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A WORLD BANK STUDY



# Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change

IMPACT ASSESSMENT  
AND ADAPTATION OPTIONS

William R. Sutton, Jitendra P. Srivastava,  
James E. Neumann, Kenneth M. Strzpek,  
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## Preface

Changes in climate and their impact on agricultural systems and rural economies are already evident throughout Europe and Central Asia (ECA). Adaptation measures now in use in Albania, largely piecemeal efforts, will be insufficient to prevent impacts on agricultural production over the coming decades. There is growing interest at the country and development partner levels to have a better understanding of the exposure, sensitivities, and impacts of climate change at farm level, and to develop and prioritize adaptation measures to mitigate the adverse consequences.

Beginning in 2009, the World Bank embarked on the Regional Program on Reducing Vulnerability to Climate Change in ECA Agricultural Systems for selected ECA client countries to enhance their ability to mainstream climate change adaptation into agricultural policies, programs, and investments. This multi-stage program has included activities to raise awareness of the threat, analyze potential impacts and adaptation responses, and build capacity among client country stakeholders and ECA Bank staff with respect to climate change and the agricultural sector. This report is the culmination of efforts by the Albanian institutions and researchers, the World Bank, and a team of international experts headed by the consulting firm Industrial Economics, Inc., to jointly undertake an analytical study, *Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change*.

The approach of this volume is predicated on strong country ownership and participation, and is defined by its emphasis on “win-win” or “no regrets” solutions to the multiple challenges posed by climate change for the farmers of Eastern Europe and Central Asia. The solutions are measures that increase resilience to future climate change, boost current productivity despite the greater climate variability already occurring, and limit greenhouse gas emissions—also known as “climate-smart agriculture.”

Specifically, this report provides a menu of climate change adaptation options for the agriculture and water resources sectors, along with specific adaptation actions, that are tailored to four distinct agro-ecological zones (AEZs) within Albania. This menu reflects the results of three inter-related activities, conducted jointly by the team and local partners: (1) quantitative economic modeling of baseline conditions and the effects of climate change and an array of adaptation options; (2) qualitative analysis conducted by the team of agronomists, crop

modelers, and water resources experts; and (3) input from a series of participatory workshops for national decision makers and farmers in each of the AEZs. This report provides a summary of the methods, data, results, and adaptation options for each of these activities.

This study is part of the World Bank's ECA Regional Analytical and Advisory Activities (AAA) Program on Reducing Vulnerability to Climate Change in ECA Agricultural Systems. Albania is one of four countries to participate in the program, with the other country participants being Moldova, the former Yugoslav Republic of Macedonia, and Uzbekistan. A book, *Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia*, covering all four countries was published in April 2013 (the book can be found at <http://dx.doi.org/10.1596/978-0-8213-9768-8>). The book also contains a technical appendix with details on the methodologies applied.

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# Abbreviations

AAA	Analytical and Advisory Activities Program
AEZ	agro-ecological zone
ATTC	Agriculture Technology Transfer Centers
B-C ratio	benefit-cost ratio
CMI	Climate Moisture Index
ECA	Europe and Central Asia
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GCM	global circulation model
GDP	gross domestic product
GHG	greenhouse gas
GIS	Global Information Systems
IFPRI	International Food Policy Research Institute
IoEWE	Institute of Energy, Water and Environment
IPCC	Intergovernmental Panel on Climate Change
KASH	Agribusiness Council
LAP	Land Administration and Protection
MoAFCP	Ministry of Agriculture, Food and Consumer Protection
MoEFWA	Ministry of Environment, Forests and Water Administration
NEAP	National Environmental Action Plan
NPV	net present value
O&M	operations and maintenance
SEI	Stockholm Environment Institute
SPAM	Spatial Production Allocation Model
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEAP	Water Evaluation and Planning System



# Executive Summary

## Introduction

Agricultural production is inextricably tied to climate, making agriculture one of the most climate-sensitive of all economic sectors. In countries such as Albania, the risks of climate change for the agricultural sector are a particularly immediate and important problem because the majority of the rural population depends either directly or indirectly on agriculture for their livelihoods. The rural poor will be disproportionately affected because of their greater dependence on agriculture, their relatively lower ability to adapt, and the high share of income they spend on food. Climate impacts could therefore undermine progress that has been made in poverty reduction and adversely impact food security and economic growth in vulnerable rural areas.

