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**Working Paper**

## Russia's food security and climate change: Looking into the future

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## **Russia's Food Security and Climate Change: Looking into the Future**

*Sergey Kiselev, Roman Romashkin, Gerald C. Nelson, Daniel Mason-D'Croz, and Amanda Palazzo*

### **Abstract**

Global climate change presents long-term risks to agriculture. In general, global climate change is expected to positively affect Russian agriculture. In high and middle latitudes, global warming would expand the growing season. Acreages of agricultural crops may expand toward the north, although yields would likely be lower due to less fertile soil. However, in the south there is a possibility of drier climate, which has a negative impact on crop yields and livestock productivity. In addition, climate change is expected to increase the scarcity of water resources and encourage weed and pest proliferation, and it is expected to increase the short-term risks associated with an increase in extreme weather events and natural disasters. This paper uses data on current conditions to simulate future scenarios and examine possible impacts on crop production in the Russian Federation. It also considers adaptive measures for agriculture in response to climate change.

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## Introduction

The first part of this paper is an overview of the current food security situation, the underlying natural resources available in Russia and the drivers that lead to the current state, focusing on income and population growth. The second part reviews the Russia-specific outcomes of a set of scenarios for the future of global food security in the context of climate change. These country-specific outcomes are based on IMPACT model runs from July 2011.

In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Working Group reports that “climate is often defined as ‘average weather’. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years)” (Le Treut et al., 2007, pg.96)).

The unimpeded growth of greenhouse gas emissions is raising average temperatures. The consequences include changes in precipitation patterns, more and more extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.

Agriculture is vulnerable to climate change in a number of dimensions. Higher temperatures eventually reduce yields of desirable crops and tend to encourage weed and pest proliferation. Greater variations in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there might be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. The impacts are

- Direct, on crops and livestock productivity domestically
- Indirect, on availability/prices of food domestically and in international markets
- Indirect, on income from agricultural production both at the farm and country levels

## Regional impacts of climate change

While the general consequences of climate change are becoming increasingly well known, great uncertainty remains about how climate change effects will play out in specific locations.<sup>1</sup> Figure 1 shows changes in average precipitation globally between 2000 and 2050 for four General Circulation Models (GCMs), each using the A1B scenario. Figure 2 shows the change in average maximum temperature. In each set of figures, the legend colors are identical; a specific color represents the same change in temperature or precipitation across the models.

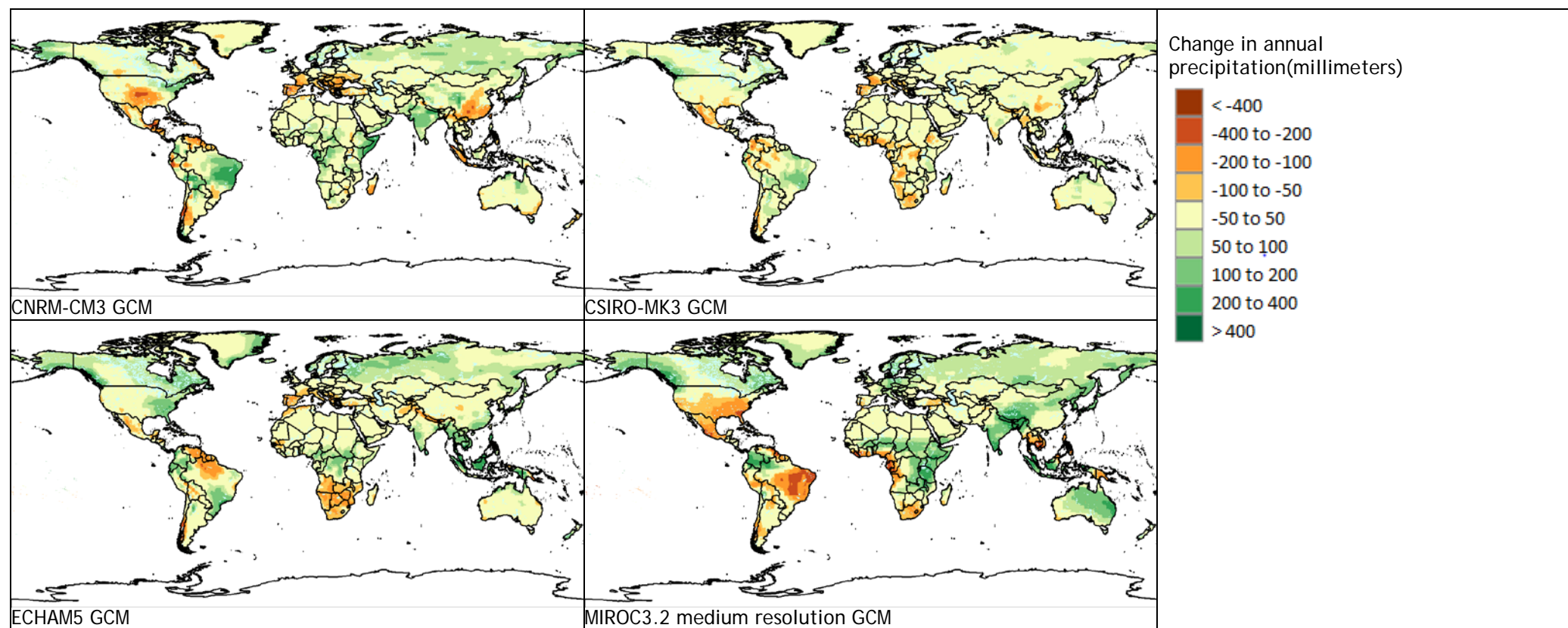
A quick glance at these figures shows that substantial differences exist. For example, in Figure 1 the MIROC GCM predicts that Southeast Asia will be much drier, while the ECHAM model has the same region getting wetter. In South Asia, the MIROC GCM has an increase in precipitation, especially in the northeast, while the CSIRO GCM has a drier South Asia. In northeast Brazil, the CNRM GCM shows significant drying while the MIROC scenario has a sizeable increase in

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<sup>1</sup> To understand the significant uncertainty in how these effects play out over the surface of the earth it is useful to describe briefly the process by which the results depicted in the figures are derived. They start with global (or general) circulation models (GCMs) that model the physics and chemistry of the atmosphere and its interactions with oceans and the land surface. Several GCMs have been developed independently around the world. Next, integrated assessment models (IAMs) simulate the interactions between humans and their surroundings, including industrial activities, transportation, agriculture and other land uses and estimate the emissions of the various greenhouse gasses (carbon dioxide, methane and nitrous oxide are the most important). Several independent IAMs exist as well. The emissions simulation results of the IAMs are made available to the GCM models as inputs that alter atmospheric chemistry. The end result is a set of estimates of precipitation and temperature values around the globe often at 2 degree intervals (about 200 km at the equator) for most models. Periodically, the Intergovernmental Panel on Climate Change (IPCC) issues assessment reports on the state of our understanding of climate science and interactions with the oceans, land and human activities.

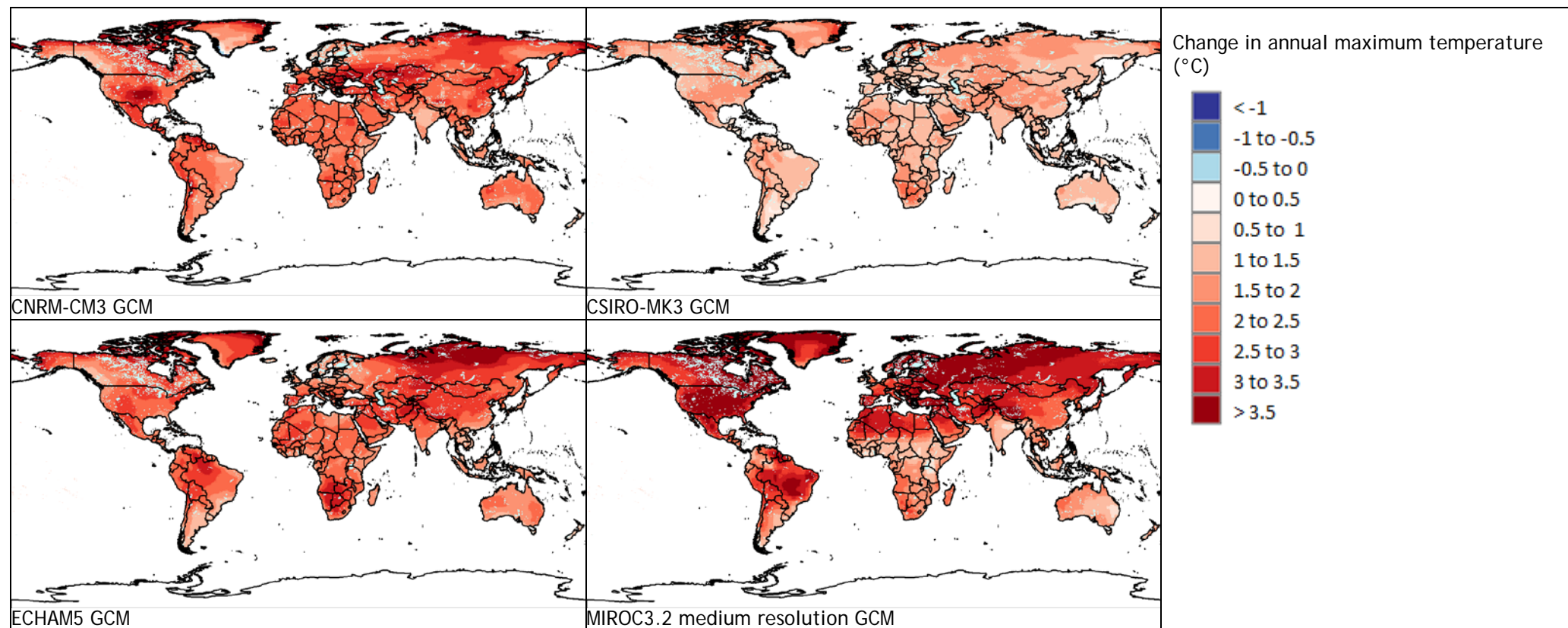
precipitation. In Figure 2, we see that the MIROC and ECHAM GCMs predict very big temperature increases for northeast South Asia, but they differ on whether northwest South Asia will also experience such a severe temperature increase. These figures illustrate qualitatively the range of potential climate outcomes using current modeling capabilities and provide an indication of the uncertainty in climate-change impacts. The differences across models are why policymakers must avoid seeking specific solutions for specific locations - unless there is significant agreement across models. Rather, it is important to note general trends and to consider policies that are helpful and robust across the range of climate outcomes.

Figure 1. Changes in mean annual precipitation between 2000 and 2050 using the A1B scenario (mm per year).



Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org>.

Figure 2. Changes in annual maximum temperature between 2000 and 2050 using the A1B scenario (°C)



Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>.



## **Agriculture, Food Security and Russian Development**

The food security issues in Russia are in the focus of attention for policy-makers. Several official documents were adopted in recent years. One of the most important is the Food Security Doctrine, which was approved by the Decree of the President of the Russian Federation of January 30 2010, #120. The issue of food security is in the focus of current agricultural policy. In the draft of the State Program of Development of Agricultural Sector and Regulation of Markets of Agricultural Products, Raw Materials and Food for 2013-2020" among goals on the first place is "provision of food independence within the parameters defined the Food Security Doctrine of the Russian Federation"

In Russia, there is a clear understanding of the strong impact of climate factors on yield and agricultural efficiency. Climate risks have been included in the list of risks in all major official documents as possible obstacles for achieving goals and tasks of agricultural development.

Since 1999, Russia's agriculture has demonstrated positive dynamics. The exception to this trend was 2010 due to extremely abnormal drought in a majority of the regions of the Russian Federation.

Growth in agricultural output was influenced by an increase in prices for agricultural products, and growth of consumer demand for food due to rising real incomes. The domestic support increase in the frameworks of implementation of Priority national project "Development of agro-industrial complex", State Program of agricultural development and regulation of the markets of agricultural products, raw materials and food for 2008-2012, support for market infrastructure development contributed to strengthening competitiveness of domestic agricultural and food products.

However, the Russian Federation is still heavily dependent on international food markets as a net food importer. The increase in imports is accompanied by an increase in agro-food exports. Since 2002, Russia has significantly increased its grain supply to the world market.

The growth of agricultural production is not sustainable due to significant climatic risks of agricultural activity, risks of increased competition from imports of agricultural and food products, reduction of the population, and the possibility of worsening macroeconomic conditions.

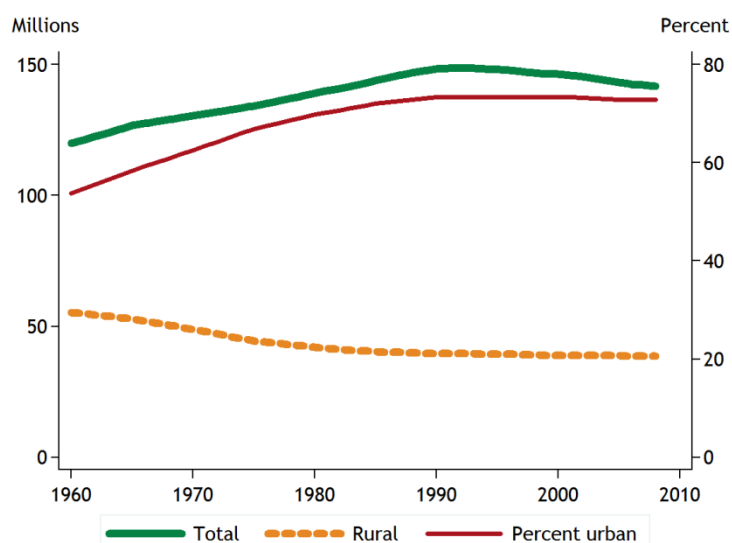
From the demand side relatively low incomes, high share of food expenditure in the structure of consumer spending and a huge differentiation in income indicate a high vulnerability of Russia's population to food prices shocks.

## **Review of the Current Situation**

### **Population**

Figure 3 shows total and rural population (left axis) and the share of urban population (right axis) in total population of Russia. Since 1994 there has been reduction of population in Russia at the background of relatively stable percentage indicators of urban and rural population.

Figure 3. Population Trends: Total Population, Rural Population, and Percent Urban, 1960-2008



Source: World Development Indicators (World Bank, 2009)

Table 1 provides additional information on average annual rates of population growth. It should be noted that in the mid-90s reduction in total population had been largely mitigated by an increase in rural population. The increase in rural population in that period was due to substantial migration flow of Russian-speaking population, refugees and immigrants from the former Soviet Republics. Since 1995 the inflow of migrants into the rural areas declined sharply, that resulted in the reduction of the rural population.

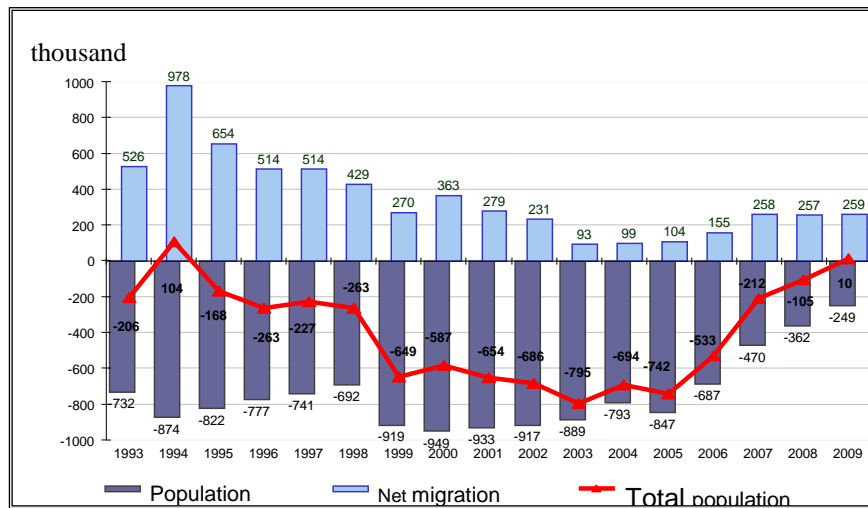
Table 1. Average Annual Population Growth Rates, 1960-2009 (%)

Decade	Total Population Growth Rate	Rural Population Growth Rate	Urban Population Growth Rate
1960-1969	0.87	-0.95	2.45
1970-1979	0.58	-1.38	1.77
1980-1989	0.64	-0.71	1.24
1990-1999	-0.01	0.14	-0.06
2000-2009	-0.34	-0.32	-0.35

Source: Calculations, based on The RF Federal State Statistics Service data

The economic recovery and GDP growth were accompanied by a decrease both in rural and urban population till 2009. In 2009, the population of Russia increased by 10.5 thousand people or 0.01%. It was the first population increase since 1994. The population growth occurred due to a significant decrease in population loss and increase in net migration. The resident population of Russia on January 1, 2010 amounted to 141.9 million, of which 103.7 million people (73%) - urban population, and 38.2 million (27%) - rural population.

Figure 4. Population Trends: Population loss and net migration, 1993-2009



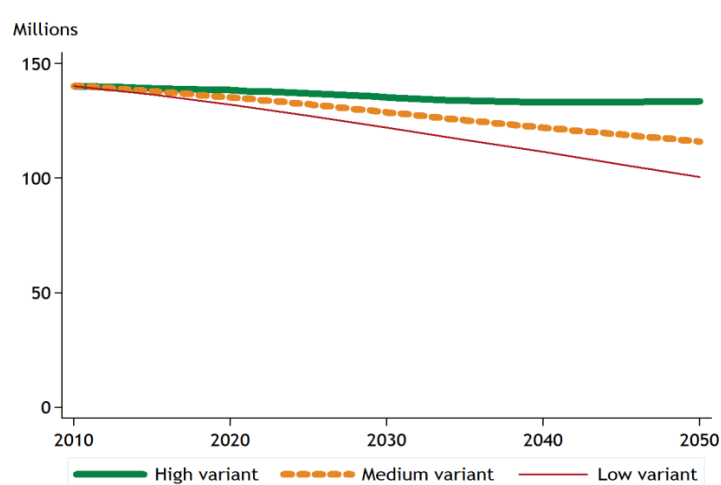
Source: Present demographic situation in Russia (The RF Federal State Statistics Service, 2010)

Changes in population in 2009 had no effect on its distribution. More than a quarter (26%) of Russia's population live in the Central Federal District, where the population density is 57 persons per square kilometer. It is the highest indicator in Russia, where the average population density is 8.3 persons per square kilometer.

Other densely populated areas are located in the North Caucasus Federal District, where the population density is 54 persons per square kilometer. Republic of Sakha (Yakutia), Kamchatkiy Region, Magadan Region, Nenetskiy, Chukchiy, and Yamalo-Nenetsiy Autonomous Districts are the most sparsely populated. The population density in these regions is less than 1 person per square kilometer.

Figure 5 shows population projections by the UN Population office through 2050. Under different scenarios, there is a trend of declining population in Russia.

Figure 5. Population scenarios for 2010 to 2050

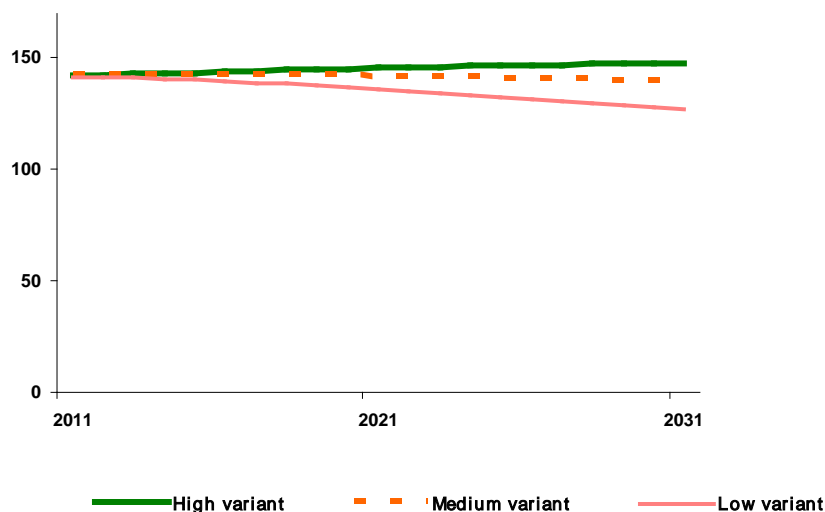


Source: UN Population Projections (United Nations 2008).

However, the UN Population Projections are different from the official Russian projections. The latter are characterized by a moderate population decline for the medium and low scenarios, whereas

the high scenario demonstrates a slight population increase in Russia. This scenario is very optimistic and it is far from existing reality. Probably it reflects the desire of Russia's political leaders.

Figure 6. Population projections for 2011 to 2031



Source: The RF Federal State Statistics Service.

## Income

The income available to an individual is the single best indicator of their resilience to stresses in the agricultural and food markets. Figure 7 shows trends in GDP per capita and proportion of GDP from agriculture. The agricultural share is included both because its vulnerability to climate change impacts as well as an indicator of the level of development of the country. As development increases, the importance of agriculture in GDP tends to decline.

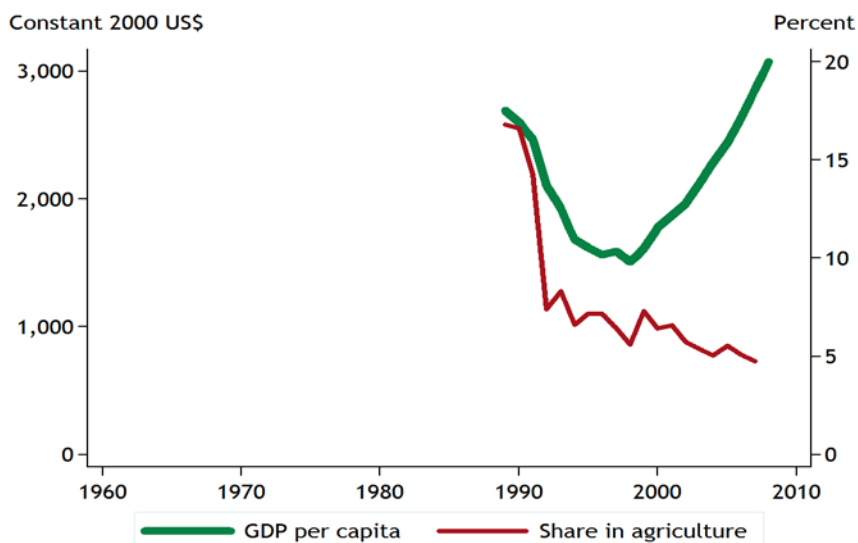
Since 1999, the Russian economy has been growing quite rapidly. During the period from 1999 to 2010, the average annual GDP growth rate was 5.4%. The cumulative GDP growth for the period following the default of 1998 amounted to 186.7%.

