THE ADAPTATION CHALLENGE

Key issues for crop production and agricultural livelihoods under climate change in the Russian Federation

Worker with combine harvester, Rubtsovsk, Altay Krai, 2011. Photo: Anna Moiseenko

Climate change has serious implications for global food production and food security. Part One of this report uses scientific data on current changes and future scenarios to examine possible impacts on crop production in the Russian Federation. It considers what measures Russia might need to implement to achieve its desired aim of playing a leading role in ensuring global food security. Part Two uses interviews with farmers to highlight ways in which they are adapting to new climatic conditions, but also the problems those conditions are posing, particularly to smallholders. It considers what more should be done to support their efforts to boost their resilience and contribute to national food security.

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EXECUTIVE SUMMARY

‘Russia is ready to assume a leading role in addressing yet another global task – food security. We should not allow food shortages or excessive price hikes on world food, which… is something we have witnessed in recent years. Russia, with its vast crop areas, the largest in the world, has significant capabilities. We invite all investors, all potential partners to cooperate in this sphere.[1]

Dmitry Medvedev, Prime Minister of the Russian Federation at Rio+20, June 2012

‘Agriculture has simply fallen out of favour. Everyone has rushed to earn money – no one thinks about developing agriculture [any more]. I hope new people will come into farming…This is what has happened to nature: social and economic changes go hand in hand with climate changes’

Elena, female, 42, self-employed farmer, Altay Republic

In the face of the threat of climate change, can Russia use its resources and play a key role in ensuring global food security? This research report provides an analysis of the impacts of current and future climate change on crop production in Russia, and on Russia’s aspiration to become a leading global food producer.

The report is comprised of two parts. The first aims at assessing the extent of the actual and potential impacts of climate changes on crop production in the Russian Federation and also what potential Russia has to supply agricultural products to the world market under certain projected climate conditions. The second is an analysis of the results of qualitative research based on interviews with smallholder farmers from Altay Republic (West Siberia economic area), Republic of Buryatia (Eastern Siberia economic area) and Krasnodar region (North Caucasus economic area). The choice of the regions was determined by the role that farming and agriculture play in the lives of individuals, the community, and the local economy and by the distinctive patterns of climate change impacts on agriculture of those regions.

MAIN FINDINGS OF THE REPORT

1. **It is essential to understand that the climate is changing throughout Russia, but the changes are highly regionally specific.** The enormous extent of Russia’s territory and the variety of its environments cause different climate change impacts in different regions. Climate change effects are observable in European Russia and in Eastern Siberia, but they differ in many ways. Some impacts are region-wide. For example, a growth of dryness has been most notable in the southern regions of European Russia.
2. **Droughts and floods are increasing in frequency.** There is increasingly strong evidence linking the increasing atmospheric concentration of greenhouse gasses and an increase in the frequency and/or severity of extreme weather events.[2] Global Climate Models (GCM)[3] show that Russia and Central Asian States (CAS) will experience warming accompanied by decreases in the yearly number of frost days (days with surface air temperature below 0ºC) and decreases in the duration of extremely low winter temperatures and annual ranges of extreme temperatures. An increase is projected in the duration of summer temperature high extremes. The most severe heat waves are projected to occur in West Siberia and CAS.[4] Besides droughts, climate changes are also expected to cause an increase in other dangerous meteorological events, such as high waters, hail, sleet, frosts, hard frosts, strong heavy rains, hurricanes, etc.

   The droughts of 2010 and 2012 – that in the former case led to ***imposition of an export ban*** and in the latter to decreases in exports of almost 20% – showed how vulnerable

Russia's agriculture will be as global warming intensifies and especially if mitigation efforts continue to fail. The droughts also highlighted the lack of adequate investment in mechanisms to help farmers and citizens in general – particularly in vulnerable communities – adapt to climate change.

3. **As well as increasing extreme events, climate change will exacerbate chronic problems.** In wetter regions an increase in average annual and seasonal temperatures together with a growth of moisture content – as warmer air can hold more moisture – creates favourable conditions for wider distribution of pests, weeds, and plant diseases. It leads to increased workload for farmers and the need for more chemicals to eliminate pests, the use of which can be detrimental to the health of workers.
4. **Climate change will exacerbate water inequalities**. Water resources are distributed unequally among the regions. A reduction in water resources by 5–15% is expected at the same time as an increase in water consumption in many densely populated regions (Central and Black Soil Zone, the South of Russia, the North Caucasus, the South of Siberia), which are regions already characterized by water deficiency. Water resources will decrease in those regions most important for crop production.
5. **There is a pressing need for a farsighted and ambitious adaptation policy**. According to the National Report on Climate Change Issues prepared by the Ministry of Economic Development and Trade of the Russian Federation (2002), one can pick out certain positive consequences of climate change for crop production, namely:

- an increase of areas appropriate for farming;
- an increase in the duration of the vegetation growing period;
- an increase of hot periods impacting agricultural cultures;
- an improvement in winter conditions for field and orchard crops;
- an improvement in conditions for some farm operations, including harvesting.

At the same time, the National Report noted that it will not be possible for Russia to attain advantages over other countries which are food exporters without action to adapt agriculture to the expected changes in climate and the natural environment. It should be emphasized that even in those regions where climate change impacts may be more conducive to agriculture, adaptation is still needed.

Although the agricultural potential of many territories which are not so suitable for agriculture now may be increased in the future, the main agricultural areas will experience significant losses in the absence of adequate adaptation measures. Given the growing global demand for agricultural products, the most important tasks are to implement adaptation policies in key agricultural regions and increase the efficiency of agricultural production in order to strengthen the competitiveness of domestic products in the world market. This is especially important for wheat production.

6. Smallholder producers in particular feel the adverse impacts of climate change and pay a high price in trying to adapt to changing conditions. Adaptation measures come at a great financial cost for smallholder farmers. They do not have the required support from the regional or national authorities. As a result they struggle to pay their loans back, which forces some of them to leave agriculture altogether. Insurance could be a great help but currently, bureaucracy makes the insurance process painful and time consuming so many farmers are unable or reluctant to insure their crops. Therefore, adaptation policies and practice should have a particular focus on supporting smallholders.

RECOMMENDED MEASURES TO INCREASE THE RESILIENCE OF RUSSIAN AGRICULTURE FOR ADAPTATION TO CLIMATE CHANGE

The following measures taken by the relevant actors could help to increase the resilience of Russian agriculture not only to climate change, but also to other stresses both environmental and economic.

1. Federal and regional governments should formulate and implement clear and consistent agricultural adaptation strategies at both federal and regional level. Given the different scenarios of climate change impacts on crop production in various regions, it is important to look carefully at these variations and implement appropriate and specifically tailored adaptation measures. The adaptation policy should also cover the possibility that at some point there may have to wholesale change to the agrarian specializations of the regions, their land-use and crop production patterns. Possible measures could include:

- In the regions with warmer and more humid climates, expanding plantings of later ripening and higher yielding varieties of grains and legumes, sunflower, canola, soybean, plus late-ripening varieties of potatoes and species of fodder crops that can thrive at relatively high temperatures.
- In the arid regions, expanding planting of winter crops, e.g. wheat in the steppe regions of the Volga and the Urals, barley in the Northern Caucasus.
- In the arid region, rehabilitating existing irrigation systems and expanding irrigated agriculture. However, irrigation can be inefficient and wasteful of water unless it is done very carefully and scientifically, therefore it must be accompanied by measures to rationalise water use through the widespread introduction of moisture saving technologies (e.g. snow retention, reducing unproductive evaporation, drip irrigation).
- Investing in reforestation and afforestation and reintroducing these modalities as effective and traditional adaptive measures for land use stability. Afforestation intertwined with agriculture not only exerts a favourable influence on soils, moisture regimes and crop microclimates, but also binds carbon and thus inhibits global warming.

2. Both state and private actors invest in research and development, which would allow them to formulate and implement evidence-based adaptation strategies. Possible measures could include:

- Development of seeds more resistant to changing climate conditions, especially seeds resistant to higher temperatures and drought. Farmers already use drought resistant seeds, self-pollinating seeds, and seeds with shorter maturing periods. Some farmers also choose to use European seeds because of their higher yielding capacity in comparison with Russian seeds.
- Selection of cultures adjusted for each specific climate zone. As different regions of Russia will be impacted differently by climate change, there needs to be information available on the possible impacts in each zone, as well as cultures suitable for the new climatic conditions.
- Modernisation and expansion of observation networks, development of early warning systems on possible crop losses, as well as adoption of modern methods of data evaluation. Given that climate change will see an increase in dangerous meteorological events that are hard to foresee or predict, it will be essential to improve the accuracy of weather forecasts and particularly, ensure that they can be disseminated very rapidly and efficiently to enable recipients to take appropriate action in advance of the event.
- Development of educational programmes for farmers, managers and employees to disseminate knowledge on adaptation techniques.

3. Both state and private actors support small and medium-sized farmers to sustain agricultural production under the changing climatic conditions. Smallholders are already attempting, but struggling to adapt to these changing climate conditions, and they are not being properly supported in their struggle. Smallholders are already having to invest a lot of their limited resources into adaptation measures. These also require an increased workload. Possible measures could include:

- Development of a specific programme aimed at reducing risks caused by climate change, which would take into account regional differences, as well as difference in socio-economic situations of farmers. This could be achieved through introduction of climate risk management tools which are not yet used in Russia, such as, for example, a weather insurance index or progressive subsidy mechanisms.
- Reduction of agricultural loans interest rates. At the moment, the minimum interest rate is 14%, and smallholders whose yields in some regions are in decline due to changing climate conditions struggle to pay the loans back.
- Reducing bureaucratic procedures for farmers trying to obtain subsidies and crop insurance premiums. They also need prompt and adequate compensation for losses caused by severe climatic events.
- Allowing farmers to use subsidies for both domestic and foreign inputs of production. Currently, farmers can use loans only towards purchasing Russian-produced inputs, which many of them find less efficient for climate change adaptation.
- Implementation of long-term land rental agreements, which would motivate farmers to invest in mid- and long-term climate change adaptation measures.

We conclude however that the current situation is that the absence of adaptation and support for smallholders and agriculture in general which is revealed by our research means that unless this is addressed, the future of Russian agriculture looks uncertain – and with it the potential for Russia to play a key role in ensuring global food security in the face of current and future climate change.

PART 1

SERGEY KISELEV

Professor of Economics, Eurasian Centre for Food Security under Lomonosov State University

ROMAN ROMASHKIN

Associate Professor of Economics,Eurasian Centre for Food Security under Lomonosov State University

SERGEY BOBYLEV

Professor of Economics, Faculty of Economics, Lomonosov State University

SOFIA SOLOVIEVA

Associate Professor of Economics, Faculty of Economics, Lomonosov State University

1.1 CHARACTERISTICS OF CHANGING CLIMATE

According to the majority of Russian scientists, most of the current observed climate changes are caused by increases in concentrations of anthropogenic greenhouse gases since the middle of the twentieth century.[5] The links between the two are clear. The continuing increase in atmospheric concentrations of greenhouse gases is driving further global temperature increases – the results of which include changes in precipitation patterns, more extreme and abnormal weather events, melting glaciers, rising sea levels, oceanic acidification and shifting seasons.

It is possible to pick out a number of key parameters of climate change in the Russian Federation.