Recent flooding events in Albania have underscored these risks. Although no single weather event of this type can be directly tied to climate change, an increase in extreme temperature and rainfall events such as these are consistent with the best known science of the impacts of climate change.

The need to adapt to climate change in all sectors is on the agenda of national governments and development partners. International efforts to limit greenhouse gases and mitigate climate change now and in the future will not be sufficient to prevent the harmful effects of temperature increases, changes in precipitation, and the increased frequency and severity of extreme weather events.

At the same time, climate change can also create opportunities, particularly in the agricultural sector. Increased temperatures can lengthen growing seasons, higher carbon dioxide (CO<sub>2</sub>) concentrations can enhance plant growth, and in some areas rainfall and the availability of water resources can increase as a result of climate change.

The risks of climate change cannot be effectively dealt with, and the opportunities cannot be effectively exploited, without a clear plan for adaptation. This includes steps for aligning agricultural policies with climate change, for developing capabilities at key agricultural institutions, and for making needed infrastructure and on-farm investments. Developing such a plan ideally involves a combination of high-quality quantitative analysis and consultation of key stakeholders, particularly farmers, as well as in-country agricultural experts.

In order to be effective, plans for adapting the sector to climate change must strengthen both human capital and physical capital in their capacity. Many of these investments would also yield instant returns under current climate conditions in terms of increased agricultural productivity and improved competitiveness of the agricultural sector. However, the capacity to adapt to climatic changes, both in mitigating risks and in taking advantage of the opportunities that climate change can create, is in part dependent on financial resources. Adaptive capacity is particularly low among smallholder farmers in Albania, who have limited access to financial resources. As a result, development partners will continue to have an important role in enhancing the adaptive capacity of the Albanian agricultural sector.

Another key factor in Albania's development of an adaptation plan for agriculture is furthering its work toward European Union (EU) accession. Albania has already developed laws on agriculture land use, land protection, and environment to be in compliance with European standards and requirements. Along with these needed reforms, the EU encourages action toward climate change preparedness and adaptation. As outlined in a 2009 EU White Paper on the topic, these actions could include systematic assessment of climate risks, development of outreach initiatives to train farmers in such areas as improving water use efficiency, and identification of needs for financing of adaptation measures. The White Paper also stresses the need to integrate cost-effective adaptation to climate change in the EU Rural Development Policy, sometimes referred to as the "second pillar" of the Common Agricultural Policy.

In response to these challenges, the World Bank and the government of Albania embarked on a joint study to identify and prioritize options for climate change adaptation in the agricultural sector. The approach for this study was centered on four objectives:

- Raising awareness of the threat of climate change
- Analyzing potential impacts on the agricultural sector and assessing adaptive capacity
- Identifying practical adaptation responses and the potential for greenhouse gas emission reductions
- Building capacity among national and local stakeholders to assess the impacts of climate change and to develop adaptation measures in the agricultural sector, defined to encompass crop (including cereals, vegetables, fruits, and forage) and livestock production.

The first phase of this work involved raising awareness of the threats and opportunities presented by climate change, beginning with a national Awareness Raising and Consultation Workshop. The second phase of the study involved quantitative and qualitative analysis of climate impacts and adaptation and mitigation options, a capacity-building workshop, and consultations with Albanian farmers and experts. The analysis was conducted to provide results that are specific to four agro-ecological zones (AEZs) of Albania, to key crops important to the Albanian agricultural economy, and across a range of future climate change scenarios.