Also the positive dynamics affected Russia's agriculture. The average growth rate of gross agricultural production for 1999-2010 amounted to 2.4% per year. During this period the decline in agricultural production was observed only in 2010 due to abnormal drought. In 2010 agricultural production declined by 11.3%.

The following factors contributed to the increase of agricultural production in Russia:

- Favorable weather conditions
- Real incomes growth
- Development of the food industry, generating demand for agricultural output
- Strengthening the role of vertically integrated companies (agricultural holdings) in Russia's agricultural market
- Increase in domestic support for agriculture (availability of soft crediting) and application of program-target methods of regulation in agricultural sector

Figure 7. Per capita GDP (constant 2000 US\$) and share of GDP from agriculture

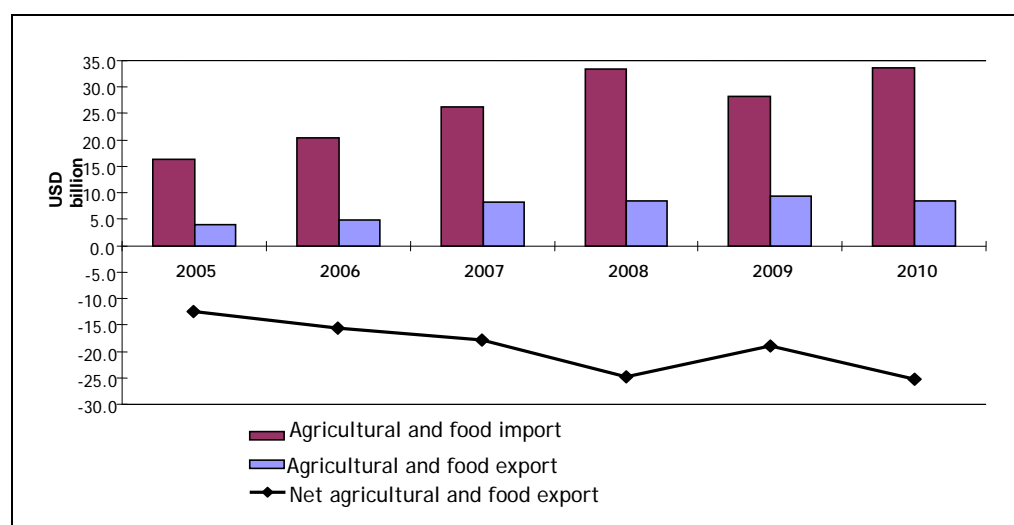


Source: World Development Indicators(World Bank 2009).

Growth in agricultural production occurred along with the increase of agro-food imports as a result of real appreciation of national currency, increase in real disposable incomes, increase of domestic prices for the agricultural products, and the limited capacity to meet consumer demand through domestic production. Meat, dairy products and raw sugar are the most sensitive to imports.

During 2008-2010, the values of agricultural and food imports reached a record level. The average annual value of agricultural and food imports for this period totaled to 31.8 billion dollars. This is almost 52% more in comparison with the preceding three-year period of 2005-2007.

Figure 8. Foreign trade in agricultural and food products in Russia, 2005-2010 (USD Billion)

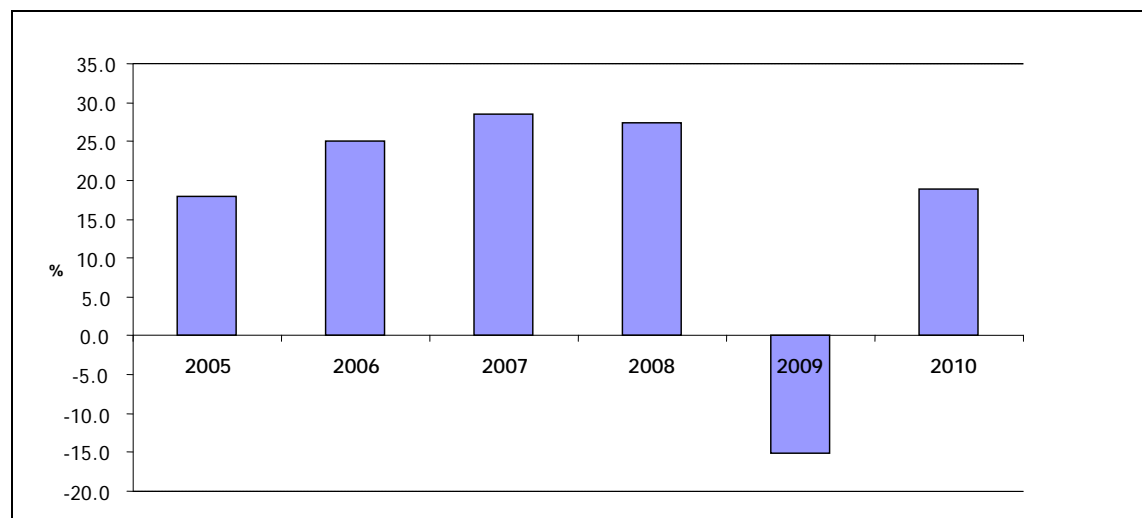


Source: The RF Federal Customs Service

The significant increase in agro-food imports was accompanied by a slowdown in its growth rate. In 2008, the agro-food imports increased by 27.5% compared with the previous year. In 2010, the growth rate of imports was 18.8%. This increase in imports can be explained by the 15% reduction in the value of imports in 2009 due to national currency devaluation, the decrease of world prices for agricultural

and food products, and the increase of demand for domestic production. However, in 2010, the growth of the value of imports has led to an increase in net imports of agricultural and food products to 25.2 billion dollars. The share of imports of agricultural and food products in total imports of the Russian Federation amounted to 15.5%.

Figure 9. Growth rates of agricultural and food imports in Russia, 2005-2010 (%)



Source: calculations based on the RF Federal Customs Service data

Russia's agro-food export has been growing along with the import increase. Since 2002, Russia became one of the largest suppliers of grain in the world market. In addition, the modernization of the food industry contributed to increasing Russia's export of beer, ice cream, dairy and meat products. Increasing exports reflect an increasing competitiveness of the domestic food industry.

### Climate Changes

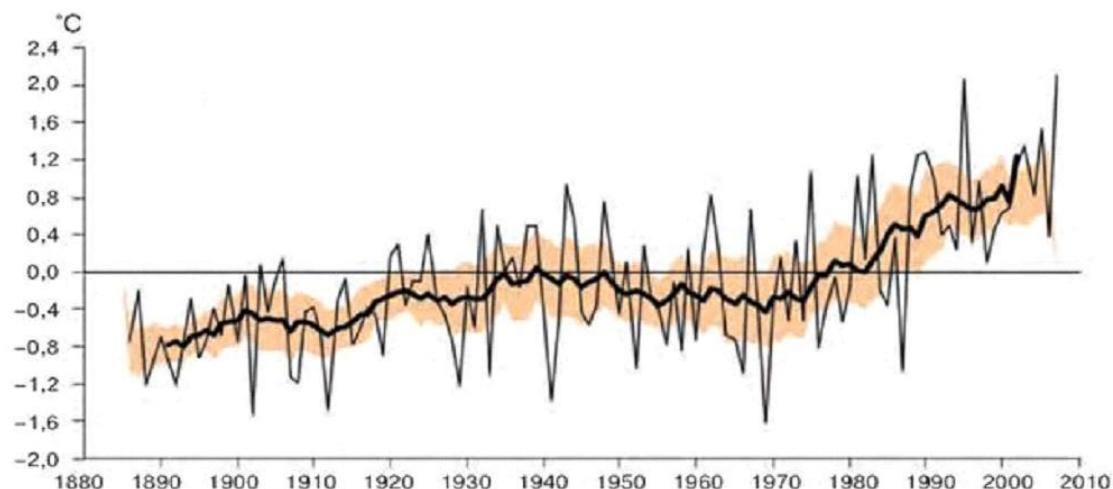
Climate changes are clearly visible in Russia. These changes appear in the increase of average annual temperature and precipitation.

According to Roshydromet, the average temperature increased by 1.29°C over 1907-2006 in Russia, that almost twice surpasses a world indicator. The last years are characterized by rather warmer weather that allows making a conclusion about an increase in the rates of a warming. Warming is more appreciable in the spring and in the autumn.

The vegetation period increases and the agricultural zone extends due to warming. However there are also the negative consequences of warming connected with expansion of areas of distribution of various plant pests and diseases. By estimations of the Ministry of Emergency Situations, shift of permafrost borders may open variolic and anthracic burials. Besides, according to the British ecologists, permafrost thawing may cause to additional emission of 85 billion tons of greenhouse gases in the atmosphere. Compared to 13 billion tons, which are released into the atmosphere by all mankind of a planet, such greenhouse gas emission can lead to climate calamity.

Warming will cause to the growth of intensity of forest fires. By estimates of the Ministry of Emergency Situations, duration of the fire-dangerous period in the middle latitudes of Russia may increase by 30-40% or by 50-60 days taking into account the existing rates of warming. As a result of forest fires depth of soil frost penetration will increase, the superficial drain and water erosion in vast territories will amplify, the probability of floods will raise under conditions of plentiful precipitation and fast snow thawing. These processes will impact negatively on agricultural production and fertility of soils.

Figure 10. Temperature deviation from the average temperature of 1961-1990 in Russia (°C)



Source: the RF Federal Meteorological Service data.  
The smoothed curve was obtained by 11-year run averaging

Not only temperature conditions but also rainfall amount is important for agricultural production. By and large the changes are favorable for Russia – annual rainfall has increased by 7.2 mm per 10 years over 1976-2006. This trend remained unchanged in 1976-2010, and annual rainfall increased by 8.5 mm per 10 years. In whole over the period from 1936 the annual rainfall increased in the 50s, and dry-weather period was in the mid-60s – 70s. From the mid 70s an increase of annual rainfall is observed.

There are differences between seasons however. There is a distinct increase of precipitation amount in spring. In autumn as well as in winter it shows up to a smaller extent. An increase of rainfall amount in summer is insignificant. The summer linear rainfall trend coefficient comprised 0.33 mm/month per 10 years over 1976-2009 period, and even became negative over 1976-2010 period, – 0.01 mm/month per 10 years.

Thus, increase of precipitation in the vast territory of Russia is mainly connected with stronger spring high waters and floods. For the summer period the amount of precipitation changed slightly. In such conditions growth of temperature leads to aridity that has an adverse effect on agricultural production in the summer.

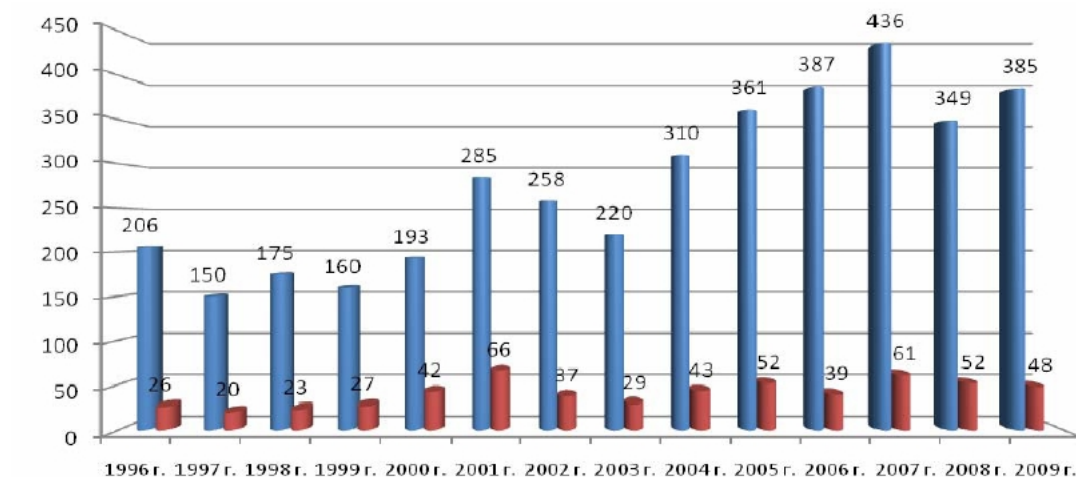
Besides the droughts climate changes are also reflected by an increase of other dangerous meteorological events, such as high waters, squalls, hails, sleets, frosts, hard frosts, strong heavy rains, hurricanes, etc. Such situation is clearly seen in the Russian Federation. Nowadays, the relationship between climate changes and increase of dangerous meteorological events frequency is beyond any doubt.

According to the Ministry of Emergency Situations, 297 dangerous meteorological events were fixed in 2011. This number exceeds the mean annual values of 262 dangerous meteorological events by 13.3% but is 36% less than the values of 2010 (467 dangerous meteorological events). As a whole the year 2010 was abnormal in terms of the dangerous meteorological events number, caused damages. As a rule, the greatest numbers of dangerous meteorological events in the Russian Federation are occurred during the period from May to August.

Such activities as agriculture, transport, energy and power supply, housing and communal services experience the most negative influence of dangerous meteorological events. The annual damage from the impact of dangerous meteorological events in Russia estimated up to 60 billion rubles (about 2

billion dollars). The tendency of increase of dangerous meteorological events will remain in the future, therefore losses from the hydrometeorological events will raise and expand to more and more territories.

Figure 11. Annual numbers of dangerous meteorological events in the Russian Federation (blue - all events, red - unforeseen events) (in numbers)



Source: the RF Federal Meteorological Service data

As far as water resources is concerned, the popular belief is that Russia has water in abundance, and in the long term it can serve as a source of water resources for other countries. The Lake Baikal is often mentioned in this context. However, quite good water endowment is combined with very unequal distribution of water among the regions. As it is noted in Roshydromet publications, the increase in renewable water resources by 8-10% is expected in Russia. Taking into account decrease in population, water endowment per one inhabitant will increase by 12-14%.

Improvement of water endowment will occur in the North and the Northwest of the European Russia, the Volga region, the Non-Black Soil Center of Russia, the Urals, and also the most part of Siberia and the Far East. Now these regions have more than 95% of water resources of the country.

At the same time reduction of water resources by 5-15% and increase of their consumption is expected in many densely populated regions (Central and Black Soil Zone, the South of Russia, the North Caucasus, the South of Siberia), which characterized by deficiency of water resources. As a result of the climate changes, being accompanied by certain demographic shifts, inequality of water resources distribution among regions will increase. Deficiency of water resources will increase in the regions, where the main part of crop production is located.

Thus, climate changes will influence both positively and negatively on Russia's agriculture. In spite the fact that agricultural potential of many territories, which are not so suitable for agriculture now, may be increased in the future, the main agricultural areas will lose their positions in case of the lack of complex adaptation measures.

### Vulnerability

Vulnerability is the lack of ability to recover from a stress. Poor people are vulnerable to many different kinds of stresses because they lack the financial resources to respond. In agriculture, poor people are particularly vulnerable to the stresses of an uncertain climate. In this report the focus is on income, both level and sources. At the national level, vulnerability arises in the interactions among population and income growth and the availability of natural and manufactured resources. National per



capita income statistics reported above show averages, but potentially conceal large variations across sectors or regions.

Figure 12 shows the distribution of the proportion of the population living on less than \$2.00 per day. In Russia less than 10% of people can be considered as poor taking into account such criteria.

Figure 12. Poverty (percent below US\$2 per day)



Source: Wood et al. (2010) available at [labs.harvestchoice.org/2010/08/poverty-maps](http://labs.harvestchoice.org/2010/08/poverty-maps)

However, to characterize poverty in Russia another criterion is used in the national socio-demographic statistics. According to Russia's socio-demographic statistics, poor people are those, whose income is less than minimum cost of living (subsistence level). Subsistence levels are different across the regions. Average Russia's subsistence levels measured in dollars for 2008-2010 are presented in Table 2. The number of people with incomes below the subsistence level is shown in Figure 11.

Table 2. Subsistence levels in Russia (average per capita, dollars per month)

	2008	2009	2010
For all socio-demographic groups	185.1	162.7	187.4
For specific socio-demographic groups			
- working-age population	200.4	175.9	202.2
- pensioners	146.9	129.4	148.9
- children	176.9	155.6	180.8
Ratio of per capita incomes to minimum cost of living, percent	325.3	326.8	326.2

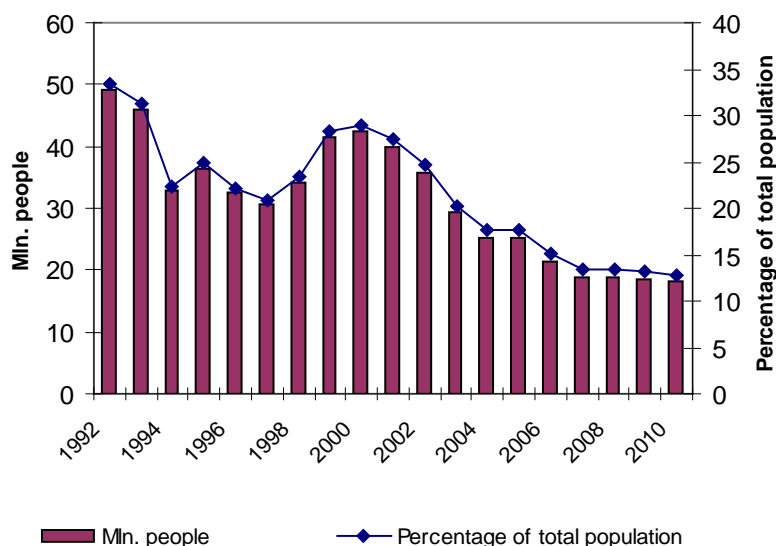
Source: Calculations based on the RF Federal State Statistics Service and Bank of Russia data.

According to Figure 13, the number of poor people has declined steadily. 18.1 million people or 12.8%<sup>2</sup> of Russia's population had incomes below the subsistence level in 2010. About 58% of poor people live in urban areas, while 42% live in rural areas.

Also there are significant regional disparities in terms of poverty level. The following regions of Russia are characterized by the lowest levels of poverty: Republic of Tatarstan (8.1%), Belgorod region (8.6%), The City of St. Petersburg (8.7%), Republic of North Ossetia-Alania (8.7%), Republic of Dagestan (9.3%). The most disadvantaged regions with high levels of poverty are the following: Republic of Kalmykia (36.2%), Republic of Tyva (26.3%), Republic of Mary El (24.5%), Amur region (24.4%), Altai territory (24.3%).

<sup>2</sup> Average poverty level in Russia in 2010.

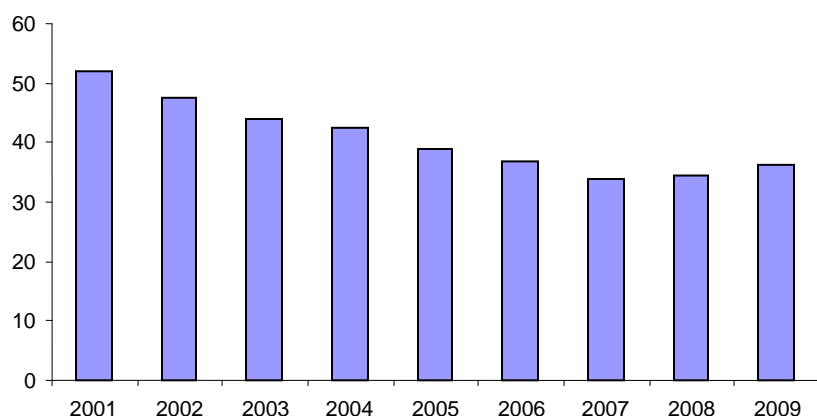
Figure 13. People with incomes below the subsistence level



Source: The RF Federal State Statistics Service.

Subsistence level in Russia is quite low compared with the same indicators for developed countries. Low incomes, high share of food expenditure in total consumer spending (see Figure 14) and a huge differentiation in income (in 2009 the coefficient of income differentiation<sup>3</sup> was 16.7 times) indicate a high vulnerability of Russia's population to food prices shocks.

Figure 14. Share of food expenditures in total consumer expenditures



Source: The RF Federal State Statistics Service.

Table 3 provides some data on additional indicators of vulnerability and resiliency to economic shocks: the level of education of the population, literacy, and concentration of labor in poorer or less dynamic sectors.

<sup>3</sup> Coefficient of income differentiation characterizes the degree of social stratification and is defined as the ratio between the average incomes of 10% of the population with the highest incomes and 10% of the population with the lowest incomes.