Temperature changes

Observed surface temperatures over land in Russia have increased, on average, at a greater rate than in the rest of the world. According to Roshydromet, the average temperature in Russia increased by 1.29°C between 1907 and 2006 – and it has been accelerating. Looking at the period 1976–2006, the average warming was 1.33°C, while between 1976 and 2010 it was 1.54°C.[6] This is significantly higher than the 0.74°C average global warming between 1907 and 2006.[7] Since the turn of the century, yearly temperatures in Russia have been consistently warmer than previously. Compared with the 1961–1990 average rate, the temperature was higher by 2.06°C in 2007 (the warmest year so far), by 1.88°C in 2008, by 0.54°C in 2009, by 0.65°C in 2010, and by 1.66°C in 2011.

Temperatures have increased in all seasons but spring and the autumn have got warmer to a greater extent. The average annual linear temperature trend coefficient over 1976–2009 is 0.47°C per 10 years, but the same coefficient for the spring and the autumn is 0.58 and 0.51 °C per 10 years respectively.

The growing period for vegetation increases and the agricultural zone extends due to warming. However there are also negative consequences connected with expansion of areas of distribution of various plant pests and diseases. The Ministry of Emergency Situations has also warned that the shift of permafrost borders may open up burials in which smallpox viruses and anthrax bacteria are still viable.[8]

Warming will increase the number and intensity of forest fires. The Ministry of Emergency Situations estimates that the duration of the fire-risk period in the middle latitudes of Russia may increase by 30–40% or by 50–60 days by the mid 21st century, taking into account the existing rates of warming. As a result of forest fires, the depth of frost penetration into soils will increase, surface drainage and water erosion across vast territories will amplify, and these changes, with plentiful precipitation and faster snow thawing, will increase the probability of floods. These processes will impact negatively on agricultural production and soil fertility. The current year 2012 has been little better than the drought year 2010 and clearly demonstrates the severity of the problem. Abnormally hot weather in spring and summer caused forest fires in 11 regions of Siberia and the Urals. The surface area covered by wildfires was 20% more in 2012 than in 2011.[9]

Precipitation changes

The changes observed in rainfall so far and modelled for the future are favourable for Russia. Annual rainfall increased by 7.2 mm per 10 years over 1976–2006. This trend remained unchanged up to 2010, by which time annual rainfall had increased by 8.5 mm per 10 years. Previous to the increase in rainfall from the mid-1970s, annual rainfall had increased in the 1950s, and was then followed by a drier period from the mid-1960s to 1970s.

However, there are noticeable differences between seasons. There has been a distinct increase of precipitation in spring, less so in autumn and winter, and the increase in rainfall in summer is insignificant or even, latterly, negative. Thus the increase of precipitation in the vast territory of Russia is mainly connected with stronger spring rains, and, as a consequence, high waters and floods. Moreover, the lack of precipitation in the summer periods combined with the growth of temperature leads to aridity that has had an adverse effect on summer agricultural production and increases the risk of drought.

Regional variations

It is essential to examine the regional aspects of climate change in the Russian Federation. Climate change may impact either broadly positively or broadly negatively owing to the huge extent of Russia's territory and the variety of its climatic zones.

A positive average annual temperature trend is observed in all regions but particularly in European Russia and Eastern Siberia.

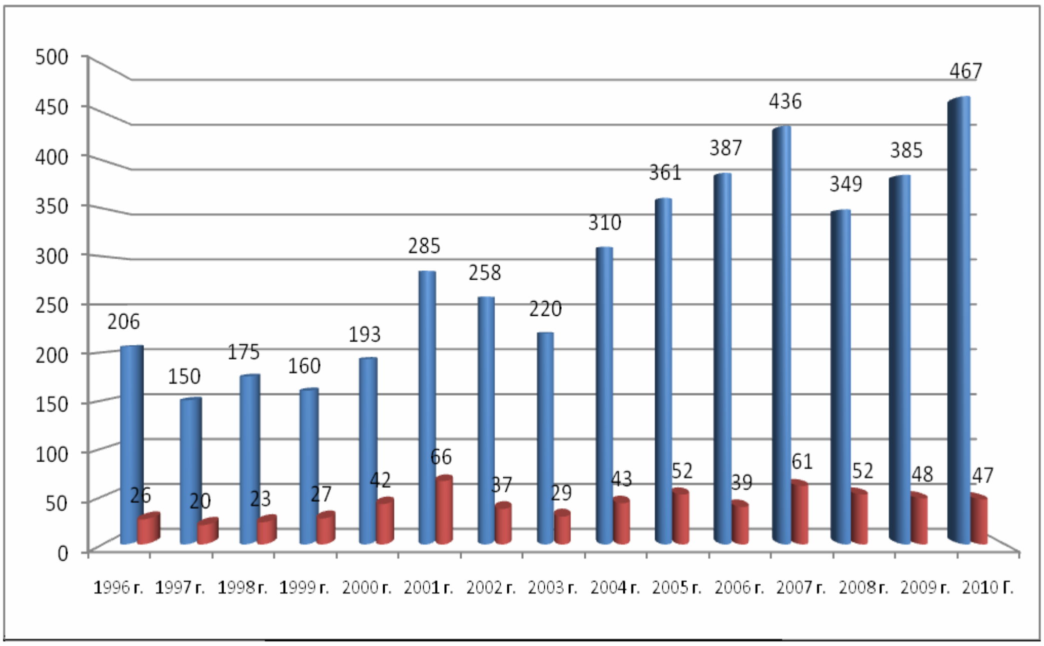
Eastern Siberia is distinguished by a strong temperature rise in spring, autumn and summer, but a fall in temperature in winter. This combination and contrast of considerable warming in spring and in autumn and a negative temperature trend in winter makes Eastern Siberia unique among Russian regions, and the most disadvantaged from the point of view of temperature.

In rainfall terms, changes occurring in Eastern Siberia are unfavourable as well. Rainfall is increasing in total and especially in spring. There is a decreasing trend in winter and summer, although not very large.

Given the large size of certain regions it is also important to consider possible changes within regions. European Russia, for example, comprises Central, North-West, Volga and South Federal Districts. European Russia accounts for about 70% of total Russian grain production. However, South of Russia and Central Black Soil regions are seeing increasing aridity that impacts negatively on grain production.

Dangerous meteorological events

Figure 1: Annual numbers of dangerous meteorological events in the Russian Federation (blue – all events, red – unforeseen events)



Source: The Report on Features of Climate in the Territory of the Russian Federation in 2010, 2011, Roshydromet, p. 52.

The above are trends, but according to the Ministry of Emergency Situations, 297 dangerous meteorological events occurred in 2011. This number exceeds the mean annual number of 262 dangerous meteorological events by 13.3% but is 36% less than the number in 2010 (467)[10]. In terms of the number of events and the damages caused, 2010 was abnormal. As a rule, the greatest number of dangerous meteorological events in the Russian Federation occurs during the period from May to August.

The annual damage from the impact of these events in Russia is estimated to be up to 60 billion rubles ($2 bln)[11]. With climate change the upward trend is expected to continue into the future and expand into more territories, and losses from these hydro-meteorological events will increase.

Impacts on water resources

The impacts of climate change upon water resources merit particular attention given the popular belief that Russia has water in abundance and in the long term can serve as a source of water for other countries. Lake Baikal is often mentioned in this context. As it is noted in Roshydromet publications, an 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%.

However, this water endowment needs to be viewed in the context of very unequal distribution of water among the regions. An improvement in water endowment will occur in the North and the Northwest of European Russia, the Volga region, the Non-Black Soil Centre of Russia, the Urals, and also the majority of Siberia and the Far East. At the present time these regions have more than 95% of the water resources of the country.

Yet at the same time a reduction in water resources of 5–15% and an increase in 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 are already characterized by their deficiency in water. As a result of climate changes, along with demographic shifts, the current inequality of water resources distribution among regions will increase. Moreover, a deficiency of water resources will increase in those regions where the most crop production is located.

It should be noted that in terms of water supply at the present time, Russian agriculture is in a difficult situation:

- about 80% of croplands are located in areas of unstable and insufficient moisture;
- about 10% of croplands are located *in areas of over-moistening.*[12]

Zones of precarious and inadequate moisture are *the main arable regions,* especially regions of the South of Russia (Astrakhan, Volgograd , Republic of Kalmykia, etc.), the North Caucasus (Stavropol, Rostov), the Volga (Saratov, Samara, etc.) the Urals and the Siberia (Chelyabinsk, Sverdlovsk, Tyumen, Orenburg, Altai, Republic of Buryatiya, etc.). Precarious moistening, for example, is typical for the Central Black Soil region (Voronezh, Tambov, etc.). The most favourable agricultural region in Russia, Krasnodar, has an average annual rainfall of 400–600mm in the plains. In Iowa, USA, which was often compared with Krasnodar region in Soviet times, the average annual rainfall is 710–970mm.

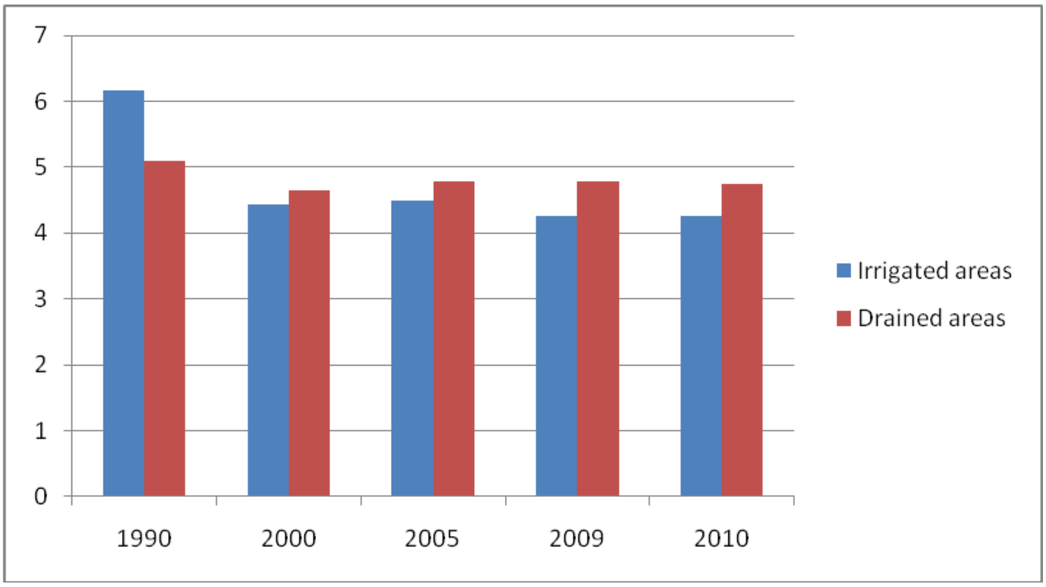
Reclaimed areas are of special value in these conditions, as their use facilitates production of stable crops. Nowadays there are only 9m ha of reclaimed areas in Russia, 4.25m ha of which are irrigated, and 4.75m ha are drained (see Fig. 9).

Reclaimed areas cover 8% of the total area of croplands and produce about 15% of gross crop production. They produce up to 70% of vegetables, the whole of Russia's rice harvest, more than 20% of succulent feeds, and fodder and other products are also produced there.

As a result of the socioeconomic crisis about 1.9m ha of irrigated areas were not involved into agricultural land transactions after 1990 anymore and became fallow lands. Construction of new irrigation and drainage systems was virtually stopped, while only 5–10% of the required reconstruction works on existing systems was carried out. The technical state of reclamation systems has also become worse; this is especially true in regard to farm-irrigation systems. At present as a consequence of defects in farm irrigation systems, irrigation is absent on more than 1.8m ha of previously irrigated areas or on more than one-third of the – supposedly – irrigated land.

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

Figure 2: Evolution of reclaimed areas in Russia (million ha)



Source: Report on the State and Utilization of Agricultural Lands. Ministry of Agriculture of the Russian Federation, Moscow, 2011, p. 24.

