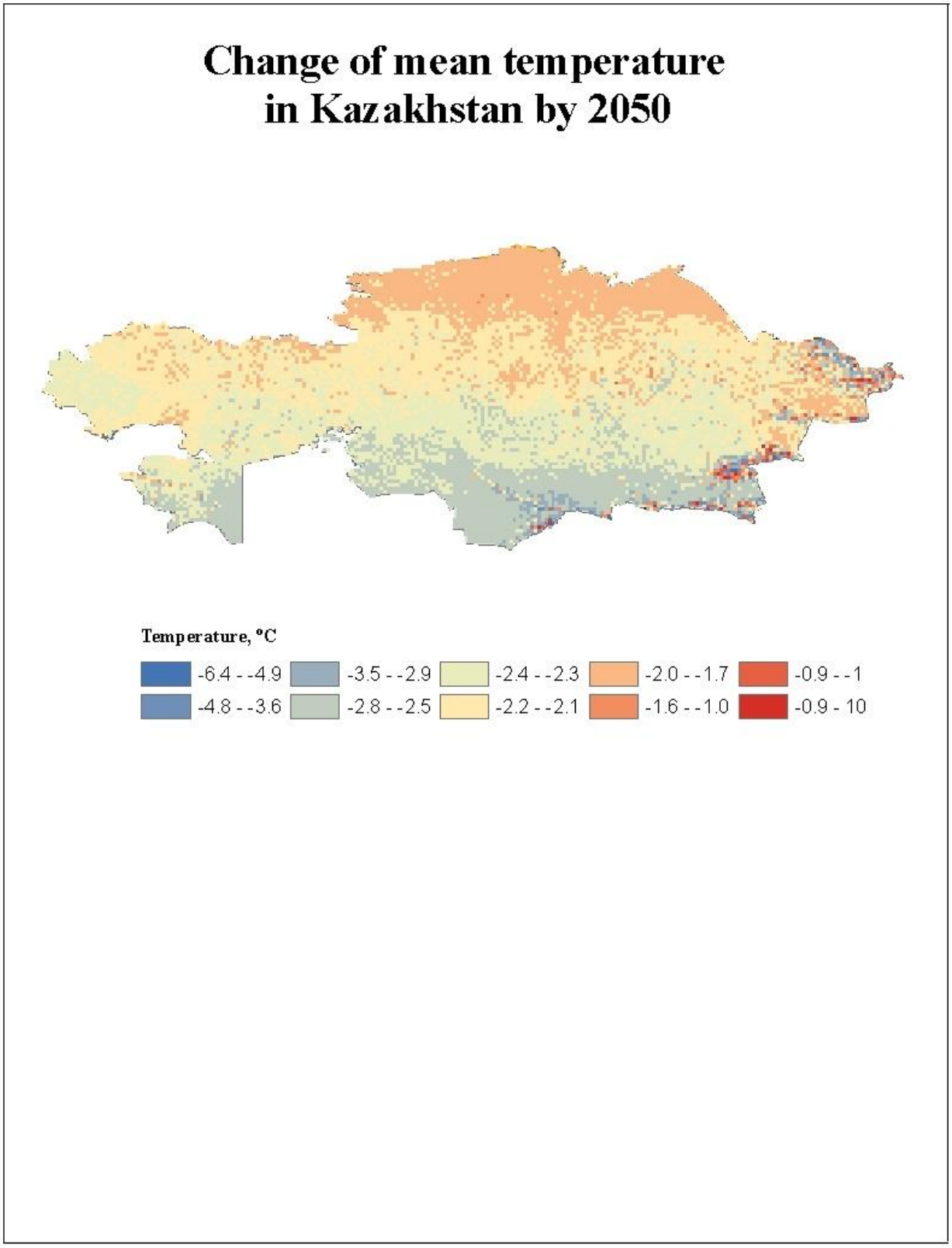

Figure 7. Change of mean temperature in Kazakhstan by 2050.

