Met Office

Impacts of Climate Change
Ukraine

January 2010

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Introduction

The Ukraine has an estimated gross domestic product (GDP) of US$179.7 billion, (Economy Watch, 2009) with approximately 9% of this from agriculture, 32% from industry and the remaining 59% from services (CIA World Factbook, 2008).
Ukraine's main agricultural products are grain, sugar beets, sunflower seeds, vegetables, beef and milk. The primary industries are related to mining, energy generation and metal processing. Ukraine is particularly rich in iron ore, and both ferrous and non-ferrous metal products form a major part of Ukraine's export industry, alongside the trade of machinery and transport equipment, chemicals, and food products (CIA World Factbook, 2008). In the first quarter of 2009 the fiscal aggregate of goods and services exported from the country was over US$8.3 billion, with the commodities imported valued at US$9.8 billion, the majority of which were related to the energy industry (Ukraine State Committee of Statistics, 2009).

Present Climate

The climate of Ukraine is largely temperate. The south shore, which lies on the Crimea, has a warmer Mediterranean climate. Rainfall is unevenly distributed, generally being higher in the north and west of the country due to the influence of the Carpathian Mountains. There are regular snowfalls between October and April and winter temperatures range between -8°C and 2°C, dependent on location, with lower temperatures inland away from the moderating effect of the Black Sea. Extremely cold spells can occur when easterly winds blow in from Siberia, which can drop the temperatures to as low as -20°C to -30°C. Summers are generally warm, becoming hot in the south, with temperatures ranging from 18°C to 27°C.

Projected Changes in Climate

Little research has been conducted into how the climate in Ukraine specifically will change over the course of the 21st century. Most research has concentrated on the larger area of Northern Europe, which includes Ukraine.

Table 1. Projected changes for the period 2080-2099, relative to 1980-1999, for Northern Europe.
From multi-model simulations using the medium-high emissions scenario (Christenson et al., 2007).

Region	Season	Range of projected temperature change (°C)	Range of projected precipitation change (%)
Northern Europe	Dec to Feb	+2.6 to +8.2	+9 to +25
	Mar to May	+2.1 to +5.3	0 to +21
	Jun to Aug	+1.4 to +5.0	-21 to +16
	Sep to Nov	+1.9 to +5.4	-5 to +13
	Annual	+2.3 to +5.3	0 to +16

Generally the large scale patterns of change for Europe show a substantial warming by the end of the 21st century in the north, with a lesser, but still important warming in Mediterranean areas (Table 1 and Figure 1). The projected summer warming in parts of central and eastern Europe, including Ukraine, may be closely connected to higher temperatures on warm days than to a general warming (Raisanen et al., 2004; Kjellstrom et al., 2004 and 2007). It is likely that for Ukraine, inland areas, away from the moderating influence of the Black Sea, will see the greatest increases in temperature during the 21st century. Owing to the projected increase in warm extremes in the future Ukraine may experience an increase in summer dry periods by the late 21st century.

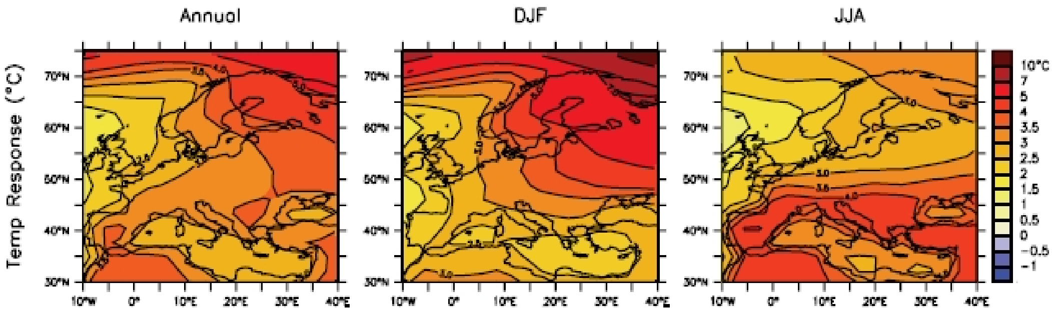

Figure 1. Annual mean, Dec, Jan & Feb (DJF) and June, July Aug (JJA) temperature changes between 1980 - 1999 and 2080 - 2099, from multi-model simulations using a medium-high emissions scenario (Christensen et al, 2007)