Finally, thus far we have considered trends that, while accelerating, are still spread over several decades. It should be noted however that it is possible that future climate change will not be so linear but will instead see very rapid acceleration and the climate ‘jump’ to a new and more extreme state. There are mechanisms which might cause this to happen. For example, according to many scientists, permafrost thawing may cause the release of an additional 85 billion tons of greenhouse gases – mainly methane – into the atmosphere. Compared with the 13 billion tons which has been released into the atmosphere by all of mankind so far, such emissions would lead to utter calamity.[13]

1.2 CURRENT AND NEAR-FUTURE CLIMATE CHANGE IMPACTS ON CROP PRODUCTION

Regional impacts on grain production

Grain production has a special place in the agrarian sector of the Russian Federation. The value of grain production accounts for 16% to 20% of gross agricultural production. Grain crops occupy about 60% of the cultivated areas.

Production of crops depends on complex interactions; including moisture content, warmth thermal conditions during winter and climate continentality.[14] Changes in all of these over the period 1975–2004 were in general positive for the agrarian sector in the Russia's regions which provide the most significant share of grain production.[15] At the moment climate-related crop yield increases have occurred in many agricultural regions of Russia. The calculated parameters for grain crops in the Stavropol Territory have increased by 30% over 20 years, for example.[16] As we shall see, however, these trends may not remain positive, with increasing aridity a particular threat.

At the same time there are other regions where climate changes have had negative impacts. A deterioration in moisture content is observed in the Central Black Soil, Central, East-Siberian, Far East and Northwestern regions and has had a negative impact on grain crops in the Central Black Soil and East-Siberian regions. Less warmth has a negative impact on grain production in Ural region, and a deterioration of conditions for winter-crops on grain production in the West Siberian region. Grain yields have benefited from the reduction in climate continentality, consisting in a decrease in amplitude of day and night air temperature.

A significant decrease in minimum temperatures is notable in the most important agricultural zones of Russia, the Central Black Soil Region, the Volga Region, and the North Caucasus, which negatively impacts winter crops*.* Conditions for winter crop cultivation and expansion of the area under cultivation have improved in the North Caucasus, steppe zones of the Volga Region, Southern Urals and in some areas of Western Siberia.[17]

In general, changes have led to a more stable regime for crop production. This is most noticeable in the zone where there is a high risk of winter crops being killed (the Orenburg and Samara Regions, Republic of Bashkortostan, Republic of Tatarstan).[18] With more favourable temperature conditions and if there is conservation of sufficient moisture, a rise in the yield of grain and feed crops is expected in the Northern and North-Western Regions, the Central, Volga-Vyatka Regions, and in the Far East.

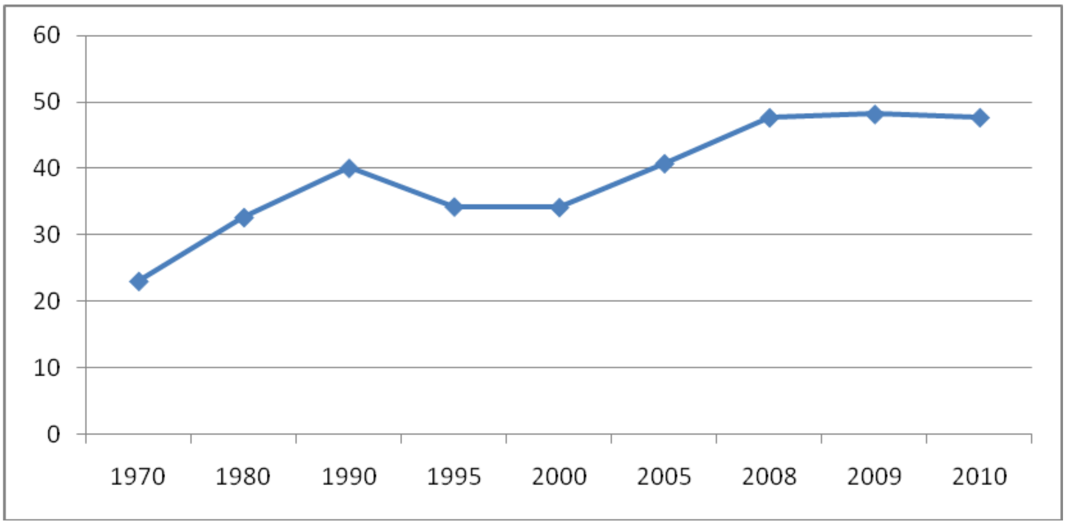
The number of frost-free days has increased by 5–15 in average in a number of regions (north-eastern part of the Northwestern Federal District, Central and Volga Federal Districts). The border of cultivation of mid-season varieties of corn and late-season varieties of sunflower will move northward to the latitude of Moscow – Vladimir – Yoshkar-Ola – Chelyabinsk in the near future. Expansion of the cultivation area of sugar beet to the Ivanovo – Izhevsk – Kurgan line will become possible. Conditions will be created for farming of subtropical crops in some southern regions.[19]

An increase in the duration of the growing period and the period without frosts occurs in some regions (the northeast part of the Northwest Federal District, the Central and Volga Federal Districts). Those will contribute to better conditions for conducting agricultural work and will reduce production losses while harvesting.

At the same time, however, warming and an increase in dryness in a number of regions located in the Asian part of Russia are being associated with reductions in grain crop yields, for example in Baikal region.

The share of winter wheat in the total wheat crop area has been increasing and this is partly down to climate factors (see Fig. 3).

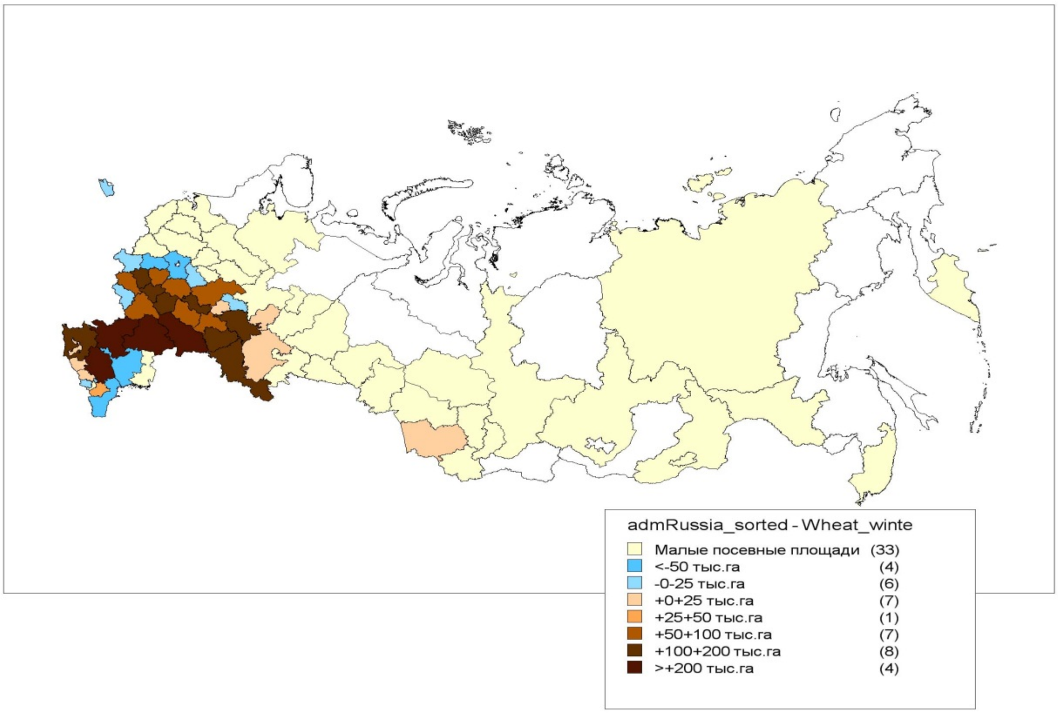
Figure 3: Share of winter wheat in the total wheat crop area, %



Source: Rosstat

However the changes in winter wheat cropping areas differ from region to region (see Fig. 4). The largest growth of cultivation area (more than 200 ths. ha) is shown by the Stavropol Territory, Rostov, Saratov, and Volgograd Oblasts. The Republic of Tatarstan, the Krasnodar Territory, Tambov and Lipetsk Oblasts, The Republic of Mordovia, Oryol, Samara, and Orenburg Oblasts are also characterized by a considerable increase in the winter wheat cropping area (from 100 ths. ha to 200 ths. ha). On the other hand, a significant reduction in the winter wheat cropping area (more than 50 ths. ha) has occurred in the Republic of Dagestan, Kaluga Oblast, the Republic of Kalmykia, Moscow Oblast.

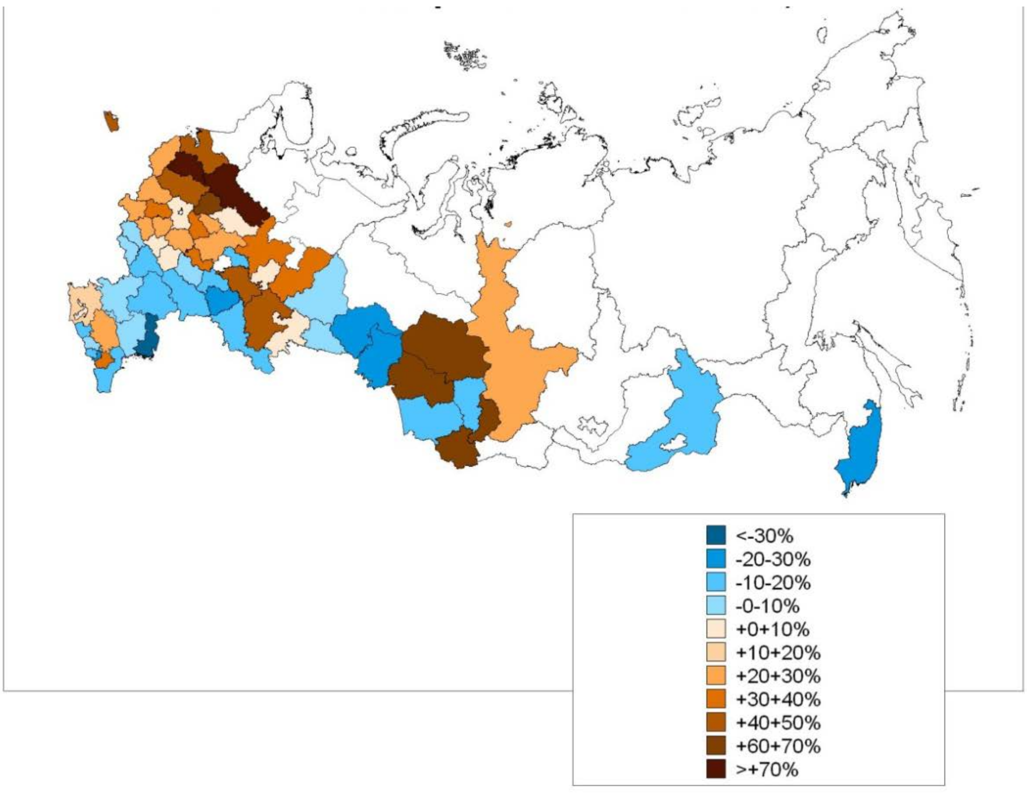
Figure 4: Map of changes in winter wheat cropping area 2007–2011 compared with 1990–1994, ths. ha



Source: Eurasian Center for Food Security under Lomonosov Moscow State University

This increase in the area cultivated by the largest grain producers, located in the south of Russia and in the North Caucasus, contributed to a large degree to increasing Russia's wheat production and to Russia's occupying second place in the world ranking of leading exporters.