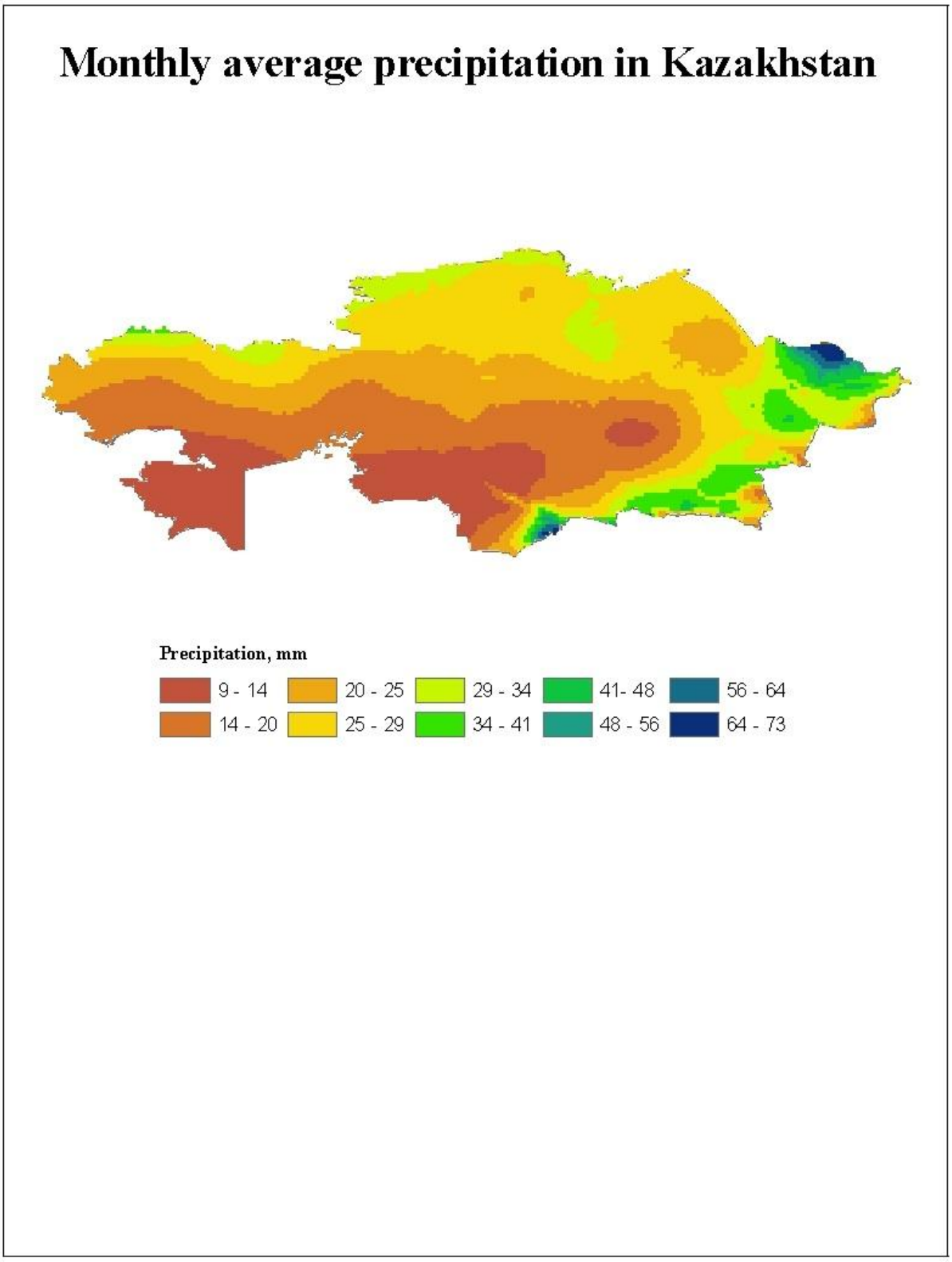

Figure 8. Monthly average precipitation in Kazakhstan.

