The Former Yugoslav Republic of Macedonia[i]

CLIMATE CHANGE AND AGRICULTURE COUNTRY NOTE

September 2010

www.worldbank.org/eca/climateandagriculture

This Country Note for Macedonia is part of a series of country briefs that summarize information relevant to climate change and agriculture for four pilot countries in the Europe and Central Asia (ECA) Region, with a particular focus on climate and crop projections, adaptation options, policy development and institutional involvement. The Note series has been developed to provide a baseline of knowledge on climate change and agriculture for the pilot countries participating in the **Regional Program on Reducing Vulnerability to Climate Change in ECA Agricultural Systems**. This note for Macedonia was shared with the Government and other agricultural sector stakeholders and used as an engagement tool for a National Awareness Raising and Consultation Workshop, held in Skopje in May 2010. Feedback and comments on the Note from this consultation process have been incorporated into this updated version in collaboration with the Macedonian Ministry of Agriculture, Forestry and Water Economy (MAFWE).

Climate Change Exposure and Risk for Macedonia

More than 19% of Macedonia's population is employed in agriculture and this sector accounts for 12% of the country's GDP. Furthermore, more than 36% of Macedonia's rural population earns less than US$5/day and is highly vulnerable to any change in agricultural income. Because agriculture is highly climate sensitive, this rural population is acutely exposed to the risks associated with climate change. Historical data indicate that Macedonia is characterized by a highly variable climate that has already experienced an increase in mean temperature and moisture deficits, as well as an increase in the severity of extreme events like drought, heat waves and forest fires. Climate projections for the future indicate that Macedonia, on average, will be exposed to[4,18,20]:

- *A 1.9°C increase in mean annual temperature by 2050, with the greatest warming projected to occur in summer (2.5°C increase)*
- *A decline in mean annual precipitation by 5% by 2050, with a decline in summer of 17%*
- *A more marginal and risky agricultural production environment, as changes in climate exacerbate the already significant crop moisture deficit, especially during summer*
- *Increased exposure to new pests and diseases for agricultural crops, forests and livestock*
- *Increased growing seasons, providing opportunities in some areas for new crops, increased productivity and changes to cropping patterns*

In this Note

Macedonia at a Glance[3]

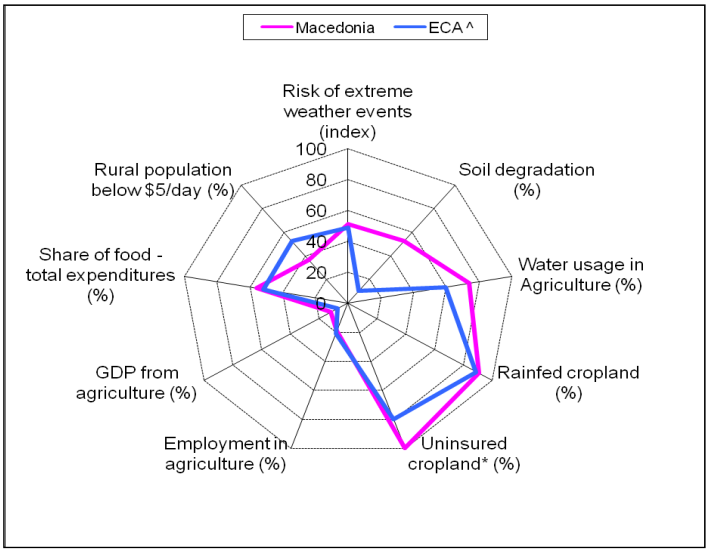
Population	*2,066,718 (2010 est)*
Population below the poverty line	*28.7%*
GDP	*US $9.22 billion (2009)*
GDP Per Capita	*US $4,515 (2009)*
Agriculture as a % of GDP	*11%*

[i] Note that The Former Yugoslav Republic of Macedonia will be referred to as "Macedonia" in the interest of conciseness

I. Introduction

The Europe and Central Asia (ECA) Region of the World Bank recently released a report titled "*Managing Uncertainty: Adapting to Climate Change in Europe and Central Asia*"[1]. The report is a flagship document that raises awareness of the threats, challenges and opportunities that ECA countries and communities will face in adapting to climate change across a variety of economic sectors. This Country Note was developed as a basis for beginning work in Macedonia under a World Bank regional program designed to enhance the ability of ECA countries to integrate climate change adaptation into agricultural policies, programs and investments[2]. To support the Macedonian Government in this effort it was agreed that the Ministry of Agriculture, Forestry and Water Economy (MAFWE) and the World Bank would work together to jointly develop the Macedonian Response to Climate Change for Agriculture.

***Figure 1*: Macedonia Vulnerability Indicators**



Note: ^ECA statistics come from transitioning and developing economies in Eastern Europe and Central Asia, where available; employment in agriculture (% of total employment); rain-fed cropping (% of cropland); water usage in agriculture (% of total annual freshwater extraction); uninsured cropland (estimate); soil degradation (% of total land); risk of extreme weather events (additional 1:20 year events 2070-2100 vs. 1961-1990); share of food – % of total expenditures; GDP from Agriculture; Sources: World Development Indicators 2008; EarthTrends 2003, FAO AGL 2005; Baettig, M. et al., 2007. ECA Databank

Agriculture is of significant importance to Macedonia in terms of employment, rural livelihoods, food security and exports. This sector, however, is highly climate-sensitive and potential adverse changes in temperature, precipitation and the frequency of extreme events (e.g., droughts, heat waves, floods, forest fires) are likely to exacerbate existing inequalities between the rich and the more vulnerable poor populations in the country. This deterioration will place a strain on institutions, food supply and rural growth. Additionally, the country's limited financial resources and underdeveloped institutional capacity to respond to natural climatic hazards pose a threat to future sustainable agricultural production and rural development.

Figure 1 displays nine climate change vulnerability indicators and compares Macedonia to the Europe and Central Asia (ECA) Region average for transition economies. Although agriculture and rural livelihoods in Macedonia appear to be equally or less vulnerable than the ECA average to climate change for a number of indicators, three categories where Macedonia appears more vulnerable than other countries in the region are soil degradation, percentage of GDP derived from agriculture and share of food as a percentage of total household expenditure. When compared to high income European countries (for categories where figures are available), the differences in vulnerability to climate change are stark, with high income European countries having an average of just 4.5% of the population employed in agriculture, as opposed to 19.4% in Macedonia. Furthermore, the average GDP derived from agriculture for high income European countries is just 2%, compared to 12% in Macedonia[3].

II. Overview of Agriculture

Land use for agriculture in the form of cropland and pastures is substantial in Macedonia and occupies approximately 50% of the surface area of the country (see ***Figure 2***), with forests constituting another 37%. The vast majority of cropland in the country is rain-fed, with an estimated area of irrigated cropland of less than 10%[3]. With the exception of the western parts of the country, water deficiencies occur during the summer season and result in significant moisture stress for summer and annual crops. In an average year, evapo-transpiration is higher than rainfall, resulting in crop water deficits of approximately 250mm in western areas and 450mm in eastern areas[4]. Such high levels of moisture stress adversely impact crop production and quality and make reliable, cost-effective and timely irrigation almost a

Acknowledgements:

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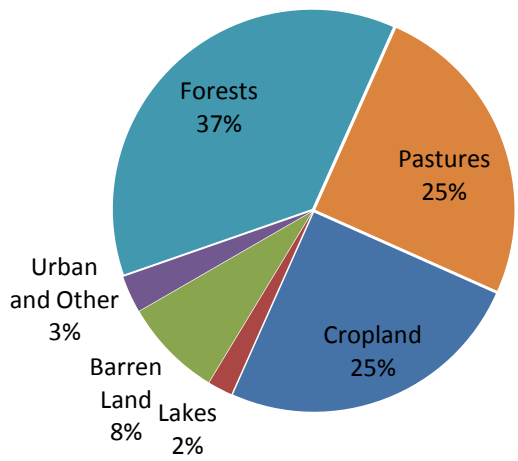
Figure 2: **Land Use in Macedonia**



