KRISZTINA HEGEDÜS

CHANGES IN THE RUSSIAN CLIMATE AND ITS CONSEQUENCES

The Russian Federation is the single largest country in the world. Therefore, its climate differs greatly. In this paper, we analyze the Russian climate change, and the situation that Russia faces. How will global warming change Russia's climate system? What are the consequences both in Russia's environment and in the Russian economic system? Is it possible that, along with the many negative environmental and economic effects, there could be some economic advantage? How does Russia try to avoid the unfavorable climate changes?

KEYWORDS: CLIMATE CHANGE, RUSSIA, GLOBAL WARMING, RUSSIAN CLIMATE

JEL O13, O52, P28, Q01, Q16, Q18, Q30, Q48, Q54, Q58,

1. INTRODUCTION

Like any country in the world, the Russian Federation perceives the consequences of climate change as well. Maybe even more, because Russia has the largest territory and climate change affects Russian regions differently. In addition, air temperature warming is well above the global average. However, the climate change has positive and negative outcomes. This puts Russia in a difficult situation. Obviously, Russia would like to avoid the negative consequences of warming, so developing green technology would help. On the other hand, Russia owns huge fossil fuel reserves; what is more, about 67% of the Russian export revenue comes from mineral product export. So it does not seem to be Russia's best interest if the partner countries adopt greener, more sustainable or renewable technologies. At the same time, global warming could damage the transportation system of these fossil energy resources. Therefore, Russia faces a complex problem. While its whole economy basically depends on the consumption of the fossil energy resources, they have to create more sustainable development, and slow down global warming.

In this paper, we analyze the Russian climate change and the situation that Russia faces. How will global warming change Russia's climate system? What are the consequences both in Russia's environment and in the Russian economic system? Is it possible that, along with the many negative environmental and economical effects, there could be some economic advantage? How does Russia try to avoid the unfavorable climate changes? Does the Russian Government have some plan, or what role does Russia play in the international community?

To answer these questions, at first we have to see what Russian climate is like today. Then in the second chapter, we will see how Russia contributes to the climate change with greenhouse gas emission, and how they try to reduce it, and how they took part of the Kyoto Protocol. Next we discuss the changes in the Russian

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environmental system: they way surface air temperature increased, the permafrost zone melted, and whether there are more extreme climatic events than a few decades ago, and how these changes will possibly continue. So there have to be some consequences for the environmental changes in the economy, and in fact there are. In the following chapter, we examine the changes in the agricultural system and the most important question for Russia: the changes in the energy production and the transportation system. At last, before the conclusions, we look at the Russian environmental regulation method, especially how Russia tries to minimize the negative factors of climate change.

2. RUSSIA'S CLIMATE

The Russian Federation, with its 17,075,200 square kms, is the single largest country in the world. Therefore its climate differs greatly. For example, in Northern Siberia, there is a cold arctic climate, while near the Black Sea, there is a sub-tropical hot climate. We can find moderate continental climate in the northern part of Russia, which is formed by the western wind rose. Besides, the Gulf Stream influence can be felt in the Murmansk region. Furthermore, the central part of Russia, such as Siberia and the Ural Mountains, has continental climate with moderately warm summers and really cold winters. Sub-tropical climate can also be found in the southern territory of the Russian Federation, like Sochi and its region. Thus we can find wholly different landscapes in one country, like grassy steppes in the south or frosty tundra in the north, as well as Russia has the deepest lake in the world (Lake Baikal) and Europe's highest mountain (Mount Elbrus in the Caucasus) [NIC 2009].

Russia has a 37,653 km long coastline along the Arctic, the Pacific Ocean and several seas. It also has thousand of rivers (approx. 100,000), and with Lake Baikal, Russia possesses more than one fifth of world's fresh surface water reserves, although these reserves are not equally distributed in the territory of Russia. Moreover, the area where 80% of the population and the industry are concentrated possesses only 8% of the water resources [WWF 2008].

Therefore, climate change will affect Russia in many different ways, but some argue that Russia already feels the consequences of global warming. From that, some questions emerge. How does Russia contribute to the climate change, and what can we say about its GHG emission? More importantly: What can Russia do to avoid global warming, or, as it seems unavoidable, how will Russia reduce the negative consequences of climate change?

3. RUSSIA AND THE WORLD

3.1. RUSSIA'S CONTRIBUTION TO GHG EMISSION

Russia seems to play a big role in the debates on climate change. First and foremost, Russia has a significant share in the world's fossil fuel stock. Russia has a 5.6% share from the World's known oil stock, which is enough for the second place after