Figure 5: Map of changes of winter wheat yield in 2006–2010 compared with 1986–1990, %



Source: Eurasian Centre for Food Security under Lomonosov Moscow State University

Changes to agricultural pests and diseases

Climate changes lead to shifts in the distribution areas of agricultural pests and diseases. Growth of pest populations and the advance of some pests to the North have been observed. Thus, the area of distribution and acclimatization of Colorado beetle for example has reached the 62nd parallel of northern latitude[20] (Petrozavodsk – Syktyvkar – Khanty-Mansiysk). The area where Colorado beetles now exist extends continuously to the North and the East, consistent with the potato growing zones.

Locusts are also extending their range northwards and appeared in Bashkiria in 2011. According to Rosselkhozcenter, the area in which locusts exist in sufficient numbers to cause economic damage above a certain threshold is constantly growing. It reached 382.8 thousand ha in 2008, 983.7 thousand ha in 2010, and 1052.4 thousand ha in 2011.

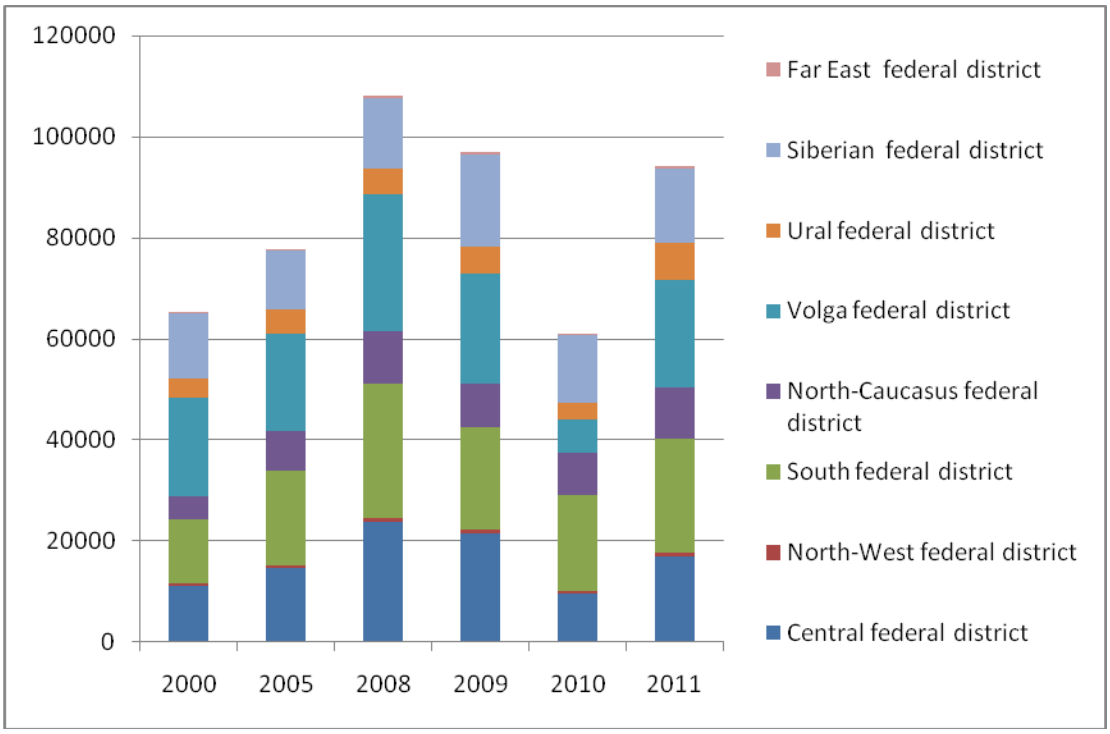
In general it is evident that climate changes – an increase in average annual and seasonal temperatures together with a growth in moisture content – can create favorable conditions for the wider distribution of pests, weeds, and diseases. These matters require detailed study which is essential for working out adaption measures. The Ministry of Agriculture estimates that timely measures to combat locusts prevented possible losses of 50 billion rubles ($1.7 bln) in 2011. In other words, the potential losses caused by locusts would have been comparable to the direct losses suffered by agricultural producers due to the drought of 2010. This is a good example of the vital importance of prevention through effective monitoring and rapid action.

Impacts of the 2010 and 2012 droughts

The impacts of the extreme drought of 2010 on grain production have been analyzed in detail by Roshydromet in the ‘Report on Features of Climate in the Territory of the Russian Federation’ (2010). The drought caused the loss of about 44% of grain production (about 50 million tons) in Russia in comparison with 2008, which was a bumper year (see Fig. 6). The monetary value of losses corresponded to 250 billion rubles in 2011 prices. The losses from the drought amounted to 37.5 million tons or 48% of grain production in European Russia. At the same time in the Siberian Federal District gross grain production was reduced by only 4% compared with 2008, and the share of Siberia in grain production grew to 22%. The drought of 2010 especially affected summer grain production in European Russia, where losses of summer grain reached 50.9% compared with crop production in 2008. High losses of summer grain were also observed during droughts in 1972 and 1981. Summer grain losses in European Russia were balanced to some extent but not completely by an increase of summer grain produced in Siberia.

The extreme drought in 2010 had a huge impact not only on grain crops. Production of leguminous crops was reduced by 37%, potato by 32%, sunflower seeds by 17%, sugar beet by 11% and vegetables by 10% compared to the previous year. The drought of 2010 was the most significant for the last 60 years in terms of losses of agricultural crops. More than 21.5 thousand farms in 43 of Russia’s regions suffered from this drought, and the losses of crops occurred over an area of more than 13.3 million hectares (about 18% of the area cultivated). Farmers’ financial losses accounted to 41.8 billion roubles ($1.4 billion)[21]. This is equivalent to 3.5% of gross crop production. The drought resulted not only in worsening financial and economic conditions of agricultural production, it also aggravated food security issues due to the rise in food prices. Additional budgetary funds for agricultural support also needed to be allocated. The support from the Federal budget was 35 billion roubles ($1.166 billion), from which 25 billion roubles ($833 million) were granted in the form of the budgetary credits and 10 billion rubles ($333 million) were distributed as subsidies. The support from regional budgets was 11.1 billion roubles ($370 million).

Figure 6: Cross grain production (ths. tons)



Source: Rosstat

Unfortunately, the summer of 2012 has not been much better: 20 regions of Russia declared an emergency situation and asked the federal government for financial support. According to the Russian Ministry of Agriculture, drought caused about 37 billion roubles ($1.2 billion) of damage. The 2012 drought has destroyed crops, including grains and legumes, on 7.6 percent of the total sown area.[22] The impacts of the drought of 2012 have not yet been systematically analysed, but the estimations of the Ministry of Agriculture available at the moment of writing of this report indicate that the export of grain has decreased by almost 20% in the period between July and September 2012 when compared with the same period of 2011[23], while the overall grain crop this year has been 17% smaller than that of last year.[24]

1.3 LONG-TERM CLIMATE CHANGE IMPACTS ON CROP PRODUCTION

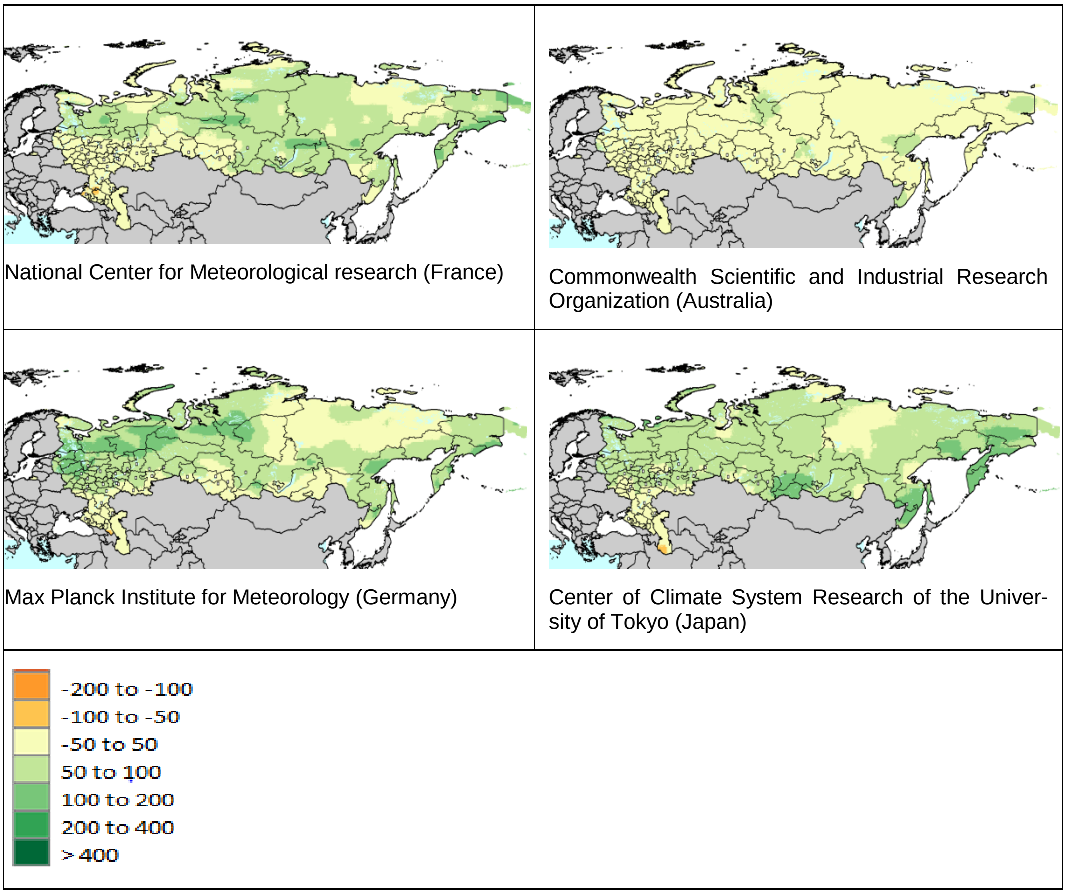
For the purpose of long-term forecasting of climate changes, Global Climatic Models (GCM) are used; such models calculate the interactions of physical and chemical processes in the atmosphere with oceans and land surfaces taking into account various scenarios of greenhouse gas emissions as a result of human activity. The result of such modelling is an estimate of future rainfall and temperature changes throughout the world. Figures 7 and 8 are based on different GCMs using the IPCC A1B greenhouse gases emission scenario.[25] They depict changes up to 2050 in annual average rainfall and maximum temperature over a month (i.e. highest average daytime temperature).

Simulation results with various GCMs indicate an increase of rainfall amounts for the majority of Russia's regions up to 2050. For southern regions of Russia all GCMs predict quite small changes in rainfall. The same situation is typical of the Black Soil area, the Volga Region, the Southern Urals and the South of Siberia.

All GCMs demonstrate an increase of maximum temperature over a month. The GCM of the Centre of Systemic Climate Researches (Japan) predicts the largest temperature increase. In this case the temperature will increase by more than 3.5 °C in the western part of country and in the north, and between 3–3.5 °C in the south, in the Far East and on the south of Siberia.

Hence the climate over the major part of Russia on the base of forecasts up to 2050 will be more warm and humid. However the increase in maximum temperature may be accompanied by little change – a reduction or only a small increase – of rainfall in the south, in the Volga and Black Earth regions, and in the Southern Urals and South of Siberia. According to Roshydromet estimations, *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 will be necessary to change the specialization of the traditional agricultural regions in the direction of more drought-resistant crops (maize, millet, etc.), to carry out major irrigation works, and to implement technology in agricultural production to a greater extent.