Source: http://www2.mst.dk/udgiv/Publications/2000/87-7909-888-6/html/images/kap13_2.jpg

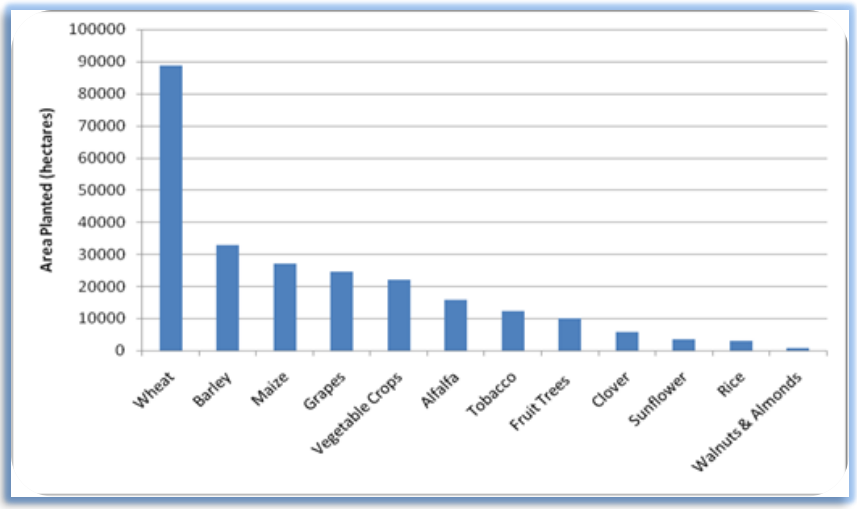
necessity for the production of competitive, high value summer and perennial crops[4].

The area planted in 2007 for the production of a variety of crops in Macedonia is displayed in ***Figure 3***. By area, wheat is clearly the major annual crop grown, with smaller areas used for barley, maize and a range of vegetable crops. Grapes are the main perennial crop in Macedonia and occupy close to 25,000ha[5]. Although the area occupied by fruit and nut trees is relatively small, potential exists to expand this area in the future. As most crop production is rain-fed, there can be significant changes in mix and crop area planted on a year-to-year basis, depending on the timing and quantity of rainfall, as well as associated extreme events, like droughts and floods[3].

In terms of certified organic agriculture production, figures from 2006 indicate that a mere 500 hectares, across approximately 100 farms, were using organic farming systems in Macedonia[6]. Presently, the major organic crops grown are cereals, with smaller areas of high value organic fruits, vegetables and nuts also being grown[6]. Given the increasing demand for organic produce and the suitability of cropland in Macedonia, there is significant scope for expansion of the organic agricultural sector – especially for high-value horticulture and vegetable crops.

Projected changes in climate are serious risks to agricultural production, water availability, food security and economic growth for rural livelihoods in Macedonia. Across the country there will be significant variation in both vulnerability and associated adaptive capacity, depending on a range of factors. These factors include the current climatic exposure, financial capacity, social structures, institutional capacity, knowledge and education, and access to infrastructure. Areas that are already under marginal rain-fed production will be at increasing risk, while communities in relatively high rainfall or irrigated areas will have more adaptation options to buffer their production systems against projected changes in climate. If appropriate measures are put in place, potential opportunities to increase production as a result of climate change also exist in some instances.

Figure 3: **Area Planted by Crop in Macedonia, 2007**



Source: State Statistics Office of the Republic of Macedonia, 2007. Census of Agriculture, 2007,

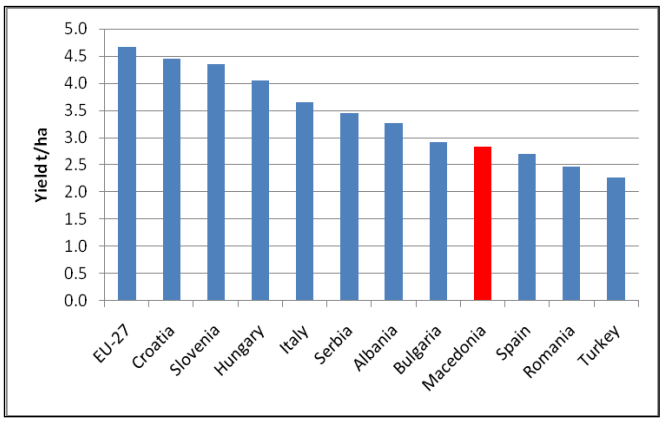
III. Agriculture and the Adaptation Deficit

The sensitivity of the agricultural sector to climate has important implications in Macedonia. With a considerable proportion of the rural population dependent on agriculture for their livelihood, rural communities are particularly vulnerable to risks posed by changes that may occur as a result of climate change[3]. This risk is further intensified by Macedonia's relatively low productivity associated with a lack of adaptive capacity to the present climate, also known as "the adaptation deficit". This deficit is best illustrated by a comparison of wheat yields from other countries in the region, as displayed in ***Figure 4***. For example, the average wheat yield for Macedonia from 2005-07 was just 82% of Serbia and 61% of the EU-27 countries[7]. This underperformance can be attributed to a complex set of factors, including distortions and imperfections in agricultural output and input markets; poor quality public services in areas like agricultural education, extension, research and market information systems; delays in farm restructuring; undeveloped agricultural land markets; lack of access to finance; unsustainable

management of soils; insufficient irrigation; and high vulnerability to natural hazards like droughts, floods, frosts, and severe storms[8,9].

For example, the average wheat yield for Macedonia from 2005-07 was just 82% of Serbia and 61% of the EU-27 countries[10]. This underperformance can be attributed to a complex set of factors, including distortions and imperfections in agricultural output and input markets; poor quality public services in areas like agricultural education, extension, research and market information systems; delays in farm restructuring; undeveloped agricultural land markets; lack of access to finance; unsustainable management of soils; insufficient irrigation; and high vulnerability to natural hazards like droughts, floods, frosts, and severe storms[11,12]. As challenges created by this unfavorable environment for agriculture will increase as a result of climate change, it is imperative that action be taken to address the adaptation deficit as part of any climate change adaptation strategy.

Figure 4: Comparative Average Wheat Yields, 2005-07



Source: www.faostat.fao.org

IV. Agriculture and the Economy

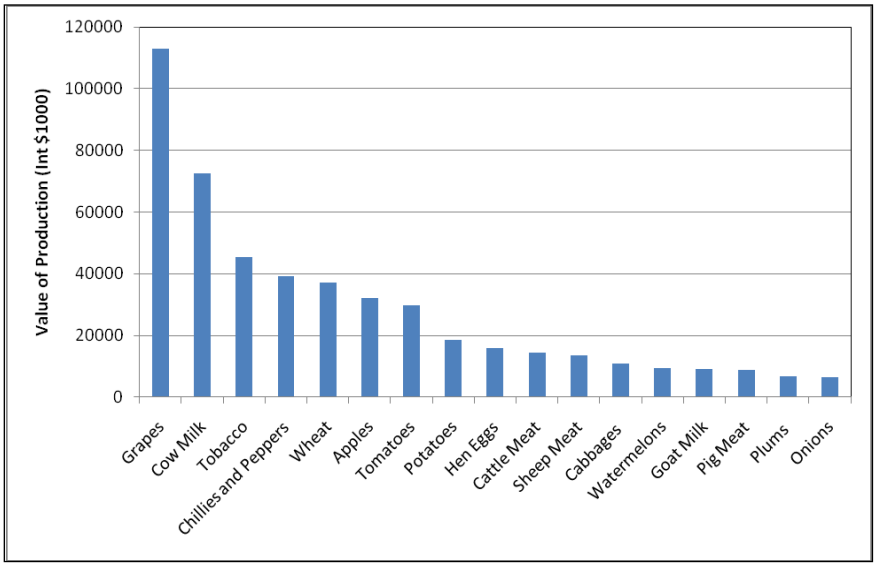
The economy of Macedonia has gone through a major transition since achieving independence in 1991. Although GDP in the country declined throughout the 1990s, this trend reversed during the new millennium, with total estimated GDP reaching US$ 9.22 billion in 2009 and per capita GDP reaching US$ 4,515[3] Agriculture has traditionally been an important and relatively stable contributor to the Macedonian economy since independence. Despite structural and non-structural changes to the agricultural sector, post-independence agricultural GDP marginally increased at an average annual rate of 0.2% from 1990-2000[3].