OPEC. Its share in oil consumption is even bigger than its share in reserves: 12.9%. As for natural gas reserves, Russia leads with a 23.7% share in the world's known natural gas reserves. Russia is responsible for 17.6% of the world's natural gas consumption [BP 2010]. It also has a big export share in both the oil and the gas sector. Furthermore, about 67% of Russia's export revenue comes from the export of mineral products (including fossil fuels) [gks.ru 2011]. With these data, it is clear that the Russian economy depends greatly on the fossil fuel trade. Therefore, we can see that it is not in Russia's best interest for the world to "go green", and stop using the fossil fuels, which does not seem to happen in the near future. But it could be beneficial for Russia to reduce its own fossil fuel consumption and its dependence on these energy sources. According to the latest data, with 1532.6 Mt CO_2 (in 2009), Russia is the world's fourth largest emitter of CO_2 after China, the USA and India [IEA 2011]. It is an almost 30% reduction since 1990, but we have to add that the collapse of the Soviet Union with its heavy industry in 1991 played a significant role in it. Previously, the USSR was the second largest emitter, and because of its industrial development, the emission growth was pretty fast [Lioubimtseva 2010]. The bottom year for the CO_2 emission was 1998, after that the Russian economy started to recover from the crisis and so the emission slowly started to grow by app 2–3% per year. The top growth was in 2006 with 4% CO_2 emission expansion, then it seemed constant for a few years, when in 2009 decreased by 4% largely due to the global financial crisis *(see Table 1)*. Although Russia's emission looks good in the light of the Kyoto Protocols emission reduction plan the per capita emission is still pretty high, almost four times higher that China's per capita emission)

Table 1. Annual greenhouse gas (GHG) emissions for the Russian Federation, in Gg CO_2 equivalent[1]

Category	Base year (1990)	1998	2000	2006	2009
1 Energy	2,717,153.69	1,643,915.25	1,665,849.48	1,792,463.13	1,782,606.65
2 Industrial Processes	257,523.35	134,165.68	166,705.98	187,703.55	158,358.79
3 Solvent and Other Product Use	561.61	517.34	522.89	531.96	544.94
4 Agriculture	317,286.52	158,379.02	149,062.33	133,851.01	142,374.66
6 Waste	58,651.10	51,442.81	56,366.59	68,942.05	75,385.15
Total	3,351,176.28	1,988,420.10	2,038,507.26	2,183,491.70	2,159,270.18

Source: UNFCCC Data Interface

1 The reporting and review requirements for GHG inventories are different for Annex I and non-Annex I Parties. The definition format of data for emissions/removals from the forestry sector is different for Annex I and non-Annex I Parties.

3.2. RUSSIA AND THE KYOTO PROTOCOL

The Russian Federation joined the UN Climate Convention in 1994, and played a significant role in the Kyoto Protocol's existence in 2004. For the Kyoto Protocol to enter into force, Annex B Parties[2] had to ratify it, accounting for 55% of 1990 carbon emissions [UNFCCC 2010]. As we know, the USA did not ratify it, although it had 34% of 1990 global carbon emissions. Other large countries/groups have already ratified it (like EU, Japan etc.), therefore Russia's 16.4% share in the 1990 carbon emission was a game changer, and Russia ratified it in 2004. Why did it ratify it so late, when signed in 1999? For Russia, it was not an easy decision to ratify such a document like the Kyoto Protocol. As already mentioned, Russia has a large amount of the world's fossil fuel resources, and Russia does not belong to the most developed countries, so it needs a great amount of energy (and with that GHG emission) to develop. Therefore, it is natural that Russia uses these resources. So why even consider ratifying such documents? Even though we could think that signing and ratifying the Kyoto Protocol is not beneficial for Russia, it did ratify the Protocol. So there has to be some positive effects on Russia. What were the reasons of the Russian yes to the Protocol? The original plan was the global reduction of GHG emissions by 5% until 2012 from the 1990 levels, and the Russian commitment was to keep the emission at the 1990 level [UNFCCC 2011]. These aims were easy to reach for Russia, and also for some Eastern European countries, because for them the 1990 emission was already high, and after the end of the Soviet era (and with that many industrial projects), the GHG emission automatically reduced. Although there has been a slight increase in the level of the greenhouse gas emission since 1998, Russia can still easily meet the criteria's of the Kyoto protocol; moreover, Russia has a great surplus of carbon credits for the first commitment period from 2008 to 2012. Thus Russia could trade with these unused emission units. We have to mention that Russia has not made any commitment yet for the further periods. Also Russia could benefit from some modernization of its industry, even better if it means some GHG emission along the process.

The countries that joined the Kyoto Protocol have to reduce their GHG emissions trough national measures. The Protocol offers three market-based mechanisms as an opportunity for cooperation between the countries, thus creating a "carbon market" [UNFCCC 2011]. The three mechanisms are the following:[3]

- Emission trading
- The Clean Development Mechanism (CDM)

2 Parties that have accepted targets for limiting or reducing emissions under the Kyoto Protocol are listed in Annex B to the Protocol. These Parties are known as Annex B Parties, mostly industrialized countries and economies in transition. (for more information see unfccc.int › Kyoto Protocol)

3 Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare (emissions permitted for them but not "used up") to sell this excess capacity to countries that are over their quota. The Clean Development Mechanism (CDM), as defined in Article 12 of the Protocol, allows a country with an emission reduction or emission limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to