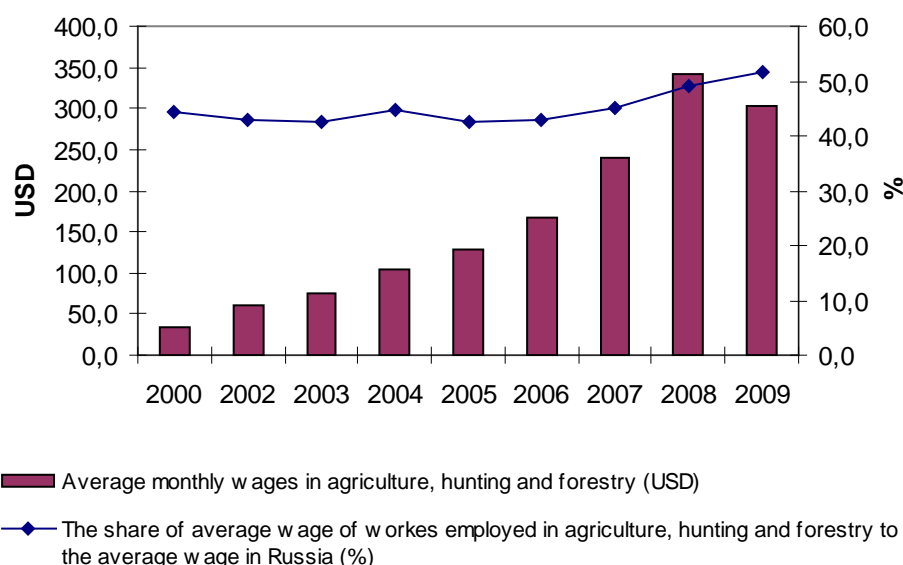
**Table 3. Education and labor statistics**

Indicator	Year	Value
Primary school enrollment: Percent gross (3-year average)	2007	95.8
Secondary school enrollment: Percent gross (3-year average)	2007	84.3
Adult literacy rate	2007	99.5
Percent employed in agriculture	2007	9

Source: World Development Indicators (World Bank 2009).

As for the level of primary and secondary education, Russia still holds rather high positions. The same is for high education. But the quality of education becomes lower. This is characteristic of rural areas especially.

In Russia, agriculture employs about 9% of the economically active population. This is due to low labor productivity. Along with the reduction of rural population, growth in capital investments in the agricultural sector against the background of relatively low wages (see Figure 15), and further declines in the number of people employed in agriculture is expected.

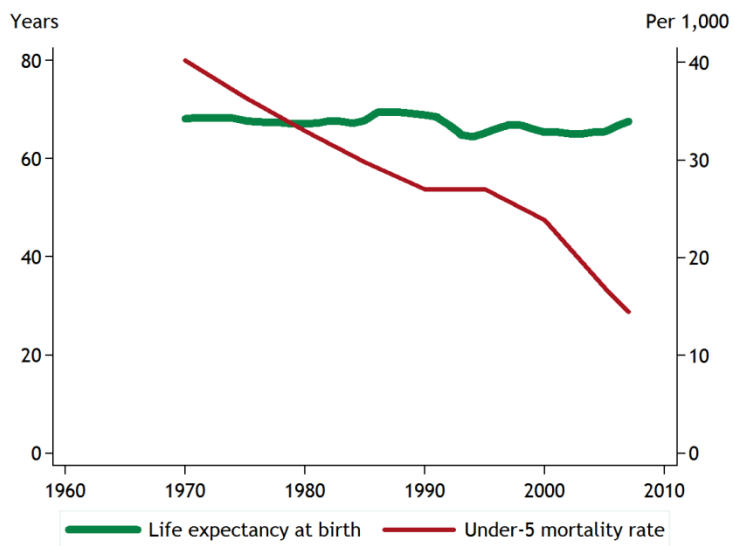
**Figure 15. Wages of workers employed in Russia's agriculture, hunting and forestry**

Source: The RF Federal State Statistics Service.

The outcomes of significant vulnerability include low life expectancy and high infant mortality. Figure 16 shows two non-economic correlates of poverty, life expectancy at birth and under-5 mortality.

Life expectancy at birth in Russia is relatively low compared with developed and developing countries. In 2009, life expectancy at birth in Russia was 68.7 years. At the same time life expectancy for men was only 62.8 years. In contrast, the infant mortality rate is gradually decreasing.

Figure 16. Well-Being Indicators: Life Expectancy at Birth and under 5 Mortality Rate



Source: World Development Indicators (World Bank, 2009)

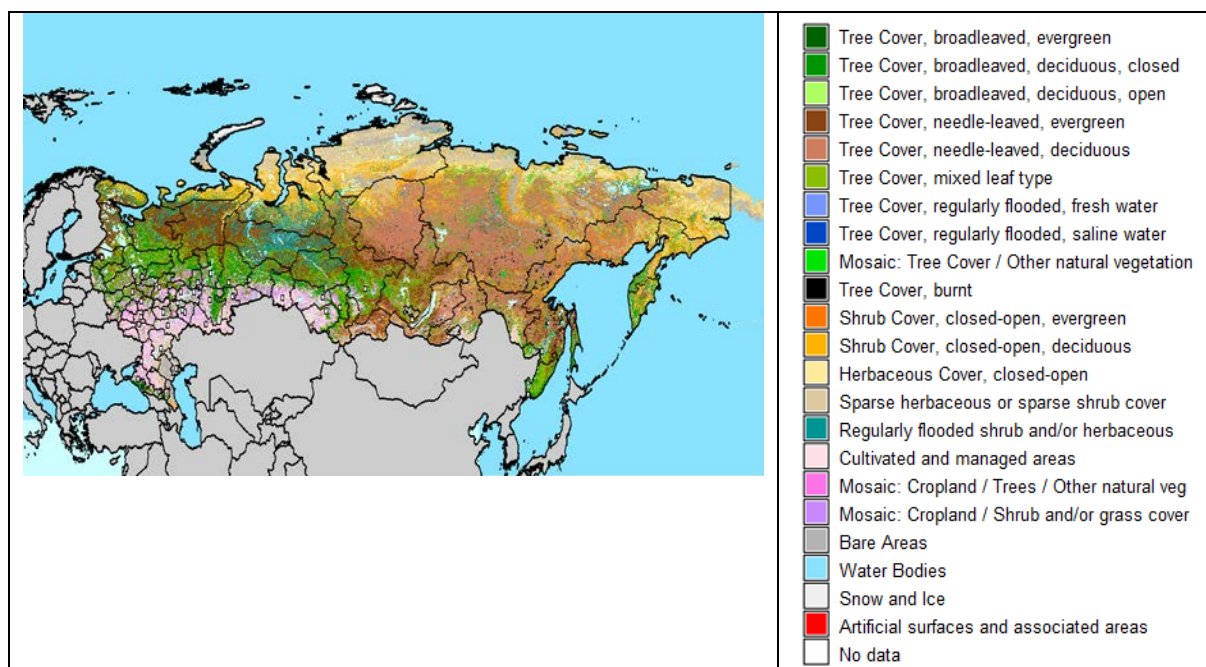
## Review of Land Use and Agriculture

Agricultural production is dependent on the availability of land that has sufficient water, soil resources and an adequate growing season.

### Land Use Overview

Russia is the most extensive country in the world. Its area reaches 1709.8 million ha and occupies a large part of Eastern Europe and Northern Asia. Russia's territory is located in the arctic, subarctic and - most of it - in a temperate climatic zones. The climate is continental almost everywhere in Russia. The average annual surface temperature varies from  $+12\div 14^{\circ}\text{C}$  in the North Caucasus regions to  $-16\div -14^{\circ}\text{C}$  in the Republic of Sakha (Yakutia). Permafrost constitutes more than 67% of Russian territory. Figure 17 shows Russia's land cover as of 2000.

Figure 17. Land cover, 2000



Source: Source: GLC2000(JRC 2000).

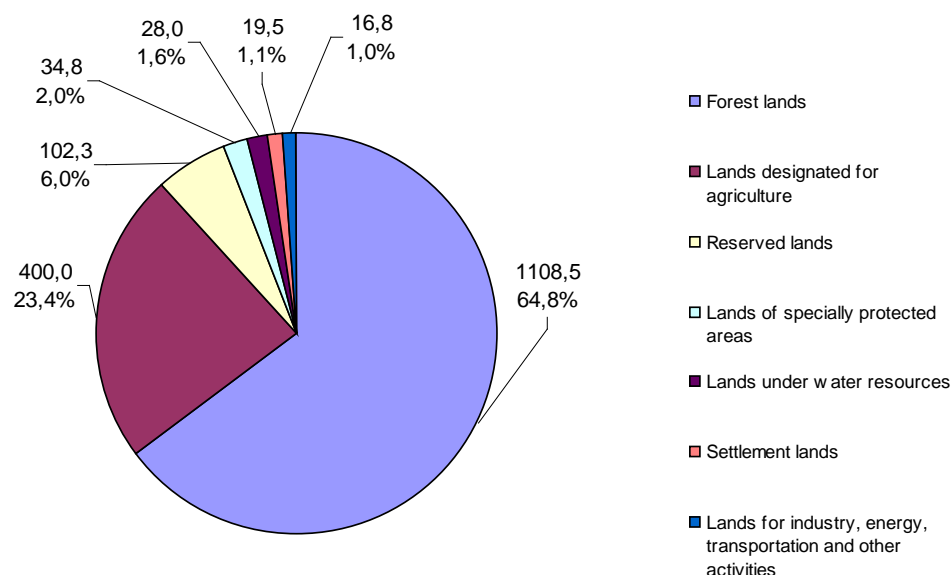
The main components of the territory of Russia are forest lands and lands occupied by other vegetation (see Figure 18). Lands, designated for agriculture, occupy 400.0 million ha or 23.4% of the land area of Russia. In terms of agricultural production, especially valuable lands are the following types of agricultural lands: arable land, hayfields, pastures, fallow land and lands under perennial plants (orchards, vineyards, and others).

The share of agricultural lands is relatively small. Arable land is the most productive type of agricultural lands. The share of arable land amounts to about 7% of the total country area or 28.9% of the lands designated for agriculture (see Figure 19). However, Russia has one of the highest rates in the world supply of arable lands (115.3 million ha) and arable land per capita (0.81 ha per capita). As of 1 January 2010, a significant part of the lands designated for agriculture was in state and municipal property - 270.7 million hectares or 67.7%. Individuals owned 119.5 million ha or 29.9% of the lands designated for agriculture. 9.8 million hectares or 2.4 per cent of the lands designated for agriculture were in the ownership of legal entities.

By the beginning of 2010, agricultural enterprises and individuals used more than 190.7 million hectares or 86.5% of agricultural lands from all land categories. At the same time, more than 184.0

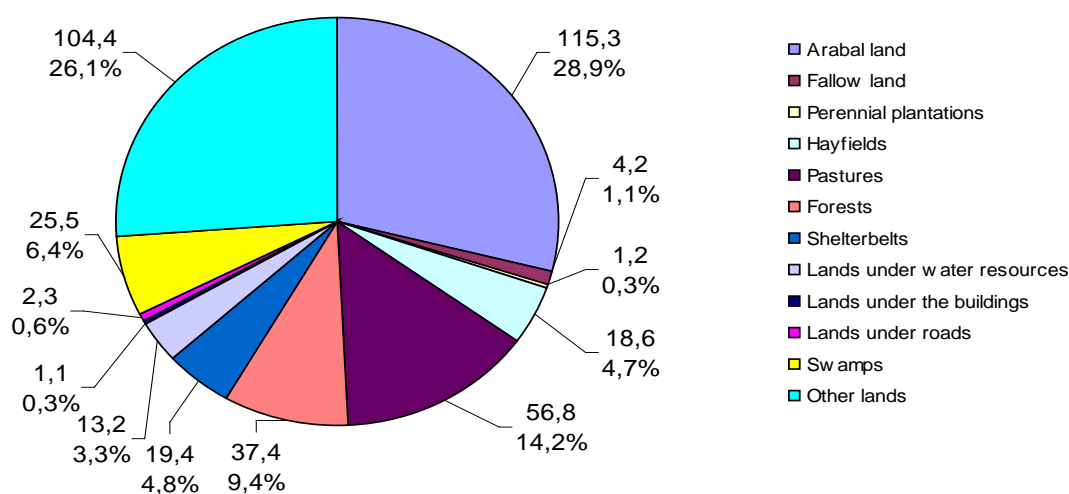
million hectares of agricultural lands from the lands designated for agriculture were used by them. To produce agricultural products 64.4% of agricultural lands were used by agricultural enterprises, and 35.6% - by individuals.

Figure 18. The composition and structure of the lands in the Russian Federation in 2010, million ha and %



Source: Report on the status and use of agricultural land, the RF Ministry of Agriculture, 2011.

Figure 19. The composition and structure of the lands designated for agriculture in the Russian Federation in 2010, million ha and %



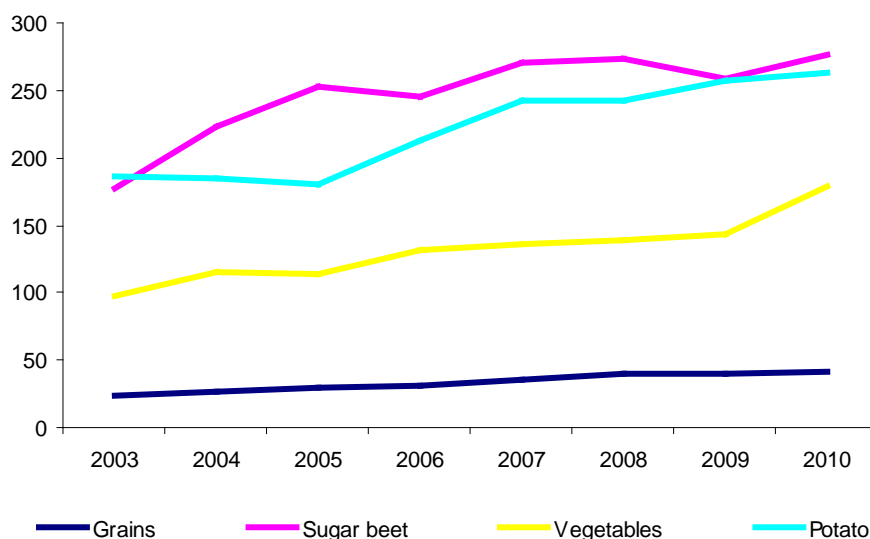
Source: Report on the status and use of agricultural lands, the RF Ministry of Agriculture, 2011.

One of the main directions of the agricultural policy of the Russian Federation is to increase soil fertility and crop yields. Currently, soil quality continues to decrease. The annual removal of nutritive

materials from the soils due to agricultural activity is three times higher than their rehabilitation due to mineral and organic fertilizers application. Applications of organic and mineral fertilizers are less than 10% (53-54 million tons) and 30% (2.3 million tons) of science-based requirements respectively.

At the same time, it should be noted that the use of mineral fertilizers per hectare of agricultural crops is increasing (see Figure 20). However, less than a half of agricultural lands are fertilized and fertilizer doses remain low. Such situation reduces sustainability of land-use due to a permanent decrease in natural soil fertility.

Figure 20. Application of mineral fertilizers for agricultural crops, kg/ha



Source: Report on the Status and Use of Agricultural Lands, the RF Ministry of Agriculture, 2011.

In order to preserve, restore and improve soil fertility Russia provides partial compensations for the costs of mineral fertilizers acquired by agricultural producers. Some activities on improvement of agricultural lands are funded by regional authorities and agricultural producers. However, the funds for such activities continue to decrease due to a systematic reduction of regional budgets allocated to carry out these works and the lack of financial resources of agricultural producers for improvement of agricultural lands.

Russian agriculture operates in complicated natural and climatic conditions:

- 80% of arable lands are located in areas of unstable and insufficient moisture,
- Over 10% of arable lands are located in areas of redundant moisture.

Reclaimed areas are of special value in these conditions, as their use facilitates stable crops production. Nowadays there are only 9m ha of reclaimed areas in Russia, 4.25m ha of which are irrigated, and 4.75m ha are drained.

Reclaimed areas cover 8% of total area of croplands and allow one to produce about 15% of gross crops production. Up to 70% of vegetables, the whole of rice, more than 20% of succulent feeds, fodder and other products are produced there.

As a result of socioeconomic crisis about 1.9m ha of irrigated areas discontinued their involvement into agricultural land transactions after 1990 and were transferred into unimproved lands. A construction of new irrigation and drainage systems was virtually stopped, while only 5-10% of the required reconstruction works of existing systems was carried out. Technical state of reclamation system has also become worse; this is especially true in regard to farm-irrigation systems. At present as

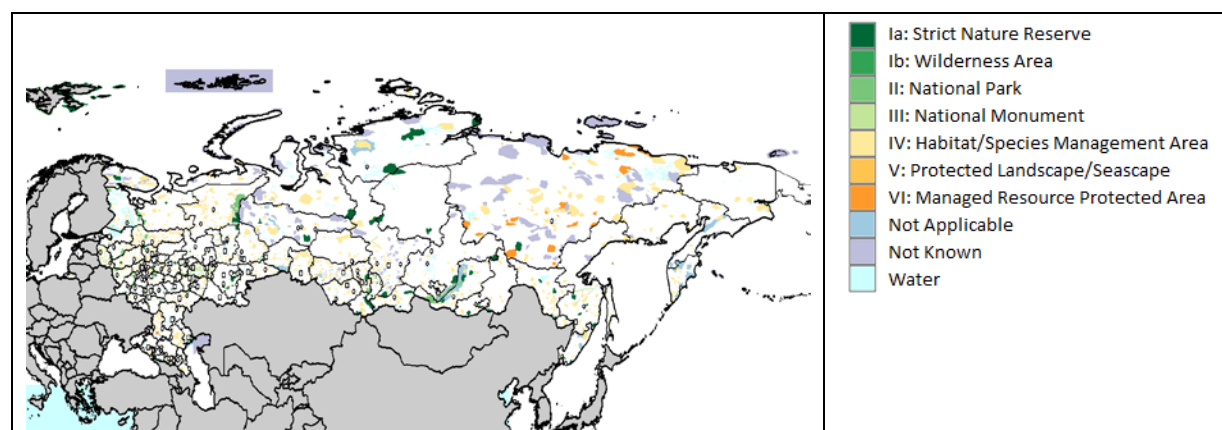
a consequence of defects of farm-irrigation systems, an irrigation is absent on more than 1.8m ha of irrigated areas or on more than one third of them.

Under present-day conditions a federal budget requirement for the hydraulic work reconstruction constitutes 6-8bn rubles, while actual financing is 1.5-2bn rubles. Demand for the current repairs of constructions comprises 2bn rubles with actual financing of 0.3-0.6bn rubles. In these conditions the restoration of amelioration systems is a priority among the other measures that should be implemented for adaptation to climatic changes.

Thus, to ensure the sustainability of agricultural production using existing irrigated lands it is extremely important to provide necessary investment in reconstruction and modernization of hydraulic structures and expenditures on maintenance of on-farm irrigation systems.

Figure 21 shows the locations of protected areas, including parks and reserves. These locations provide important protection for fragile environmental areas, which may also be important for the tourism industry. Such non-agricultural activity is essential for providing the sustainability of development in some rural areas.

Figure 21. Protected areas



Source: World Database on Protected Areas (UNEP 2009). Water is from Global Lakes and Wetlands Database (WWF)(Lehner and Döll 2004).

In terms of the extent of market infrastructure development, important role belongs to the system of communications between rural and urban areas. Urban areas provide potential markets for agricultural products. Policy makers need to keep in mind the importance of transport costs when considering capacities for agricultural expansion; that is, if fertile but unused land is far from markets, it represents potential land for expansion only if transportation infrastructure is put in place, and if the land does not conflict with preservation priorities seen in Figure 21.

### Agriculture Overview

Tables 4 to 6 show key agricultural commodities in terms of area harvested, value of the harvest, and food for people (this last item was ranked by weight) for the period centered around 2006-2008. Wheat, barley, sunflower seed are the most important crops in terms of area harvested. These three crops use more than 70 % of total harvested area. Potatoes, wheat and tomatoes retain the top three positions in terms of value of production. Barley is the fourth most important crop.



**Table 4. Harvest area of leading agricultural commodities, average of 2006-2008**

Rank	Crop	% of total	Area harvested (000 hectares)
1	Wheat	43.90%	24,207
2	Barley	16.60%	9,126
3	Sunflower seed	10.20%	5,642
4	Oats	6.10%	3,346
5	Potatoes	4.80%	2,637
6	Rye	3.60%	1,967
7	Maize	2.40%	1,333
8	Buckwheat	2.00%	1,091
9	Sugar beet	1.70%	910
10	Soybeans	1.40%	744
	Total	100.00%	55,102

Source: FAOSTAT (FAO 2010)

A substantial part of agricultural output (47.1%) is produced by household plots. Household plots mainly specialize on labor-intensive crop production (potatoes, vegetables), meat and milk (about 50% of gross output of these products), wool (60% of wool gross output), eggs (25% of eggs gross output). The shares of agricultural enterprises and private farms account for 45.4% and 7.5% of total agricultural production respectively.

**Table 5. Value of production for leading agricultural commodities, average of 2006-2008**

Rank	Crop	% of total	Value of Production (million US\$)
1	Potatoes	26.00%	7,962.70
2	Wheat	19.80%	6,071.40
3	Tomatoes	8.90%	2,720.20
4	Barley	6.50%	1,985.00
5	Cucumbers and gherkins	5.40%	1,662.80
6	Sunflower seed	5.00%	1,528.50
7	Sugar beet	3.50%	1,066.30
8	Cabbages and other brassicas	2.90%	875.2
9	Apples	2.70%	826.1
10	Vegetables fresh nes	1.90%	583.9
	Total	100.00%	30,642.80

Source: FAOSTAT (FAO, 2010)

Wheat, potatoes and vegetables are the three top food commodities in terms of consumption. These commodities account for more than 50 percent of total volume of food consumption.