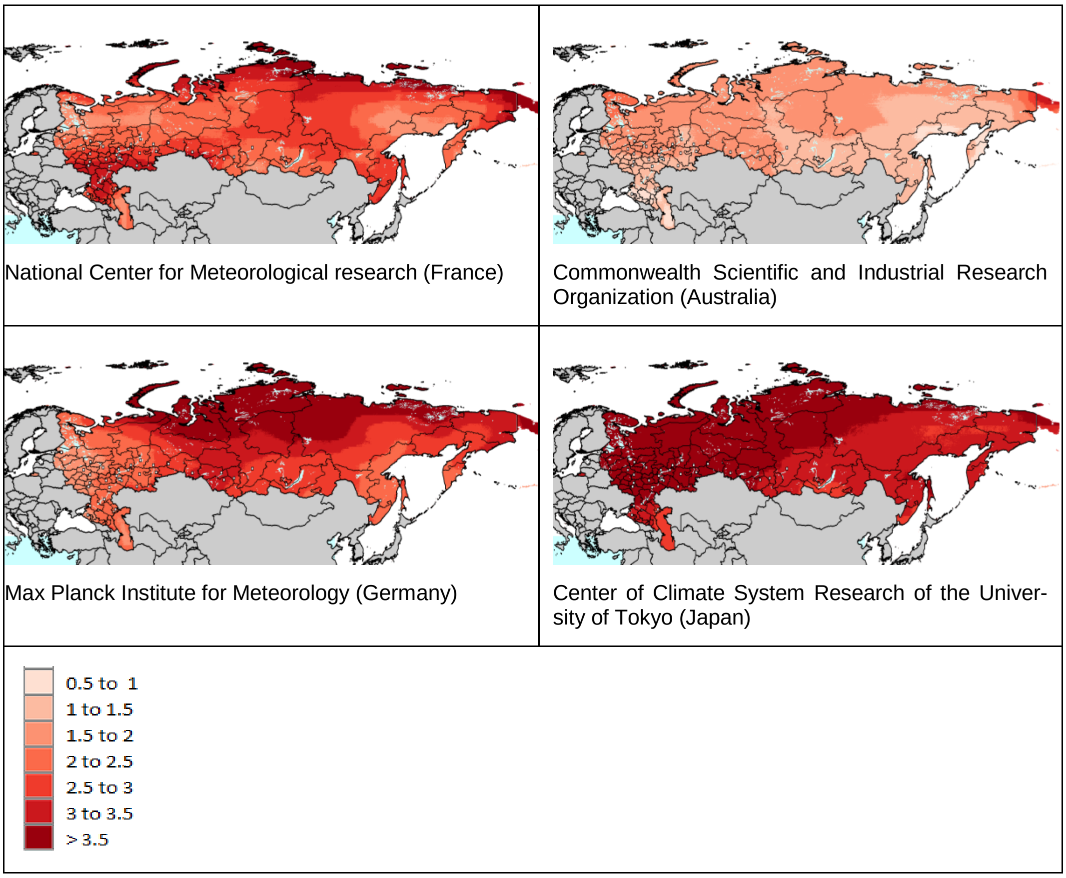
Figure 7: Changes of annual average rainfall in the Russian Federation between 2000 and 2050 based on the A1B greenhouse gases emission scenario (millimeters)



Source: International Food Policy Research Institute

In the absence of measures to adapt to the expected increase in aridity in the major grain-producing regions, grain yields up to 2020 can be estimated using forecasts by Roshydromet on the basis of the most arid climate change scenario (see Table 1). According to these estimates, a significant reduction in grain yield in 2020 is expected in the North Caucasus, the Urals and the Central Black Soil regions, i.e. the most productive areas. Losses in grain yields for the country as a whole could reach 10–12 million tons or about 13% of the gross grain harvest in 2011.

Figure 8: Changes of maximum temperature over one month with highest average day-time temperature in the Russian Federation between 2000 and 2050 based on the A1B greenhouse gases emission scenario (°C)



Source: International Food Policy Research Institute

The International Food Policy Research Institute (IFPRI) estimated the effect of various factors – temperature and rainfall, soil quality, fertilizer use, number of sunny days in each month – on the crop yields and cultivation areas of the country's primary crop products with regard to their location, varieties, and cultivation technologies. Virtually similar results were achieved within the scope of scenario analysis using the data on climate changes from all GCMs. Figure 9 shows maps of changes in the yield of rainfed crops in 2050 compared with 2000 under simulation scenario A1B based on GCM of the Centre of Climate System Research (Japan). This GCM was chosen because it estimates the impacts of the most arid climate change scenario, i.e. the worst-case scenario and assuming no adaptation.

Table 1: Changes of climate-related crop yields and grains harvests under climate warming: arid scenario.

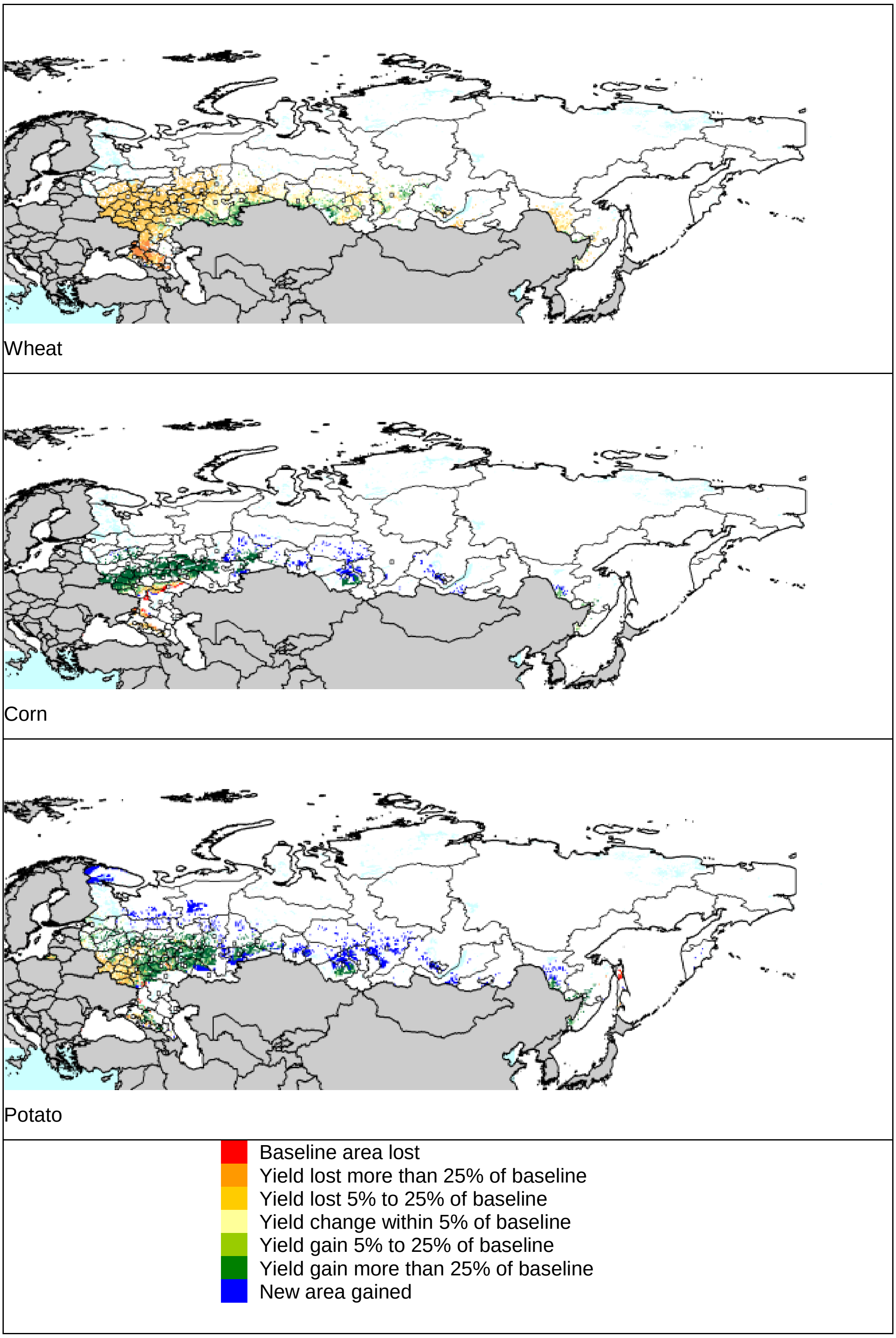
Regions	**Total grain harvest, in average per year, thousands tons**	**Share of region in the total grain harvest,%**	**Changes of climate related crop yields, % of average level of 2001–2005**		**Changes of climate related crop yields in comparison with average harvests of 2001–2005, thousands tons**	
	2001-2005	2001-2005	2010	2020.	2010	2020
North	220,3	0,3	4,8	7,1	10,6	15,6
North-West	117,1	0,1	4	7,9	4,7	9,3
Kaliningrad Region	218,6	0,3	2	4	4,4	8,7
Central	5110,5	6,5	-1,9	-0,8	-97,1	-40,9
Volga-Vyatka	3250	4,1	-5,6	-6,8	-182,0	-221,0
Central Black Soil area	8905,9	11,3	-6,9	-14,1	-614,5	-1255,7
Volga Region	15074,4	19,1	-13,3	-13,5	-2004,9	-2035,0
North Caucasus	20503,7	26,0	-22,1	-23,8	-4531,3	-4879,9
Urals	10396,7	13,2	-14,2	-15,9	-1476,3	-1653,1
West Siberia	11751,4	14,9	-7	-12	-822,6	-1410,2
East Siberia	2830,3	3,6	-12	-18	-339,6	-509,5
Far East	387,3	0,5	4	7	15,5	27,1
Total	78766,2	100,0	-12,7	-15,2	-10033,3	-11944,5

Source: Strategic Forecast of Climate Changes of the Russian Federation for the Period 2010-2015 and Their Impacts on Branches of Russia's Economy, Roshydromet, Moscow, 2005, page 53.

The scenario analysis shows that the increase of wheat yield by 5% to 25% by 2050 as compared with 2000 is observed only on the territories bordering the northern part of Kazakhstan. The wheat yield in other regions will decrease or changes will be small (about 5%). An absence of adaptive measures will lead to a significant decrease in wheat yield in the Krasnodar Territory, which is the main wheat producer and exporter at the moment.

On the other hand, climate changes will favour increases in corn yield in regions where corn is traditionally cultivated. In addition, new territories for corn cultivation will appear on the south of Western Siberia.

Figure 9: Yield change map for rainfed crops in 2050 compared with 2000 under climate change scenario A1B based on GCM of the Center of Climate System Research (Japan).



Source: International Food Policy Research Institute

PART 2

DARIA UKHOVA

Regional Research Officer, OXFAM

YULIA YEVTUSHOK

Programme Coordinator, Climate Change and Economic Justice, OXFAM

2.1 SOLITARY STRUGGLE: FARMERS FACING CLIMATE CHANGE IN THE RUSSIAN REGIONS

As demonstrated in the previous chapter, climate change could have positive impacts on agricultural production in some of the Russian regions. However, without proper adaptation measures, these regions are unlikely to see all of the benefits of this. In addition, climate change is projected to negatively affect agricultural production in the other regions, including those with high concentrations of agriculture at present, and adaptation measures are urgently needed here. These changes will particularly affect people working in agriculture in the latter regions, especially smallholder farmers, because they depend on agriculture for their livelihoods and have few or no other means of earning a living.