■ Joint Implementation (JI)

It seems that Russia has a serious amount of carbon credits to trade with (estimates range from $US 40 billion to $US 60 billion), and it also has the greatest GHG reduction potential with over 150 Mt CO_2, which is about 58% of the global JI market [Lioubimtseva 2010]. This creates an uncertainty in the global carbon market, as the cooperation set by Kyoto Protocol expires in 2012, and the Copenhagen Accord was not successful and did not put any further cooperation into motion after 2012, just simply extended all existing negotiating mandates. So now it seems that Russia has a potential to control the future of the trade system with its huge surplus of unused emission permits. Once Russia puts these emission permits on the global carbon market, it would likely lead to the collapse of the price of carbon [Lioubimtseva 2010]. Another issue is that after the Kyoto Protocol's duration and in lack of a new legally binding international treaty, Russia's emission is likely to grow as shown in Figure 1. As mentioned above, Russia has a massive potential to reduce GHG by JI projects, but that does not mean that Russia will exploit all of it. Also, in 2008 in Poznan the Russian delegation declared that Russia will make quantitative commitments for the period following the expiration of the Protocol in 2012. There has not been any such commitment ever since, and now it seems that Russia will not make any commitment until 2017. "Considering the progress of the talks, the composition of negotiating teams, the attitude of the United States, I can assume with a great share of probability that no new agreement will be adopted in the next four to five years after the expiry of the Kyoto Protocol," said Oleg Pluzhnikov, an official with Russia's Ministry of Economy [Point Carbon 2011]. So what could happen with Russian emissions after 2012? In Figure 1, there are three scenarios for the Post-Kyoto period for Russia. As Michael Yulkin calculates in the Innovation scenario, Russia will reach 80% of its 1990 emission by 2020. In that scenario, Yulkin assumes that Russia will double its GDP in the period from 2012 to 2020. The other scenario will be likely if Russia reaches some of the figures the Russian Government has already declared: by 2020 the share of renewables in the electricity production will increase by up to 4,5%, and the energy intensity of GDP should be reduced to 40% below the 2007 level. The best scenario contains other special measures, such as the ones also declared by the Russian Government: APG flaring should be reduced to only 5% by 2012, which is highly unlikely at the moment. Also the Russian Federation could create an emission trading scheme (ETS) system similar to the EU ETS system[4] [Yulkin 2009].

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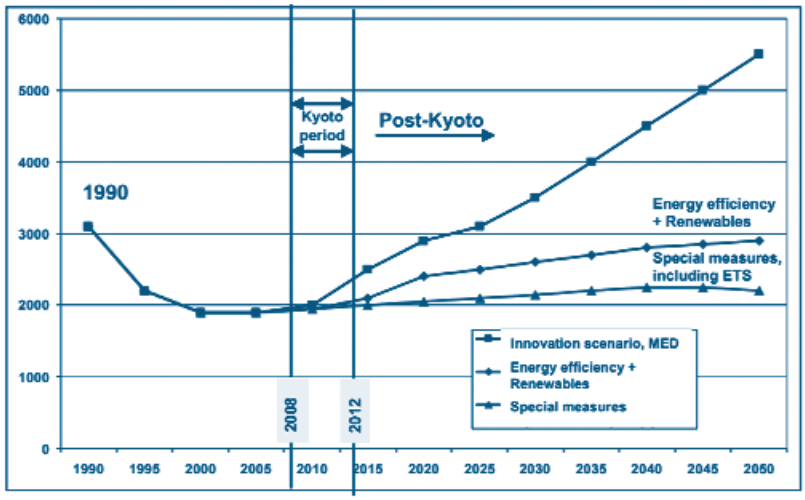
one ton of CO_2, which can be counted in meeting the Kyoto targets. The mechanism known as "joint implementation," as defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one ton of CO_2, which can be counted in meeting its Kyoto target. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer. (For more information visit http://unfccc.int/kyoto_protocol/mechanisms).

4 For furher information see: Yulkin [2009].



Source: Yulkin 2009

Figure 1. Russian GHG emission (Mt CO_2)

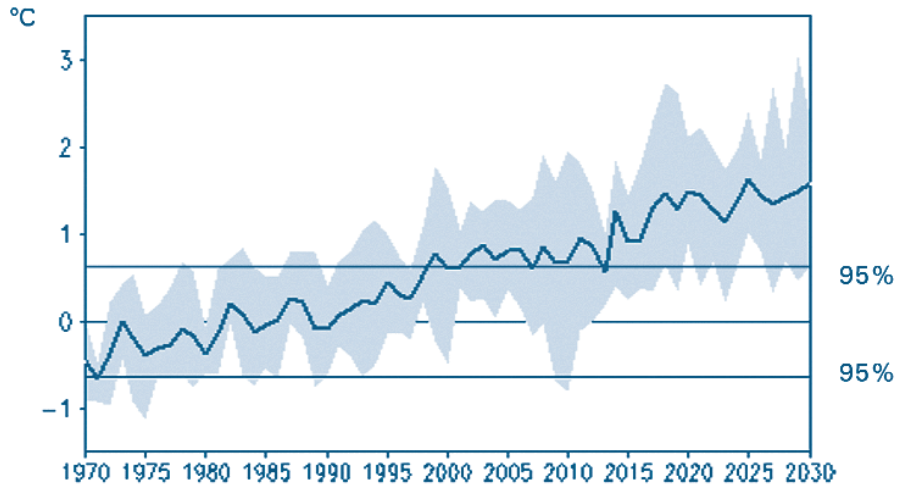
We saw how Russia contributes to climate change and how they take part in the international conventions against the climate change. What we have not analyzed is why Russia should bother about taking part in this kind of agreement, or asking the same question otherwise, how the climate change affects the Russian Federation.