**Table 6. Consumption of leading food commodities, average of 2003-2006**

Rank	Crop	% of total	Food consumption(000 mt)
1	Wheat	27.53%	18,999
2	Potatoes	27.15%	18,736
3	Other Vegetables	14.16%	9,768
4	Sugar Refined Equiv	8.23%	5,676
5	Root Tuber Dry Equiv	5.43%	3,747
6	Tomatoes	4.22%	2,913
7	Other Fruits	4.19%	2,891
8	Apples	3.86%	2,662
9	Onions	3.15%	2,175
10	Sunflower seed Oil	2.08%	1,434
	Total	100.00%	69,001

Source: FAOSTAT (FAO, 2010)

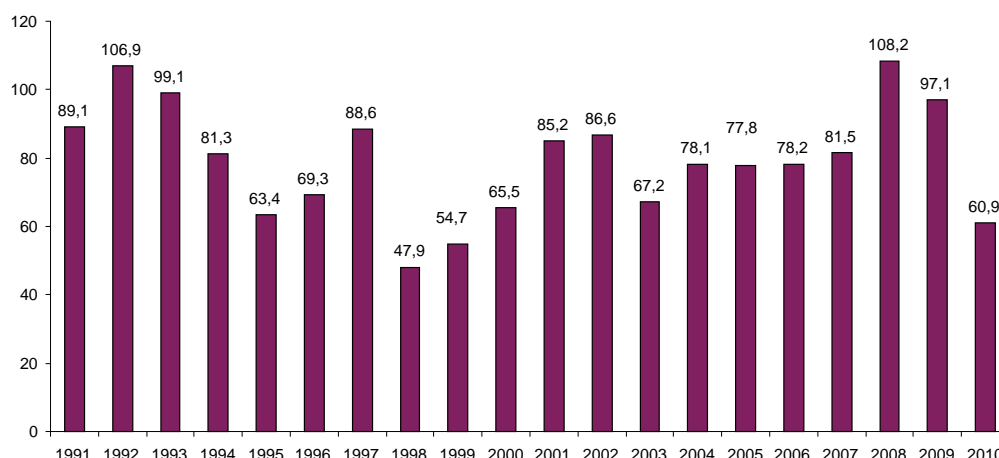
The Food Security Doctrine of the Russian Federation defines that the share of domestically produced plant agricultural products in their total supply should be:

- grains - not less than 95%,
- sugar - at least 80%,
- vegetable oil - at least 80%,
- potatoes - not less than 95%.

Grain is an important product for the provision of food security, self-sufficiency and agricultural export supply. Grain production is about 16% of the gross agricultural output. Grain crops occupy about 60% of the cultivated area.

Since the early 90s and until the financial crisis of 1998, there was a reduction in sown area, grain yields and gross output. Subsequent economic growth contributed to the increase of gross output of grains. Since the beginning of 2000, Russia transformed from a net importer to a net exporter of grains. In 2008, Russia had the highest harvest since 1991 (see Figure 22).

Figure 22. Gross grain harvests in Russia, million tons

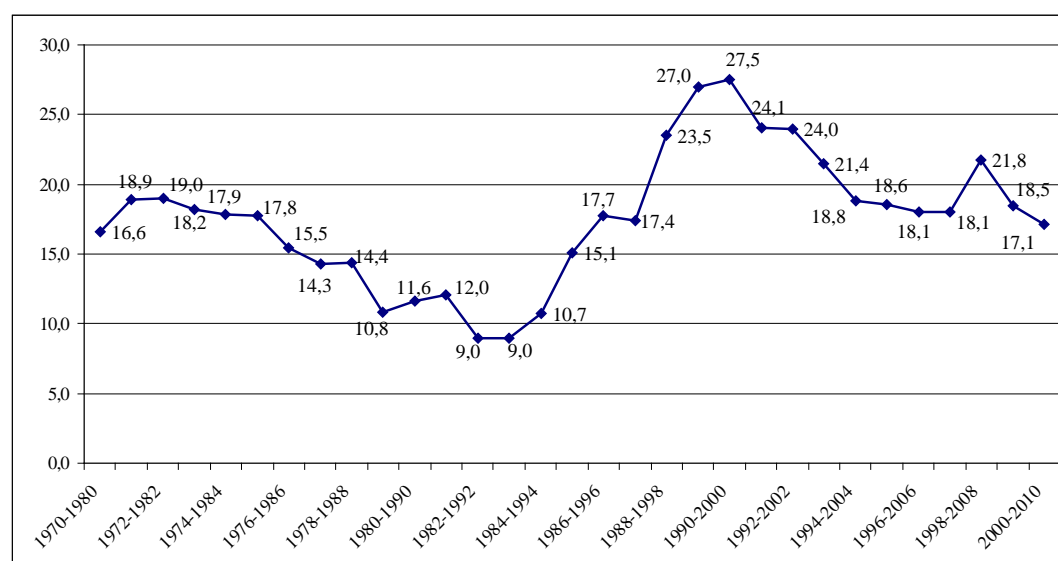


Source: The RF Federal State Statistics Service.

Along with the reduction of grain production in 1990s, there was an increase in the coefficient of variation<sup>4</sup> of gross grain production that characterizes the low level of sustainability of production. This causes serious problems for the coherent development of the livestock industry, processing and export orientation of the grain sector. The maximum value of the specified coefficient was in 1990-2000 (27.5%). Since 2000, the variability of crop yields has decline. However, the coefficient of variation is still relatively high compared to its lowest values observed in the 1980s.

<sup>4</sup> The coefficient of variation is obtained by dividing the standard deviation into of the mean value of grain production.

Figure 23. Coefficients of variation of grain production in Russia in 1970 - 2010, %



Source: calculated using the data of The RF Federal State Statistics Service

Wheat is the main type of grain produced in Russia. It accounts for more than 60% of grain output. Figure 24 and Figure 25 show the estimated yield and growing areas for rainfed and irrigated wheat in 2000. These figures are based on the SPAM data set (Liangzhi You, Wood, and Wood-Sichra 2009), a plausible allocation of national and subnational data on crop area and yields. As a general observation, Russian wheat production is concentrated in the south of the country. Currently, the largest wheat producers are Krasnodar region, Stavropol region, Rostov region, Altai Territory, Republic of Tatarstan, Republic of Bashkortostan, Volgograd region, and Saratov region. Traditionally, high yields of wheat are collected in Omsk and Novosibirsk regions (the south of Siberia).

The use of grain for fodder is the main expenditure items of the grain balance sheet. By 2000, consumption of grain used for fodder declined by nearly 40 million tons or about 50% compared to 1990. This is due both to the reduction of livestock and poultry, as well as increases in efficiency of feed utilization. However, since the beginning of the implementation of Priority National Project "Development of agricultural and industrial complex" there has been an increase in grain consumption as a result of growth in poultry and pig production. In the long run, development of the livestock industry will require the increase of grain production.

Figure 24. 2000 Yield and harvest area density for rainfed wheat

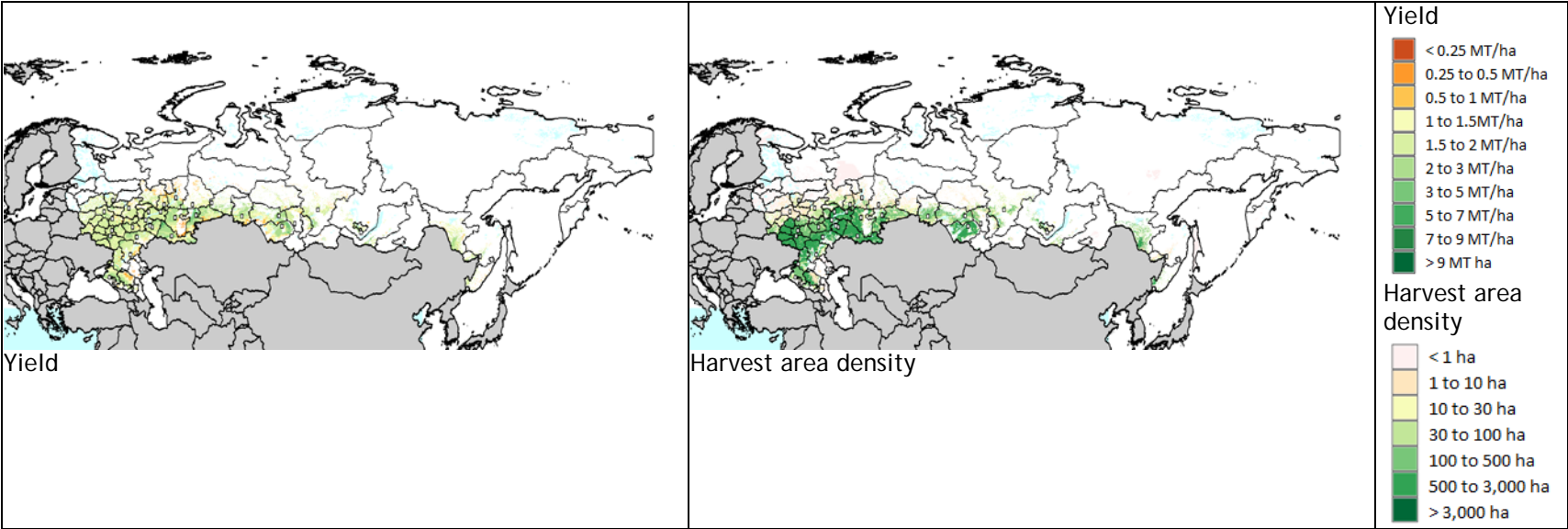
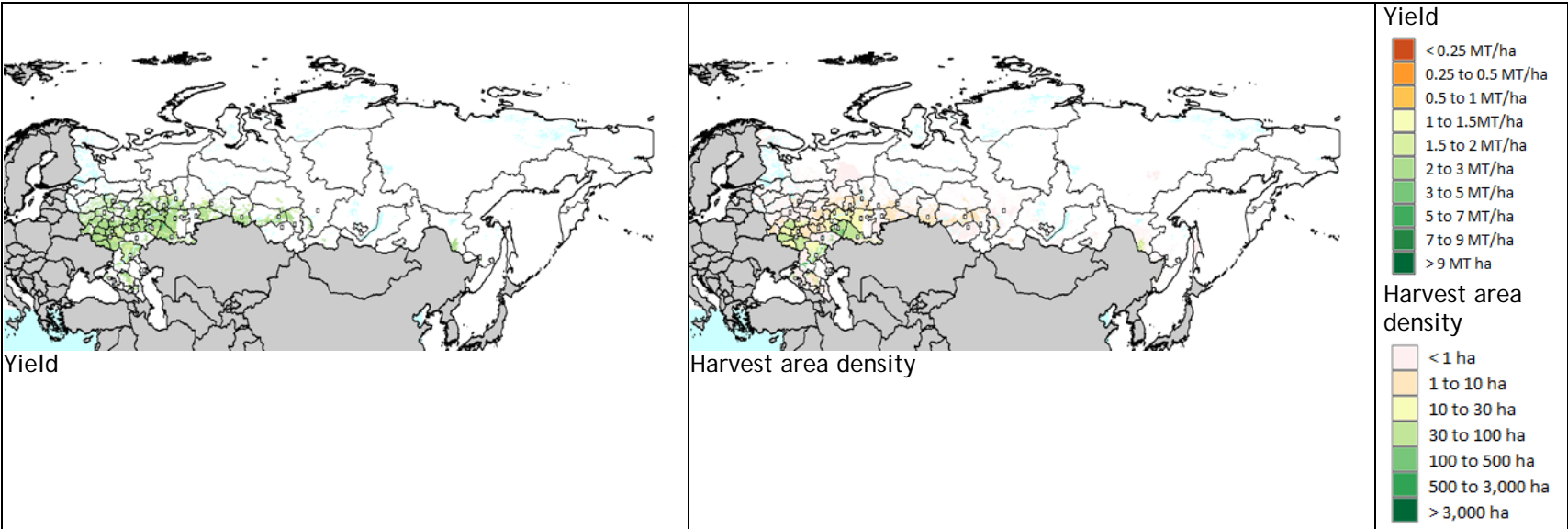


Figure 25. 2000 Yield and harvest area density for irrigated wheat



Since 2000, Russia has become a net exporter of grain. Record volumes of grain (21.8 million tons) were exported in 2009 (see Table 7).

Grain has the largest share in the value of the agro-food exports from Russia. However, it should be noted that in 2008 and 2010, exports of grain were significantly below its potential volumes due to the use of export restrictions. Thus, grain export regulation is directly dependent on the availability of grain in the domestic market. In the case of an excess grain supply, export support is carried out in the form of providing the preferential terms for rail transportation of grain.

The following factors hamper the development of export:

- instability of grain production,
- the lack of transportation infrastructure development,
- the lack of port and terminal infrastructure development,
- low technological level of elevators.

**Table 7. Russia's Import and export of grains in 2008-2009**

	Import				Export			
	2008		2009		2008		2009	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD
Grains	957,7	467,3	423,3	227,3	13493,2	3254,5	21778,5	3444,0
Wheat	178,7	61,8	94,6	21,7	11720,2	2864,4	16821,2	2753,0
Rye	0,1	0,0	0,1	0,1	23,1	5,3	8,2	1,1
Barley	131,5	50,9	32,4	4,3	1496,1	323,9	3490,0	439,2
Oat	4,1	0,8	0,0	0,0	6,4	1,5	2,0	0,4
Maize	362,2	182,6	38,0	60,4	198,4	30,5	1358,0	188,3
Rice	271,2	167,9	257,1	140,4	23,0	20,4	92,3	60,5
Buckwheat, millet and other grains	9,9	3,2	1,1	0,3	26,1	8,4	6,7	1,6

Source: The RF Federal State Statistics Service.

Another distinctive feature of the grain market is the use of state purchase and commodity interventions to limit price volatility. The most significant volumes of state grain purchases took place in 2008-2009. At that time the state purchased 9.6 million tons of grain. Conducting procurement interventions aims at removing the excess volume of grain from domestic market and thereby at supporting the producers of grains. State commodity interventions, carried out in the lean years, aimed at supporting the livestock producers and grain processors.

Sugar market also has a certain specific. Despite the overall decline in sugar production (see Table 8), the share of sugar produced from sugar beet is growing. In 2008, the share of sugar produced from sugar beet reached a record level of 65.5%. The dynamic growth of sugar production from domestic raw is due to the following factor:

- active use of state instruments of foreign trade protectionism in order to replace imported raw materials to domestic ones;
- increasing the productivity of the sugar industry (in 2009, output of sugar from sugar beets reached a record level of 15.02%);
- increase in acreage of sugar beets.

**Table 8. Sugar beet and sugar production in Russia in 2008-2009**

	2008	2009
Sugar beet		
- Production, 1000 tons	28995.3	24892.0
- Changes in production, % to a previous year	100.6	85.8
Sugar produced from the sugar beet		
- Production, 1000 tons	3481.4	3289.3
- Changes in production, % to a previous year	107.8	94.5
Sugar produced from raw sugar imported		
- Production, 1000 tons	2391.2	1733.6
- Changes in production, % to a previous year	83.0	72.5
Share of sugar produced from sugar beet in total volume of sugar, %	59.3	65.5

Source: calculations based on The RF Federal State Statistics Service.

Russia is among the top three world producers of sugar beets. A good harvest in 2008 contributed to the fact that Russia took the 2nd position in the world after the EU. The harvest areas for sugar beet are concentrated in Krasnodar, Kursk, Voronezh, Belgorod and Tambov regions. The share of these regions in total sugar beet production accounts for more than 60 percent. Also significant volumes of sugar beet are produced in the Republics of Bashkortostan and Tatarstan (see Figure 26 and Figure 27).

The existing capacity of the sugar industry could meet the domestic consumption needs for sugar. However, imports of raw sugar form a significant part of sugar resources in the Russian market. Raw sugar is imported due to the lack of domestic raw materials for sugar processing.

Russia is a net importer of raw sugar (see Table 9). Therefore, the special role belongs to the state regulation of foreign trade in sugar aimed at the replacement of imported raw sugar with domestic raw materials. In particular, the Government of Russia uses a floating duty on imports of raw sugar that is tied to the world price of this commodity (particularly the price at the New York Commodity Exchange).

However, it is worth noting a downward trend in imports of raw sugar. In 2009, imports of raw sugar was 51.8% compared to the previous year due to increases in world sugar prices and the application of a seasonal duty on imports of raw sugar.

**Table 9. Russia's import and export of sugar in 2008-2009**

	Import				Export			
	2008		2009		2008		2009	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD
Raw sugar	2419.9	944.2	1253.3	507.3	53.5	25.3	133.7	56.7
White sugar	165.1	87.4	258.9	147.3				

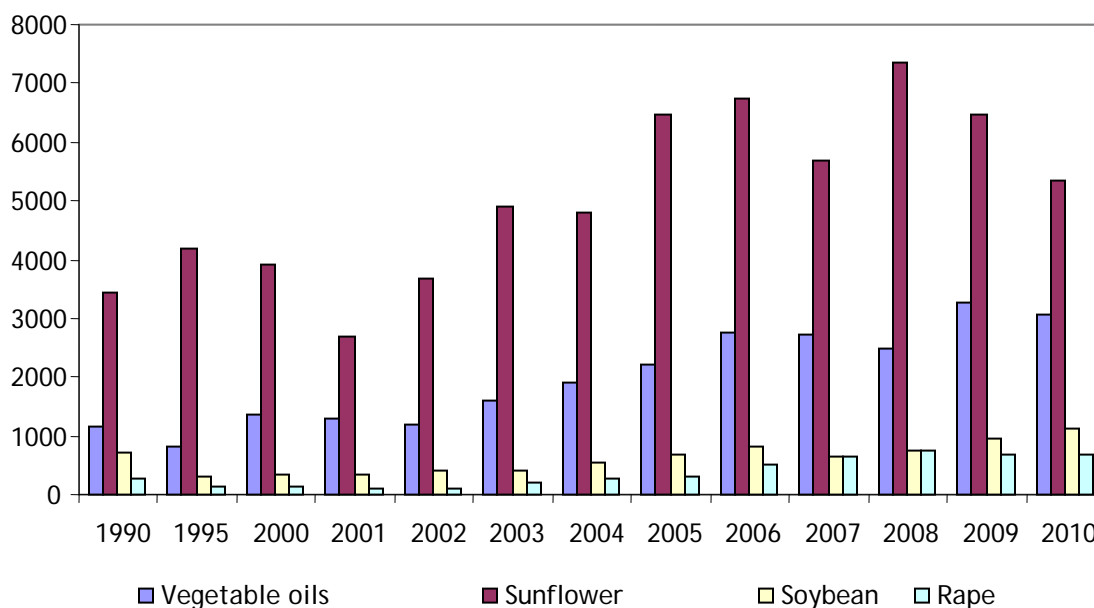
Source: The RF Federal State Statistics Service.

The Republic of Belarus remains the main supplier of white sugar to Russia. In 2007-2008, imports of white sugar was regulated by the agreement between the Government of Russia and the Republic of Belarus. Under this agreement the volume of sugar exported from Belarus to Russia in 2008 amounted to 100 thousand tons. In 2009-2010, the agreed volumes of sugar exported to Russia was increased to 150 thousand tons per year. For 2011 and the following years, the supply of sugar from Belarus was increased to 200 thousand tons.

Russia is the world leader in the production of sunflower seeds and sunflower oil. However, strengthening of Russia's position in the world market of vegetable oils began only in 2007. The share of

sunflower seeds in total production of oil-yielding crops is about 75-80%. Production of rape and soybean increases gradually (see Figure 30).

Figure 26. Production of oil seeds and vegetable oils in Russia in 1990 - 2010, thousand tons



Source: The RF Federal State Statistics Service.

Production of vegetable oils in Russia reached 3.07 million tons in 2010. From 2002 to 2010, production of vegetable oils had increased by more than 2.5 times due to the policy to encourage domestic producers by raising import duties on vegetable oils in 2002. Rostov region and Krasnodar territory are the leading producers of vegetable oils in Russia.

Export values of vegetable oils significantly exceed values of oilseeds exports (see Table 10). Development of oilseeds export is limited by the application of 20% export duty. Since 2009, rape seeds export has exceeded export of sunflower seeds. The main share in the import of oilseeds accounts for soybeans. Traditionally Russia exports mainly sunflower oil and imports tropical oils.

Table 10. Russia's import and export of oil seeds and vegetable oils in 2008-2009

	Import				Export			
	2008		2009		2008		2009	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD	1000 t	mIn USD
Oil seeds	693,9	574,4	1070,8	674,1	198,1	88,1	334,5	110,9
Sunflower	11,8	80,7	13,0	81,0	85,0	29,7	103,1	28,2
Soybean	561,6	326,6	959,3	442,9	4,5	1,2	1,8	0,5
Rape	7,2	12,2	0,5	4,6	48,1	24,4	128,4	43,0
Vegetable oils	1131,2	1404,5	751,9	747,4	603,3	803,5	985,1	775,1

Source: The RF Federal State Statistics Service.