The third phase of the study was to develop a plan for the Albanian agricultural sector to be more resilient to current and anticipated changes in climate, while also contributing to greenhouse gas emission reductions. The methods used here include benefit-cost analysis, where data are available; qualitative analysis by the team that visited the country; and consultations with Albanian farmers to evaluate the impacts of climate change and the needs for better adapting to it. A previous draft of this report was discussed in detail at the National Dissemination and Consensus Building Conference, organized in Tirana, Albania, at which participants reached an overall consensus on a set of adaptation options for adoption.

### **Challenges and Opportunities for Albania's Agricultural Sector**

The study revealed a number of challenges and opportunities for Albania's agricultural sector under projected climate changes:

- *Temperature will increase and precipitation will become more variable in Albania as a result of climate change.* These findings are consistent with recent changes in climate in Albania, and will persist and grow more severe over the next few decades.
- *The direct temperature and precipitation effects of future climate change on crops are mixed.* Climate change is projected to have the potential to improve yields of wheat (if pest damage does not increase) and irrigated alfalfa, to reduce yields for grapes and olives, and to have relatively modest effects on other crops studied. These findings were presented to Albanian farmers and they concur that these effects are consistent with their experience. Some Albanian experts noted, however, that the recent decline in wheat yields might be attributable to increased incidence of pest damage to this crop.
- *Farmers in Albania have inadequately adapted to the current climate; this effect is sometimes called the adaptation deficit, which, in Albania, is considerable.* As a result, many of the climate adaptation measures identified in this study can have immediate benefits in improving yields, as well as improving resiliency to future, more severe climate change.
- *Water resources are abundant in Albania, and will continue to be through 2050 under a wide range of climate change scenarios.* In many cases, however, farmer training is needed in the Intermediate and Lowlands agro-ecological zones (AEZs) to ensure more efficient use of water during dry seasons, and additional investment is needed in these regions in irrigation and water storage infrastructure to take best advantage of these water resources in the agricultural sector. Moreover, improved drainage capacity is required to avoid the damaging effects of severe floods. Farmers have confirmed these findings.
- *Direct effects of climate change on the livestock sector, particularly beef cattle, chickens, and even sheep, could be negative.* While methods to reliably quantify these effects are currently not applicable to Albania, it can be anticipated that the temperature stress effect on livestock will be gradual over time. Farmers

also confirmed that they have not yet seen an effect of climate on their livestock production.

- *National-level adaptation and capacity building is a high priority.* While decreasing the adaptation deficit of the sector is a long-term process, there are several measures that could be undertaken immediately to strengthen the sector's adaptive capacity. These include: expanding extension service capacity; improving provision of short-term and long-term forecasts of meteorology to farmers; encouraging consolidation of farmland into larger holdings to facilitate more substantial investments in on-farm technology; and encouraging private sector efforts to adapt to climate change.
- *Studies should be conducted at the national level to more specifically map and assess crop suitability and the functionality of existing drainage capacity, particularly in flood-prone areas, and new drainage capacity standards should be considered.* Other institutional capacity improvements should focus on identifying seeds for drought-tolerant varieties and temperature-tolerant livestock on the current international market for adoption in Albania, as well as training farmers in more efficient use of water and to make use of new short-term forecast information. The analysis in this study indicates these measures have high benefit-cost ratios and are also favored by Albanian farmers.
- *At the AEZ and farm levels, high-priority adaptation measures include improving drainage (Intermediate and Lowlands areas), rehabilitating secondary irrigation capacity (Lowlands), optimizing fertilizer and water application (all AEZs), providing more climate resilient seed varieties and the know-how to cultivate them effectively for high yields (all AEZs), and encouraging wider use of hail nets (Southern Highlands).* Improving drainage capacity is the most effective method to address issues associated with severe flooding. All of these measures also have high benefit-cost ratios and are favored by Albanian farmers, although the use of hail nets requires further study.

Table ES.1 provides a summary of the key findings, including the climate change impacts (incorporating assessments of sensitivity, adaptive capacity, and vulnerability), climate hazards that cause those impacts, and the adaptation options to address the impacts at both the national and AEZ levels. A check mark indicates that the corresponding adaptation option will either reduce the climate change impact directly or will do so indirectly by closing the adaptation deficit.