4. CLIMATE CHANGE IN RUSSIA

What can we say about the climate change of Asia or Russia in general? The Intergovernmental Panel on Climate Change (IPCC) has the most popular reports (the latest is published in 2007 under the title of Fourth Assessment Report) on the climate change. There has not been country report yet, but only a regional one. For Asia, the report predicts a warming above the global average in northern Asia, which is basically Russia. Also a very popular international organization, the World Wildlife Fund (WWF) compiled a report on the Russian climate change.

Surface air temperature: This report stated that during the 20th century, Russia's average surface temperature rose by 1°C, which is 0.3°C above the average global temperature rise of the Earth. Between 1990 and 2000, the surface temperature rose by 0.4°C, which is extremely high, but in the beginning of the 21st century, this growth seemed to slow down, and during the period from 2000 to 2010 it has hardly changed, but we should add that in the recent years Russia experienced plenty of "local records". The WWF adds that the climate change is not just a slow global warming process, but primarily amplifies the imbalances of the climate, such as the winters could be colder and summers hotter, so the average could stay put, with growing differences. The meteorological observatory of the Moscow State University collected data, and according to them, in the period from 1990 to 2000, the average surface air temperature rose by 3.7°C in January, 3.4°C in April, 1.3°C in July, 2 in October in comparison with the period 1901–1910.

However the fluctuation of the temperature was even 3–5 times stronger [WWF 2008]. By the middle of the XXI century, the temperature rise will be 2.6 ± 0.7°C, in winter even higher 3.4 ± 0.8°C [Roshydromet 2008].



Source: Roshydromet [2005]

Figure 2. Increase in surface air temperature in Russia compared to 1971–2000[5]

Figure 2 shows the average air temperature change in Russia, but as we already mentioned due to the great diversity of the Russian territory, the climate change affects Russia in many different ways and intensity.

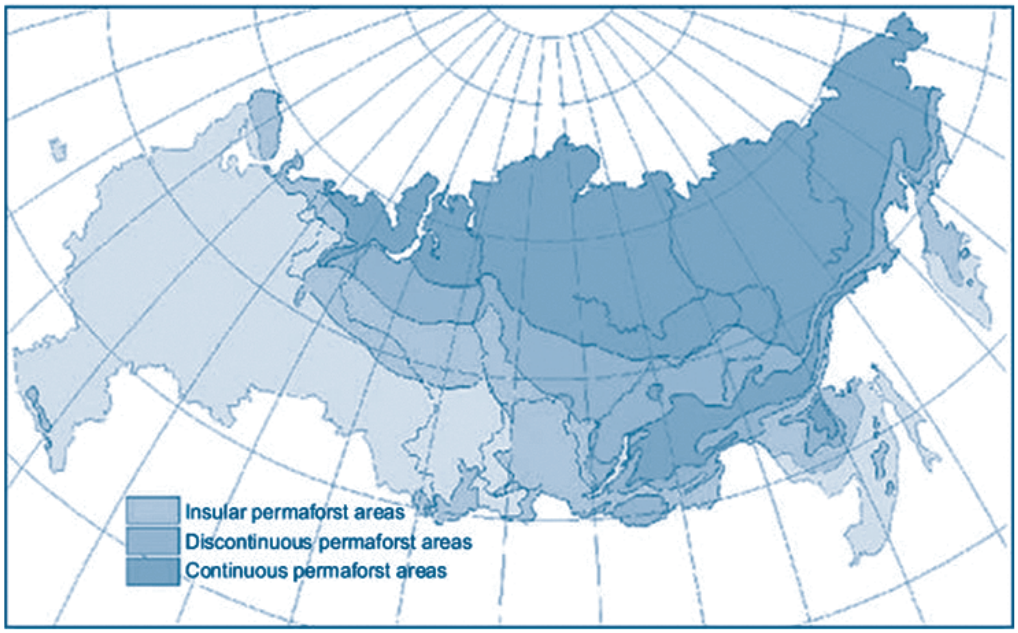
The climate change affects the Arctic Region most, the rise of the surface temperature in the Arctic are almost double the rate of the global average [NIC 2009]. Also in comparison with 2000 by 2015 could be huge warming in Western Siberia the temperature could rise by 3–4°C, by 2–3°C in Yakutia, by 1–2°C in the Far East and "only" by 0.5–1°C in Central Russia. The temperature rise differs not only by regions, but also by seasons. In winter there will be a higher temperature rise, by 1°C on average, and not more than 0.4°C during the summer [Kokorin–Gritsevich 2007].