The sector further expanded from 2000-2007 at an average annual rate of 1.3%[3]. At the commodity level, grapes, cow milk, tobacco, chillies and peppers, wheat, apples and tomatoes made the most significant contribution to the average value of agricultural production in Macedonia from 2005-07 (*see* ***Figure 5***).

While field crops like wheat, barley and maize are grown extensively and occupy a large percentage of total cropland (*see* ***Figure 3***), their contribution by value is significantly less than the contribution made by grapes, tobacco and the combined value of various fruits and vegetables, which garner a higher price[10].

Although the sector has grown, its share of GDP nonetheless declined marginally from 13% to 12% between 1995 and 2007, as other sectors of the economy – such as services – have grown at a faster pace[3]. However, when the agricultural sector is combined with the agro-processing sector, the overall contribution of agriculture to the Macedonian economy increases to 16% of GDP[12] and it is clear that there is potential for greater value-adding in this sector. These figures highlight the inherent vulnerability of the national economy to climate related events that impact the agricultural sector.

Figure 5: **Average Value of Agricultural Production by Commodity, 2005-07**



Source: Adapted from http://faostat.fao.org

V. Agriculture and the Environment

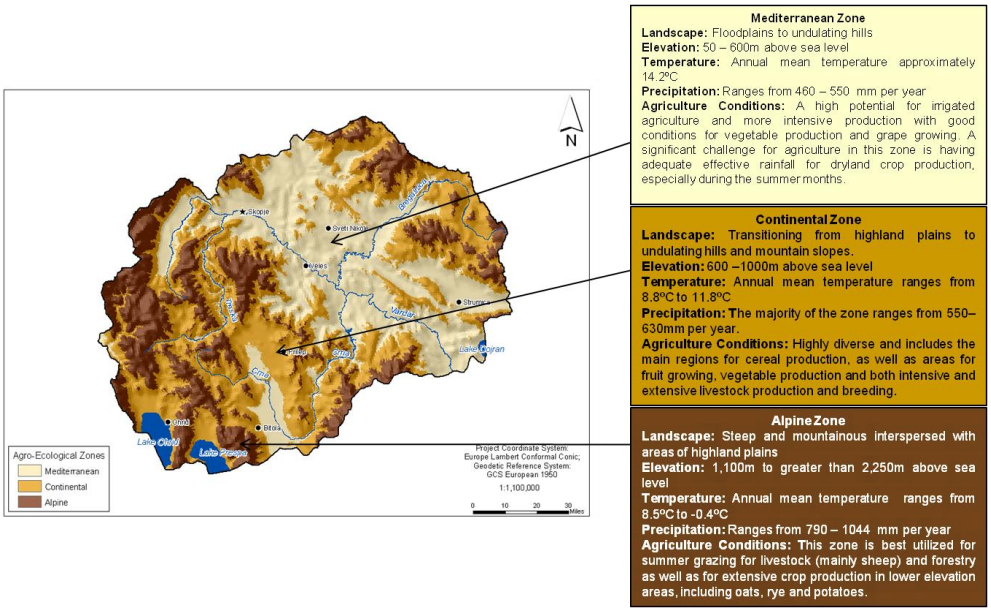
Agri-environmental management has implications for the resilience of agriculture to climate change. The most significant impacts agriculture has on the Macedonian environment are associated with soil degradation; water-logging and salinization as a result of unsustainable agricultural practices and land use; poor water management; and biodiversity degradation[12]. All of these issues adversely affect the natural resource base of the country and increase the vulnerability of agricultural systems and rural livelihoods to external shocks such as climate change. Soil erosion is a significant problem across vast areas of the country, primarily as a result of poor land management. Approximately 48% of the country is impacted by severe or very severe rates of erosion[13]. Although erosion results from steep slopes, climate, land cover patterns, soil properties and other natural processes, human factors like poor cultivation practices, overgrazing and deforestation have all combined to accelerate the rate of erosion in Macedonia and contribute more broadly to land degradation across the country[12]. Poor agricultural practices at the farm level (e.g., improper crop rotations, burning of crop residues, and poor water and nutrient management) also combine with the impacts of soil erosion and result in significant soil degradation[12]. High rates of erosion have also created pollution of waterways and have negatively impacted the function of reservoirs and irrigation infrastructure[12]. In the irrigation sector, poor on-farm irrigation system design, inefficient application practices and inadequately maintained irrigation system infrastructure have created widespread water-logging and salinization,[12] which negatively impact both short- and long-term agricultural productivity on affected lands and waste precious water resources that could otherwise be utilized. It should be stressed that many of the environmental problems caused by agriculture can be addressed concurrently by bridging the adaptation deficit to the current and projected future climates. This highlights the importance of integrating environmental sustainability into the climate change agenda while simultaneously increasing agricultural sector competitiveness, productivity, sustainability and profitability.

VI. The Climate Context

Climate Description and Historical Trends

Due to its proximity to both Continental and Mediterranean air masses, as well as the complex geography of valleys and mountains across the country, Macedonia has a highly diverse climate (*see* ***figure 6***). The various microclimates of Macedonia have produced a highly diverse agricultural sector with a large range of crops grown.

***Figure 6*: Agro-Ecological Zones of Macedonia**



The climate ranges from alpine in the west and north-west of the country, to Mediterranean in the southern districts of the Vardar river valley[14], and is characterized by cold winters, hot summers and a highly variable precipitation regime[15]. Alternating periods of long drought and high intensity rainfall are also a common feature of the climate. This oscillation in climate, when combined with poor land management, results in soil erosion and land degradation[16] and creates a challenging environment for the agricultural sector, particularly for farmers of rain-fed crops.

Annual mean temperatures range from approximately 8°C in the north-

west regions of the country to 15°C in central areas[17]. Precipitation generally increases from east to west across the country, with annual precipitation ranging from about 400mm in the south-eastern and central districts to over 1000mm in the mountain areas that border Albania and Kosovo[18]. Although there is considerable inter-annual variability, general historical trends indicate that overall average temperature across Macedonia has moderately increased by approximately 0.2°C while precipitation has decreased significantly by approximately 100mm.[ii,17]

Climate Projections

The Second National Communication of Macedonia outlines climate projections for the country. The general trends from this analysis indicate that Macedonia will become hotter and moderately drier as time passes, with substantial reductions in summer precipitation and more frequent and severe extreme events such as droughts and floods[18]. This analysis was performed using four general circulation models (GCM's), a combination of six different emission scenarios and four time horizons. As demonstrated by the ensemble range for both temperature and precipitation in ***Table 1***[18], there are significant differences in the extent of the potential changes between the four GCM models and associated emissions scenarios.

Table 1: Future Climate Projections for Macedonia Compared to the 1961-90 Period

Time Horizon	Temperature Projections		Precipitation Projections	
	Ensemble Average °C	Ensemble Range °C	Ensemble Average (%)	Ensemble Range (%)
2025	1	0.9 – 1.1	-3%	-1% – -6%
2050	1.9	1.6 – 2.1	-5%	-2% – -7%
2075	2.9	2.2 – 3.6	-8%	-4% – -12%
2100	3.8	2.7 – 5.4	-13%	-5% – -21%

Source: Adapted from Ministry of Environment and Physical Planning, 2008. Second National Communication on Climate Change, the Republic of Macedonia, Skopje

However, from a trend perspective, all models are in agreement in projecting increased temperatures and decreased precipitation across the four time horizons. The ensemble average projects that the mean temperature for Macedonia will increase by 1.0°C and 1.9°C by 2025 and 2050, respectively. For the same time horizons, mean precipitation is projected to decline by 3% and 5%, respectively. Together, this will result in increased aridity.