## **Vulnerability of Albania's Agriculture to Climate Change**

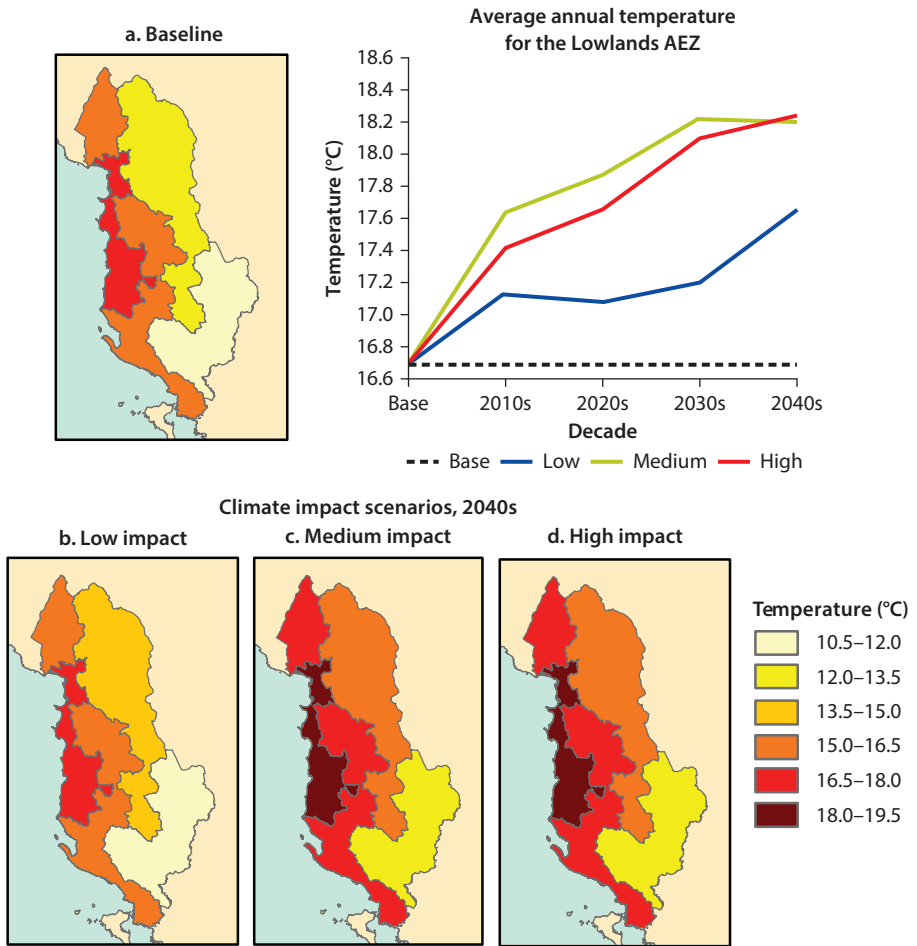
Analysis of recent climate data and information gathered from farmer workshops supports the finding of an increasing trend in temperature in Albania. Farmers also have observed an increasing trend in extreme heat events. Analysis in this study indicates this trend will accelerate in Albania in the near future, as shown in map ES.1. Although uncertainty remains regarding the degree of warming that will occur in Albania, the overall warming trend is clear and is evident in all four AEZs. Over the next 40 years, average warming will be about 1.5°C. This can be