As Part 1 also shows, the impact of climate change on agriculture is not a matter of the distant future, and one can already observe the changes taking place, especially in some of the regions. Moreover, modelling (see page 17) allows us to understand the future direction of these changes. In this chapter, we focus on the experiences of farmers from three distinct regions in which, as was shown in the previous chapter, climate change has already affected agriculture and where projections show it's likely to have further impacts on the agricultural potential of those regions in the future.

First, we look at the Republic of Altay (West Siberia economic area) – one of the poorest and least developed regions of Russia, where large numbers of people are engaged in subsistence farming, and where so far the impact of climate change has been mixed, but which has resulted in substantial increases in the productivity of winter crops. Then, we turn to the Republic of Buryatiya (East Siberia economic area) – also a comparatively poor region, where subsistence farming is highly important, but where, from the agricultural point of view, the climate changes have been negative and are projected to stay negative in the future. We finish this chapter with an overview of the farmers' situation in Krasnodar region in the south of Russia (North Caucasus economic area). Krasnodar is the leading agricultural region, commonly referred to as 'the granary of Russia', where agriculture and the food industry are the leading sectors of the economy, employing a large proportion of the population, and where climate changes represent a serious threat to agricultural activities.

The main goal of this chapter is to highlight the ways in which climate change impacts on smallholder farmers in the regions considered, and, furthermore – based on the farmers' accounts of their experience of adaptation – to provide evidence which could help both local and regional governments, the business community, and smallholders themselves to develop tailor-made adaptation strategies.

With the help of its partners**,** Oxfam conducted semi-structured interviews with 29 farmers in these regions (see Annex 1 and Annex 2 for details). We took a conscious decision not to focus exclusively on grain producers, but to include in our sample also those who grow fruit and vegetables, as well as farmers engaged in livestock breeding, since this would allow us to account for a wider range of experiences and to triangulate our findings.

2.1.1 Altay Republic, West Siberia economic area

Box 1: The role of agriculture in the Altay Republic[26]

Altay Republic was not industrialised during the Soviet period, and agriculture was the leading sector of the region's economy. Although in the first post-Soviet years the agricultural sector contracted, in the last six years it has again become the leading sector of the economy. Large enterprises have been replaced by middle-sized and small enterprises in the post-Soviet years. Self-employment in the agricultural sector has substantially increased. The main types of agricultural production are livestock and the growing of a variety of plants. Poverty and the low density of population in the region are the main factors impeding the development of the market. According to the UNDP's index of human development, this region ranks very low among the Russian regions, i.e. number 77 out of 80 (data from 2009).[27] People's incomes, educational level, and life expectancy in the Altay Republic are substantially lower than the national average. More than 80% of the Republic's budget comes in the form of subsidies from the federal budget.

As discussed in Part 1, climate change happening in Western Siberia has rather mixed effects on agriculture. On the one hand, an increased incidence of droughts in summer has obvious negative consequences. On the other hand, changing weather conditions in winter means some parts of Western Siberia are becoming more favourable for cultivation of, for example, winter grain crops. Productivity of winter wheat crops in Altay Republic has, indeed, increased by 60–70% over the course of fifteen years, which could at least partially be attributed to the changing climate conditions (see Figure 4 in Part 1).

However, contrary to what might have been expected from the above data, the farmers we interviewed in Altay Republic painted a rather gloomy picture of what is happening with the climate in their region, how this affects their work, and what costs they have to pay to adapt to the new weather conditions. Notably, the farmers' observations about the character of the climate changes and also their effects have been very consistent:

Box 2: Farmers' observations of the changing climate in the Altay Republic

- Colder winters
- Much hotter summers with increased frequency of droughts
- Longer spring and autumn periods with increased incidence of ground frost in the first summer months
- Increased diurnal temperature range
- Increased frequency of storm winds, which interviewees related to a systematic deforestation[28]
- Disappearance of ground waters vital for farming, which interviewees also associated with the deforestation

Table 2: Seasonal climate change effects on agricultural production in the Altay Republic

Season	Climate change effects
Winter	• Farmers who have livestock have to double or even triple the amount of fodder given to animals in winter, because of the low temperatures.
Spring	• Droughts impoverish the soil. In spring, it is now drier than it used to be, and this impedes development of seeds.
Summer	• Droughts in the first summer months followed by rainfall in late summer impede grain ripening. As one of the farmers told us, because of this year's severe drought there will be no wheat harvest, as in many farms the decision was taken not to harvest the crop, since the expenses incurred to do this are likely to exceed the incomes earned. • Droughts do not allow farmers to stock up with sufficient amounts of hay for their livestock. • Droughts impede ripening of berries. • Droughts have almost eradicated mushrooms in the forests. • Ground frost in June last year spoiled cucumbers and potato tops, as well as flowers on the fruit trees. This year ground frost destroyed flowers on blackcurrant bushes and strawberries. • Heavy rainfall in July and August also cause rot and phytophthora (moulds) on vegetables. • Strong winds break plants and branches of fruit trees.
Autumn	• Cold dew causes rot on vegetables, so it is very difficult to preserve them.

Some farmers also pointed out **an increase in the frequency of extreme weather conditions** which negatively affect crops, e.g. hail storms and floods. For example, the fruit garden of Larisa (female interviewee, 50 years old) was completely destroyed by the flood in 2006.

Box 3: Adaptation measures used by farmers in the Altay Republic

- Selecting new sorts of crops and new cultures which are more frost resistant and have shorter growing periods and at the same time ceasing to sow cultures with long growing periods, e.g. barley
- Using greenhouses to protect vegetables from radical diurnal temperature changes. Some farmers even install heating systems in greenhouses to protect plants from extremely low temperatures at night
- Cultivating seedlings in the greenhouses. Previously seeds were planted directly into open ground
- Tying up plants such as tomatoes and cucumbers to protect them from rot caused by heavy rains in late summers
- 'Shadowing' (a term used by one of our respondents) plants, e.g. cabbage, eggplants, peppers, from excessive sunlight. Farmers cover vegetables with materials available at hand.
- Intensifying watering during summer droughts

The farmers work hard to adapt to the changing climate conditions, but this requires substantial additional time and financial investments. For example, smallholders incur significant additional costs, since they need to invest extra resources in building and maintaining greenhouses, as well as paying for their heating. When asked how their workload has changed due to changed weather conditions, the interviewees pointed out that it had substantially increased. In spring, they need to repair and prepare greenhouses, which are now used as one of the main adaptation measures. Moreover, at night, greenhouses need to be heated, and this also implies additional time has to be invested. In summer, the workload has increased, since watering needs to be done much more frequently. Finally, in late summer and early autumn, the workload has increased due to the necessity of ‘preserving the harvest’, which, as it was pointed out above, is increasingly affected by rot and phytophthora mould.

Importantly, increases in labour input related to climate change adaptation are also clearly gendered, especially in subsistence farms. As one of the respondents (Alexandra, female, 58) pointed out, a gendered division of labour in subsistence farms has always existed – men usually deal with more physically demanding tasks, such as digging soil or constructing, while women do the rest of the tasks, such as watering, crop weeding, dealing with vermin, conserving, etc. The kind of adaptation measures that farmers use in this region results in a disproportionate increase in traditionally female tasks, such as taking care of greenhouses, planting seedlings, ‘saving crops from illnesses’. Galina (female, 61) also pointed out that changing climate conditions, in particular the very hot summer weather, plus the increased workload, make farming significantly more difficult for people in the older age group, for whom work in such weather conditions leads to increased health risks.

However, it is not only the increased amount of work and expenses that the farmers lament. **One of their major concerns is that they see no real support from the state, although, in their opinion, this support is essential for sustaining agricultural production in their region under the changing climate conditions.** For example, one of the farmers pointed out that while frost-resistant seed selection is an issue that should be dealt with at the regional level, it is not happening. And this lack of support is experienced particularly painfully by the smallholders who need it most.

‘It’s a shame that on TV they say that there is support to the agricultural sector and that so much money is channelled down… while we – those who really live in villages – don’t see any support! Well... maybe the big agri-complexes do...’

Andrey, male, 43

As our interviews have shown, smallholders are not (yet) experiencing the potential benefits of the changing climate. Macro models – which are certainly important for agricultural planning at the country level and that paint a relatively positive picture of the climate changes and a quite bright future for farming in this region – do not account for the experiences of smallholders who are struggling with the negative sides of these changes and who are not properly supported in their struggle. Smallholders need to be supported to make the most of the opportunities suggested by macro models, as well as to cope with the negative impacts of changing climate.

2.1.2 Republic of Buryatia, East Siberia economic area

Box 4: The role of agriculture in the Republic of Buryatia

Buryatia is located in the zone of high risk and extreme farming. Therefore, volumes of agricultural production vary greatly from year to year. However, because of low real incomes and high unemployment, people are increasingly turning to agricultural activities. The contribution of subsistence farming to the budgets of both urban and rural households is steadily increasing. Agricultural production in the region is heavily privatised: 90% of potatoes, 80% of vegetables, 83% of meat, and 90% of milk is produced by private farms. The main types of agricultural production are livestock and plant growing.[29] As in the republic of Altay, the poverty of the population impedes the development of the market in Buryatia. According to the regional index of human development, this region ranks number 66 out of 80 (data from 2009).[30] Despite comparatively high educational levels, the population of the region has lower than national average income and life expectancy.

Eastern Siberia, which contains the Republic of Buryatia, is the region with the most negative climate change patterns, which are expected to only get worse in the future (see Part 1 for details). The climate here is getting increasingly more continental – a trend which is the opposite of the general trend in the country. In addition, precipitation in this region is decreasing. The forecast for Buryatia is that these trends will continue in the future (see Figures 7 and 8 in Part 1).

The farmers that we interviewed in this region are conscious of, and concerned about, the climate changes, which are already seriously affecting their work, and they are trying to find ways to adjust to the new conditions. But adaptation is difficult for numerous reasons. As in the Altay Republic, the interviewees' observations about climate change were very similar.

Box 5: Farmers' observations of the changing climate in Buryatia

- Somewhat colder, but less snowy winters.
- Longer, but less rainy springs, with increased incidence of ground frost in late spring and early summer.
- Hotter and more arid summers. *'The steppe is not as green as before – before it was blossoming.'* (Olga, female, 43 years of age)
- Shorter summers with increased incidence of ground frost or snow in late summer/early autumn.
- Except for the early ground frost, warmer and longer autumns.
- Increased diurnal temperature range.
- Stronger winds, which farmers consider to be caused by deforestation[31]
- Local rivers are drying up and becoming shallower, which farmers relate to deforestation and construction of hydropower station(s) in Mongolia.

The most important agricultural problem caused by climate change in Buryatia is a **shortened cropping season**. As Grygoryi (male, 23) told us, in 2009, when the snow fell on 15 September, his family's farm lost 30% of the harvest, and ever since then they have tried to reap the harvest earlier. Because of the shortened cropping season some plants do not reach full maturity, and, overall, the yields have decreased substantially. Moreover, not all the crops – such as cabbage or carrots – can be harvested so early, since they would simply rot before farmers could sell them.

Tamara (female, 56) who started working in agriculture in 1978 indicated: '*From a hectare of cabbage we used to get 22–25 tons. Now, we get about 15 tons. According to technological norms, 30 tons of potatoes should be collected from one hectare of land. It's not us who invented this. And it's precisely how it was before, even more. But now we harvest only 10–12 tons*.'