There is significant seasonal variation in impacts. Projections on a seasonal basis for 2050 show increased temperatures for all seasons, ranging from 1.5°C to 2.5°C for spring and summer, respectively[18]. For the same time period, mean precipitation is projected to increase slightly in winter (1%), decline moderately in autumn (4%) and spring (6%) and decline significantly in summer (17%[18]). Given the importance of spring and summer precipitation for crop flowering and growth, this projected decline in precipitation has significant implications for the agricultural sector.

Table 2: **Future Sub-National Climate Projections for Macedonia Compared to the 1961-90 Period**

Time Horizon	Mean Temperature Projection °C			Mean Precipitation Projection (%)		
	South-East	Central	North-West	South-East	Central	North-West
2025	1.2	1.1	1.3	-3	-3	-2
2050	2.3	2.2	2.6	-5	-6	-3
2075	3.4	3.3	3.9	-9	-9	-5
2100	4.6	4.5	5.3	-12	-13	-8

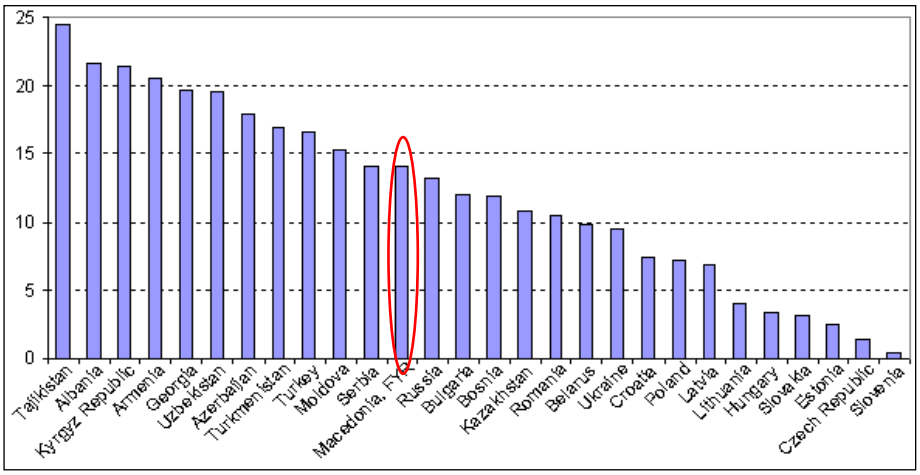
Source: Adapted from Ministry of Environment and Physical Planning, 2008. Second National Communication on Climate Change, The Republic of Macedonia, Skopje.

There is also significant spatial variation. Because of the complex geography of Macedonia, there will be important differences in the magnitude of climate changes at a sub-national scale. The Second National Communication outlines these differences via localized empirical downscaling projections for the south-east, central and north-west parts of the country (*see* ***Table 2***). The greatest warming is projected to occur in the mountainous north-west region of the country – where only minimal reductions in precipitation are projected by 2050. The south-east and central regions of the country are projected to warm at a slightly slower pace, although precipitation will decline at a greater rate especially in the second half of the century[18]. The implications for agriculture become much clearer when seasonal and sub-national projections are combined. For example, in the south-east region, summer precipitation by 2100 is projected to decrease by 19% while temperature will increase by 6°C[18]. Such extreme changes in the temperature and precipitation will place tremendous strain on agricultural production, thus highlighting the importance of adaptation.

[ii] Temperature and precipitation trends are summarized on a national basis, although it should be noted that there are no spatial trends across the country.

The recent World Bank report "*Adapting to Climate Change in Europe and Central Asia*" developed a series of indices to assess the exposure, sensitivity and adaptive capacity of countries in the ECA Region to climate change. These indices are based on a range of relevant parameters. The vulnerability index displayed in ***Figure 7*** is a combination of the exposure, sensitivity and adaptive capacity indices. The vulnerability of Macedonia to climate change, based on this index, can be classified as medium compared to other countries in the region. The main underlying drivers of vulnerability identified were the high exposure to extreme climate events, moderate adaptive capacity and particular social and productive structures – which all increase the sensitivity of Macedonia to climate change[19].

Figure 7: Climate Change Vulnerability Index, ECA Region



Source: The Source: World Bank, 2009. Adapting to Climate Change in Europe and Central Asia, Washington DC.

VII. Impacts of Climate Change on Agriculture and Water Resources

Agricultural Risks and Opportunities

Although both risks and opportunities for the agricultural sector in Macedonia may result from climate change, the downside risks for the country outweigh any potential benefits[20]. Macedonia is not positioned to take full advantage of the opportunities offered by those particular crops that could benefit from climate change - as demonstrated by the significant current yield gap between Macedonia and its neighbors - unless investments and structural changes are implemented which address the country's relative inefficiency, poor adaptive capacity and low productivity in the agricultural sector[19].

Even though mean annual rainfall is only projected to decline moderately in the first half of the century, crop producers will face greater water deficits and a more arid and risky production environment due to increasing temperatures, longer dry periods and the potential for drought[18]. Furthermore, changing climatic conditions may lead to problems associated with an array of agronomic issues, including: ineffective soil drainage; damage to soil structure, reducing land productivity; increased water scarcity for irrigation; and exposure to new pests and diseases that will challenge existing plant and animal genetics and management[20].

***Table 3:* The Most Vulnerable Agricultural Regions and Crops by 2100**

Vulnerability	Agro-Ecological Zone and Location	Crop
Most Vulnerable	Mediterranean Zone: Povardarie	Grape
Highly Vulnerable	Mediterranean Zone: Strumica	Tomato
	Mediterranean Zone – Gevgelija: southern Vardar valley	Tomato
	Mediterranean Zone – Skopje: Kumanovo valley	Winter Wheat
	Mediterranean Zone – Ovce Pole	Winter Wheat
Less Vulnerable	Continental Zone: Pelagonija valley	Alfalfa
	Continental Zone: Prespa/Ohrid region	Apple

Source: Adapted from Ministry of Environment and Physical Planning, 2008. Second National Communication on Climate Change, The Republic of Macedonia, Skopje.

On a positive note, the length of the growing period will increase across Macedonia, as the number of frost days is projected to decrease greatly[21]. This increased growing period will provide opportunities for crop distribution changes and longer-season crops, especially for winter crops and mountainous areas. However, as overall climate change is projected to have a negative impact in almost all important agricultural regions in the country, there exists a continued need to develop and implement adaptation options to increase the resilience of agricultural systems in Macedonia[18].

The Second National Communication outlines the most vulnerable agricultural regions to climate change and their associated crops in 2100 (*see* ***Table 3***). Based on analysis by

national scientists, the most vulnerable region identified was the Povardarie region in the central part of the country, where the most vulnerable crop is grapes[iii,18].

The other regions categorized as highly vulnerable are in the central and eastern part of the country, from north to south across the Mediterranean agro-ecological zone. The less vulnerable areas are in the mountainous western parts of the country, in the Continental agro-ecological zone[18]. Changes in temperature, precipitation and water scarcity will affect cropping conditions, as well as the livestock sector in terms of animal health, nutrition, husbandry and livestock-related infrastructure[18]. Changing climatic conditions will also adversely affect fodder and forage production and pasture biomass, which could lead to volatile feed prices, increased competition for grazing lands and increased water scarcity[18].