Permafrost:[6] Permafrost melting could be a huge problem in Russia, as the permafrost zone covers almost 63% of Russia's territory (it means about 10.8 million square km). Figure 3 shows that there are different kinds of permafrost areas, such as continuous permafrost zones which means that permafrost covers more than

5 Surface air temperature increase in Russia calculated using the ensemble of models for the period of up to 2030 relative to the reference values of 1971–2000 (based on the computations made by the Voeikov Main Geophysical Observatory). Dispersion of model assessments (assessments of different models included into the ensemble) is described by the gray region comprising 75% of average model values. A 95%-significance level of temperature changes averaged over the ensemble of models is specified by two horizontal lines.

6 The term "permafrost" is often associated with massive ice buried under the ground and it does not imply the presence of the frozen water. Frozen ground may be "dry"; the term "permafrost" refers to any subsurface materials that remain below 0°C for at least two consecutive years [Anisimov–Reneva 2006 p.169].

90% of the territory, discontinuous permafrost areas from 50% to 90% permafrost density and insular permafrost zones from 10% to 50% density.



Source: Emerging Market Venue [2010]

Figure 3. Russia's permafrost areas

The permafrost areas are melting massively due to the last decades' temperature increases in the top layer of the frozen ground. Calculation on the WWF study suggests that by 2030 the total permafrost area could shrink by 10–12%, by 2050 that shrink could reach 15–20%, so the borders shift by 150–200 km to North-East. The seasonal thawing may increase by 15–25%. The most affected area is the Arctic Region, since the beginning of satellite observations in 1979 the minimum seasonal sea ice area observed in September decreased by 9% in 10 years. The total ice-coveredd area was the lowest in 2007: it shrank from 7.5 million square km to 4.3 million square km. The WWF also predicts that in West Siberia (where gas and oil fields lie) the frozen ground temperature will rise by 1.5–2°C, from an average of –5°C or –6°C to –3°C or –4°C [WWF 2008]. The problem is that this high frozen ground temperature is unstable for industrial use. The thawing of permafrost might cause another problem: the process could release huge amounts of methane (greenhouse gas) currently trapped in the frozen soil [Discovery News 2011].

Water resources: As we already established, Russia has one fifth of world fresh water reserve, so it should mean that unlike some regions in the world, there will not be any problem with the water supply. However, water reserves are unevenly distributed within the country. Only 8% of the resources are in the most industrialized zone, where 80% of the population is concentrated. So there could be some shortage in some regions in Russia. Also another problem is that the surface and the underground waters are polluted significantly [WWF 2008]However,

according to Roshydromet, the renewable water resources will increase in the next 30 years by 8–10%, but the regional supply will still be a problem, because a reduction of 5–15% is forecasted in the least provided areas, but to make the problem even more difficult, an increase expected in the demand or the use of water in that very same area. For example, in the Moscow Region there will be a decreased water supply by 2015, together with a significant demand for water resources due to the economic development and also because of the growth of the population in the area. So the main problems are the distribution, not matching the demand, and the water resources become more and more polluted [Roshydromet 2005].

Precipitation: Precipitation changes are difficult to measure, and even more difficult to suggest that the changes are connected to global warming. However, it has certainly increased over the past 30 years (7.2 mm / 10 years), but not equally in every area and in every season. The highest increase occurred during spring in the western and northeastern regions of Siberia and in the European part of Russia (16.8 mm / 10 years), and even decrease was observed during winter in the northeastern regions of Siberia. The duration of dry periods also decreased, and there has been a slightly increase in the numbers of extremely large precipitations. According to the forecasts of the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), precipitation during winter will increase all over the country by 2050, depending on the regions in summer time. Precipitation most likely will decrease in the southern regions of European part of Russia and Southern Siberia, but that does not mean that high intensity precipitation will decrease as well [Roshydromet 2008].

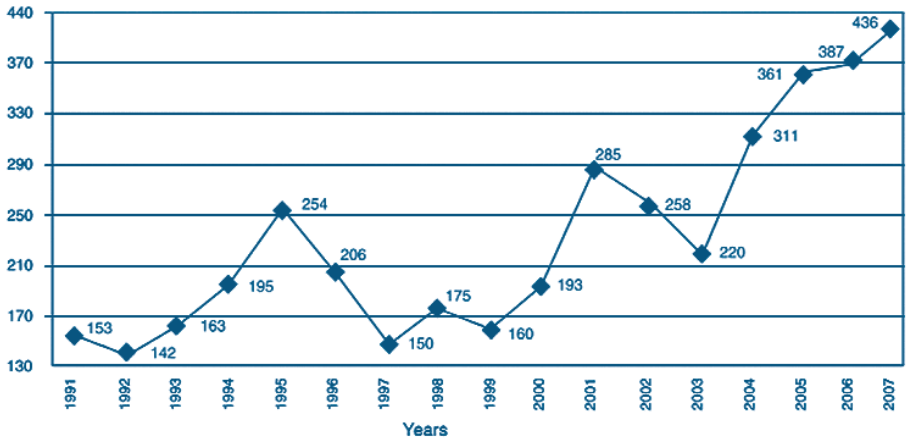
Snow cover: Another consequence of the climate change is that the snow cover has shrunk significantly in spring and summer over the last 30 years, and also there is a decreasing tendency in snow depth. The main reason for these changes is that the rise of air temperature or the increase in precipitation. The forecasts predict an expected reduction of the snow cover during the next decades. This could lead to more frequent and extensive flooding [Roshydromet 2008].