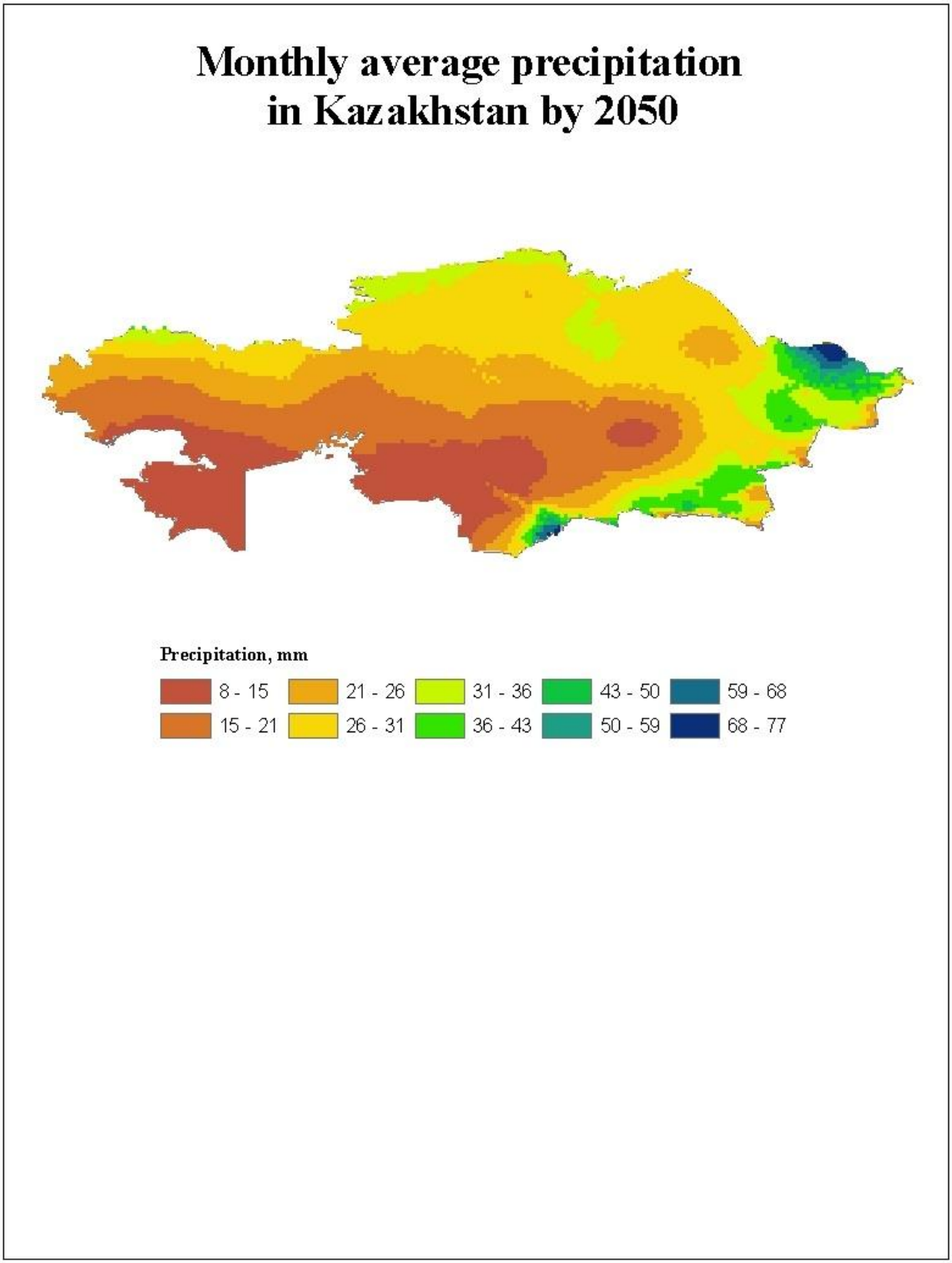

Figure 9. Monthly average precipitation in Kazakhstan by 2050.