**Table ES.1 Key Climate Hazards, Impacts, and Adaptation Measures at the National and AEZ Levels**

Climate change impact		Adaptation measure to address impact										
		National level					AEZ level					
		Improve farmer access to technologies and information	Provide timely hydrometeorological forecasts through mass media	National policy measures to consolidate farm holdings	Encourage private sector involvement in adaptation	Improve crop varieties	Improve irrigation efficiency	Improve irrigation infrastructure	Improve drainage	Optimize agronomic practices: fertilizer application and soil moisture conservation	Improve irrigation water quality	Implement floodplain land-use management measures
Rainfed and irrigated crop yield reductions	Higher temperatures	✓		✓	✓	✓			✓	✓		
	Increased pests and diseases	✓	✓	✓	✓	✓			✓			
Rainfed crop yield reductions	Lower and/or more variable precipitation	✓		✓	✓	✓	✓	✓	✓	✓		✓
Irrigated crop yields reduction	Decreased river runoff and increased crop water demands	✓	✓	✓		✓	✓	✓	✓	✓	✓	
Crop quality reductions	Change in growing season	✓	✓	✓	✓	✓		✓	✓	✓	✓	
	Increased pests and diseases	✓	✓	✓	✓	✓			✓			
Livestock productivity declines	Higher temperatures (direct effect)	✓		✓	✓							✓
	Reductions in forage crop yields (indirect effect)	✓		✓	✓	✓		✓	✓	✓	✓	✓
Crop damage occurs more frequently	More frequent and severe hail events	✓	✓	✓								
	More frequent and severe drought events	✓	✓	✓		✓		✓			✓	
	More frequent and severe flood events	✓	✓	✓				✓			✓	
	More frequent and severe high summer temperature periods	✓	✓	✓		✓		✓				

**Map ES.1 Effect of Climate Change on Temperature through 2040s for the Three Climate Impact Scenarios**

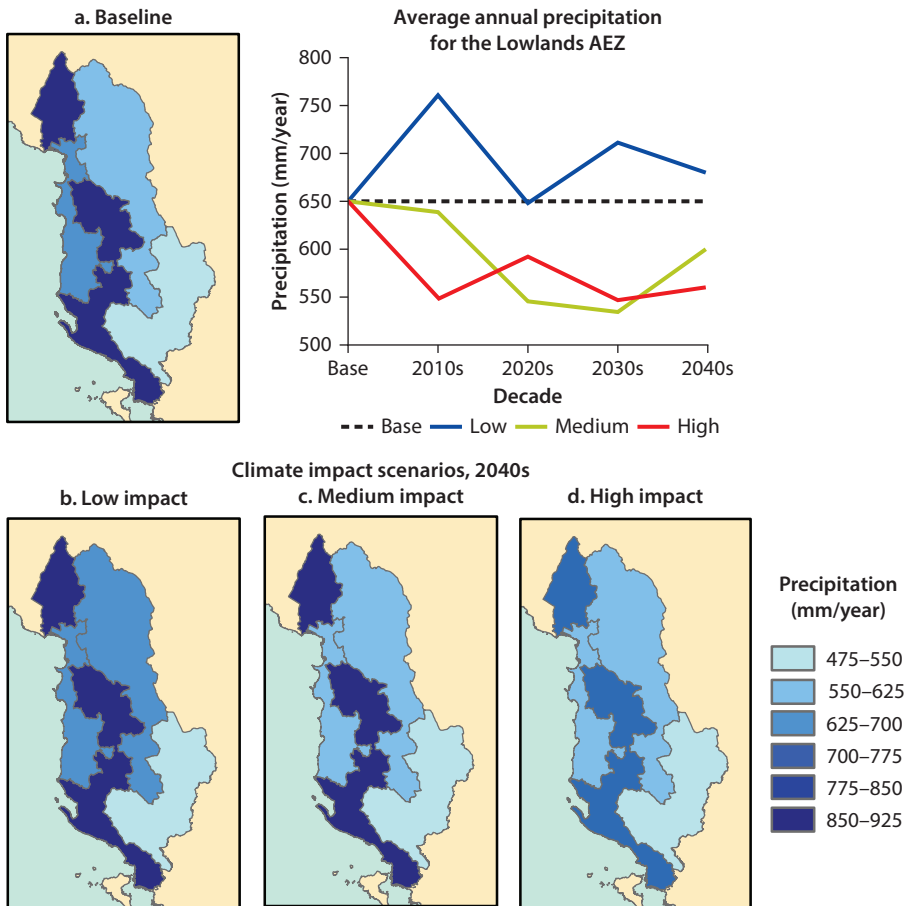


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compared with the less than 0.5°C increase in temperature observed over the last 50 years.