Table 3: Climate change effects on agricultural production by season in Buryatia

Season	Climate change effects
Winter	• Decreased precipitation in winter and spring leads to the soil getting drier. • Strong cold winds destroy trees and bushes
Spring	• Sowing happens later because of the risk of late ground frost. • Strong winds blow the fertile topsoil off.
Summer	• Summer droughts negatively affect yields. • Increased number of pests, such as sod webworms, grasshoppers, blister beetles, lice, armyworms. • Decreased number of pollinating insects. • Large diurnal temperature changes hamper vegetation and cause plant sickening (e.g. bacterial blight, etc.). The farmers also relate diurnal temperature changes to increases in the number of pests. • Large diurnal temperature changes hamper vegetation and cause plant sickening (e.g. bacterial blight, etc.). The farmers also relate diurnal temperature changes to increases in the number of pests.
Autumn	• Farmers try to reap the harvest earlier to avoid the risk of losing it because of early ground frost or snow.

Box 6: Adaptation measures used by farmers in Buryatia

- **Seed selection:** In particular, farmers increasingly use drought resistant seeds, self-pollinating seeds, and seeds with shorter maturing periods. Some farmers also choose to use European seeds because of their higher yielding capacity in comparison with Russian seeds.
- **Increased use of greenhouses to protect vegetables from ground frosts and consequences of diurnal temperature changes:** As in the Republic of Altay, greenhouses often have heating systems.
- **Covering bushes and trees with special materials** and/or soil for winter periods to protect them from cold and wind.
- **Cultivating vegetable and herb seedlings** rather than planting seeds directly in the open ground to shorten the growing period.
- **Increased use of organic:** e.g. manure for 'warming up' the soil, and mineral fertilisers.
- **Increased use of anti-pest chemicals**.
- **Increased watering**.
- **Additional ramming of seed plots during sowing**, which is meant to prevent the fertile topsoil being blown off by the wind and taking the seeds with it.
- **Use of new equipment:** e.g. for raising plant stems flattened by the early snow in autumn.
- **Purchasing energy-efficient equipment** to save on fuel in anticipation of possible losses of harvest
- **Using weather forecasts**.

Adaptation requires additional labour inputs from farmers, and in most cases farmers in Buryatiya bear this increased burden on their own shoulders. As in the Altay Republic, several interviewees emphasised that the burden of labour increased unevenly for men and women, and also that older farmers find it more difficult to adapt to changing climate conditions. For them it is very hard to bear a more onerous labour burden combined with the increased diurnal temperature range, which can provoke strokes.

Adaptation measures also imply substantial additional financial investments. Building or purchasing greenhouses and using more expensive windproof plastic or glass in them, storing up additional firewood for heating greenhouses, purchasing expensive anti-pest chemicals, paying for additional water used for intensified watering in summer are all expensive – and often simply unaffordable – measures for the famers that we interviewed. Notably, only two of the interviewees mentioned crop insurance, which is often presented as one of the main policy recommendations to help people adapt to climate change impacts. Evgenyi (male, 55) said that for his farm it was unaffordable. Grygoryi (male, 23) said that his farm started insuring small areas of land, but overall he was rather sceptical about the potential red tape one would encounter when trying to receive the compensation.

Overall, the farmers that we interviewed in Buryatiya had a rather fatalistic attitude towards the climate change, which could be explained by the fact that many of them totally depend on farming for their livelihoods: *'Despite harsh climate conditions we do our work, because we don't have any other source of income. What else can we live on?'* (Tamara, female, 56). However, the sustainability of this kind of unsupported adaptation was questioned by many farmers.

'*I think agriculture could dwindle. Because we are people of the old school, we know that it feeds us, we get something from it, and we get our children habituated to this kind of labour. My children can still work like this, on the land. But fiddling on this land… they're fed up with this. And I understand them; I pity them, because I have lived a similar life myself. I understand that they want to sleep, to go dancing, to travel to the city to buy something. But they don't see any of that – none of that. Willing or not, they have to sweat blood on this land. My children could still bear with it. But my grandchildren will think differently. And my children will try to give them education, so that they could go to the city…'*

(Tamara, female, 56)

2.1.3 Krasnodar Krai, North Caucasus economic area

Box 7: The role of agriculture in the Krasnodar Krai[32]

The agricultural sector in the Krasnodar Krai region is the biggest and the most developed in the country. The region produces 7% of the country's gross agricultural product. The region produces large amounts of grain and other crops and has a very well developed and growing food industry, supplied by access to relatively cheap agricultural produce. The food industry accounts for 50% of industrial production in the region. The majority of the farms in Krasnodar Krai are large collective farms, many of which also process agricultural produce. The proportion of smallholders is higher in the peripheral, more arid parts of the region. Unemployment rates here are much lower than the national average, since the agricultural sector provides the population with jobs. However, low unemployment rates may conceal the part-time or seasonal nature of employment. Moreover, people are considered as self-employed, even if they just own some livestock or land. But, overall, Krasnodar does rank high in the regional human development index rating – 16th out of 80 – since its population has life expectancy higher than the Russian average, and comparatively high income.[33]

Krasnodar Krai has always been one of the key agricultural regions in Russia, and it is often referred to as 'the granary of Russia'. As shown in Part 1, in the last fifteen years, climate change has made it possible to expand winter grain production. However, recent trends, such as an increasing incidence of drought combined with increasing lack of water resources in this region, as well as an increasing number of extreme weather events, e.g. floods,[34] have already negatively affected agricultural production. In the absence of adaptation measures, agricultural production in Krasnodar Krai might radically decrease.

As our interviews have shown, the changes are already affecting agricultural production and, consequently, the livelihoods of many farmers here. For many of them, the losses incurred due to changing climate conditions are dramatic.

'I haven't planted anything this year. Two years ago, I lost my harvest because of the drought. Then again last year – because of the continuous rainfall at the end of the summer. For me, it was a real disaster – tomato bushes were basically washed away together with the soil down into the river. Imagine a stream of mud mixed with plants – and it all goes to hell right in front of your eyes. After this adversity, I went bankrupt. So, this year I haven't planted anything, since I simply had no money. And the fields are overrun by weeds.'

Alexander, male, 56

Just as in the other two regions, the observations of our interviewees in Krasnodar Krai were highly consistent.

Box 8: Farmers' observations of the changing climate in Krasnodar Krai

- Weather increasingly 'unpredictable'
- Harsher and damper climate, with precipitation now more unevenly distributed throughout the year
- Colder (with longer periods of negative temperatures at night), but less snowy winters
- Disappearance of the phenomenon of 'February windows' (very sunny and warm periods, when temperatures would go up to 20–22°C)
- Longer, colder, and damper springs
- Much hotter and more arid summers, with air temperature going up to 40°C, and soil temperature getting up to 60°C
- Longer, damper, and warmer autumns, but with increased incidence of early ground frost (already occurring in October)
- More radical temperature changes, especially during the seasonal change from spring to summer. 'If yesterday it was +10°C, tomorrow it could already be +30°C.' (Vasilyi, male, 60)
- Increased diurnal temperature range
- Stronger winds in winters, springs and summers that the farmers relate to deforestation[35]

As our interviewees indicated, climate change has already had profound impacts on agricultural activities.

Table 4: Climate change effects on agricultural production by season in Krasnodar Krai

Season	Climate change effects
Winter	• Cold and snowless winters are detrimental for winter grain crops. Three farmers told us that their farms lost all the winter grain crops this year. The soil just froze through – the temperature in winter fell to as low as -35C in the complete absence of snow. Two farms have completely reseeded the crops in spring. • Disappearance of so-called 'February windows' means that it has become impossible to seed potatoes so early.
Spring	• Snowfalls now sometimes occurring in March are another problem for winter grains – while melting during the day, at night melted snow turns into a thick layer of ice, which basically causes plants to rot. • Because of the longer and damper springs, the sowing season now, on average, starts two weeks later than before. Water stays on the fields for longer than before, so it is impossible to get machinery onto the fields. Last year, Oxana (female, 32) said her farm for the first time ever simply did not manage to sow corn at all. • Radical temperature changes during the seasonal change from spring to summer inhibit plants' development. • Increased diurnal temperature range is also very damaging for the harvest. In 2011, Vasilyi (male, 60) lost 70% of his strawberries because of the night ground frosts in spring – during the day the temperature was 20°C, while at night it went down to 0°C. • Strong rainfall damages harvests. This year, in Alexey's (male, 55) farm, 10 hectares of sunflowers were completely damaged by the rains, and on the other sunflower fields herbicides that he had applied shortly before the rainfall started were washed away.
Summer	• Summer droughts together with dry hot winds (sukhvoei) 'burn' crops. And because of the later sowing, plants are less prepared to resist droughts.
Autumn	• Because of the early rains, farmers have to rush with the harvesting. Many do not manage to harvest in such a short time, and plants rot in the fields. • Early ground frost kills plants that have not been reaped yet. Because of the ground frosts farmers growing vegetables can't benefit from long warm autumns which climate change has brought. Otherwise, it would have been possible to have cucumbers, tomatoes, cabbage, and potatoes in November. • Long periods of warm weather in late autumn and early winter negatively affect winter grain crops. In these periods, plants grow too actively to be able to later resist cold snowless periods coming in the second half of winter. • Moreover because of these unusually warm periods some types of vermin, e.g. carabid beetles, are now found on the fields as late as in December, while previously they survived only until mid-November. They represent an additional danger for winter grain crops

Apart from the impact of changing climate, **pollution caused by the local industries further aggravates the situation of the farmers**. Evdokiya (female, 86) told us about the pollution coming from the chemical plant in a town near her village. *'Emissions happen at night, and in* *the morning poisoned dew subsides on the bushes and erodes the leaves. The plants start sickening.'*

Box 9: Adaptation measures used by farmers in Krasnodar Krai

- Selecting cultures adjusted for specific climate zone. E.g., Vladimir (male, 57) told us that sugar beet grows very well in Krasnodar Krai region even under the new climate conditions, and profit from the sugar beet harvest allows his farm to cover financial losses incurred due to the climate.
- Seed selection. Our interviewees prefer to use Russian sorts of grains, vegetables, berries, etc. Although they yield smaller harvests, they are more frost- and disease-resistant that the European ones.
- Manual cultivation during rainfall
- Increased watering during summer droughts
- Using systems of drip irrigation
- Using 'dry irrigation' techniques
- Using 'no till' techniques
- Earlier crop harvesting due to the risks of early ground frost in autumn
- Increased use of organic and mineral fertilizers
- Increased use of 'anti-stress products' to help plants resist droughts and cold weather
- Strict adherence to crop rotation
- Reseeding of winter crops in spring. The problem is that doing this might disrupt crop rotations. Vladimir (male, 64) pointed out that this year his farm had to reseed the damaged fields with corn, although, according to the crop rotation plan, corn should only be seeded on those fields next year. This means that next year corn crops on those fields will likely be affected by pests.
- Observing weather forecasts
- Supplementing agricultural activities with other types of business activities, such as, for example, agritourism
- Covering plants with soil and insulating materials for the winter period
- Using greenhouses for vegetable growing
- Manual chemical spraying of pests. Farmers have to use this technique – which is rather dangerous for health – for eliminating pests appearing on fields of winter crops in late autumn/early winter (a new phenomenon discussed above). Farmers can't use technical equipment for this purpose, since it could damage young plants.
- Planting seeds deeper (down to 10 cm) to save plants from droughts. This technique is somewhat risky, since it lowers plants' chances to compete with weeds.
- Farmers also emphasized the importance of forest belts in protecting the crops.