Figure 27. 2000 Harvest area density for rainfed sugar beets

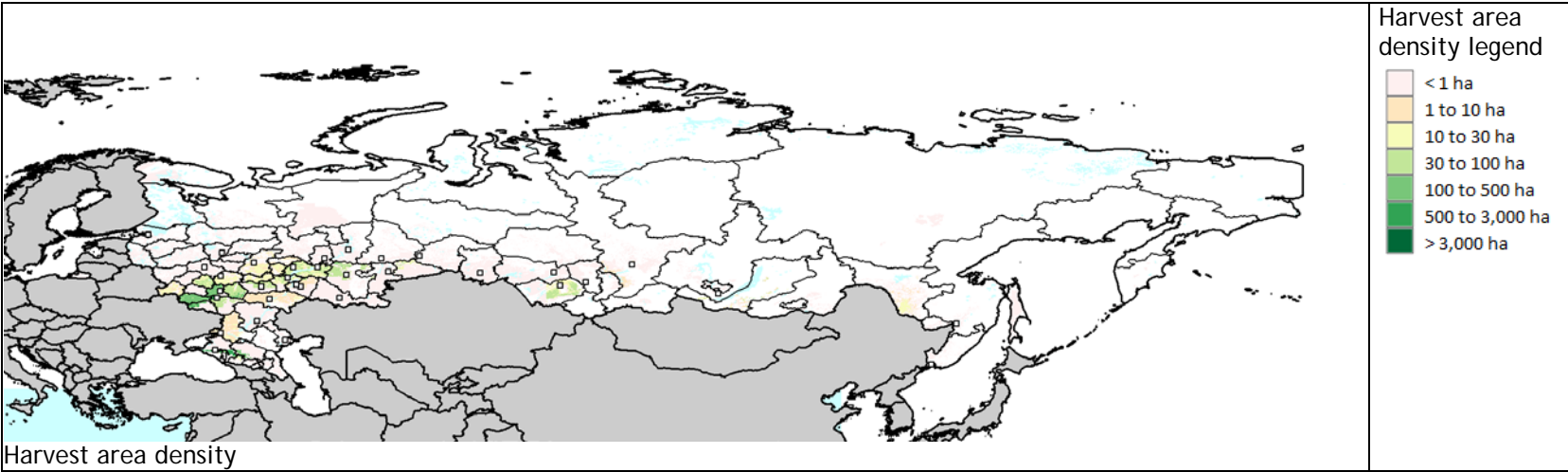


Figure 28. 2000 Harvest area density for irrigated sugar beets

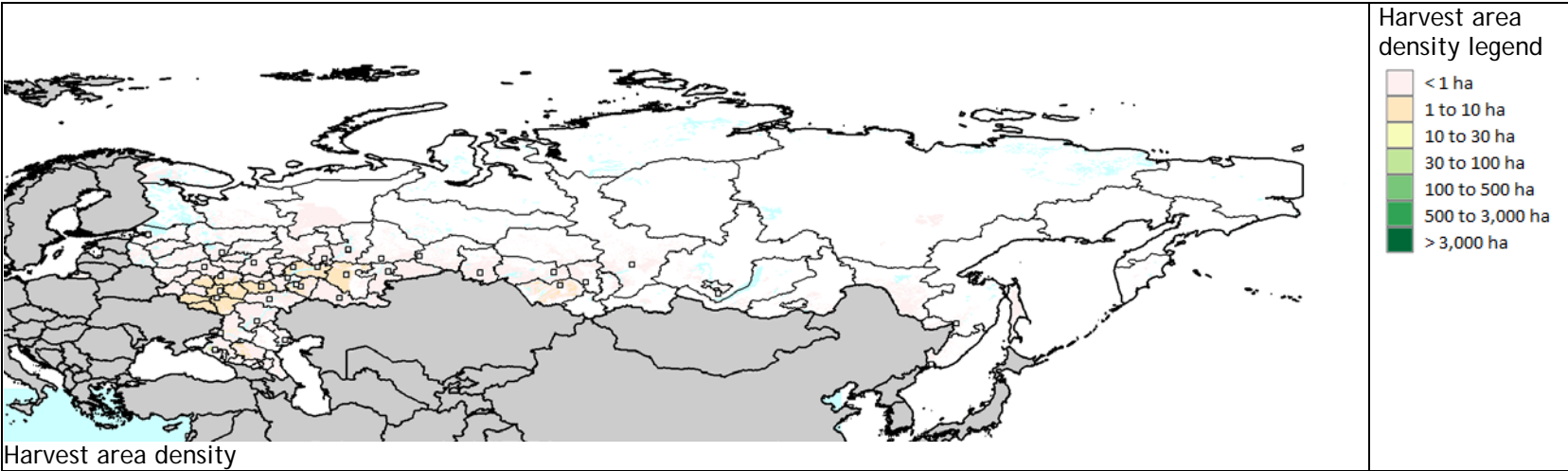




Figure 29. 2000 Yield and harvest area density for rainfed potatoes

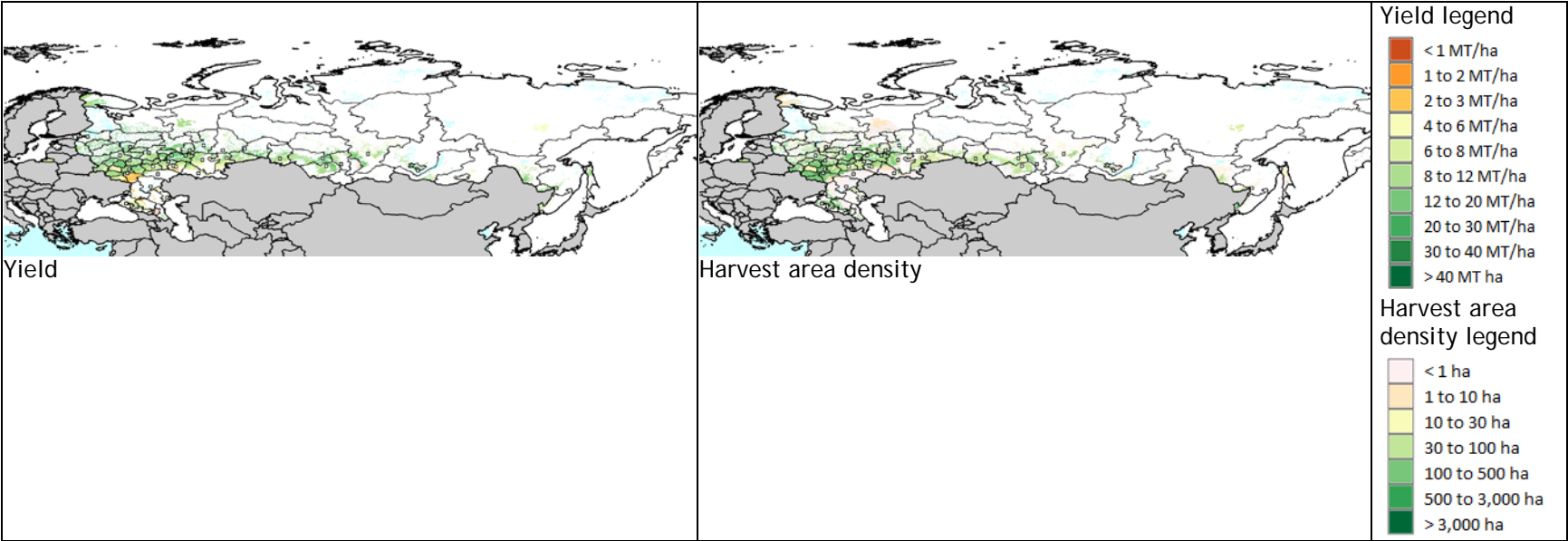
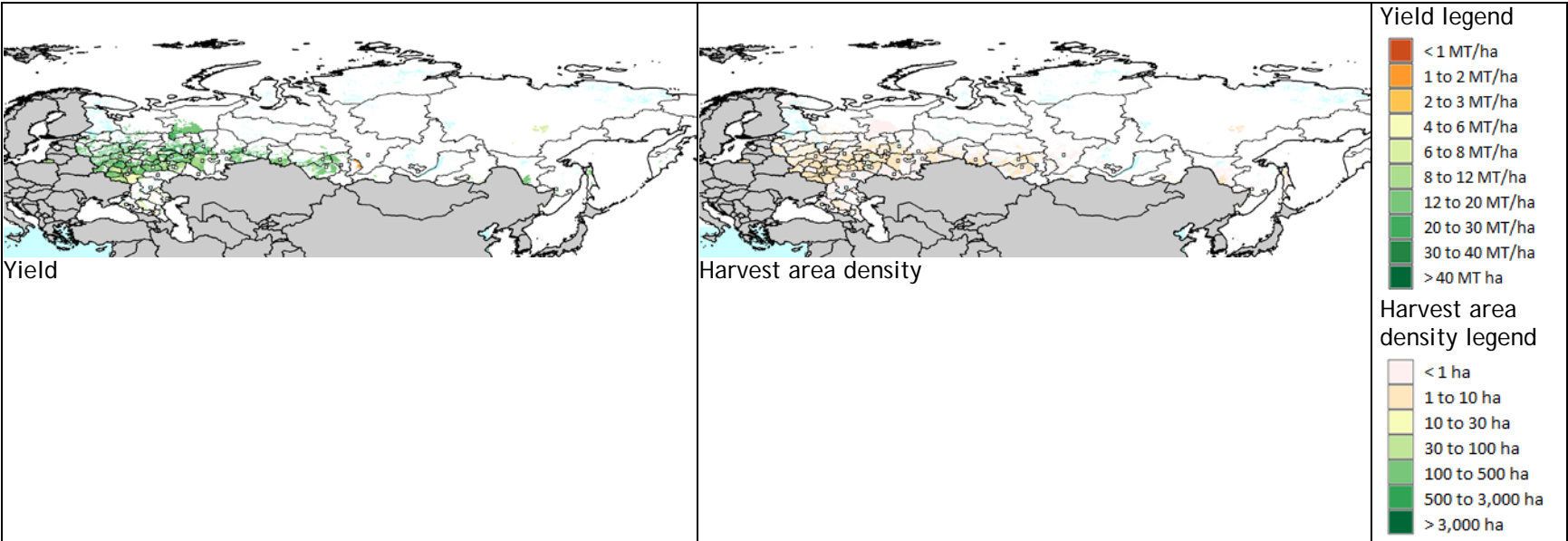


Figure 30. 2000 Yield and harvest area density for irrigated potatoes



The main trends in the market of vegetable oils are the following:

- increasing consumption of sunflower oil,
- increasing prices for vegetable oils,
- increasing consumption of non-traditional for Russia vegetable oils (palm, coconut, olive oils).

After China, Russia is the second largest producer of potatoes. Currently, more than 80% of potatoes are produced by household plots. The share of imported potatoes in its total supply is less than 2%. Imports of potatoes are seasonal. Potatoes are produced in all regions. Republics of Bashkortostan and Tatarstan are the leading potato producers in Russia.

Thus the main markets for crops in Russia have certain peculiarities. Based on the availability of land and human resources, Russia is able to meet the domestic demand for the main crops by domestic production. Part of crop output can be exported. However, sustainable development of exports requires the development of market infrastructure to ensure the competitiveness of domestic production in the world market.

The most successful regions form a rather compact area of agricultural production from the Belgorod region and Krasnodar territory through the Volga region and Southern Urals to the Altai region. Outside of this are relatively successful centers of agricultural production are concentrated in Moscow, Leningrad, Nizhny Novgorod and Sverdlovsk regions, as well as in the Republics of Tatarstan and Bashkortostan. Half of the total increase in agricultural output in recent years produced only 15 regions. With all this going on in the southern regions from 50 to 75% of agricultural enterprises operate successfully, while at the periphery of the black soil zone of Russia only 25% or less of enterprises are relatively successful. In the areas with unfavorable climate conditions only agricultural enterprises located in the suburbs have relatively high level of development.

In many regions, including the north-west and central regions the depression of agriculture outside of suburban areas is a result of the reduction of working age people and underdeveloped social and engineering infrastructure in rural areas.

Long-term risk for the development of agrarian sector is the increase in the number of older people and reduction of the population. With the general reduction of the proportion of rural population, its absolute reduction will occur more rapidly.

## Scenarios for Adaptation

In this section, the current status of the country with respect to vulnerability is reviewed. This includes a brief overview of current population trends, per capita income growth and its distribution, and the state of agriculture.

To better understand the possible vulnerability to climate change, it is necessary to develop plausible scenarios. The Millennium Ecosystem Assessment's Ecosystems and Human Well-being: Scenarios, Volume 2, Chapter 2 provides a useful definition: "Scenarios are plausible, challenging, and relevant stories about how the future might unfold, which can be told in both words and numbers. Scenarios are not forecasts, projections, predictions, or recommendations. They are about envisioning future pathways and accounting for critical uncertainties" (Raskin et al. 2005).

For this report, combinations of economic and demographic drivers have been selected that collectively result in three pathways - a baseline scenario that is "middle of the road", a pessimistic scenario that chooses driver combinations that, while plausible, are likely to result in more negative outcomes for human well-being, and an optimistic scenario that is likely to result in improved outcomes relative to the baseline. These three overall scenarios are further qualified by four climate scenarios: plausible changes in climate conditions based on scenarios of greenhouse gas emissions.

## Biophysical Scenarios

This section presents the climate scenarios used in the analysis and the crop physiological response to the changes in climate between 2000 and 2050.

### Climate Scenarios

As mentioned in the introduction, we used downscaled results from 4 GCMs with 2 SRES scenarios for each GCM. Figure 31 shows precipitation changes for Russia under 4 downscaled climate models with the A1B scenario<sup>5</sup>.

In general all models demonstrate the increase in precipitation for most parts of Russia. Minimal changes in precipitation are predicted by the CSIRO GCM. In this case, there is even a chance of precipitation decrease. Wettest climate is modeled by the CNRM, ECHAM, MIROC models. However, the simulations result in differences with respect to the regional component of changes in precipitation.

As for southern regions of Russia, all models predict rather small changes in precipitation. Southern areas may face either decrease or increase in precipitation. The same situation is predicted by CNRM and CSIRO GCM for the black soil zone of Russia, the Volga regions and Southern Ural regions. Though, ECHAM and MIROC models' simulations resulted in wetter climate for these parts of Russia.

Thus, for Russia as a whole changes in precipitation will have no adverse effects. However, there is a probability of slight precipitation decrease in the South of Russia.

Figure 32 shows changes in maximum temperature for the month with the highest mean daily maximum temperature. All GCMs demonstrate the increase in temperature for all parts of Russia.

Minimal temperature increases are predicted by the CSIRO GCM. According to this GCM the highest maximum temperature rise occurs in the Chukotka Autonomous Okrug - the eastern region of the country. In this region the maximum temperature increase by 3 - 3.5°C. For most parts of the country (regions of the central zone of the European part of Russia, northern territories, south of Western Siberia), the maximum temperature rise will be from 2 to 2.5°C. In the south of the country, Volga regions, Southern Urals regions, south of Eastern Siberia, most territories of the Far East the temperature will increase by 1-1.5°C.

The other GCMs predict higher temperature growth. MIROC GCM shows the highest temperature rise. In this case the temperature increase by more than 3.5°C in the western part of the country and in the northern regions. To a lesser extent (from 3 to 3.5°C) maximum temperature rises in the south of the country, Far Eastern regions and in the South of Siberia.

ECHAM GCM forecasts temperature increase as approaching to the northern latitudes of Russia. Maximum temperature growth is observed in the northern territories. In regions where agricultural production is concentrated now, the temperature rise is moderate.

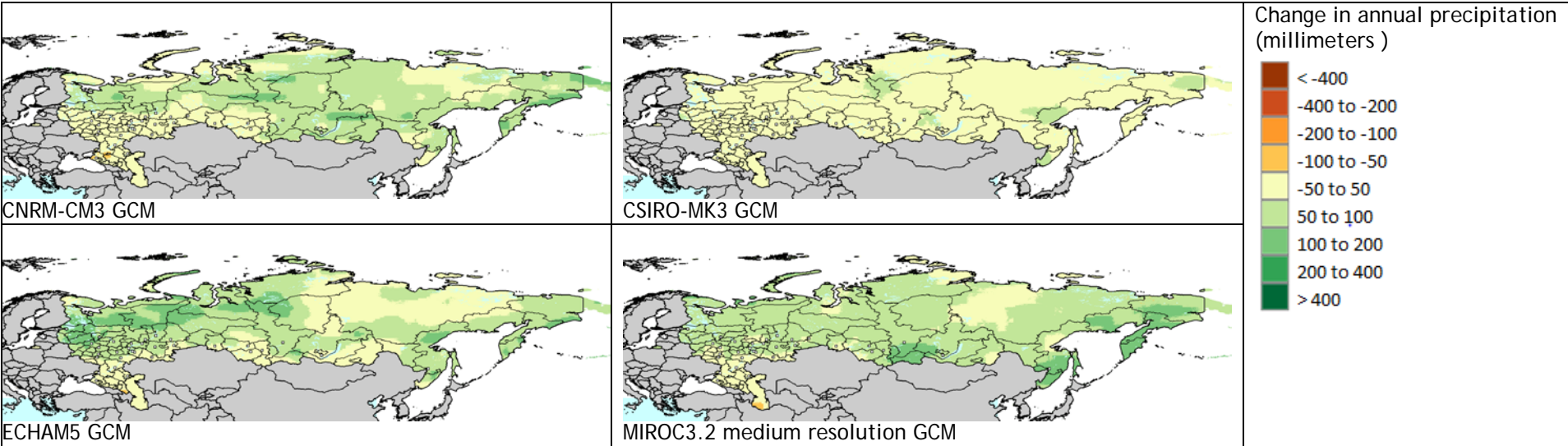
CNRM GCM predicts the highest temperature growth in the extreme northern territories of Russia. As moving away from these territories the temperature increases to a lesser extent. Nevertheless, the relatively high temperature rise is observed in the southern regions, the Black Soil regions, Southern Ural regions, the Volga regions of the country.

Hence the climate on the major part of Russia on the base of forecasts up to 2050 will be more warm and humid. However the increase of maximum temperature may be accompanied by a reduction or small increase of rainfall on the country's south, in the Volga and Black Soil regions, and in the Southern Urals and South of Siberia. Besides, the frequency of droughts in major grain-producing regions of Russia may increase by 1.5-2 times. In these circumstances, to adapt to drier conditions, it is necessary to change the specialization of the traditional agricultural regions in the direction of expansion of drought-resistant crops (maize, millet, etc.), to carry out major irrigation works, and to implement technology into agricultural production aimed at the rational use of water and land.

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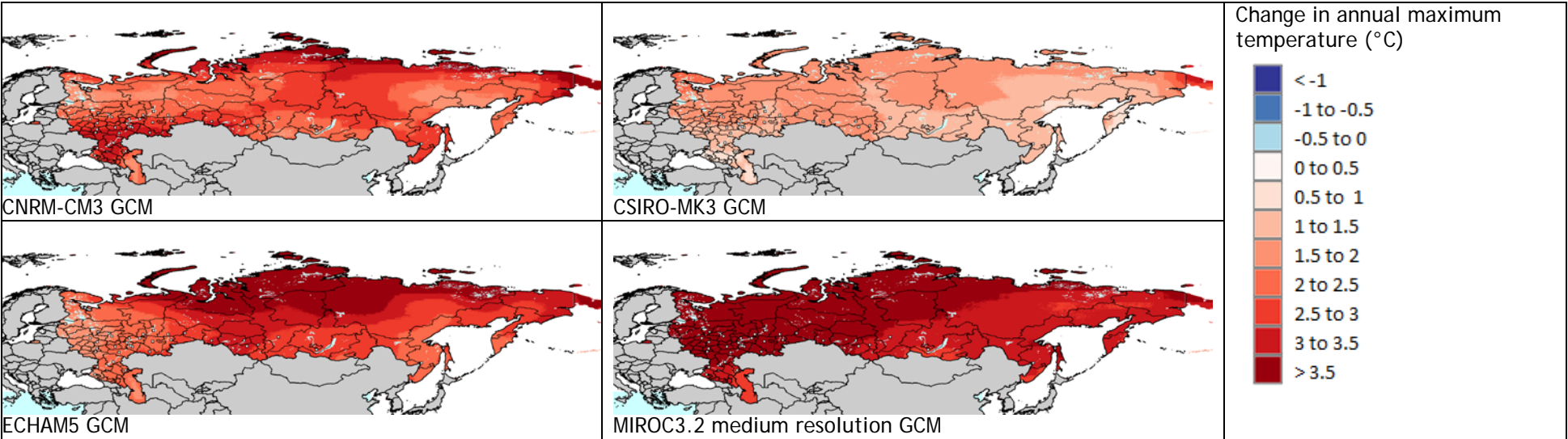
<sup>5</sup> A1B scenario is described by a balanced use of all energy sources (fossil fuels and non-fossil fuels). This scenario is characterized by rapid economic growth, increase of world population to 9 billion people by 2050 with subsequent gradual decrease, fast dissemination of new and efficient technologies, equalization of income and style of life in different regions, broad social and cultural interaction in the world.

Figure 31. Changes in mean annual precipitation for Russia between 2000 and 2050 using the A1B scenario (millimeters)



Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>

Figure 32. Changes in normal annual maximum temperature for Russia between 2000 and 2050 using the A1B scenario (°C)



Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>

### Crop Physiological Response to Climate Change

The DSSAT crop modeling system (Jones et al. 2003) is used to simulate responses of five important crops (rice, wheat, maize, soybeans and groundnuts) to climate, soil, and nutrient availability, at current locations based on the SPAM dataset of crop location and management techniques (Liang You and Wood 2006). In addition to temperature and precipitation, we also input soil data, assumptions about fertilizer use and planting month, and additional climate data such as days of sunlight each month.

We then repeated the exercise for each of the future scenarios for the year 2050. For all locations, variety, soil and management practices were held constant. We then compared the future yield results from DSSAT to the current or baseline yield results from DSSAT. The output for several rainfed key crops (wheat, maize, potato) is mapped in Figure 33 to Figure 35. The comparison is between the crop yields for 2050 with climate change compared to the yields with 2000 climate.