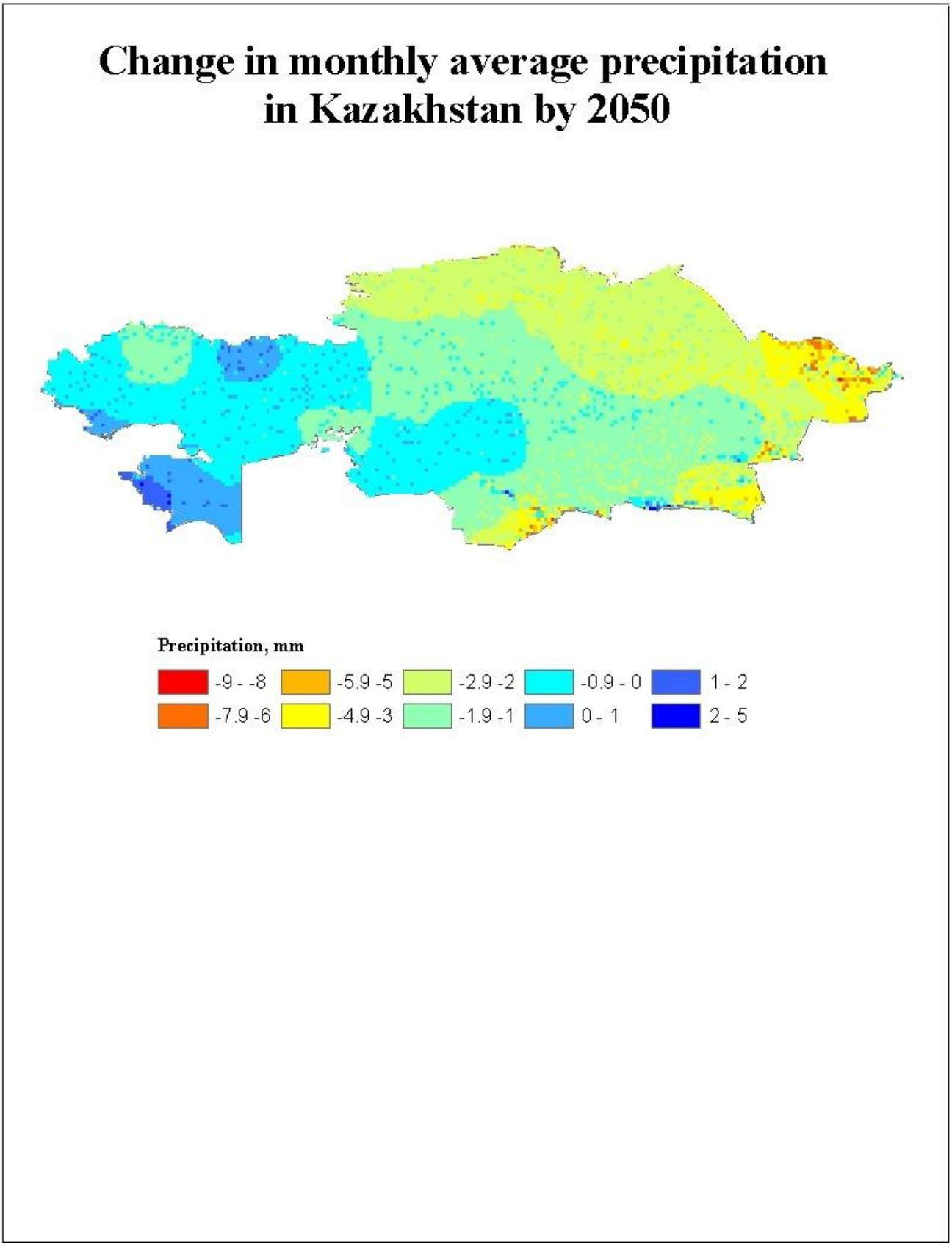

Figure 10. Change in monthly average precipitation in Kazakhstan by 2050.

Figure 11. Area suitable for growing grain in Kazakhstan.