The largest increases in rainfall are projected for winter in northern and central Europe, including the Ukraine, (Table 1 and Figure 2; Alcamo et al., 2007) although less is projected to be in the form of snow. Fewer days of snow and frost, along with shorter frost seasons and a widening of frost-free areas are projected throughout northern Europe over the coming century. One multi-model study suggests that by 2100 the Ukraine may see approximately a 60 day reduction in the number of days with frost cover, and a 50 day reduction in days with snow cover in the northern part of the country by 2100, relative to the 1961 to 1990 average. The study also found that changes in snow cover in northern and central Europe, including Ukraine, correlated well with increases in winter maximum temperatures; an increase of 1°C corresponding roughly to a decrease of 10-15% of days with snow cover (Jylhä et al., 2008).

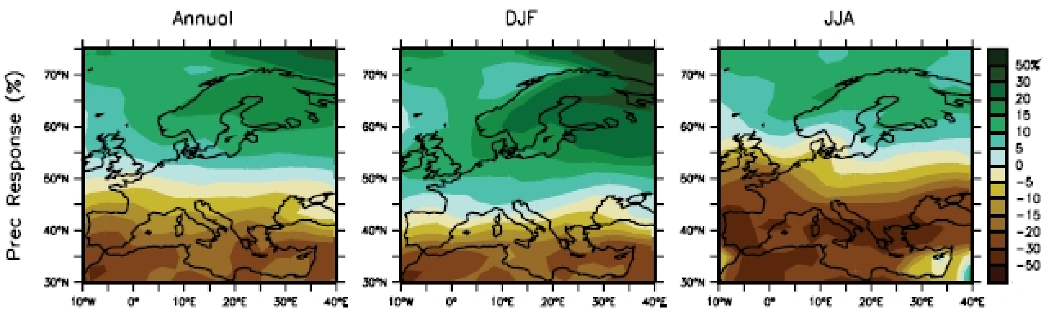

Figure 2 Annual mean, Dec, Jan & Feb (DJF) and June, July Aug (JJA) precipitation changes between 1980 - 1999 and 2080 - 2099, from multi-model simulations using a medium-high emissions scenario (Christensen et al, 2007)

A number of modelling studies using various greenhouse gas emission scenarios give some confidence for a decrease in annual runoff in eastern Europe (Chang et al., 2002, Etchevers et al., 2002). Groundwater recharge, the movement of water downward from the surface, is likely to be reduced in central and eastern Europe with the largest reductions in valleys and lowlands, such as the Ukrainian steppes (Eitzinger et al., 2003). The southern steppes can experience quite severe dust storms (sukovi) during the short spring caused by dry easterlies. This could cause more erosion if the groundwater recharge reduces and the easterly blasts continue. Projections give an increase in intense, short duration rainfall events over most of Europe, including Ukraine, which is likely to lead to an increased risk of flash floods in the future (EEA, 2004).

Impacts of Climate Change

Energy

Ukraine is one of Europe's largest energy consumers, using over twice the amount per unit GDP than Germany (EIA 2004). The generation capacity of the current infrastructure is estimated as 53 million kW; 65% being from thermal power plants (steam turbine and diesel types), 26% from nuclear sources and 9% from hydroelectric plants (Ukraine Gateway, 2009).

Hydropower is currently the key renewable energy resource in Europe, accounting for 20% of all energy generation. Hydropower potential in Europe is expected to decline by 6% by the 2070s due to changing rainfall patterns and the increased incidence of drought. Major decreases in the Mediterranean region are projected to be partially offset by a 15-30% increase in generation capability in northern and eastern Europe, including Ukraine (Alcamo et al, 2007).