Precipitation changes are much more uncertain than temperature changes, as indicated in map ES.2. The medium-impact projection indicates about 50 millimeters less annual precipitation nationally, with most of this decline occurring in the Lowlands AEZ. The range of outcomes across the low- and high-impact alternative scenarios, however, encompasses an increase in annual precipitation of 30 millimeters and a decrease of 90 millimeters by 2050. Uncertainty at the regional level is even higher, and annual precipitation declines in the Lowlands and Intermediate AEZs—including areas around Lushnje, Vlores, Fushe-Kruje, and Shkodra—could be as large as 150 millimeters. Modeling in this study shows that the mountainous areas of Albania, particularly around Korce, will experience only modest declines in annual precipitation.

**Map ES.2 Effect of Climate Change on Precipitation through 2040s for the Three Climate Impact Scenarios**



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The annual averages, however, are less important for agricultural production than the seasonal distribution of temperature and precipitation. Temperature increases are higher, and precipitation declines greater in July and August relative to current conditions. Summer temperature increases over the next 40 years can be as much as 4–5°C in the northern mountains of Albania. In addition, projected precipitation declines are greatest in the key May-to-September period, when precipitation is already the lowest, particularly in the southern and northern mountains.

These seasonal changes in climate have clear implications for crop and livestock production, if no adaptation measures are adopted beyond those that farmers already employ (such as changing planting dates in response to temperature changes). Results for climate change impacts to crops if no adaptation is implemented are summarized in Table ES.2. The results show that grapes and olives will be most affected by climate change, with grape yield declines in all AEZs and

**Table ES.2 Effect of Climate Change on Crop Yield 2040–50 Relative to Current Yields under Medium-Impact Scenario, No Irrigation Water Constraints and without New Adaptation Measures**  
% change

<i>Irrigated/rainfed</i>	<i>Crop</i>	<i>Intermediate</i>	<i>Lowlands</i>	<i>Northern Mountains</i>	<i>Southern Highlands</i>
Irrigated	Alfalfa	6	4	6	13
	Maize	-3	-4	-11	1
	Tomatoes	0	-11	-8	-4
	Watermelon	N/A	-6	N/A	N/A
Rainfed	Alfalfa	-6	-3	-2	7
	Grapes	-17	-20	-21	-18
	Grassland	-5	-3	-7	10
	Olives	-3	-21	N/A	N/A
	Wheat	10	7	24	20

Note: Results are average changes in crop yield, assuming no effect of carbon dioxide fertilization, under medium-impact scenario (no adaptation and no irrigation water constraints). Declines in yield are shown in shades of orange, with darkest representing biggest declines; increases are shaded green, with darkest representing the biggest increases. N/A = the crop is not grown in that AEZ, according to local stakeholders.

olives particularly affected in the Lowlands AEZ. Yield increases can result, however, for winter wheat, as climate change will likely result in an extended growing season, more moderate fall and winter temperatures, and greater precipitation and water availability during the wheat growing season. Alfalfa production should also increase in most regions. Effects on maize vary by region, with increases in the Southern Highlands and decreases in other regions, probably because current temperature is most moderate in the mountainous Southern Highlands and so increases can enhance yields. The other crops analyzed should experience relatively modest crop yield changes compared to current yields.

The direct effects of climate change on livestock, by contrast, could be much more severe, but the methods available for quantitatively assessing effects on livestock are relatively untested. There is a robust literature establishing that temperature increases decrease livestock productivity, but modeling tools are not suitable for quantifying the effect in the Albanian context.

## Stakeholder Consultations

Extensive stakeholder consultations with local government officials, farmers, and experts within the scope of this study conveyed several messages:

- *Address the lack of timely meteorological information needed to respond effectively.*
- *Address the lack of access to alternative crop varieties (particularly seeds) and know-how to make best use of these varieties.*
- *Rehabilitate irrigation and drainage infrastructure.* Farmers confirmed that water is generally available for irrigation, as the quantitative modeling indicated, but that secondary and, in some cases, primary irrigation infrastructure is in disrepair and limits crop production in some areas, and that overall drainage infrastructure needs to be improved. Depending on the specific climate-related

risk faced by each AEZ, the priority infrastructure was for either irrigation (some parts of the Lowlands) or drainage (other parts of the Lowlands and the Intermediate, and to a lesser extent the mountainous AEZs).