Like in the other two regions, adaptation measures come at great financial cost for the farmers**.** Currently, they incur higher fuel expenses. Because of the damper weather in spring, the soil is heavier – this creates an additional load for tractors, and, consequently, additional expense of diesel. Reseeding also results in a significant increase in fuel consumption. Reseeding also causes indirect losses, since the fields of winter wheat are usually reseeded with corn, which does not require as much fertilizer as wheat does, and, therefore, those fertilizers that had been already have basically been wasted*.* Building greenhouses, as well as purchasing special technical equipment (e.g. fans for blowing snow off the trees, equipment for 'no till', etc.) are big investments. 'Anti-stress products' now widely used by the farmers are very expensive, since only foreign produced products are really effective, from the farmers' point of view

The problem of adaptation costs is aggravated because instead of support from the local authorities and food producers, farmers say they encounter broken promises, the desire to profit from other's adversities, or simple lack of understanding of what kind of assistance programmes they really need. Food producers often make farmers sell their produce for below the market prices. For example, Oxana (female, 32) whose farm now reaps sunflowers earlier said that oil producers give them a 'take it or leave it' low price for the moist seeds, knowing that the farmers cannot risk hanging on to the seeds and must sell them.

Most of the interviewees pointed out that the local government subsidy programmes cover only technical equipment and anti-stress products produced in Russia. This, for example, basically prevents farmers from using 'no till' technique discussed above, since the equipment for it is produced only abroad.

Red tape holds up crop insurance applications. '*Previously I insured my crops, but then stopped. To be honest, doing that (insuring) doesn't make much sense. Insurers just suck money out of us. To prove the fact that the crops died, to calculate acreage, to prove damage – you have to collect a bunch of papers, to undergo expert visits. Every day I wake up at 5–6 a.m. and finish work at 1 a.m., and I don't have either time, or the desire to run to those offices and collect papers.'* (Alexey, male, 55)

Getting subsidies also implies sometimes impossible struggles with red tape. *'When I got hit by adversity (floods in 2011), they (the local authorities) introduced the programme of greenhouse development. In the city administration, they advised me to take out a bank loan to build a greenhouse. I was really tempted by this idea – having a greenhouse is a completely different thing from a risky business of growing tomatoes in open ground. I took a loan for 300,000 roubles (6,000 GBP) and built it. But I have not got the compensation (a grant to pay back the loan) The city administration told me that I violated some conditions of subsidy provision. Either they didn't like the business plan, or something else. Now I'm totally in debt, without any operating assets. Most likely I won't use the greenhouse this year.' (*Alexander, male, 56)

Local authorities do not hold to their promises when it comes to compensating for losses. *'Regional authorities promised to those farmers who had to reseed winter crops this year to pay compensation of, as far as I remember, three thousand roubles per hectare (approx. 60 GBP per hectare). But in our district department of agriculture I was told that there would be no money, and I should not even wait for it. The government just let us down this year.'* (Alexey, male, 55)

Local authorities continuously fail to repair run-down irrigation systems in the villages. *'We don't have a centralized water supply like in suburban dacha communities. Boring individual wells is very expensive. There is a pond in the village, and it would be possible to install a pumping station there. But there is a problem – sewage from our houses is draining in there. The thing is that the sewage treatment facilities were broken when there was still a collective farm, and now nobody's repairing them. The mayor promises to do that before elections, but then just shrugs his shoulders that there's no money. For some reason, money for changing paving slabs in the centre of the city is found every year, but for repairing the sewage in our village – no.'* (Natalia, female, 55)

The situation with **land rent** has made some farmers unwilling to make investments in adaptation. For example, Vladimir's (male, 66) farming cooperative that specialises in fruit growing has decided not to change the cultivated cultures, since they are not sure whether their rent agreement will be prolonged, and investing in new fruit trees should be a long-term project.

To conclude, the absence of adaptation and support for smallholders and agriculture in general means that the future of Russian agriculture looks uncertain – and with it the potential for Russia to play a key role in ensuring global food security in the face of current and future climate change.

ANNEX 1: LIST OF PARTICIPANTS

A number of interviewees expressed their preference for anonymity. Therefore, it was decided not to indicate the names of the villages where the interviews were collected. Instead, we simply indicate the geographical location of the villages within the considered regions.

Altay Republic

№	Location in the region	Name, gender, age	Type of employment, farming specialisation
1	South-western	Alexander, male, 33	Director of a farming enterprise, livestock breeding and plant growing
2	South-western	Sergey, male, 57	Manager of a farming enterprise, livestock breeding and plant growing
3	South-western	Elena, female, 42	Self-employed, subsistence farm, vegetable growing
4	South-western	Andrey, male, 43	Self-employed, subsistence farm, livestock breeding and tourism
5	North-western	Nadezhda, female, 57	Pensioner, subsistence farm, vegetable and fruit growing
6	North-western	Larisa, female, 50	Self-employed, subsistence farm, vegetable and fruit growing
7	North-western	Alexandra, female, 58	Pensioner, subsistence farm, vegetable and fruit growing, livestock breeding
8	North-western	Galina, female, 61	Pensioner, subsistence farm, vegetable and fruit growing

Republic of Buryatiya

№	Location in the region	Name, gender, age	Type of employment, farming specialisation
1	Central-southern	Grygoryi, male, 23	Head of a family farming enterprise, livestock breeding and plant growing
2	Central-southern	Nadezhda, female, 52	School teacher, subsistence farm, vegetable growing
3	Central-southern	Svetlana, female, 63	Pensioner, subsistence farm, vegetable growing and livestock breeding
4	Central-southern	Svetlana, female, 32	Self-employed, subsistence farm , vegetable growing and livestock breeding
5	Central-southern	Evgenyi, male, 55	Head of a family farming enterprise, vegetable growing
6	Central-southern	Olga, female, 43	Employee of a farming cooperative, vegetable growing
7	Central-southern	Yuryi, male, 72	Pensioner, subsistence farm, vegetable growing
8	Central-southern	Elena, female, 56	Accountant, subsistence farm, vegetable and fruit growing
9	Central-southern	Tamara, female, 56	Owner of a farming enterprise, vegetable and plant growing, livestock breeding

Krasnodar Krai

№	Location in the region	Name, gender, age	Type of employment, farming specialisation
1	South-eastern	Alexander, male, 56	Owner of an individual farming enterprise, vegetable and fruit growing
2	South-eastern	Oxana, female, 32	Assistant to the head of a family farming enterprise, plant growing and livestock breeding
3	North-eastern	Vladimir, male, 57	Co-founder and director of a farming enterprise, aviculture and plant growing
4	South-eastern	Vladimir, male, 66	Owner of a subsistence farm and head of a farming cooperative, fruit growing
5	Central	Vasilyi, male, 60 Tatyana, female, 57	Owners of a subsistence farm, vegetable and fruit growing
6	Central	Lyubov, female, 53	Agronomist of a farming enterprise, plant growing
7	Central	Vladimir, male, 64	Chief agronomist of a farming enterprise, plant growing
8	Central	Alexey, male, 55	Owner of an individual farming enterprise, plant growing
9	Central-eastern	Alexander, male, 62	Owner of an individual farming enterprise, plant growing and livestock breeding
10	South-eastern	Natalia, female, 55	Pensioner, owner of a subsistence farm, fruit and vegetable growing
11	South-eastern	Evdokiya, female, 86	Pensioner, owner of a subsistence farm, fruit and vegetable growing

ANNEX 2: QUESTIONNAIRE FOR SEMI-STRUCTURED INTERVIEWS

- Would you tell us a little bit about yourself and your family?
- When did you start working in agriculture? What were the main stages of your career? Would you tell us about the farm that you are working at?
- In recent years, have you noticed any signs of climate change in your region? If yes, what in particular? How do you evaluate these changes?
- Have these changes influenced your work/work of your farm? If yes, how? *(stimulate the interviewee to provide as many examples as possible*)
- For each month, could you tell us how have your activities changed due to the climate change?
- How has the distribution of work/responsibilities between men and women in your farm changed due to the climate change?
- How do you adapt to the climate change? *(stimulate the interviewee to provide as many examples as possible*) Is it difficult? Why?
- How, in your opinion, will climate change affect agricultural production in your farm in the future?

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[23] N.Lemechko and M.Nikolaev. Climate Change, Vulnerability, and Adaptation in Agriculture – the Situation and State of Art in Russia. Sofia, 10–11 March 2008.

[26] According to the parameters used in IMPACT model, the real per capita income in Russia trebles under the pessimistic scenario (low growth rates of gross domestic product and population reduction) and increases 7 times at the optimistic scenario (high growth rates of gross domestic product and population reduction) in comparison with an indicator of 2000. Despite such indicators, in 2050 gross domestic product per capita in Russia makes only 25 % from a similar indicator in the USA.

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NOTES

Executive summary

[1] http://www.interfax.com/newsinf.asp?id=341731

[2] http://ipcc-wg2.gov/SREX/report/

[3] GCMs refer to mathematical models of the dynamic interactions of physical and chemical processes in the atmosphere with the oceans and land surfaces. They are used to model different climate change scenarios under different greenhouse gas emission trajectories.

[4] http://neacc.meteoinfo.ru/research

Part 1

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[8] http://www.unep.org/yearbook/2008/report/UNEP_YearBook2008_Full_EN.pdf

[9] http://ria.ru/infografika/20120727/710676168.html By expert estimations, the emission *of carbon dioxide* from fires in 2010 may amount to 400 million tons, that is equivalent to 18% of annual anthropogenic emissions of greenhouse gases in Russia (The Conclusion of the Public Commission on Investigation of the Reasons and Consequences of Natural Fires in Russia in 2010 (http://www.yabloko.ru/mneniya_i_publikatsii/2010/09/14)).

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of 2010 of the largest in Russia's history from the point of view of mortality (http://kommersant.ru/doc/1566066)

[14] Significant differences between day and night temperatures

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[22] http://www.bloomberg.com/news/2012-08-21/russia-s-drought-seen-by-ministry-as-destroying-7-6-of-crops.html

[23] http://latifundist.com/novosti/36239-eksport-zerna-s-rossii-snizilsya-pochti-na-20

[24] http://www.ya-fermer.ru/news/urozhay-2012-rossiya-k-10-sentyabrya-sobrala-zerna-na-13-mln-tonn-menshe-chem-v-proshlom-godu

[25] 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 billon people by 2050 with subsequent gradual decrease, quick spreading of new and efficient technologies, equalization of income and style of life in different regions, broad social and cultural interaction in the world.

Part 2

[26]Data taken from Zubarevich http://atlas.socpol.ru/portraits/alt.shtml, the regional web-site http://www.altai-republic.com

[27] UNDP (2011) *Human Developent in the Russian Federation Report 2011*: *Modernisation and Development of Human Potential.* http://www.undp.ru/documents/nhdr2011rus.pdf The average subsistence level for all socially-demographic groups of the population across Russia corresponded to 187.4 US dollars in 2010.

[28] Whilst the consequences of deforestation may have consequences for local climate, this is not the same as climate change. But since the changes caused by deforestation are said by farmers to have such great impact on agriculture, it was decided to include them in this list. Moreover, it is important to note that deforestation itself is a contributory factor to climate change in that it reduces the biosequestration of atmospheric carbon dioxide trees.

[29] Adapted from Zubarevich http://atlas.socpol.ru/portraits/buryat.shtml . The data is for 2007–2008.

[30] UNDP (2011) *op. cit.*

[31] See note 21

[32] Data taken from Zubarevich http://atlas.socpol.ru/portraits/k_kray.shtml

[33] UNDP (2011) *op. cit.*

[34] E.g. 2012 floods in Krymsk

[35] See note 21

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For more information, or to comment on this report, email Yulia Yevtushok, Oxfam Programme Coordinator, at yyevtushok@oxfam.org.uk

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