Table 4: **Climate Change Risks and Opportunities for the Agricultural Sector in the Continental South Zone of Europe, including Macedonia**

Continental South Zone	Detail of Risk/Opportunity	Magnitude	Likelihood	Priority
RISK	Crop area changes due to decrease in optimal farming conditions	LOW	HIGH	MEDIUM
	Crop productivity decrease	LOW	HIGH	MEDIUM
	Increased risk of agricultural pests, diseases, and weeds	HIGH	MEDIUM	HIGH
	Crop quality decrease	LOW	HIGH	MEDIUM
	Increased risk of drought and water scarcity	HIGH	HIGH	HIGH
	Increased irrigation requirements	HIGH	HIGH	HIGH
	Soil erosion, salinization, and desertification	HIGH	HIGH	HIGH
	Deterioration of conditions for livestock production	MEDIUM	LOW	LOW
OPPORTUNITY	Crop distribution changes leading to increase in optimal farming conditions	HIGH	MEDIUM	HIGH
	Lower energy costs for glasshouses	LOW	HIGH	MEDIUM

Source: Iglesias, A. et al., 2007. Adaptation to Climate Change in the Agricultural Sector, AEA Energy & Environment, Didcot.

A recent report undertaken on behalf of the European Commission evaluated climate change risks and opportunities for agricultural production in nine zones across Europe. This was done within a risk management framework which looks at the risks and opportunities for the agricultural sector, the magnitude of the impact, the likelihood of the impact and the priority given for investment and action.

The challenge for the Continental South zone (including Macedonia) is significant, with eight downside risks and only two upside opportunities identified in this report (*see* ***Table 4***). Four of the risks identified are classified as high priority in terms of investment and action. From this assessment it is clear that a strong focus on the development and adoption of adaptation measures is required in order to help ensure that agricultural systems in Macedonia remain resilient in the face of a changing climate.

Projected Crop Yield Impacts

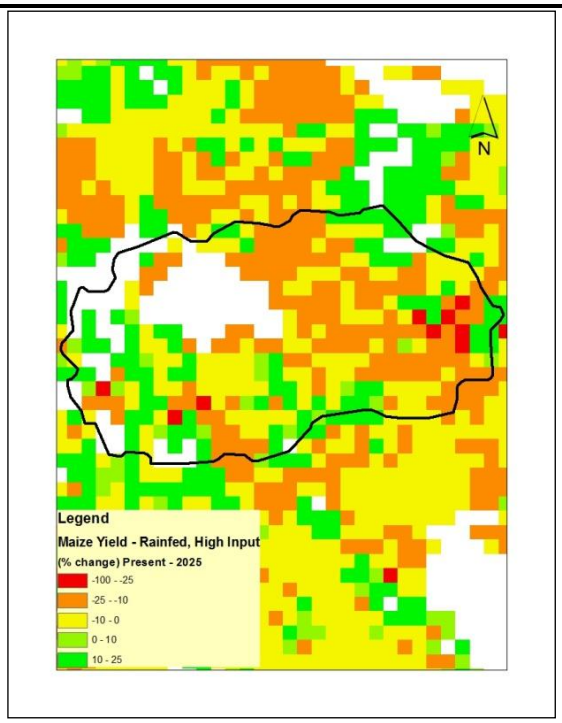
Local studies undertaken to project the impact of climate change on crop yields have been carried out over the last few years for Macedonia. Although projections vary significantly, there is general agreement that impacts will be negative after 2050 for a variety of summer and perennial crops across the majority of the country. However, the yield impact on winter crops like wheat is less certain, with both increasing and decreasing yields projected, depending on the assumptions of the underlying studies. Yield projections developed by the International Institute for Applied Systems Analysis (IIASA) for rain-fed wheat and maize yields for 2025 and 2050 are displayed in ***Figure 8***.

The projections clearly display the spatial variability of yield impacts across the country and the difference between crops for both time periods. For rain-fed wheat, the major growing areas in the continental and Mediterranean agro-ecological zones are projected to experience a moderate increase in yields of up to 10% for both 2025 and 2050. For rain-fed maize, moderate (0-10%) and severe yield declines (10-25%) are projected for the majority of Macedonia by 2025 and almost all of Macedonia is projected to experience severe maize yield declines of up to 25% by 2050, with some highly vulnerable areas projecting catastrophic yield declines of greater than 25%. As maize is a summer crop, these declining yield projections can also be used, to some extent, as a proxy indicator for other rain-fed summer crops, like vegetables.

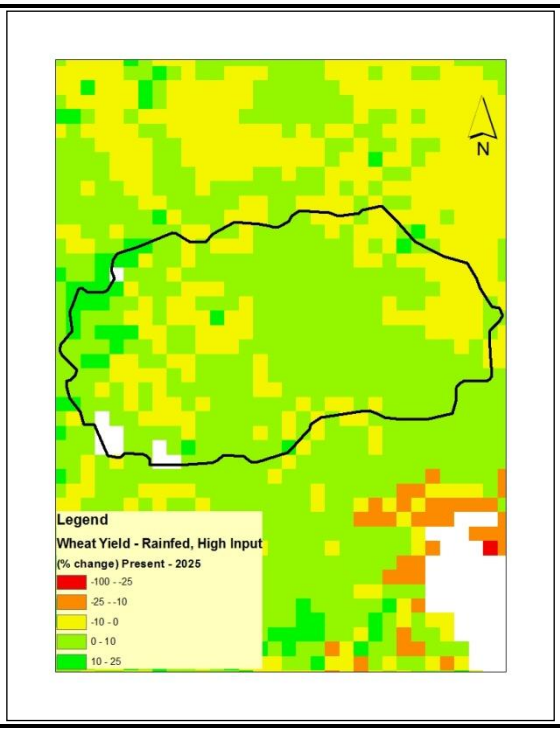
[iii] The most dominant crop in a vulnerable region is defined as the most vulnerable crop.

Figure 8: **Projected Change in Rain-fed Maize and Wheat Yields in 2025 and 2050 Compared With Present**

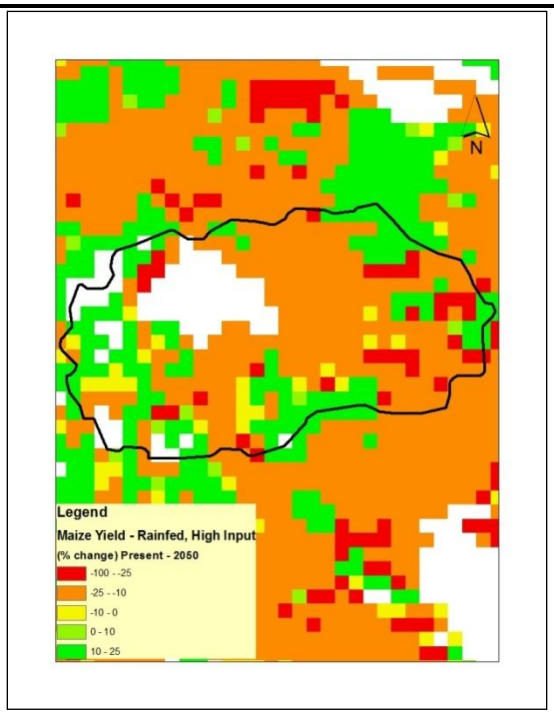
2025 Rain-fed Maize, % Change in Yields Compared with Present



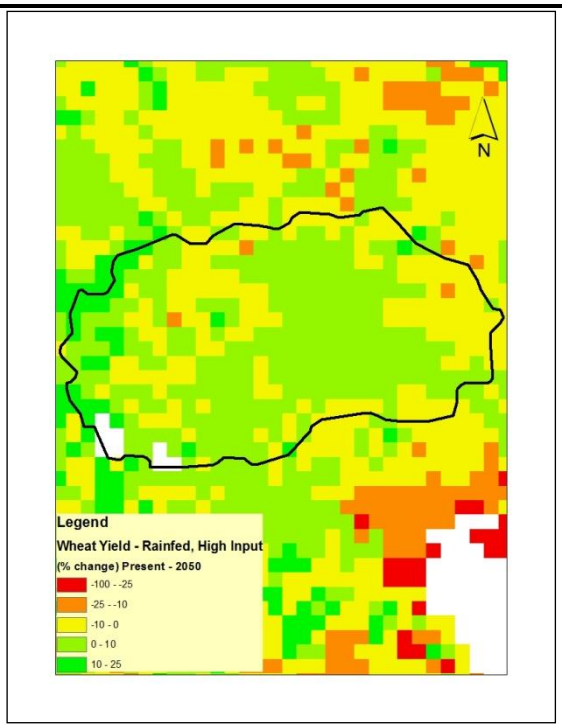
2025 Rain-fed Wheat, % Change in Yields Compared with Present



2050 Rain-fed Maize, % Change in Yields Compared with Present



2050 Rain-fed Wheat, % Change in Yields Compared with Present



Source: World Bank Climate Change Knowledge Portal http://sdwebx.worldbank.org/climateportal/ and Fischer, G., et.al. 2007. Global Agro-ecological Zone Assessment for Agriculture. IIASA, Laxenburg, Austria & FAO, Rome, Italy.