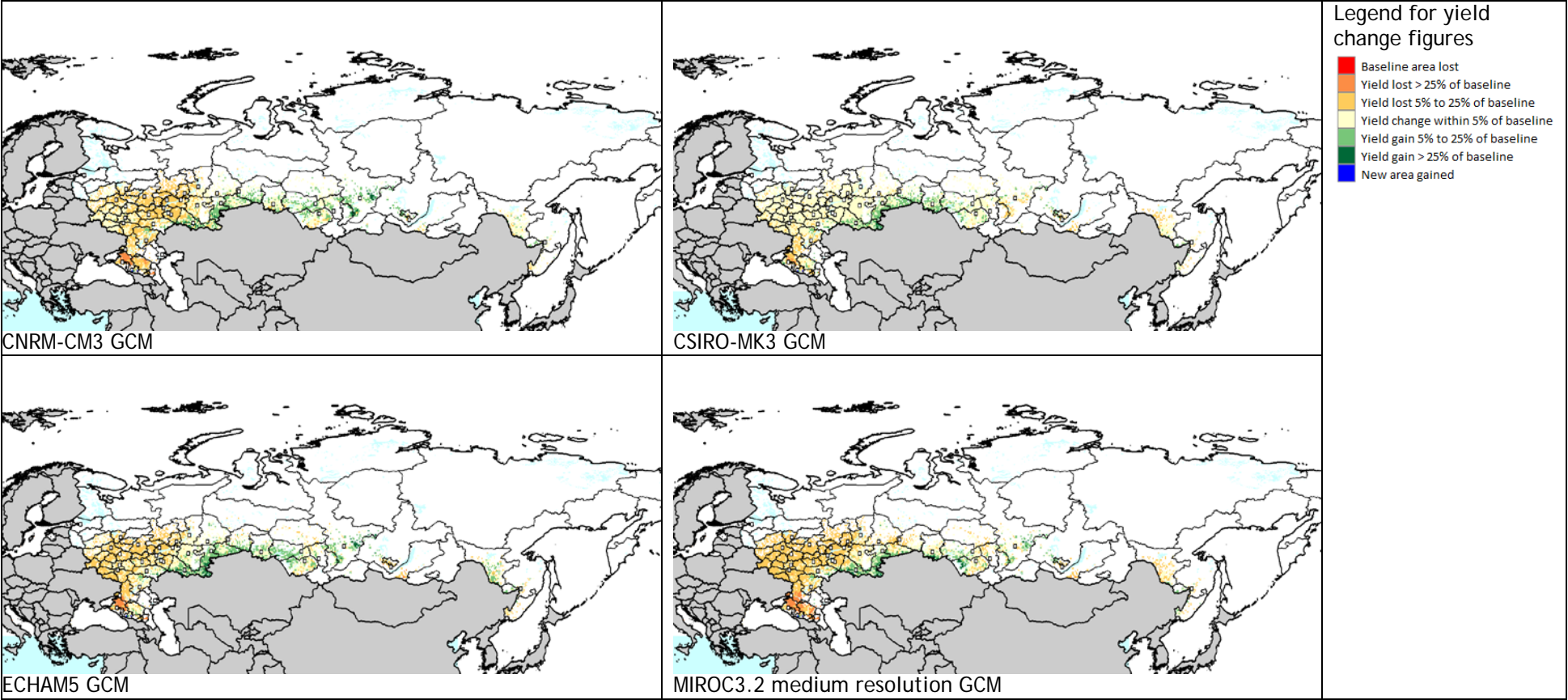
According to the simulations conducted, all GCMs demonstrate quite similar results for the rainfed crops considered. As for wheat, increase in its yields (from 5 to 25%) is observed only in the regions bordering the northern part of Kazakhstan. In other regions, producing wheat, there is a reduction of its yield. In greater extent wheat yields decline (more than 25% of the baseline) in the Krasnodar region - currently the largest wheat producer and exporter.

In contrast, climate changes will contribute to the increase of maize yields in traditional maize growing regions. In addition, new areas of maize cultivation will appear in the south of Western Siberia. However, the CNRM GCM forecasts a significant reduction in maize acreage in the regions of the Black Soil Zone and the Southern Urals.

It should be noted an increase in acreage of potato to the north of its traditional areas of cultivation, as well as in Southern Siberia. At the same time yields of potato will be less in the Black Soil Zone. Regarding potato production in the Volga and Southern Ural regions, GCMs give contradiction predictions. The CNRM model predicts the reduction of areas for potato growing in these regions. The CSIRO model forecasts a decline in potato yields, while ECHAM and MIROC GCMs predict a rise in the yield of potatoes in the Volga and Southern Ural regions.

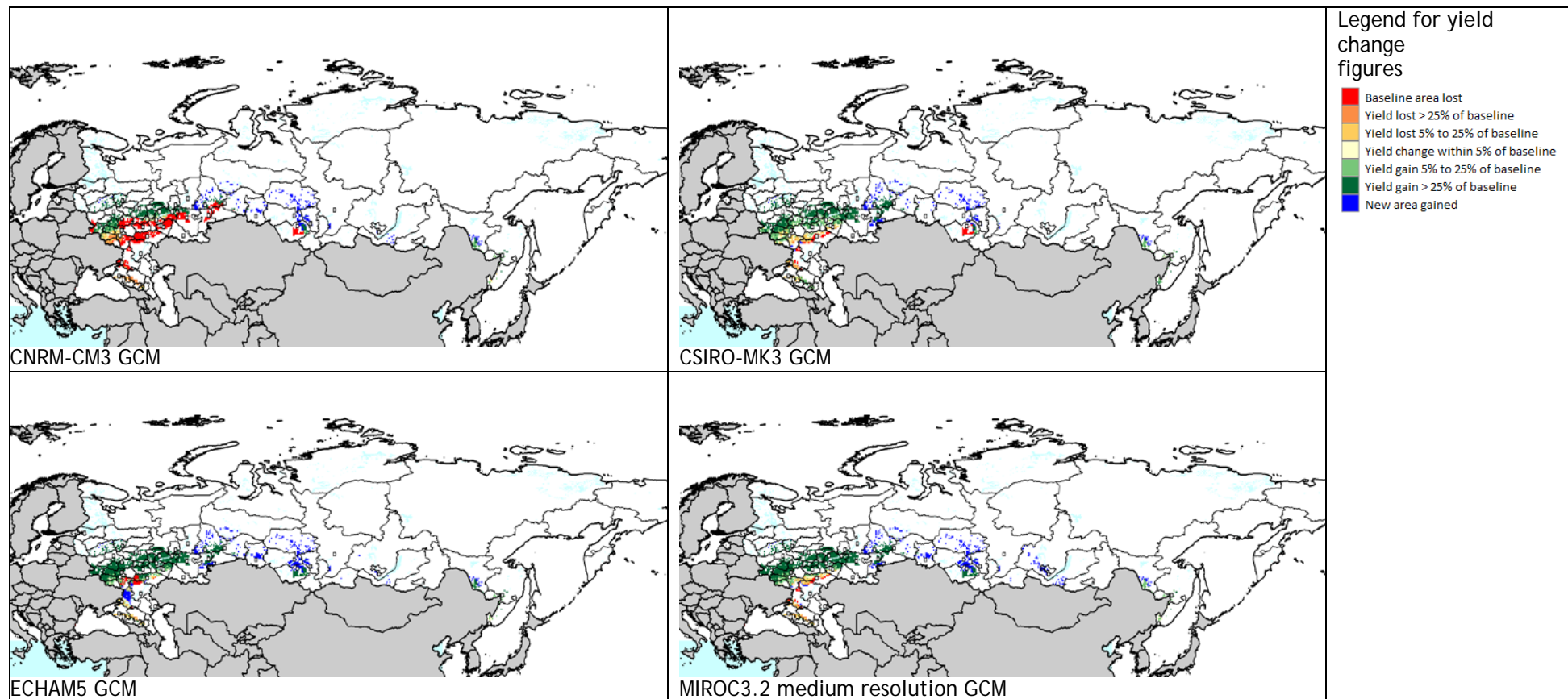


Figure 33. Yield change map under climate change scenarios: rainfed wheat



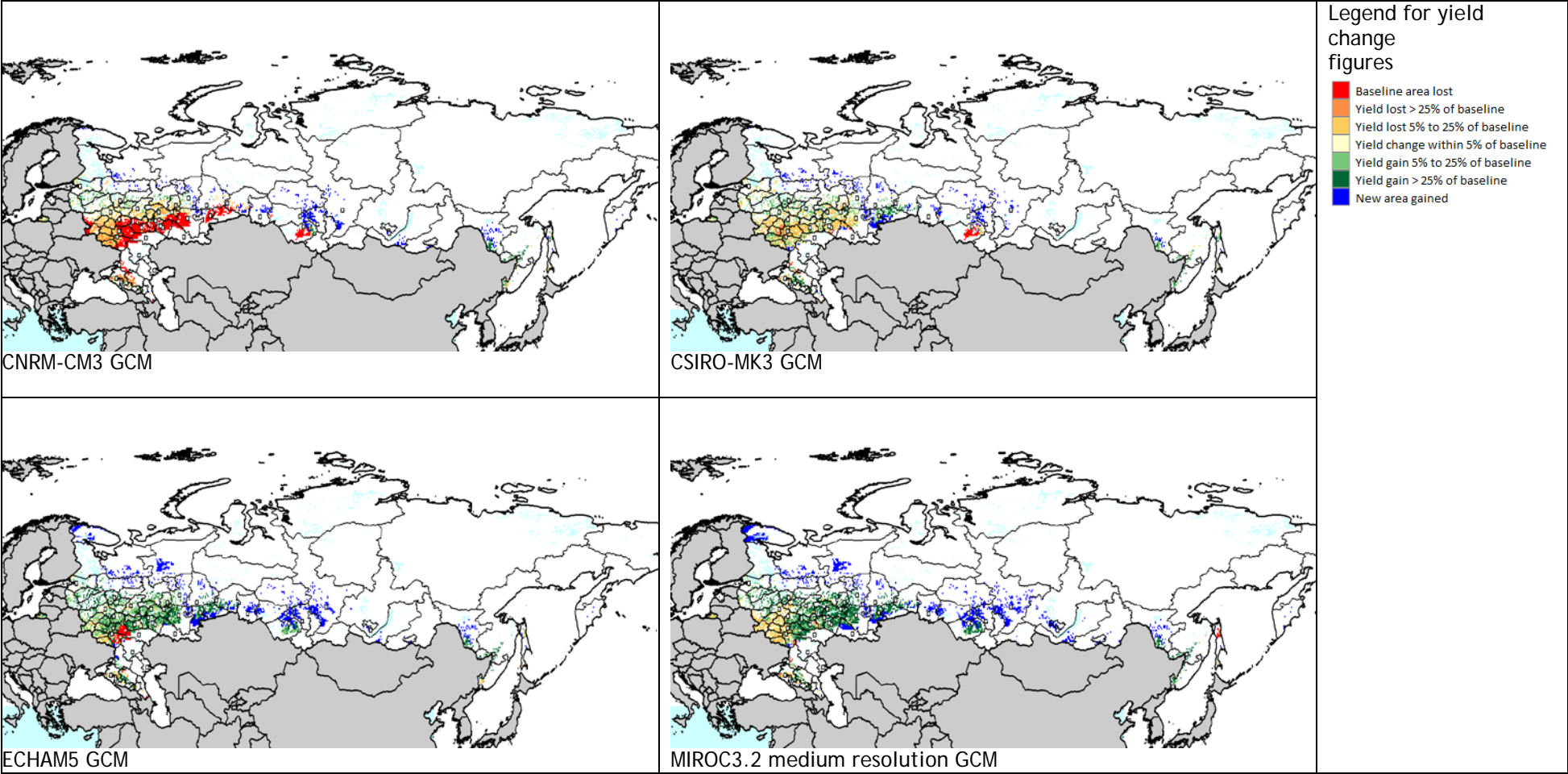
Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>

Figure 34. Yield change map under climate change scenarios: rainfed maize



Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>

Figure 35. Yield change map under climate change scenarios: rainfed potatoes



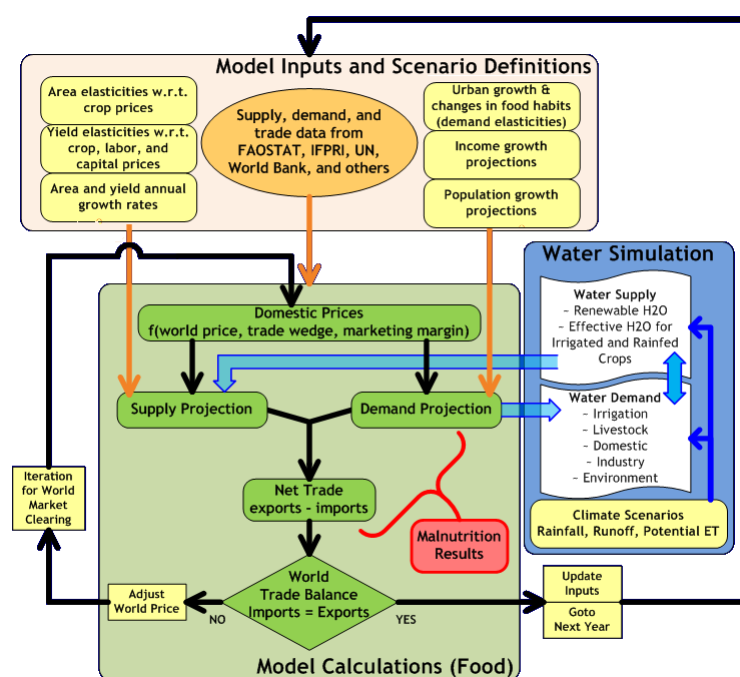
Source: IFPRI calculations based on downscaled climate data available at <http://ccafs-climate.org/>



## From biophysical scenarios to socioeconomic consequences: The IMPACT Model

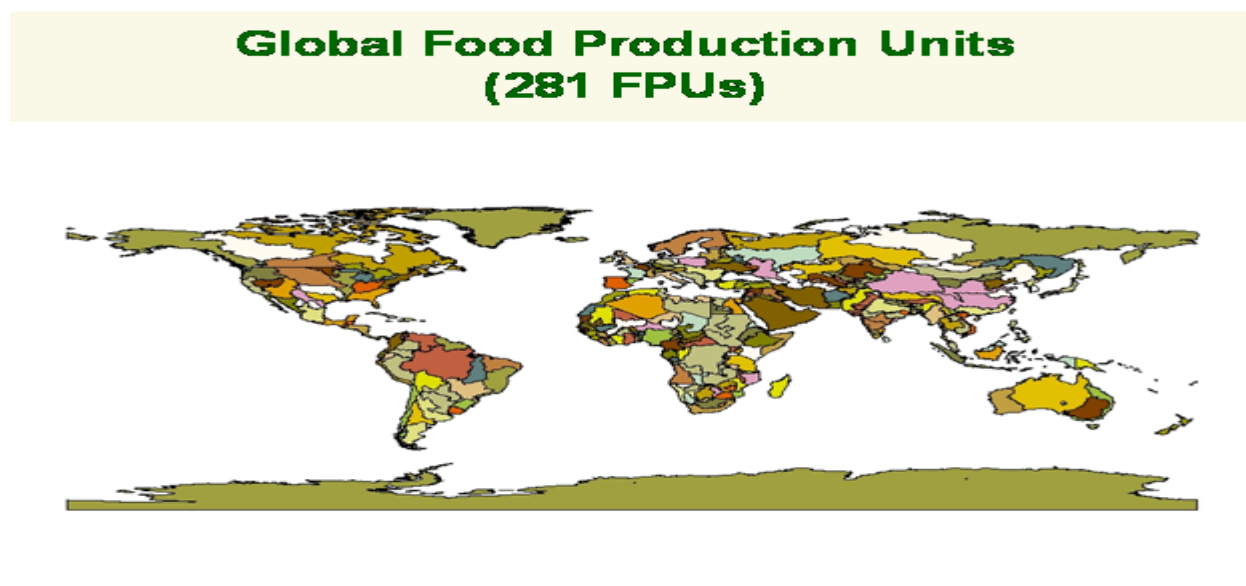
Figure 36 provides a diagram of the links among the three models used in this analysis: IFPRI's IMPACT model (Cline 2008), a partial equilibrium agriculture model that emphasizes policy simulations; a hydrology model and an associated water-supply and demand model incorporated into IMPACT; and the DSSAT crop modeling suite (Jones et al. 2003) that estimates yields of selected crops under varying management systems and climate change scenarios. The modeling methodology reconciles the limited spatial resolution of macro-level economic models that operate through equilibrium-driven relationships at a national level with detailed models of biophysical processes at high spatial resolution. The DSSAT system is used to simulate responses of five important crops (rice, wheat, maize, soybeans, and groundnuts) to climate, soil, and nutrient availability, at current locations based on the SPAM dataset of crop location and management techniques. This analysis is done at a spatial resolution of 15 arc minutes, or about 30 km at the equator. These results are aggregated up to the IMPACT model's 281 spatial units, called food production units (FPUs) (see Figure 37). The FPUs are defined by political boundaries and major river basins. In Russia 11 FPUs are located.

Figure 36. The IMPACT modeling framework



Source: Nelson, et al, 2010.

Figure 37. The 281 FPU's in the IMPACT model



Source: Nelson et al. 2010

## Income and Demographic Scenarios

IFPRI's IMPACT model has a wide variety of options for exploring plausible scenarios. The drivers used for simulations include: population, GDP, climate scenarios, rainfed and irrigated exogenous productivity and area growth rates (by crop), and irrigation efficiency. In all cases except climate, the country-specific (or more disaggregated) values can be adjusted individually. Differences in GDP and population growth define the overall scenarios analyzed here, with all other driver values remaining the same across the three scenarios.

Table 11 documents the GDP and population growth choices for the three overall scenarios for this analysis.

Table 11. GDP and population choices for the three overall scenarios

Category	Pessimistic	Baseline	Optimistic
GDP, constant 2000 US\$	Lowest of the four GDP growth rate scenarios from the Millennium Ecosystem Assessment GDP scenarios (Millennium Ecosystem Assessment 2005) and the rate used in the baseline (next column)	Based on rates from World Bank EACC study (Margulis 2010), updated for Sub-Saharan Africa and South Asian countries	Highest of the four GDP growth rates from the Millennium Ecosystem Assessment GDP scenarios and the rate used in the baseline (previous column)
Population	UN High variant, 2008 revision	UN medium variant, 2008 revision	UN low variant, 2008 revision

Source: Based on analysis conducted for Nelson et al. 2010.

The IMPACT modeling suite was run with four climate model and scenario combinations; the CSIRO and the MIROC GCMs with the A1B and the B1 scenarios. Those four outputs were used with each of the three GDP per capita scenarios. Table 12 shows the annual growth rates for different regional groupings as well as for Russia. Figure 36 illustrates the path of per-capita income growth for Russia under these scenarios. In all scenarios, Russia's income growth exceeds those of the developed group of countries and most developing countries, although it is expected to slow from the current rapid pace.

Table 12. Average scenario per capita GDP growth rates (percent per year)

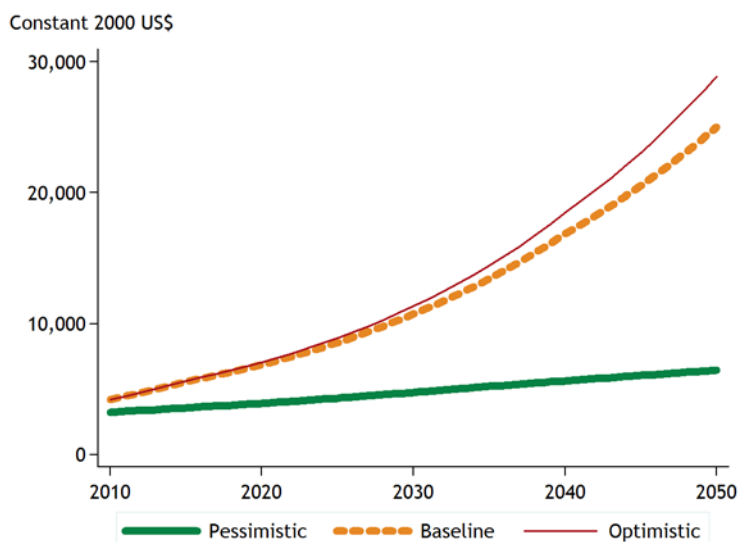
Category	1990-2000	2010-2050		
		Pessimistic	Baseline	Optimistic
Russia	-3.60	2.24	4.19	4.54
Developed	2.7	0.74	2.17	2.56
Developing	3.9	2.09	3.86	5.00
Low-income developing	4.7	2.60	3.60	4.94
Middle-income developing	3.8	2.21	4.01	5.11

World	2.9	0.86	2.49	3.22
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Source: World Development Indicators for 1990-2000 and authors' calculations for 2010-2050.

Figure 38 graphs the three GDP per capita scenario pathways, the result of combining the three GDP projections with the three population projections of Figure 5 from the United Nations Population office. The "optimistic scenario" combines high GDP with low population. The "baseline scenario" combines the medium GDP projection with the medium population projection. Finally, the "pessimistic scenario" combines the low GDP projection with the high population projection.

Figure 38. GDP Per Capita Scenarios



Source: Based on IMPACT results of July 2011, computed from World Bank and United Nations population estimates (2008 revision).

Note that the scenarios used apply to all countries; that is, in the optimistic scenario, every country in the world is assumed to experience high GDP growth and low population growth.

The GDP per capita scenario results for Russia and the U.S. can be seen in Table 13. In the pessimistic scenario, U.S. per capita income increases less than 2 times while in the optimistic scenario, it almost triples between 2010 and 2050. The Russian per capita income triples in the pessimistic scenario and increases almost 12 times in the optimistic scenario. However, despite Russia's much more rapid growth than in the U.S. its per capita income in 2050 is still only one-fifth of that in the U.S.

Table 13. Russia and U.S. Per Capita Income Scenario Outcomes (2000US\$ per person)

	2010	2030	2050
Pessimistic			
Russia	3,170	4,484	7,948
U.S.	37,504	51,132	58,291
Baseline			
Russia	4,135	10,137	23,000
U.S.	37,723	56,517	88,841
Optimistic			
Russia	4,135	10,696	26,570
U.S.	39,218	67,531	101,853

## Agricultural Vulnerability Scenarios (Crop-specific)

Figure 39 to Figure 43 show simulation results from the IMPACT model for wheat, maize, other grains, sugar beet and potato. Each crop has five graphs: one each showing production, yield, area, net exports, and world price.

Several of the figures below use box and whisker plots to present the effects of the climate change scenarios in the context of each of the economic and demographic scenarios. Each box has 3 lines. The top line represents the 75th percentile, the middle line is the median, and the bottom line is the 25th percentile.<sup>6</sup> All scenarios result in a gradual increase in real world prices for all crops considered. The relatively high price increases observed for wheat, maize and sugar beet. Against the backdrop of rising prices there is an increase in production of major crops except potatoes. Potato production falls due to reduced acreage.

The substantial increase in grain production will be caused mainly by the improvement in its yield (taking into account rainfed and irrigated exogenous productivity improvement). Particularly yields of corn and wheat will increase significantly. In addition, the area under these crops will be extended. In contrast, the increase in other grains production will be accompanied by the acreage reduction.

By 2050, production of wheat will reach 100 million tons, maize - about 10 million tons, other grains - about 40 million tons. Against the backdrop of rising incomes and declining population, almost twofold increase in grain production will cause growth of exports. Net exports of wheat will increase by more than 5 times compared to 2010.