River runoff: The annual river runoff has increased by 15–40% over the last 30 years compared to the period from 1946 to 1977. The rate of the increase depends on regions. The biggest increase (20–40%) occurred in the Asian part of Russia (on the left-bank tributaries of the Tobol and the Irtysh rivers), and there was a 10–15% increase of the European part of Russia in rivers such as Dvina, Dnieper and Don, and more that 15% increase on the left bank of the Volga River. In the forecasts it seems that during the 21st century we can not foresee any significant changes in the river runoff, in some regions it might increase, but in other region even decrease is possible [Roshydromet 2008].

These phenomena are all connected and related to each other and amplify their effects. With higher air temperature, the permafrost zone will decrease and the arctic ice will melt. The increase in precipitation along with snow melt could cause the river runoff and so on just to mention a few examples.

As we mentioned, climate change is dangerous not only because the air temperature is rising, but the weather will also be increasingly unpredictable and climate change will result an increase in the number of extreme phenomena.

These extreme phenomena called dangerous hydrometeorological events (DHE), include strong winds, hurricanes, tornados, whirlwinds, heavy rains or snow, continuous rains, downpours, hailstones, ground surface icing, heavy frogs, heavy sleet pickup, very hot or very cold periods, snow avalanches, mud-flows, agro meteorological events (frosts, droughts, hot dry winds), floods, very high or very low level of the rivers, high risk of fire, etc [WWF 2008]. But just in Russia, more than 30 types of these events have been recorded [Roshydromet 2008].



Source: WWF [2008 p.13]

Figure 4. The increase of dangerous hydrometeorological events, 1991–2007

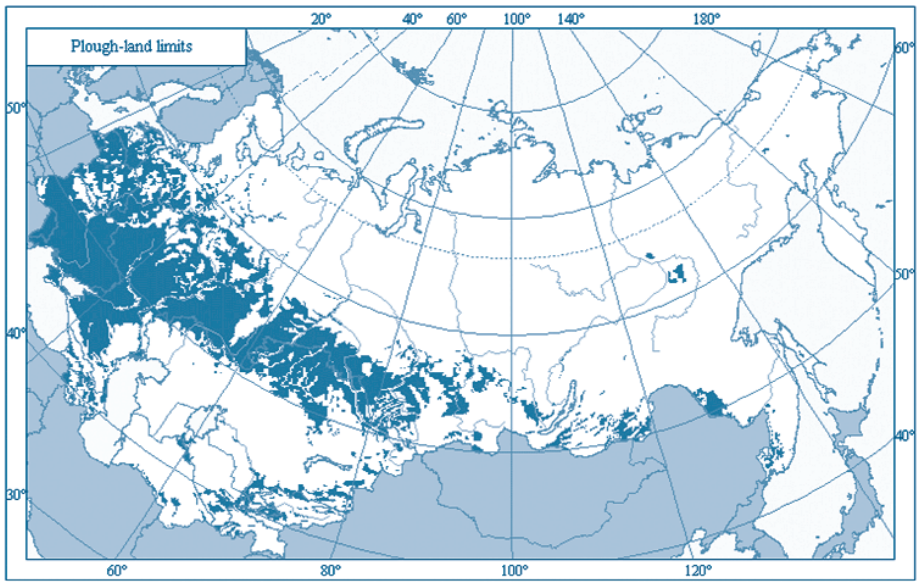
Taking these WWF data into account, the most frequent of these DHE are strong winds, hurricanes, tornados, whirlwinds representing more than 25% of the all DHE, and another 21% are heavy rains or snow, continuous rains, downpours, and hailstones. Furthermore, seasonal allocation is not consistent either, as 70% of DHE occur from April to October.

These DHE increase in Russia by an annual rate of 6.3%. According to the World Bank, the damages caused by DHE could reach as high as 30–60 billion rubles (1–2 billion dollars at the exchange rate in early November 2011). The prognoses also claim that this process is far from the end, and extreme weather events will continuously increase [WWF 2008].

5. THE ECONOMIC ASPECTS OF CLIMATE CHANGE

5.1. IMPACT ON AGRICULTURE

In a country where permafrost zone covers more than 60% of the territory, we can assume that global warming is favorable for agriculture. The agricultural area in Russia is a little more than 2,150,000 square km, which is about 13.2% of the total territory of Russia [Trading Economics 2007].