With the increasing temperatures, it is likely that the demand for winter heating will drop, whereas cooling requirements during summer months will rise. Demands on the generation and supply network are likely to increase with the projected incidences of heat waves. Ukrainian energy infrastructure is highly vulnerable to the changing climate; over 95% of power units have reached the end of their useful life (Herasimovich and Tsarenko, 2008). Existing technology may struggle to supply energy to growing cities and it is likely thermal power stations in particular will decrease in efficiency as cooling water becomes warmer or its availability decreases. It is likely that as temperatures rise and rainfall patterns and river volumes change, the management of energy generation and supply sites will need to be carefully monitored.

Infrastructure

The industrial sector employs approximately 24% of the available workforce and contributes approximately 32% of GDP. The industrial production growth rate is estimated at 5% as of 2008 (CIA, 2008).

The major industries are power generation and mining of coal and metals. As in the energy sector, older mining infrastructure is unlikely to be robust against projected increases in extremes events. Operations at open mines will be at particular risk from the projected increases in heavy downpours and flash flooding. Sea level rise and the resulting erosion are likely to stress infrastructure on the coast.

Agriculture & food supply

Ukrainian agriculture has been evolving since the country became independent in 1991, with more than two thirds of the land now being used for farming. Winter wheat is the largest crop in terms of area, dominating 95% of the agricultural land, with central and southern Ukraine being the key production zones. Spring barley is grown in eastern Ukraine and winter barley in the south.

Winter barley is not cold tolerant and as temperatures rise it is likely that its habitable zone will expand northwards, as long as soil conditions, light levels and water availability are adequate. Roughly 5% of grains and 10% of potatoes, vegetables and forage crops in Ukraine are irrigated (USDA, 2004). As summer temperatures rise and rainfall decreases, the need for irrigation may increase. Large increases in the yield of rain-fed winter wheat have been projected for northern Europe in the future, with smaller increases further south (Olesen et al., 2007). With decreases in frost days predicted, winter wheat crops, which are particularly susceptible to frost damage, are more likely to survive in to spring.

It is projected that climate change, coupled with the benefits from new crop varieties and better technology, could increase crop yields in Ukraine. Estimates show climate-related increases in wheat yield of up to 30% by 2080 (Olesen et al., 2007). However, the potential for gain in Ukraine due to more favourable conditions for crops could be offset by increased variability and extreme events. Studies of food production on the Russian border with Ukraine suggest that if the projected change in the frequency of drought is taken into account, the number of years with food production shortfalls increases substantially (Alcamo et al., 2007b). World grain yields have been growing about 1.5% on average per year but have been falling in Ukraine (World Bank, 2009). The current gap between potential and actual yields in Ukraine is 4.5 times higher than the potential increase in production climate change may cause by 2050 (Olsen and Bindi, 2002).

Water supply & flooding

Changing rainfall patterns and runoff indicate that future summer river flows are likely to decrease substantially, by as much as 50%, across central and eastern Europe, including the Ukraine (Oltchev et al., 2002 , Eckhardt & Ulbrich, 2003).
It is likely that the country will suffer increased water stress over the 21st century as severe droughts, classified today as one in 100 year events, are projected to become twice as likely by 2070 (Alcamo et al., 2007).

A recent study including part of the Ukraine (Feyen & Dankers, 2009) found a considerable decrease in river flooding over the long term, owing to warmer winters and a short snow accumulation season, leading to lower snowmelt flooding in spring. Where flooding does occur, there may be an increase in the incidence of disease following it due to increasing temperatures. Leptospirosis, a once rare infectious disease carried primarily by rodents and spread through contact with contaminated water, vegetation and mud has been detected in the Ukraine. Cholera, hepatitis A and salmonella have also surfaced in the surrounding region following flooding episodes (World Bank, 2009).

Sea level rise & coastal erosion

2.7% of the Ukrainian population live less than 10m above sea level (Cenacchi, 2008). Homes as well as industrial premises, arable land and tourist sites are already experiencing erosion problems. An increase in short, intense rainfall events combined with projected rises in sea level mean erosion could be an escalating issue for the Ukrainian coast, particularly after 2050 (Alcamo et al., 2007).

Ukraine’s fishing industry is heavily dependent on the Black Sea. With increases in temperature over the 21st century, it is likely that climate change will impact on the industry’s output. Toxic cyanobacteria, which cause water quality problems, may be encouraged to bloom earlier and in greater numbers. The projected decreases in river run-off and changing patterns of rainfall may alter water salinity, changing the fish stock available to the industry.