Modeling was also undertaken in the Second National Communication to assess the impact of climate change on agriculture in Macedonia. These models, which analyze only scenarios wherein irrigation and adaption are not present,

indicate decreases in tomato and alfalfa yields in some regions of up to 78% and 62%, respectively, by 2050. The analysis also indicates that with no adaptation and no irrigation, productivity would decline considerably for all crops in the most vulnerable areas across the country.

Potential Impacts on the Livestock Sector

The Second National Communication of Macedonia outlines direct and indirect effects of climate change on the livestock sector. Unlike for field crops, analyzing the impact of climate change on the livestock sector in a quantitative manner is still in its infancy. In terms of direct effects, increased temperatures adversely impact livestock productivity, especially for modern, highly productive animal breeds[18]. Local breeds that are better adapted to local conditions are likely to exhibit greater resilience to the more arid and warmer climate conditions projected for the future[18]. Additionally, indirect effects of climate change on the livestock sector will result in a more challenging operating environment for producers. These indirect effects include reduced pasture and fodder production that could result in more volatile feed prices and an increased risk of exposure to new pests and diseases, as the biological range of such threats expands into Macedonia[18]. The latter has important implications for public safety and access to export markets.

Projected Water Resources Impacts

The latest local modeling for the projected impact of climate change on the water resources of Macedonia was undertaken in the Second National Communication, with the results displayed in ***Table 5***. The primary catchment of Macedonia is the Vardar River, with both the Treska and Bregalnica rivers being sub-catchments of the Vardar system. For 2050, the most significant decline in water discharge of 16.1% is projected for the Bregalnica River, which drains eastern areas of Macedonia. The Treska River, which drains western areas of Macedonia, will be less exposed to changes in runoff and water discharge is consequently projected to decline marginally (3.4%). Overall the water discharge rate for the Vardar river catchment is projected to decline by 11.4% and 18.2% by 2050 and 2100, respectively. The significance of declining water availability and the importance of taking proactive water demand and supply adaptation measures is highlighted by the fact that Macedonia is already an inherently dry country with annual water resources per capita that are 70% below the European average[18].

Table 5: **Projected Changes in the Mean Annual Discharge of Surface Water from Major Catchments, Compared to Discharges in the year 2000[iv]**

Time Horizon	Catchment		
	Vardar River	Treska River	Bregalnica River
2025	-7.6%	-2.4%	-10%
2050	-11.4%	-3.4%	-16.1%
2075	-14.4%	-4.8%	-19.3%
2100	-18.2%	-7%	-23.8%

Source: Adapted from Ministry of Environment and Physical Planning, 2008. Second National Communication on Climate Change, The Republic of Macedonia, Skopje.

These projected climate changes will result in a significant shift in water demand and increased competition for water across all sectors of Macedonia - including agriculture - in the coming decades. Presently, agriculture constitutes approximately 40% of water demand and is the number one water consumer in the country[4]. However, from a historical standpoint, water demand in the sector has declined significantly. Between the early 1990's and 2004 the total irrigated area of Macedonia dropped by approximately 82%[4]. This precipitous decline resulted from both structural and non-structural changes that occurred after independence in 1991[4]. As the adverse factors are addressed, it is highly likely that demand for irrigation water in current or formerly irrigated areas will substantially increase. Pressure on water resources will grow further as some areas that did not formerly have irrigation will require it under changing climate conditions[18].

Non-climatic factors like development pathways, economic growth, improvements in living standards, and changes in land use patterns, technologies and infrastructure could significantly change water demand for Macedonia in the future. These non-climatic factors could dwarf the impacts attributed to climate change alone,[22] thus highlighting the importance of how these non-climatic factors can be influenced, positively or negatively, by policies, legislation and management at the national level[22].

In light of the potential impact of climate change on agriculture it is vital that a strong focus be placed on developing agricultural systems that are resilient and highly adaptable to a future of hotter, drier and more variable conditions to combat the adverse impact of climate change on agricultural productivity for a variety of crops while simultaneously taking

[iv] Projected changes in the availability of surface water were modeled using the A2 emissions scenario

advantage of potential opportunities which may arise from a changing climate. These opportunities include increased length of growing seasons leading to new crops, increased productivity and changes to cropping patterns in some areas.

VIII. Potential Adaptation Measures for the Agricultural Sector

Macedonia's Second Communication and other related documents propose a range of climate change adaptation options for different sectors, including agriculture, livestock and water resources (*see* ***Table 6***)[20]. A number of the adaptation options discussed in these documents include technologies which are ready for immediate implementation and are proven to increase productivity in the present – a "win-win" situation. Unfortunately, many of these options and associated action plans have not been implemented because of constraints associated with a variety of economic and social factors. In order to effectively prioritize adaptation options and focus investment within an action planning framework, in-depth analysis of effectiveness, cost efficiency and feasibility of adaptation options is required.

The importance of taking a proactive approach to adaptation in Macedonia is further illuminated by the significant synergistic benefits for agriculture and rural livelihoods via such an approach. With Macedonia's low levels of current productivity, challenging climate and high reliance on rain-fed agriculture, the benefits of immediately implementing adaptation measures are clear - especially for vulnerable rural communities. These benefits are further increased when considering the enhanced resilience these communities will achieve in the face of increased agricultural vulnerability under climate change. Moreover, some of the measures for adaptation could also be beneficial in meeting EU standards and increasing competitiveness in EU markets. The funding of such adaptation investments could be enhanced greatly through accession to the EU, via eligibility for Pillar 2 measures under the Common Agricultural Policy.

Table 6: **Adaptation Options for the Agricultural and Forestry Sectors of Macedonia**

Sector	Adaptation Option
General	Invest in research and extension services to enhance the capacity and delivery of information to the agriculture sector, with particular reference to climate change and the implementation of adaptation options
	Improve early warning and weather information systems, including frequent publication and distribution of agriculture-specific weather forecasts (e.g. short-term and seasonal forecasts, drought monitoring, etc...)
	Invest in the monitoring and detection of new pests and disease for the crop, livestock and forestry sectors through improvements in the sanitary and photosanitary regimes
	Introduction of a weather-based crop insurance program
Rain-fed Cropping	Development of new genetic varieties of crops with higher resilience to increased temperatures, lower precipitation and drought and potential for increased production via carbon fertilization
	Increase farming system water-use efficiency and reduce soil erosion via improved surface management techniques – including the adoption of minimum and zero tillage practices
	Development and adoption of improved agronomy and risk management techniques
	Land reclamation measures to increase the water holding capacity of soil via the application of manures, implementing measures that increase soil organic matter and the possible application of polymers
Irrigation	Implementation of Vardar River watershed management
	Rehabilitation of existing irrigation and delivery schemes to improve access and system water-use efficiency
	Modernization of on-farm distribution systems
	Introduction of new irrigation techniques and improvement of existing techniques to enhance field-level water use efficiency
Livestock	The adoption of improved animal breeds and grass/legume seed stock with increased resilience to projected climate conditions
	Improved farmhouse micro-climate management through the use of thermal insulating construction materials and modern ventilation systems to protect livestock from extreme conditions and increase productivity
	Improved pasture management by matching stocking rates to pasture production and integrating pasture improvement to increase feed value

Source: Adapted from Ministry of Environment and Physical Planning, 2008. Second National Communication on Climate Change, The Republic of Macedonia, Skopje. Iglesias, A. et al., 2007. Adaptation to Climate Change in the Agricultural Sector, AEA Energy & Environment, Didcot. SIDA & GRM International, 2008. Scoping Mission on Strategizing Climate Change Adaptation and Mitigation in Macedonia – Macedonian Agricultural Advisory Support Programme.