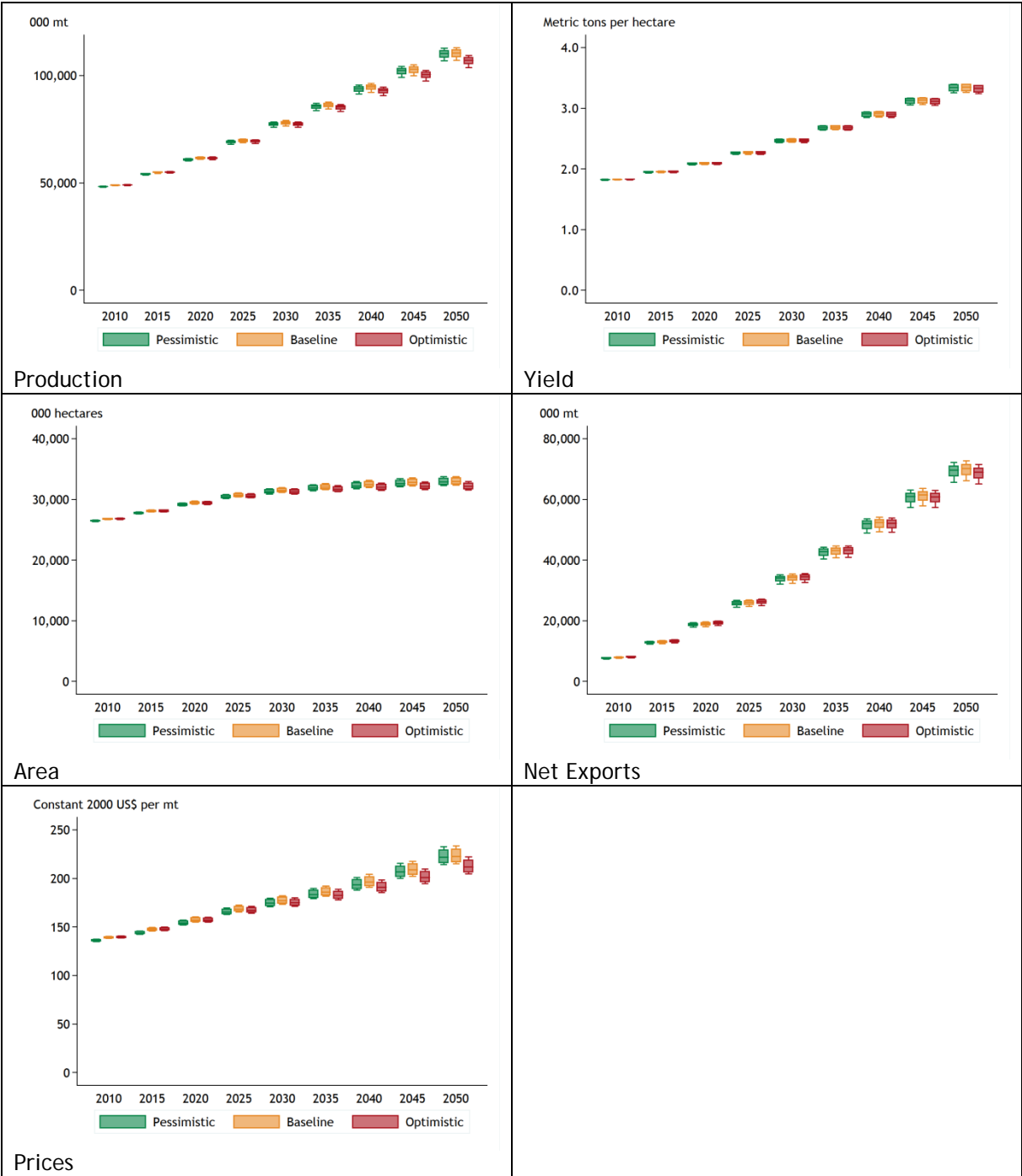
Despite the growth of sugar beet production, Russia will remain a net importer of sugar.

Thus, the applied analysis allows to estimate potential influence of climatic, demographic and economic factors on crops production. Taking into account climate changes and increase in demand for agricultural products in the world, the major challenges for Russia are carrying out adaptation policy in the main agricultural regions and increase in the efficiency of agricultural production to strengthen the competitiveness of a domestic production in the world market. This is extremely important to do for production of wheat in Russia's southern regions with a negative impact of climate changes.

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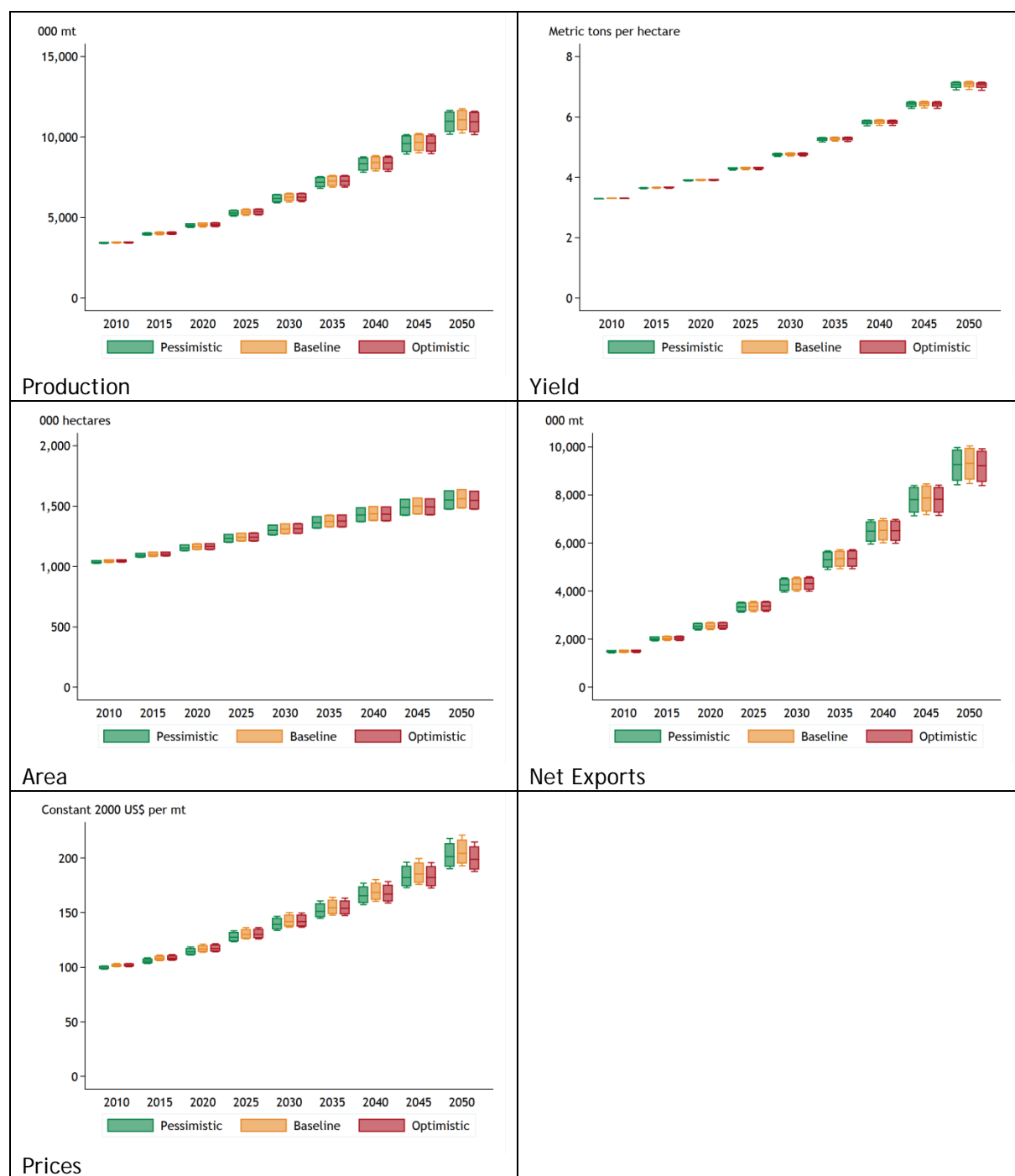
<sup>6</sup> These graphs were generated using Stata with Tukey's(Tukey 1977) formula for setting the whisker values. If the interquartile range (IQR) is defined as the difference between the 75th and 25th percentiles, the top whisker is equal to the 75th percentile plus 1.5 times the IQR. The bottom whisker is equal to the 25th percentile minus 1.5 times the IQR (StataCorp 2009).

Figure 39. Scenario outcomes for wheat area, yield, production, net exports, and prices



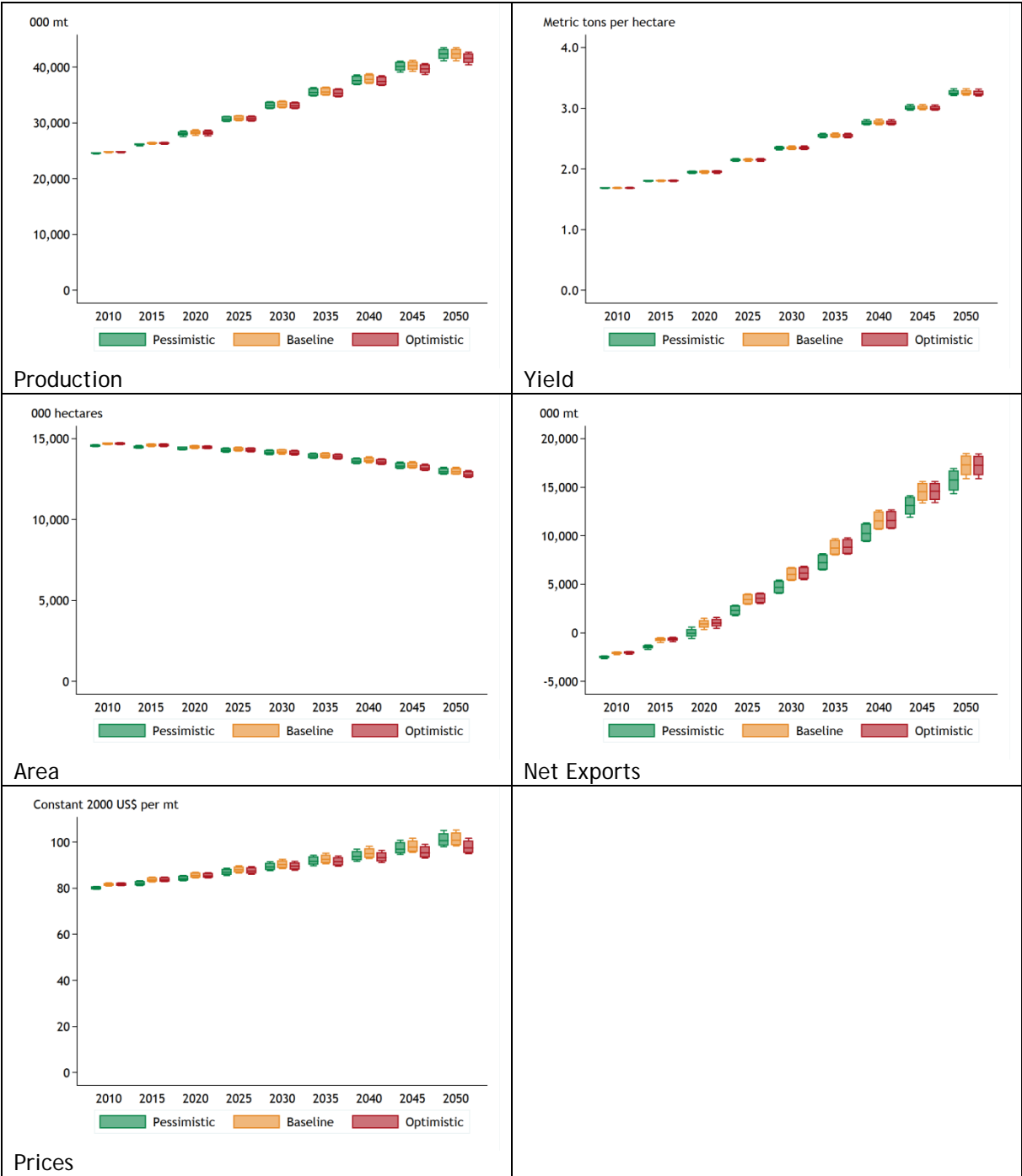
Source: Based on IMPACT results of July 2011.

Figure 40. Scenario outcomes for maize area, yield, production, net exports, and prices



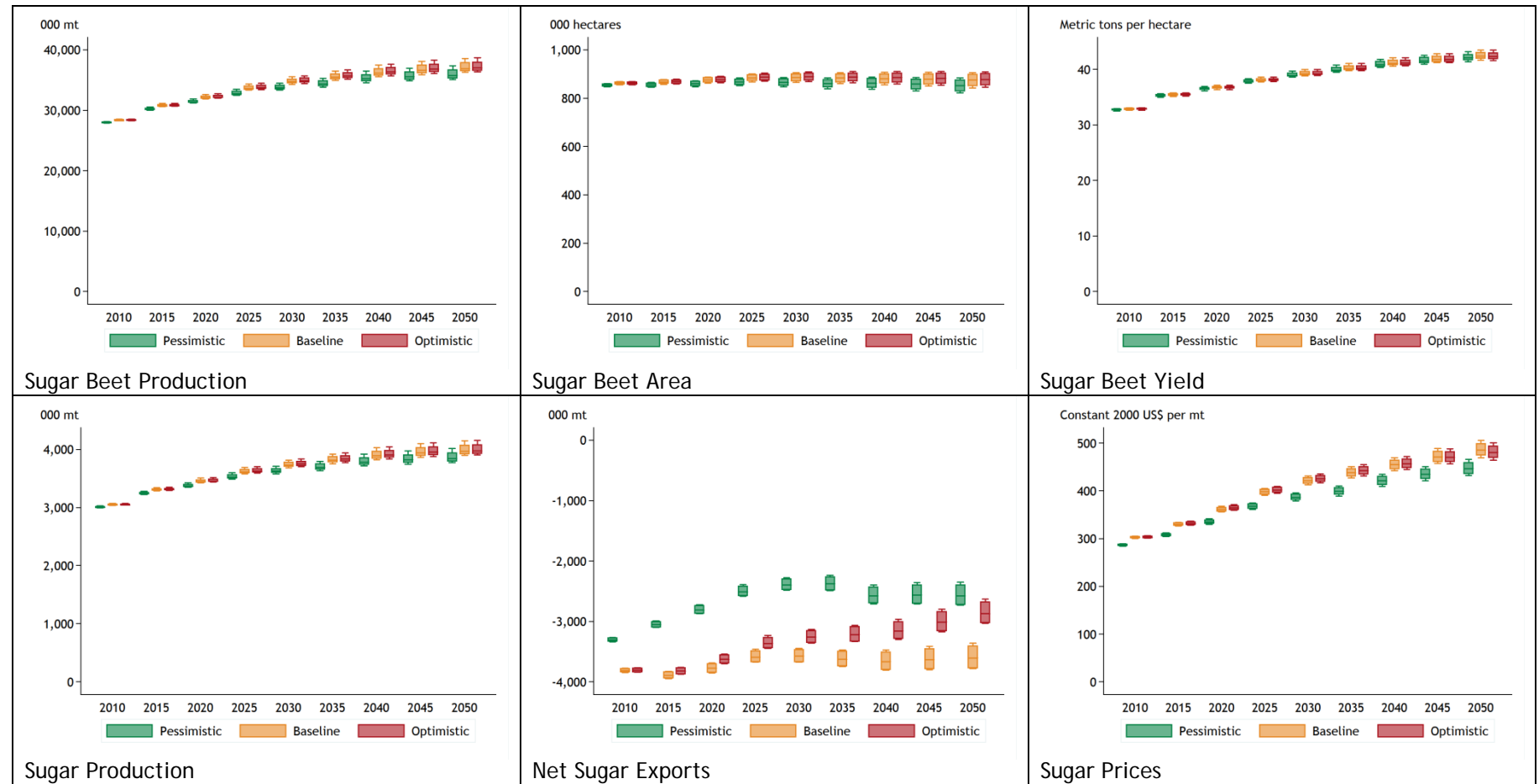
Source: Based on IMPACT results of July 2011.

Figure 41. Scenario outcomes for other grains area, yield, production, net exports, and prices



Source: Based on IMPACT results of July 2011.

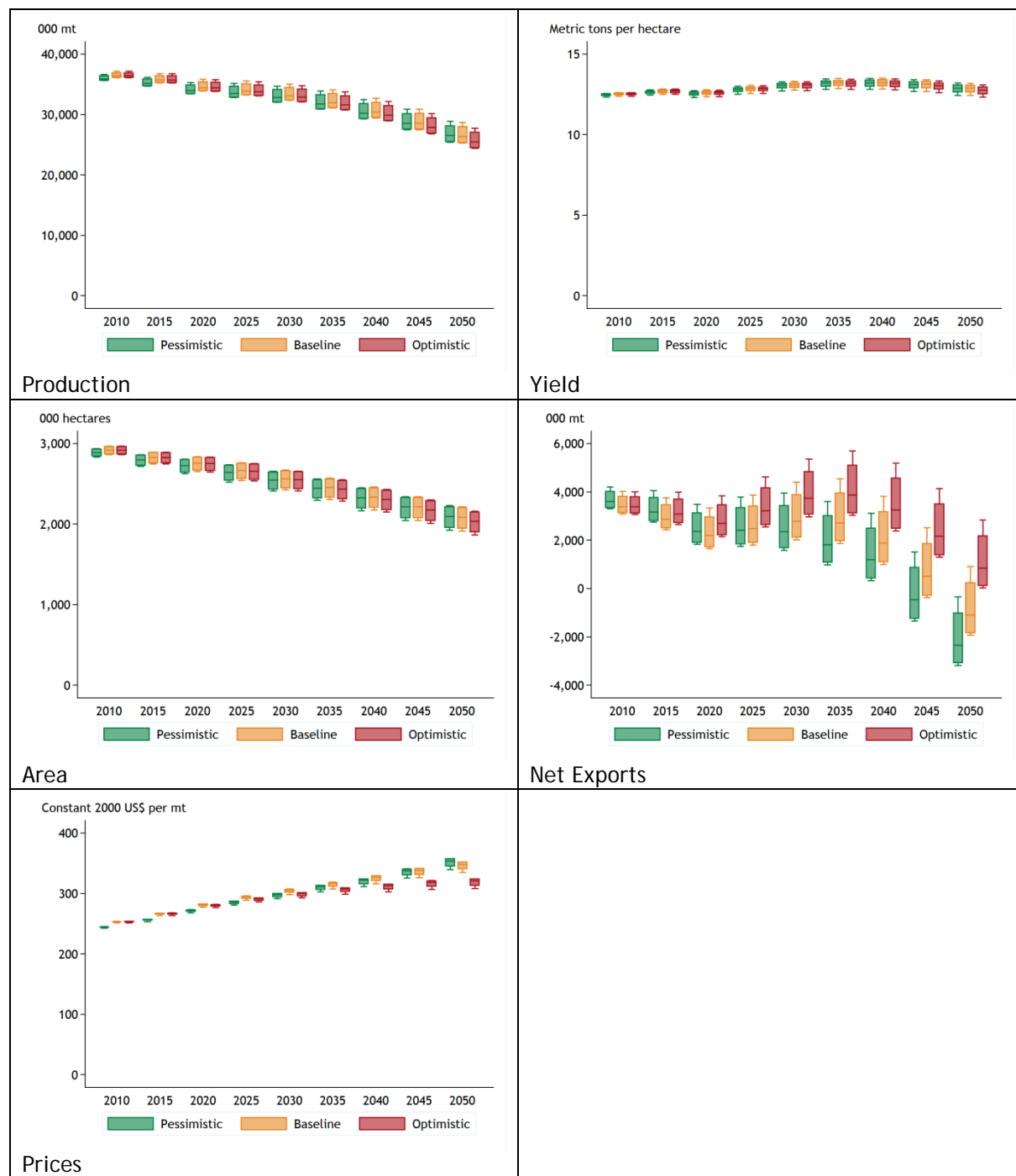
Figure 42. Scenario outcomes for sugar beets area, yield, production, net exports, and prices



Source: Based on IMPACT results of July 2011.



Figure 43. Scenario outcomes for potato area, yield, production, net exports, and prices

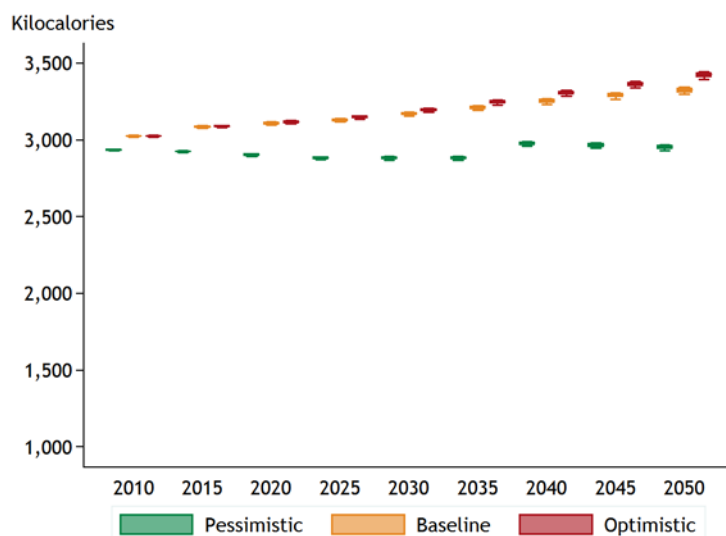


Source: Based on IMPACT results of July 2011.

## Human Vulnerability Scenarios

Figure 44 shows scenario outcomes for the average daily kilocalories per capita. The baseline and optimistic scenarios show increases in calorie availability; the pessimistic scenario has a small decline, from about 3,000 kilocalories per day in 2010 to 2,900 kilocalories per day in 2050.