Tourism

Tourism has long been a part of Ukraine’s economy, particularly due to the large areas of natural beauty and National Parks, such as Shats’Kyi, as well as the heritage of its cities. Tourism is influenced by so many factors, such as security, politics and economics that very few studies, if any, have been done into how climate change would impact on the Ukrainian tourism industry. It is possible that as areas of southern Europe become hotter and increasingly suffer water shortages that people may find tourist destinations further north, such as Ukraine, a more attractive option.

Ecosystems & biodiversity

Climate change is an overarching pressure that is expected to aggravate many of the threats to biodiversity and ultimately become the main driver of its loss in the future (Ciais et al., 2005, Thomas et al., 2004). Climate change may alter host and parasite geographical ranges, with potentially dramatic consequences for disease outbreak (Harvell, 2002).

The impact of climate change on the Danube Delta and the Carpathian Mountains is of particular concern as these regions support not only a vast number of plants and animals, but some rare ones. Flora and fauna in the Carpathians are already exhibiting responses to climate change, with the tree line increasing in altitude and other species following suit (Mindas et al., 2000). Forested areas are likely to change in character further as the climate warms and rainfall patterns alter. With climate change, it is possible that these trees may suffer from water stress, particularly in the summer, and that net growth will change in response (Alcamo et al., 2007). Any forest loss will impact negatively on soil condition. If this forest were to change dramatically, not only the fertility of the ground but its unique primeval character that makes it such a significant tourist attraction would be lost.

Human health

As the climate changes there will be significant impacts on human health. Temperature increases and a higher incidence of heatwaves will result in increased illness and death, particularly in the elderly, from heatstroke, cardio-vascular and respiratory diseases. Such changes in climate could prove a significant multiplier effect in the Ukraine as cardiovascular disease is the leading cause of death in the country, accounting for 60% of all deaths, ischemic heart disease being the single biggest killer (WHO, Highlights on Health in Ukraine, 2005).

The effect of temperature increases will likely be felt at night, in the cities, and as the greatest warming is projected for winter this means a likely reduction in the number of deaths from the cold.

Food supplies and water quality could also be affected by increases in temperature and the incidence of heatwaves, further straining the health of the population. Occurrences of diarrhoeal and other bacterial diseases are very likely to rise as temperatures and water quality issues increase. Warming of near-shore waters, along with surface temperature rises in lakes and rivers, could increase incidences of toxic algal blooms and infectious bacterial diseases (Cruz et al., 2007) posing a significant risk to human health. Changes in occurrence of *Salmonella*, *E. coli* and other food poisoning bacteria are known to be associated with rises in ambient air temperature (Fleury et al., 2006). Increases in physical and mental health problems can also be expected in line with any increases in flooding.