Rural communities have constantly adapted to changes in weather and seasons throughout history; however, the changes projected under climate change are expected to exceed the ability of farmers to autonomously adapt. Although there are many field-ready innovations that could rapidly and immediately improve the resilience of agricultural systems in Macedonia, the lack of knowledge, technologies and financial resources at the farm level is a considerable barrier to adoption. Additionally, significant investments will be required by the state and development partners to build the infrastructure,

knowledge and policy systems that could support and develop an array of adaptation options designed to increase the resilience of the farm sector into the future.

Present inefficiencies and low productivity in Macedonia's agricultural sector exacerbate the downside risks of future climate change projections are considerable and minimize upside opportunities[19]. Significant investments will be required by the state and Macedonia's development partners to build infrastructure, knowledge and policy systems that can support and develop an array of adaptation options which can increase the resilience of the agricultural sector to climate change. The focus for interested stakeholders should, therefore, be on reducing the adaptation deficit by increasing the efficiency, productivity and adaptive capacity of agriculture to the present climate. These measures should be taken in conjunction with the development of effective, long-term adaptation options for farming and livestock systems in each individual agro-ecological zone in the country. Given the inherent uncertainties of climatic developments, these adaptation options should be evaluated robustly under a range of different future climate scenarios and should be developed at both the national scale and the agro-ecological zone scale. This approach will ensure that regional and local communities have adaptation options that specifically address the climate change challenges that they face.

IX. Impacts of Agriculture on Greenhouse Gas Emissions

Macedonia is a signatory to the Copenhagen Accord and although a specific emissions reduction target was not specified, the government has submitted a list of voluntary emissions reduction measures - known as Nationally Appropriate Mitigation Actions (NAMAs)[23] - to the United Nations Framework Convention on Climate Change (UNFCCC). The NAMAs submitted by the government covered a number of sectors, including transport, energy, industry, waste, forestry and agriculture[24]. Agriculture plays an important role in mitigating greenhouse gas emissions, with many of the practices that have benefits for both productivity improvement and adaptation also having synergistic mitigation benefits (i.e., "win-win-win"). Globally, agriculture contributes 14% of total greenhouse gas emissions. When combined with land use change and forestry, agriculture accounts for 32.7% of total global emissions – second only to the energy sector[25]. As of 2005, the agricultural sector accounted for approximately 7% of Macedonia's greenhouse gas (GHG) emissions (half of the global average), behind both the energy sector (79% of total emissions) and the waste sector (10%)[26]. The land-use change & forestry sector has generally been a net sink of GHGs in Macedonia since 1990, a result primarily of reforestation, improved forest management practices and reduced rates of illegal logging. However, in years of extensive forest fires, like 2000, the sector becomes a net-emitter of GHGs[18].

Agriculture and Land-Use Change

Agriculture accounts for 32.4% and 66.4% of the emissions of the powerful GHGs methane and nitrous oxide from Macedonia, respectively[26,v]. The major source of methane emissions from the agricultural sector is enteric fermentation of farm animals, with minor levels of emissions resulting from manure management[18,vi]. Nitrous oxide emissions from the agricultural sector are predominantly a result of the inefficient application of nitric fertilizers and associated soil fertility management, although poor land and manure management practices, as well as the burning of agricultural residues, also contribute[18].

To mitigate agricultural emissions, the Second National Communication of Macedonia outlines a range of measures in various action plans for both the agriculture and forestry sectors. The strategies outlined in the respective action plans that show promise include[18]:

- *Training of farmers in the application of tools, practices and technologies to mitigate GHGs;*
- *Support to farmers to implement agricultural technologies that also reduce GHGs;*
- *Development of legislation and systems for the application of good agricultural practices;*
- *Improvement of animal genetics to improve animal productivity;*
- *Improvement in the quality of feed rations for livestock to enhance feed digestibility;*

[v] *GHG emissions can be split into three primary constituents: carbon dioxide, methane, and nitrous oxide, with each constituent having a different heating potential. For example, methane and nitrous oxide have a 21 and 310 times greater heating potential than carbon dioxide, respectively.*
[vi] *Enteric fermentation is fermentation that occurs in the digestive system of ruminant animals like cattle and sheep as a result of microbial activity.*

- *Recovery of methane through improvements in livestock manure management, including installation of methane recovery and flaring systems at selected farms.*

X. The Policy Context

The Second National Communication of Macedonia, published in 2008, is the primary policy document that assesses the impacts of projected future climate hazards and outlines adaptation options and responses. The document includes climate projections for Macedonia until 2100 and undertakes a preliminary vulnerability assessment of different sectors, including agriculture, biodiversity, forestry and water resources. This assessment includes an analysis of climate change impacts, broad recommendations and potential adaptation and mitigation options for each sector. In terms of agricultural, some basic economic analysis of the costs associated with reduced production of winter wheat, grapes and alfalfa was conducted to inform the climate change impact assessment. Furthermore, the most vulnerable agricultural regions and associated crops were identified. Although the Second National Communication identifies adaptation options and defines action plans and associated background documents, it is rather limited in terms of the economic analysis, evaluation and prioritization of potential adaptation options and associated action plans, especially at a higher resolution, agro-ecological zone scale. Implementation has also been lacking. It is therefore critical to carry out such detailed evaluation of adaptation options at a sub-national scale, and to involve high-level Macedonian Government officials – including the Minister of Agriculture, Forestry and Water Economy and the Minister of Economy – to help promote the implementation of the required actions. It is also important to build awareness of climate change challenges and capacity to analyze and address them among MAFWE staff.

National Plans, Strategies, Programs, and Analytical Studies

Currently, Macedonia does not have a focused climate change and adaptation policy document. The mainstreaming of climate change into policy initiatives within the agricultural sector is still in its infancy. This situation must be rectified in order to ensure that investments and decision making for the agricultural sector and rural development are based on an understanding of potential future climate conditions, and not just historical conditions. Given the multi-sectoral nature of climate change, the issue has been addressed – to a minor extent – in several policy documents, including:

- ***The National Agriculture and Rural Development Strategy 2007-2013.*** This document outlines long-term support to guide the development of Macedonian agriculture and rural areas. The strategy focuses on six policy focal issues which are essential for the development of the sector. In summary, the focal issues are; 1) increase agricultural sector competitiveness; 2) improve structural linkages of the sector via more structured horizontal and vertical integration; 3) achieve food quality and safety through increased controls and integration of food safety systems; 4) achieve sustainable resource management; 5) Improve living conditions in rural areas though the improvement of infrastructure, diversification of agriculture production and creation of off-farm employment and income generating opportunities; and 6) reform the regulatory and institutional framework of the sector. In order to achieve the objectives of this strategy it is clear that climate change and adaptation, as key components, need to be analyzed, integrated and mainstreamed.

- ***The National Strategy for Sustainable Development.*** This document outlines the mission and objectives for the development of Macedonia which are sustainable from the economic, social and environmental perspectives[27]. This strategy covers a number of topics relevant to the agricultural sector and rural livelihoods, including climate change, natural resource management and agro-tourism. The strategy also supports multi-sectoral initiatives that increase on-farm economic efficiency and support rural development. The strategy specifically discusses opportunities for farmers to generate energy as a second income stream via the production of bio-fuels and bio-gas, although financing arrangements would need to be organized.