Figure 44. Average daily kilocalories availability under multiple income and climate scenarios (kilocalories per person per day)



Source: Based on IMPACT results of July 2011.

As the box and whiskers plots indicate, within a particular overall scenarios climate change has relatively little impact on the average daily kilocalories per capita. The reason is the ability of Russia to import and/or export depending on how climate change affects production domestically and abroad.

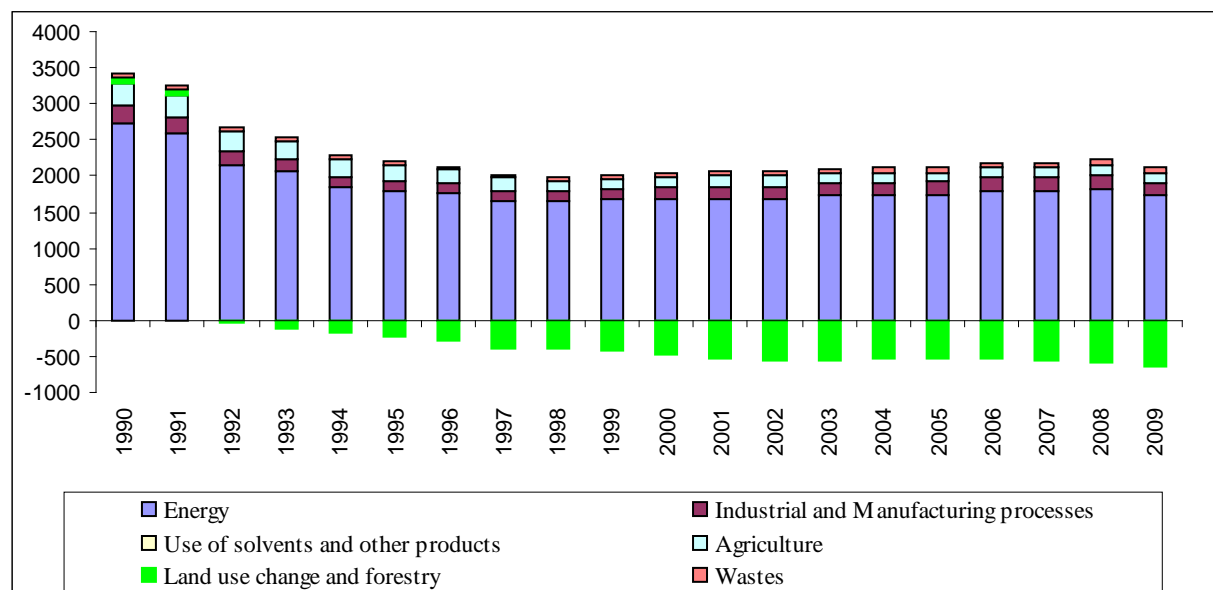
Agriculture and Greenhouse Gas Mitigation

## Agricultural Emissions History

Figure 45 shows data on the total anthropogenic greenhouse gas emissions in Russia for the period from 1990 to 2009. Since 1990 the total emission decreased significantly (57.4%). Total volume of greenhouse gas emissions includes CO<sub>2</sub> and other greenhouse gases in the sector Land use change and Forestry. This sector is characterized by a distinct tendency to reduce emissions and absorption increase during the period considered.

From 1990 to 1998, reduction of greenhouse gas emissions in Russia was caused by the negative dynamics of domestic economy. In subsequent years there was a steady increase in greenhouse gas emissions due to an economic growth. By 2008, greenhouse gas emissions rose by 2.4% (taking into account the contribution of Land use change and Forestry sector) as compared to 1998 - a year with the lowest total greenhouse gas emissions in Russia. In 2009 the emissions in the leading sectors of the economy declined (in the Energy sector by 5.2%, Industrial and Manufacturing processes - by 12.4%, Agriculture - by 0.3 %) as a result of the influence global economic crisis on the Russian Federation.

Figure 45. GHG Emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, PFCs, HFCs, SF<sub>6</sub>) in Russia by Sector (mln. tons CO<sub>2</sub>-eq)



Source: National report for 1990 – 2009 on anthropogenic emissions by sources and absorption of greenhouse gases not controlled by the Montreal Protocol, 2011

Aggregate greenhouse gas emissions in 2009 amounted to 2111.50 million tons CO<sub>2</sub>-eq. and remained significantly (37.0%) lower compared to 1990. The paces of growth in emissions observed in recent years were relatively low due to both a general increase in the efficiency of the economy and structural changes occurred.

The distribution of emissions by sector for 1990-2009 has had rather small changes. Emissions from the energy sector are dominated (in 1990 and 2009 they accounted for 81.1% and 82.3% respectively). The share of agricultural sector in total greenhouse gas emissions reduced from 9.5% in 1990 to 6.7% in 2009). This is a rather low level, given the global average level of 15%. In absolute terms, greenhouse gas emissions of agricultural sector amounted to 142.4 million tons CO<sub>2</sub>-eq. in 2009. The contribution of nitrous oxide (N<sub>2</sub>O) in the overall agricultural greenhouse gas emissions was more than twice high (68.1%) compared with the contribution of methane (CH<sub>4</sub>) - 31.9%.

In 2009, total greenhouse gas emissions from the agricultural sector of the Russian Federation amounted to 44.9% of 1990 level. During this period direct emissions of nitrous oxide from agricultural land were decreased by 46.6% and methane emissions from animal enteric fermentation processes were reduced by 59.5%. Reduction of greenhouse gas emissions is a result of reduction in livestock and poultry numbers, as well as acreage and mineral fertilizers application decreasing. Compared to 1990, livestock numbers decreased by 63.8%, pigs - by 55%, sheep and goats - by 62.2%, poultry - 34.3%. Cultivated area was reduced by 33.9% or 39.9 million hectares. The application of mineral nitrogen fertilizers declined by 70.6%, which corresponds to a reduction of nitrogen input to agricultural soils of 3.0 million tons.

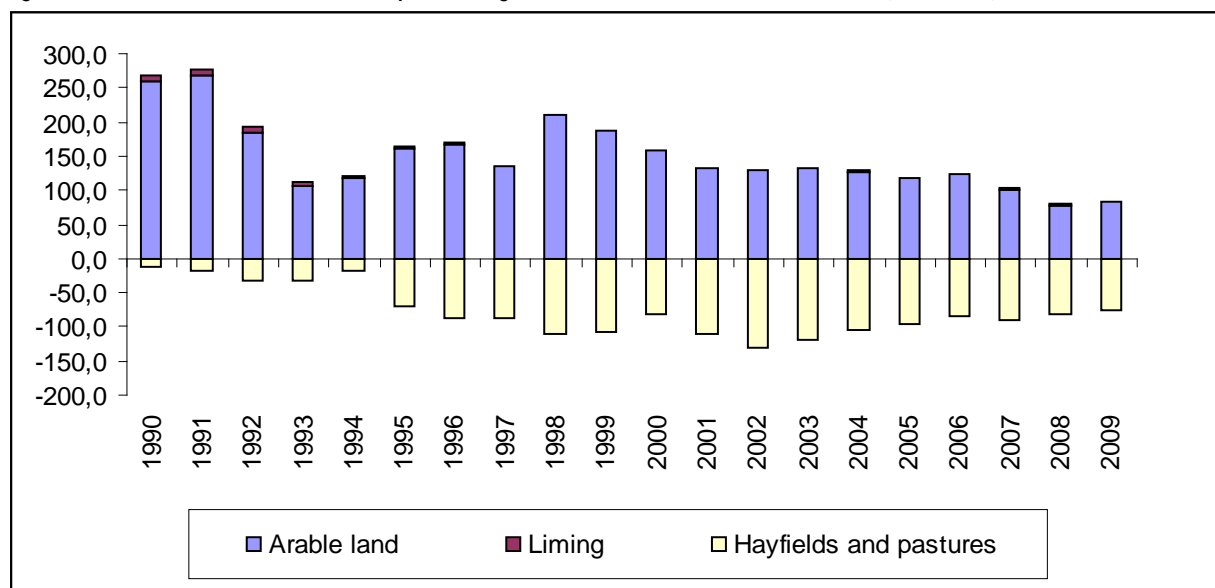
Greenhouse gas emissions due to land-use change and the forestry sector include emissions from agricultural land, organic soil, forest fires, peat activity and deforestation, as well as carbon dioxide absorption in biomass and other pools of carbon-managed forests, grasslands and lands transferred from arable to hayfields and pastures.

Dynamics of agricultural land-use emissions is characterized by a clear trend of increasing absorption and emission reductions due to the following reasons:

- emission reduction of arable land (due to the reduction of arable land, increasing the average yield of most crops in recent years and lower levels of microbial respiration of arable soils as a result of low application of organic fertilizers<sup>7</sup>);
- accumulation of soil organic carbon on land converted from arable to hayfields and pastures.

In 2009, CO<sub>2</sub> emission from arable land amounted to 83.0 million tons (see Figure 46). At the same time hayfields and pastures absorbed 76.5 million tons of CO<sub>2</sub>.

Figure 46. CO<sub>2</sub> emission and absorption in agricultural land use sector in Russia (mln. tons)



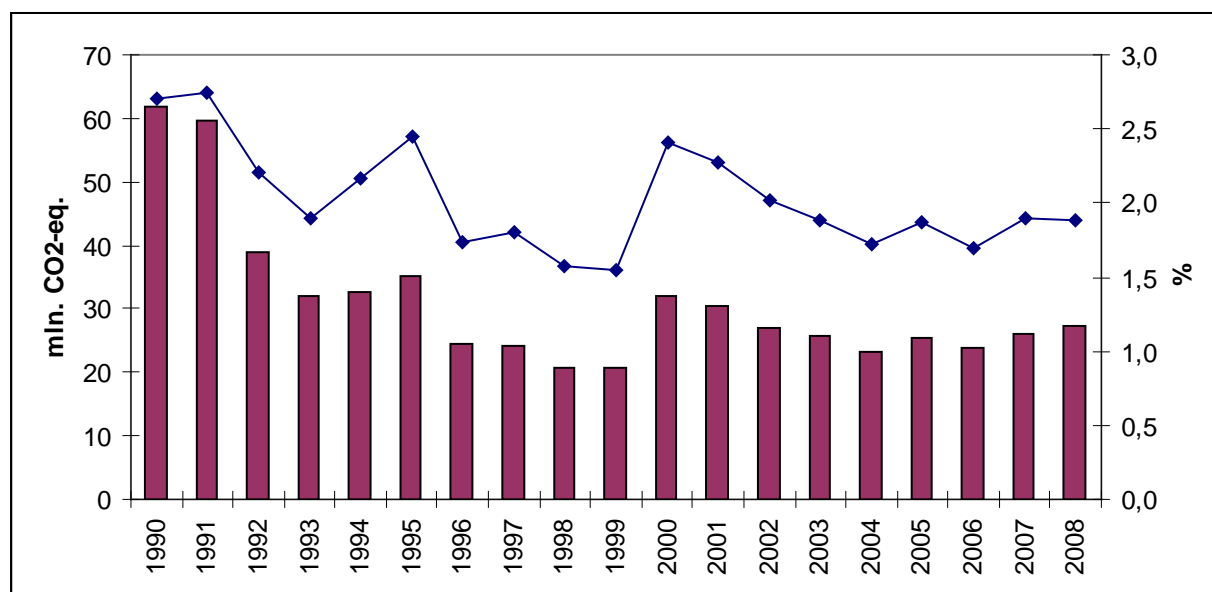
Source: National report for 1990 - 2009 on anthropogenic emissions by sources and absorption of greenhouse gases not controlled by the Montreal Protocol, 2011

Greenhouse gas emissions in Land use change and Forestry sector were dominated over absorption in 1990 - 1992 during the active usage of agricultural land and forest resources. In 2009 Land use change and Forestry sector absorbed from the atmosphere 649.6 million tons of CO<sub>2</sub>-eq.

Besides the greenhouse gas emissions from agricultural lands and animals agricultural activity produces emissions from the combustion of motor fuels (gasoline, liquefied gas, diesel and other motor fuels). Figure 47 shows such emissions for agriculture/forestry/fisheries during the period of 1990-2009. The share of agriculture in total fuel combustion activities' emissions is not large. Throughout the period considered, it declined from 2.7% in 1990 to 1.9% in 2009.

<sup>7</sup> Reduction in the numbers of livestock and poultry resulted in decreasing application of organic fertilizers. The application of organic fertilizers was reduced by 86.2% from 389.5 million tons in 1990 to 53.7 million tons in 2009. As a result of the reduction in use of organic fertilizer, the carbon input to soil was reduced from 71.1 million tons in 1990 to 9.8 million tons in 2009.

Figure 47. GHG emission from the combustion of motor fuels in agriculture/forestry/fisheries (mln. tons CO<sub>2</sub>-eq) and its share in total fuel combustion activities (%)



Source: National report for 1990 - 2009 on anthropogenic emissions by sources and absorption of greenhouse gases not controlled by the Montreal Protocol, 2011

## Technical and economic potential for mitigation of agricultural greenhouse gas emission

Currently, greenhouse gas emissions of agricultural sector are not substantial. However, since there are good reasons to predict the increase in agricultural production in the future, it is important to prevent the adverse effects of this process on climate change. To reduce greenhouse gas emissions the agricultural producers may use the following measures:

1. Optimizing the use of fertilizers on arable lands and grasslands on the basis of an exact calculation of crop needs for fertilizers, applying fertilizers with slow or controlled release of nutrients. The implementation of these measures could lead to more rational use of fertilizers and increase in crop yields.
2. Restoration of drained organic soils (peat). Such soils occupy 4.4 million hectares of arable lands. Restoration of organic soils by flooding will help to reduce carbon emissions and contribute to carbon absorption. Also it is necessary to reject completely the practice of the drainage of such soils.
3. Restoring lands degraded as a result of their intensive use, erosion, loss of organic content, acidification, etc.
4. The use of advanced agronomic practices that increase productivity and promote a more intensive carbon absorption:
  - a. The use of improved varieties.
  - b. The use of crop rotation methods, which contribute to the accumulation of soil carbon and reduce the acreage of fallow lands.
  - c. The application of advanced methods of tillage.
  - d. The use of feed additives and vaccines for livestock in order to suppress methanogenesis and enteric fermentation processes.
5. The application of anaerobic systems for the collection and storage of manure, and increase in the use of manure as a biofuel.
6. Improving energy efficiency of the agricultural sector. Using modern technology and equipment.

In addition to the measures listed above, the rural population can take part in planting forests on land previously covered by forests, and planting shelter belts on agricultural lands. These measures should be implemented in areas characterized by significant degradation of soils and forests. Their implementation will help to restore the landscape.

Implementation of the measures for the reduction of greenhouse gas emissions in agriculture is associated with significant costs. Currently, the majority of agricultural producers in Russia do not have sufficient incentives to reduce emissions of greenhouse gases. Also they do not have the necessary equipment and facilities for the introduction of new technologies and processes into production. In addition, in most regions there is the lack of information about new technologies and methods, which implementation will contribute to the increase in productivity and help to reduce greenhouse gas emissions in the agricultural sector.

In these circumstances the RF Government as part of the policy on Sustainable Development of the agricultural sector should include measures aimed at providing information for individual producers, provide technical assistance and financial aid in the implementation of the pilot projects on introduction of advanced technologies and methods of agricultural production. In addition, the provision of agricultural subsidies could be linked to the application of measures to reduce greenhouse gas emissions.

## Conclusions

Despite the positive dynamics of agricultural output and strengthening agricultural and food products competitiveness, Russia is still heavily dependent on food imports due to the limited capacity to meet consumer demand through domestic production.

Growth in exports is slow than growth in imports. To improve the situation, investments in the most problematic segments of food and processing industry are required. Particularly, it refers to the construction and reconstruction of the slaughter enterprises and enterprises for the primary processing of slaughtered animals.

The long-term risks of development of agriculture include climatic changes occurring around the globe. In general, global climate changes will positively effect Russian agriculture. In high and middle latitudes, global warming will expand the growing season. Acreages of agricultural crops may expand toward the north, although yields will likely be lower due to less fertile soils.

However, in the southern regions there is a possibility of drier climate, which has a negative impact on crop yields and livestock productivity. In addition, global warming will increase the scarcity of water resources, and encourage weed and pest proliferation.

Climate change increases the short-term risks associated with an increase in extreme weather events and natural disasters. Every year some regions in different periods of time show the weather parameters beyond the average.

In these conditions, the measures for adaptation of agriculture to climate changes should be implemented. Such measures can be focused on the following directions.

First, clear and consistent agricultural adaptation policy should be formulated. Such policy should include measures at the federal and regional levels to develop specific programs based on scientific researches. Under the policy production systems should be adapted: farming systems, changes in the share of production of various crops (growing more adapted or less risky but less profitable crops), the ratio of different varieties and crop planting dates.

The adaptation of crop production in regions with warmer and more humid climate should include expanded plantings of a late-ripening and more yield varieties of grains and legumes, sunflower, canola, soybean, late-ripening varieties of potatoes, thermophilic species of fodder crops.

Besides of that, in the arid zones the adaptation measures should be aimed at the expansion of irrigated agriculture, which should be considered as a necessary condition for the fullest use of additional warming in plant production, rationalization of water use through the widespread

introduction of moisture saving technologies (snow retention, reducing unproductive evaporation, drip irrigation), the expansion of winter crops (wheat in the steppe regions of the Volga and the Urals, barley in the Northern Caucasus).

Secondly, the adaptation policy should cover probable changes of agrarian specialization of the regions, their land-use and crops production patterns. This will require significant investment in the infrastructure development in the areas of both possible improvement and deterioration of agroecological conditions, carrying out activities on mechanization, chemicalization, amelioration, and adoption of achievements of technological progress. It is worth to mention the necessity of development transport and export infrastructure aimed at strengthening the competitiveness of the Siberian grain. In addition, it needs to implement a set of measures to restore degraded lands due to their intensive use and depletion, erosion, acidification.

Thirdly, in the frameworks of general investment policy, a specific concern should be given to particular investments aimed at adapting to climate change. As an effective and traditional adaptive measure investments to afforestation are required for the land use stability. The scale of afforestation works has decreased last years despite the objective necessity for the expansion of such work, including the reason of the obvious climate changes. It should be taken into account, that agricultural afforestation not only exerts favorable influence on soil, moisture regime, and crop microclimate, but also fulfills a function of carbon binding and thus inhibits global warming. It should help increasing yields and their stability.

Fourthly, the system of adaptation should take into account a number of important characteristics of climate change. Among them there is an increase in the number of dangerous meteorological events. Some of the events cannot be predicted or are hard to be foreseen. In this connection it is necessary to improve accuracy and reduce the time for providing weather data through the modernization and extension of observation networks, as well as the introduction of modern methods of evaluation of the observed data. Adaption to dangerous meteorological events presupposes not only improvement of forecasting and monitoring of natural environment changes. Development and application of a set of economic measures are important; it includes development of reliable system of risk management and insurance of crops and agricultural producer income.

Attention should be paid not only to the crops insurance system. Although the insurance as a result of the efforts undertaken since the drought of 2010 has become more accessible to farmers, it is not very attractive to insurers. Regional features are considered insufficiently in new system. As a result, for some regions the probability of obtaining the insurance is low.

It needs to begin developing a variety of climate risk management tools used in the world. These include insurance indices, the indices of the weather, early warning system for possible losses. This will require the implementation of pilot projects in these areas.

Fifthly, a specific program should be developed in order to carry out activities on reduction of degree of risk at extreme weather conditions. Such program may be federal or departmental, and it should take into account a spectrum of problems. However, the program implementation should presume not only allocation of financial resources. Educational programs for farmers, managers and employees should be developed and carried out. Agricultural producers should get technical and financial assistance and support to facilitate the implementation of technologies aimed at adapting to climate change.

A difference between scenarios of climate change influence, both favorable and unfavorable, on the crops production in various regions of Russia should be taken into account. In other words, different sets of adaptation measures, which consider specific character of regional climate changes, are required.

Sixth, it is necessary to increase funding for research in order to carefully study the effects of climate change on agro-ecological conditions, and on this basis to form the adaptation policy aimed at sustainability of agricultural development in the new environment.

Studying the effect of climate change influence on the spread of agricultural pests and animal diseases should be an important direction of research. In addition, the active support of research in the field of plant selection aimed at creating varieties of plants with desired characteristics is badly needed.

Scientific research on refinement of climate change forecasts in the agricultural areas of different regions should be continued. In line with these forecasts, local rural development programs considering the adaptation capabilities of individual groups of crop producers should be developed and implemented. Absence of such predictive estimates and programs may result in large social and economic losses, irrational distribution of investments and irrational specialization in agriculture in the nearest future.

It should be noted, that preparing high-quality long-term prognosis depends on Russia's participation in international projects to assess the impact of climate change on agriculture. In this connection it should intensify research in the field of data collection and analysis of spatial data with reference to specific regions and water basins. This will require the use of remote sensing equipment, carrying out works on deciphering and interpreting data, and their linkage to official statistics, the creation of database management systems, allowing easy access to the necessary data. These data should be available to users.

Seventhly, an essential component of adaptation is social support of vulnerable groups of rural population, which essential part is formed by the wage workers of agricultural enterprises and those occupied in personal subsidiary plots.

18.1 million people or 12.8% of the population have incomes below the subsistence level in Russia. 42% of these people live in rural areas. Low income groups are most vulnerable to adverse impact of climate changes and rising prices for food. Mitigation of these problems is possible through a system of insurance income of agricultural producers, that is absent in Russia. The problem of subsidizing the consumption of food for low-income groups is still actual.

Eightly, for the purpose of sustainable development of the agrarian sector and securing the presence of primary agricultural goods on the domestic market, it is essential to form food reserves (primarily, grain reserves), that is, to buy production of crop producers in yielding years for subsequent provision of crops supply stability in fail years. This measure provides support for producers and prevents abrupt and excess price fluctuations. In addition, it should be noted the importance of development and modernization of storage facilities to reduce the loss of crop production during its storage.

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