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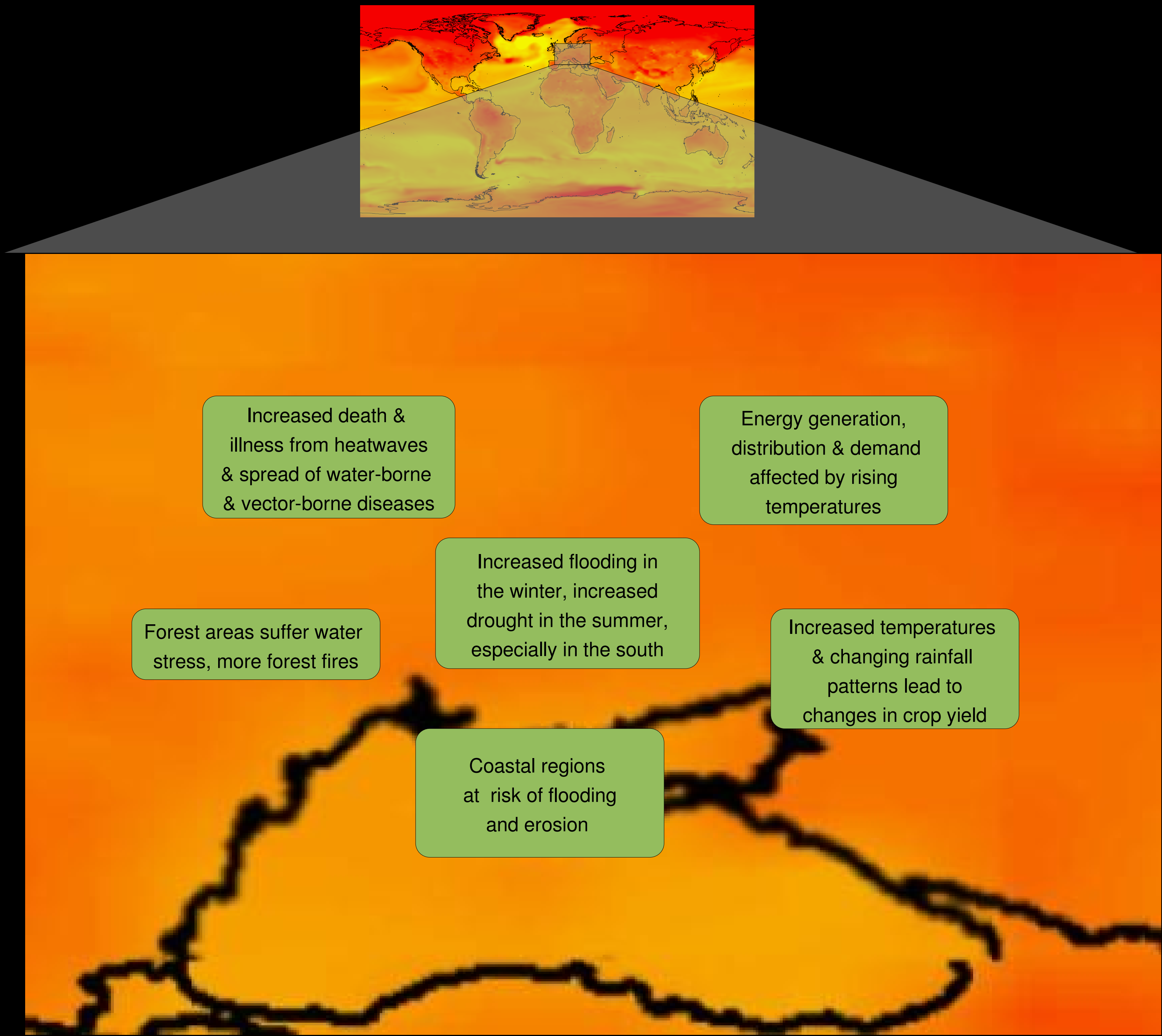
UKRAINE – HEADLINE CLIMATE IMPACTS

Temperature Change (relative to 1980 – 1990) 0˚C → 5˚C

WATER	More flooding from increased rainfall, especially in winter
	Less summer rainfall could lead to water stress
	Significant increase in the frequency of severe droughts
FOOD	Increased winter temperatures and fewer frost days decrease crop mortality
	Potential for increased food production with appropriate management
	More floods lead to loss of crops, more irrigation needed in summer
ENERGY	Demand for winter heating dropping, demand for summer cooling rising
	Efficiency of power generation & distribution decreased
	Industry needs to adapt to changing climate and invest in infrastructure
HEALTH	Increasing number of deaths from heat stress, fewer deaths during cold spells
	Surface pollution & ozone levels increase, health in cities severely affected
	Changes to the distribution of diseases, e.g. Lyme Disease
OTHER	Tourism increases as other areas, e.g. Mediterranean, become less attractive
	Coast at risk of flooding, erosion and salt water intrusion as sea levels rise
	Internationally important ecosystems, e.g. forest, affected by climate change

Met Office

Climate change impacts in Ukraine



To more than 10°C

Colour change reflects increase in mean surface temperature by 2080, from 1961 – 1990 average

From 0°C

Map showing temperature increase by 2080, relative to 1961 – 1990 average, based on medium-high emissions scenario using a Met Office Hadley Centre model

Met Office

Please refer to the '*Impacts of Climate Change – Ukraine*' summary document for further information and references on the climate change impacts outlined on the reverse side of this page.

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