In addition to these national plans and studies, the **SIDA & GRM International: Scoping Mission on Strategizing Climate Change Adaptation and Mitigation in Macedonia 2008** was also produced**.** This report undertakes a preliminary assessment of how climate change adaptation and mitigation can be mainstreamed within the rural development strategies in Macedonia. This report proposes that a two-tiered approach be taken in order to achieve these goals: first, strengthen the capacity at the local and national levels to cope with existing climate risks (with an emphasis on heat waves and flood) while simultaneously adjusting existing development paths by aligning development policies with future anticipated changes in climate. Secondly, the scoping study outlines the increasingly challenging future the agricultural sector in Macedonia has as a result of climate change. A timeframe and planning framework to facilitate necessary technical and financial support to allow the sector to remain competitive and resilient in the face of future climate challenges is also included in this study. The framework focuses on developing coherent efforts to address climate change impacts on agriculture, improving capacity and resources of public and private advisory services to provide advice to farmers, and scaling down rural development by focusing on small-scale farmers at the municipality level.

XI. The Institutional Context

Given the complexity and multi-disciplinary nature of climate change and adaptation, Macedonia has taken the important, proactive measure of mainstreaming climate change across the government via the establishment of the National Climate Change Committee[28]. This committee is chaired by the Ministry of Environment and Physical Planning and comprises 10 other members, including members from the Ministry of Agriculture, Forestry and Water Economy, the Hydrometeorological Institute, the Ministry of Finance and the Regional Environmental Center NGO and others[28]. The committee has a number of responsibilities, including overseeing national policies on climate change, ensuring these policies are consistent with national development priorities and objectives and ensuring that relevant stakeholders across Macedonia are kept informed and consulted on the development of climate change issues, policies and strategic management of all climate related projects, programs and research activities[28]. Although good initial steps have been taken through the establishment of this committee, there remains a need for greater funding and effectiveness of institutional arrangements with regard to climate change and adaptation. The primary institutions responsible for climate change issues in Macedonia include:

The Ministry of Environment and Physical Planning (MEPP). This Ministry is the national environmental authority, as well as the Designated National Authority (DNA) on climate change and the Clean Development Mechanism (CDM) to the UNFCCC for Macedonia. The Ministry submitted the Second National Communication in 2008 and established the Climate Change Project Office (CCPO) in 2000[29]. MEPP is responsible for the development and promotion of policies, strategies and action plans for protecting water, soil, flora, fauna, air and ozone from pollution. They are also responsible for managing national parks and protected areas, as well as physical planning[30].

The Ministry of Agriculture, Forestry and Water Economy (MAFWE). This Ministry is responsible for formulating and promoting policies and strategies which relate to the development of agriculture, forestry and water supply across Macedonia[30]. The Ministry is also responsible for matters relating to the protection of animals and plants from pests and diseases, as well as water resource management and associated maintenance and improvement of water infrastructure for multiple uses. MAFWE has an important role in improving rural livelihoods through increasing farm competitiveness and access to markets, as well as reducing barriers for private investment in the sector. This Ministry is also responsible for matters relating to the protection of animals and plants from pests and diseases, water resource management and associated maintenance and improvement of water infrastructure for multiple uses[30].

Agricultural Research Institutes. These institutes play important roles in improving agricultural practices through the development of farming systems and practices that improve productivity and sustainability. The five major institutes involved in the development of agriculture are the 1) Institute of Agriculture; 2) Institute of Tobacco; 3) Institute of Livestock Breeding; 4) Institute of Southern Crops; and 5) Veterinary Institute[31]. Additionally, experts from the faculty of Agricultural Sciences and Food from the Ss. Cyril and Methodius University of Skopje have also made a significant contribution to the agricultural aspects of climate change research in the country. For the Macedonian agricultural sector to develop and improve its competitiveness it is vital that the work done by these research institutes and faculty experts are closely linked with the on-ground realities and requirements of Macedonian farmers, and that results and practical measures are disseminated widely by extension services.

The Farmers' Federation of the Republic of Macedonian Farmers (FFRM). This federation is the leading voice for famers in the country. There are more than 200 farmer associations across Macedonia, most of which are based on one particular commodity[31]. The vast majority of these associations, however, are registered in name only and do not function.

XII. Ways Forward

This Country Note is just the First Step: Upcoming Activities in the Development of the *Macedonian Response to Climate Change for Agriculture*

National Awareness Raising and Consultation Workshop, Alexander Palace Hotel, Skopje

In May 2010 an Awareness Raising and Consultation workshop on Reducing Vulnerability to Climate Change in Macedonian Agricultural Systems was held in Skopje, Macedonia. During this event, the Climate Change and Agriculture Country Note was disseminated to agricultural sector stakeholders and helped generate a groundswell of support and interest for further analytical work to reduce the vulnerability of the agricultural sector to climate change. A leading figure in this support has been Mr. Ljupco Dimovski, Macedonian Minister of Agriculture, Forestry and Water Economy, who expressed his appreciation for the Country Note (prepared in collaboration with the World Bank) and indicated that climate change was already observable in Macedonia. Minister Dimovski acknowledged the impact climate change is having on Macedonian agriculture via higher temperatures, decreased precipitation and more frequent extreme events. These thoughts were echoed by workshop participants and other stakeholders, including the Hydrometeorological Institute, Agriculture Research Institute, University St. Cyril and Methodius - Faculty of Agriculture Sciences and Food, Federation of Farmers of the Republic of Macedonia (FFRM), National Extension Agency and farmers. Minister Dimovski also expressed his strong commitment and interest in enhancing the Government's ability to mainstream and align climate adaptation into agricultural policies, programs and investments. Towards this goal, he agreed that MAFWE would fully support, and work jointly with, the World Bank to develop the Macedonian Response to Climate Change for Agriculture program.

Broadly, this work involves rigorous analysis and economic modeling to assess both the impacts of climate change and potential adaptation measures for a range of farming, livestock and production systems. The analysis is currently being performed by expert staff from the international consulting firm Industrial Economics, Inc. (IEc), in close consultation with local experts across a range of organizations, under the direction of the World Bank. IEc is also delivering training and capacity building services to local experts and organizing sub-national consultation meetings with farmers, policymakers and researchers to raise awareness of the risks and opportunities posed by climate change on the agricultural sector. This work will culminate in the development of an Agriculture and Climate Change Impact Assessment & Menu of Adaptation Options that will highlight the physical, economic and social impacts of climate change on the agricultural sector and identify adaptation priorities for investments, capacity development and policy improvement. These options will be practical and operational, with a focus on "win-win-win" options that have benefits for adaptation, mitigation and the local economy. This analysis will be discussed at a high-level National Dissemination and Consensus Building Conference to be jointly hosted by MAFWE and the World Bank in January 2011. The conference will help build consensus on the way forward by identifying practical priorities for action. A Regional Knowledge Exchange Conference will follow, wherein Macedonian experts can share their experiences and results while simultaneously learning from experts from other countries participating in the Regional Program on Reducing Vulnerability to Climate Change in ECA Agricultural Systems. This forum will also explore opportunities for greater regional collaboration and assist with the establishment of regional communities of practice for experts working on agriculture and climate change issues.

The Sustainable Development Department of the ECA Region at the World Bank is carrying out a regional, three-year program of analytical and advisory activities to better determine the potential impacts of climate change on the agricultural sector in four pilot countries: Albania, FYR Macedonia, Moldova and Uzbekistan. Through the Regional Program on Reducing Vulnerability to Climate Change in ECA Agricultural Systems, the World Bank is working with stakeholders to develop practical recommendations on actions these countries can take to increase the resiliency of their agricultural sectors to the impacts of climate change. The overall objective of the program is to enhance the ability of ECA countries to mainstream climate adaptation into agricultural policies, programs and investments. This will be achieved by raising awareness of the threat, analyzing potential impacts and adaptation responses and building capacity among country stakeholders with respect to climate change impact assessment and adaptation in the agricultural sector.

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