Source: Agroatlas [2003].

Figure 5 The area of arable land in the former Soviet Union[7]

There is a popular presumption in Russia about climate change, namely that the higher the temperature is, the more area there will be for agriculture. So global warming will affect agriculture positively, because the growing season will become longer, and the land that was too north or far too cold will become arable. Moreover, it will be possible to try new types of crops [NIC 2009]. But in a study Dronin and Kirilenko demonstrate that it is not that simple, and global warming has negative effects as well along with the positives. Higher temperatures might be good for agriculture, but they showed that the warming could affect the yields negatively [Dronin–Kirilenko 2011]. So first let us examine the favorable side of global warming to agriculture. In the past 30 years, the growing season has extended by 5–10 days on average, which means that the number of the days when temperature was above 5°C has increased. Also, very cold winters have decreased by 4 to 22%, the intensity of which depends highly on the regions: in the European part of Russia, it decreased by 18 to 22% while in the North Caucasus, the decrease is only 4 to 10%. Nonetheless, this is still improvement in the conditions for growing corn. In some part of Russia (mainly in the European part) it means that the warming related corn yields has increased by 30% in the past few decades [Roshydromet 2005]. Some study estimates a 50–100% potential increase in production, mostly due to the expansion of land suitable for agriculture. Also many kinds of plant could be moved further to the north, and if the warming continues, entirely new kinds of crops could be intro-

7 Arable land layers for the territory of the former USSR were obtained by carrying out an overlay reduction of the 1:4,000,000 land resources map to the scale of 1:20,000,000, setting off areas where a minimum of 10 % of lands are tilled.

duced in Russia. For example crops like cotton, grapes, tea, citrus, and other fruits and vegetables that are native in the south could be produced in the north Caucasus and the lower Volga regions [NIC 2009].

On the other hand, as already stated, there will be a lot of negative effects of global warming on agriculture. First, warmer weather could be a catalyst for plant diseases and pests, so this will be a serious challenge in many areas of Russia. In the coming years, as mild winters will become increasingly common, they are expected to spread. This could lead to decreased yields and more polluted lands, as more chemicals will be needed to destroy the pests [Dronin–Kirilenko 2011]. Other problems the agricultural sector has to face due to the climate change are the changes in the weather. More dry periods and more extreme weather are expected in the future, which is undesired and harmful as well. Dry periods in the most important regions are expected to be 50–100% more common by 2015, and this trend will most likely continue subsequently [NIC 2009]. Therefore, the more frequent dry periods will result in another problem, namely that of water supply. To reduce the harm that dryness could cause to the plants, a highly developed water distribution system will be necessary, which Russia does not have at the moment. Along with that, the growth of the number of dangerous hydrometeorological events, such as hurricanes, tornados, floods, continuous rains, downpours, etc. will be also highly expensive, as they usually destroy the yield.

What could Russia do to avoid these undesired impacts? The key would be Russia's ability to adjust to the new conditions. The problem is that the Russian rural sector does not seem to be flexible. Moreover, supply, distribution, and management issues have historical difficulties. Dronin and Kirilenko argue in their paper that with good management, better yields, and increasing grain exports, Russia could avoid most of the negative effects. But for that, investments and a higher level of government regulation would be needed. Roshydromet propose an early implementation of irrigation operations, along with investment in the water supply system [Roshydromet 2005].

5.2. IMPACT ON ENERGY SECTOR

Considering that Russia has a huge share of the world's known fossil fuel reserves and the largest territory in the world, energy consumption and the operation of the energy system are key issues.

One of the first thought could be that with warming weather, the heating season will decrease, which is true. According to Roshydromet [2008] the heating season in Russia by 2015 will be 3 to 5 days shorter on average than in 2000. Also, winters could be warmer, so not only the heating season will shorten, but the lowest temperature in winter might increase, the same way as temperatures on the coldest day and during the coldest five-day period will increase by 20%, therefore the intensity of heating could be reduced, and it will be possible to keep the desired indoor temperature with lower fuel consumption. Therefore, the demand for energy will drop in winter time, but in warmer period of the

year, it might increase due to the use of air conditioning (both private and industrial).

Another equally or even more important consequence of global warming is its effects on the oil and gas fields along with the transportation/pipeline system. As it is widely known, the main oil and natural gas extraction fields lie in Siberia, and for a trouble-free production, the soil needs to be frozen. However, with global warming and the permafrost zone melting, the period during the ground is frozen will be reduced. The problem is that the entire infrastructure (including roads, buildings, and industrial facilities) is designed for the frozen ground, and any of them not anchored to sufficiently strong foundations will be threatened as the shifting ground endangers their structural stability [Gotz 2007]. High voltage power lines will also be vulnerable to damage as upper soil layers thaw and refreeze. Not only the melting of permafrost is a huge difficulty for Russia, but also the pipeline system. The main problem is that most of the pipelines were constructed before 1980 – they are old and not well maintained and designed for steady climate. About 50 000-km oil pipelines and 150 000-km gas pipelines have been laid in Russia, and they cross many rivers. As we discussed earlier, an increased amount of annual and seasonal runoff and change in the ice condition could be predicted for many Russian rivers, and it most likely will cause a disruption or damage in the pipeline system. These damages could lead to oil spills and gas shows, which are considered as ecological disasters. To prevent these, new updated technology would be necessary by replacing the old and used river crossing pipelines to new ones, or at least monitoring the pipelines condition will be essential to avoid the disasters [Roshydromet 2005].