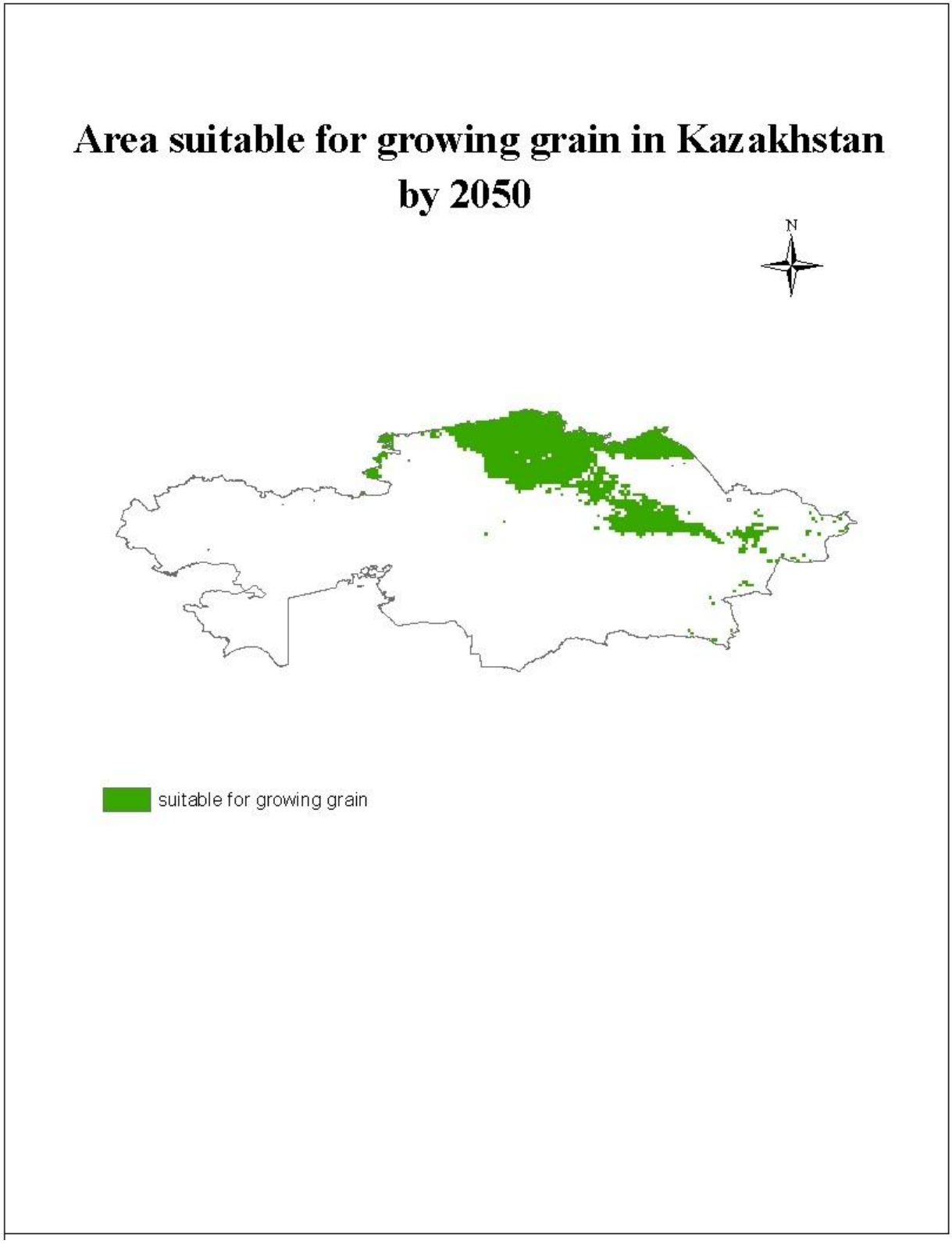

Figure 12. Area suitable for growing grain in Kazakhstan by 2050.

The results of the mapping in ArcGIS have shown that influence of climate change on agriculture should be taken more seriously into consideration. In fact climate change should be considered as the main threat to sustainable agriculture in Kazakhstan and will have many environmental, economic and social implications.

Chapter 5: Conclusion

5.1. Summary

The results of the research, as well as of international experience, has shown that sustainable agriculture can contribute for the build-up of export potential of Kazakhstan's grain and can be a tool for adaptation and mitigation of Kazakhstan's grain sector to environmental degradation and potential consequences of climate change. Furthermore, organically produced grain can conquer a solid niche among the rising middle-class of developing countries of South-East Asia due to proximity for them and that their markets are not saturated with organic production.

It should be kept in mind than fully sustainable agriculture cannot fulfill economic expectations of farmers and state, but combining it conventional gives better results than each of these types of agriculture alone. The existing techniques of zero-till, moardless plowing and some other can increase productivity so they can also contribute to the export potential of Kazakhstan's grain.

It is likely that in coming 40 years the grain production of Kazakhstan will have to develop under constraint conditions due to climate change. The area suitable for grain growing is possible to decrease by a halve. Therefore, adaptive strategies must be elaborated. The result of such changes can be a decreased export potential of grain.

5.2. Suggestions for further research

Firstly, it is be recommended to conduct a Life-Cycle Assessment (LCA) of conventionally and sustainable grown grain in Kazakhstan to evaluate their environmental impact on every stage of production starting from producing equipment for growing them and ending with

packaging and transporting them to consumers. It will also allow conducting a comparative research.

Secondly, it is recommended to conduct an economic research of sustainable agriculture in Kazakhstan and compare it with conventional.

Thirdly, it is recommended to conduct a research on the potential of China's rising middle class for Kazakhstan's organically grown grain.

Fourthly, it is recommended to conduct a research on adaptive strategies of Kazakhstan grain sector to the climate change with economic calculations of possible losses of decreasing of total size of arable lands.

The last recommendation is to conduct a research on social impacts of organic grain production in Kazakhstan.

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