There also could be problems with oil shipping. In the Arctic Ocean, the danger of icebergs will increase, and dangerous hydrometeorological events as storms, high waves, strong winds, hurricanes, tornados will occur more often, which will impede shipping [Gotz 2007].

However there could be a positive implication of the melting of sea ice in the Arctic Ocean: it could provide an opportunity to the Russian Federation to explore and exploit more fossil fuels below the Arctic Ocean.

6. NATIONAL POLICIES TO REDUCE THE NEGATIVE IMPACTS OF CLIMATE CHANGE

After joining the Kyoto Protocol in 2004, Russia published its first document about climate change and how to prepare for it in 2005. This document was made by the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) with the title "Strategic Prediction for the Period of up to 2010–2015 of Climate Change Expected in Russia and its Impact on Sectors of the Russian National Economy". This was the first paper that had some kind of strategic plan for climate change; also we used it as a reference many times on our paper. It contains a prediction for the period 2010–2015 for many different sectors along with recommendations for the governance. This document suggests that Russia has to improve the National Early Warning System for Hazardous Hydrometeoro-

logical Events to be able to foresee extreme weather event and, if possible, prevent them or at least prepare to them and warn the citizens.

In 2009 Russia developed a climate doctrine. "The Doctrine represents an overview of the goal, principles, substance, and ways of implementation of a unified public policy of the Russian Federation, both within its borders and in the international arena, on the issues related to climate change and its consequences" [Climate Doctrine of the Russian Federation 2009]. The main goal of a climate policy is a wide-ranging consideration of the negative and positive effects of climate change, and obviously the planning and implementation of actions to protect the population, economy and the Government from the unfavorable effects of climate change. In this document, there are no concrete steps to reach the goals, but only the draw-up of the possible directions, such as the decrease of the GHG emission and increase its absorption by carbon sinks and receivers. The measures that should be introduced are to improve the energy efficiency, to expand renewable and alternative energy sources, to implement a financial and tax policy which will help reduce GHG emission, and to protect and improve carbon sinks and receivers [Climate Doctrine of the Russian Federation 2009].

In 2011 the president of the Russian Federation Dmitry Medvedev issued a number of instructions after the twenty-fifth meeting of the Commission for Modernization and Technological Development of Russia's Economy. The first project is to establish a "space-based environmental monitoring system", which could help have timely information not just about the weather but also to track down the changes (such as in the forest, permafrost zones, the state of glaciers, etc.). It would be expensive, but the government visualizes its funding from state and private investments also added to the project.

The second measure would be developing alternative/green energy. Russia has a huge drop behind in that field. As Russia own one of the biggest fossil fuel reserves it was not necessary to develop green energy in the past, as it is seen in the share of the production. The renewable energy sources share only 1% of the Russian energy production. Medvedev said that they have the discussion, but developments stagnate at the ideas stage.

The third project what was discussed in that meeting is that in some regions the outdated public transport needs to be replaced with electric vehicles, and also develop the use of cars with hybrid engine. This is necessary because the air pollution is a serious problem in the big cities and this could help clean the air a bit [Russian Regional Environmental Centre 2011]

So Russia has already started the strategic planning to reduce the unwanted effects of the climate change, and it seems, that they are in the right way, but there is a question that is not it too late, as Russia has just begun to implement the plans into real action.

7. CONCLUSIONS

Due to the climate change Russia will face many changes in its climate. We can state that in Russia the air temperature will increase above the global average.

Therefore the global warming affects will magnified. Along with the warmer weather the permafrost zones are melting, more river runoff expected and more extreme conditions are projected. With that come positive and negative consequences. The favorable effects of the warming are the decreased heating season, the possibility of the fossil fuel exploitation in the Arctic Ocean and the increased agricultural land area with more kind of crops that can grow now. The undesirable effects are the imbalances of the climate with increased amount of dangerous hydrometeorological events, which costs will be high. More dry periods could be expected that is harmful for the agriculture. With warming more plant diseases and pests are projected. Furthermore Russia's GHG emission is not likely to reduce for the future, as Russia has no legally binding international convention after the expiration of the Kyoto Protocol. Therefore further air, land and water pollution is expected in the country. Russia has already recognized that some steps need to be taken to reduce some of the undesirable effects of climate change, but the problem is that most of the plans have not taken into action yet, and it seems a slow process.

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