- *Increase institutional capacity.* Capacity building was universally mentioned, especially in response to the suggestion to increase the capabilities and the reach of extension services. Currently 250 extension service personnel work in 100 small offices. The overall budget for extension is €1 million, with less than €200,000 for operations. Other capacity building options included technical training, seed and crop selection from both international and national private markets, and increasing the availability of region-specific hydro-meteorological information.
- *Improve market structure.* Farmers emphasized that overall market effectiveness would assist in making farms more productive and provide a win-win adaptive response. Farmers expressed frustration in the absence of logistical support in the country, such as processing and storage facilities. They also expressed frustration at the small size of their farms and lack of facilitation for consolidation of fragmented plots and sharing of equipment and know-how among small-holders. If farm sizes effectively could be increased, farmers would be both incentivized to invest more, and could manage production in a more efficient way.

## Menu of Adaptation Options

The proposed menus of adaptation options to improve the resilience of Albania's agricultural sector to climate change are derived from the results of the quantitative modelling, qualitative analysis, and from the farmer consultations. The results reflect four criteria for prioritizing options from among a larger menu of 29 farm-level adaptation options, 14 infrastructure options, 13 programmatic options, and four indirect adaptation options. The four criteria are:

- *Net economic benefits* (quantified benefits minus costs).
- *Expert assessment of ranking* for those options that cannot be evaluated in economic terms.
- *Win-win potential.* These include measures with a high potential for increasing the welfare of Albanian farmers, with or without climate change.
- *Favorable evaluation by the local farming community.* These results are based on the results of the first and second stakeholder consultations.

Adaptation options were evaluated based on their potential to increase resilience to climate change, by application of the above-stated evaluative criteria. Some options, if adopted, may also yield benefits in the form of reduced greenhouse gas mitigation potential. In particular, measures such as soil conservation that can enhance the retention of carbon in the soil, and optimization of agronomic practices, which can reduce energy and fertilizer use, yield greenhouse gas mitigation as well as climate change adaptation benefits. While it was not possible to quantitatively evaluate these benefits in a comprehensive manner, a qualitative

analysis of the potential for recommended measures to yield greenhouse gas mitigation benefits is also included in this report.

### **Options for National Policy and Institutional Capacity Building**

The National Conference discussed measures for adoption at the national level, including the following:

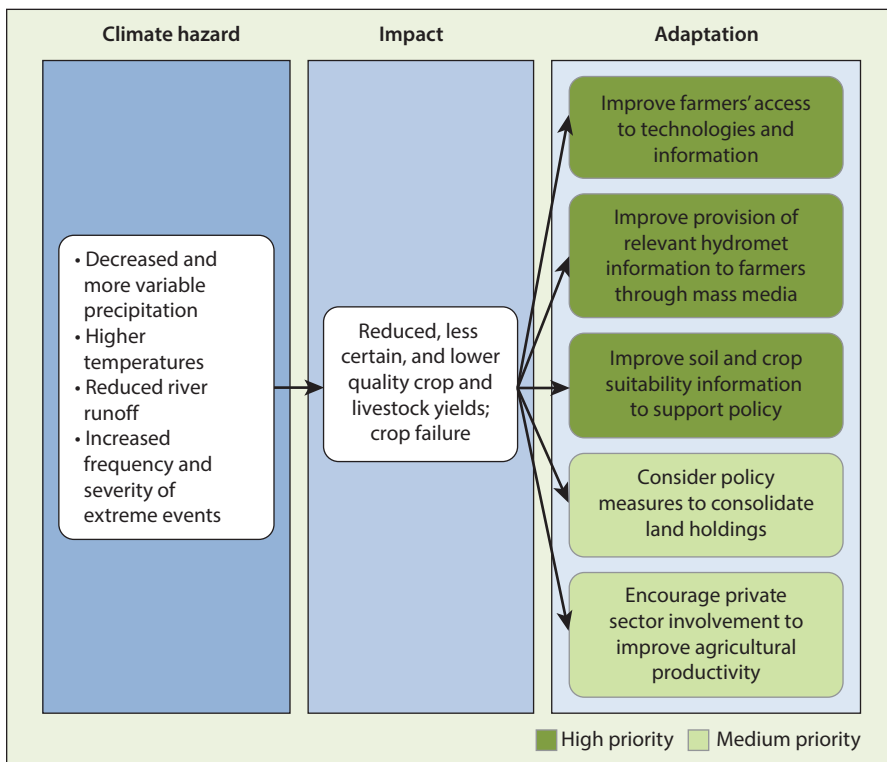
- *Increase the access of farmers to technology and information, both generally and for adapting to climate change.* The capacity of the existing research and extension agency could be improved in two areas: (1) to support better agronomic practices at the farm level, including implementation of more widespread demonstration plots and access to better information on the availability and best management practices of high-yield crop varieties; and (2) to support the same measures but with a focus on maintaining yields during extreme water stress periods that are likely to be more frequent with climate change. The first component is a short-term measure to close the adaptation deficit, and the second is a long-term measure to ensure yield gains are not undermined by future climate change. Investing in extension also has a high benefit-cost ratio.
- *Improve the dissemination of hydrometeorological information to farmers.* In every farmer meeting participants noted the need for better local capabilities for and access to hydrometeorological data, particularly for short- to medium-term temperature and precipitation forecasts. The current lead hydrometeorological institution in Albania, the IoEWE, is inadequately funded and poorly oriented to collect and disseminate climatological information to farmers. Enhanced capabilities and a better institutional focus on farmers are acutely needed in the short-term to support better farm-level decision-making and, in the medium-term, better policy-level decision-making in Albania. Investing in even a basic upgrade of hydrometeorological information delivery appears justified by economic analysis as well.
- *Improve information collection and dissemination on soil types, drainage potential, and crop suitability.* It is recommended that the existing capacity at the Fushe-Kruje Agriculture Technology Transfer Centers (ATTC) to analyze soil information throughout Albania be enhanced and better linked to both policy initiatives at the national level and local farmer education efforts, with a focus on developing crop suitability assessments to inform national policy and outreach to farmers. This measure would work in concert with others to improve drainage infrastructure (focusing drainage efforts on those areas with the greatest potential for yield increases) and where existing infrastructure is in poor repair and can be more cost-effectively rehabilitated, rather than constructing new drainage infrastructure. Crop modeling at a more specific level, linked to spatially explicit soils information, could be a powerful tool for targeting these infrastructure investments.
- *Consider national policy measures to further consolidate farm holdings.* Both the team and at least one farmer group noted that on-farm adaptive capacity is

limited by the generally small size and fragmentation of Albanian farms. The consequence of small farms is an inability to provide sufficient economies of scale to invest in adaptive measures, such as tertiary irrigation systems (for example, drip irrigation) and equipment that might both increase yields and reduce soil erosion.

- *Encourage private sector involvement to most efficiently adapt to climate change.* There may be a tendency to assume that adaptation to climate change is necessarily a public sector function, but as the economic analysis demonstrates, there is strong private sector incentive—with economic benefits greatly exceeding costs—for measures that will improve the resiliency of Albanian agriculture to climate change. The national government should focus on putting in place policies that enable the private sector to effectively assist in adaptation. For example, conducting testing of seed and livestock varieties for their suitability for Albanian climate, terrain, and soil conditions, and making recommendations of the best varieties, but allowing the private sector to provide those varieties.

Combining the above priorities with the options emerging from the National Conference generates an overall set of adaptation measures at the national level. Figure ES.1 links the climate change hazards to impacts, and then these impacts to the national-level adaptation options. Measures shaded in darker green

**Figure ES.1 Adaptation Measures for National Policy and Institutional Capacity Building**

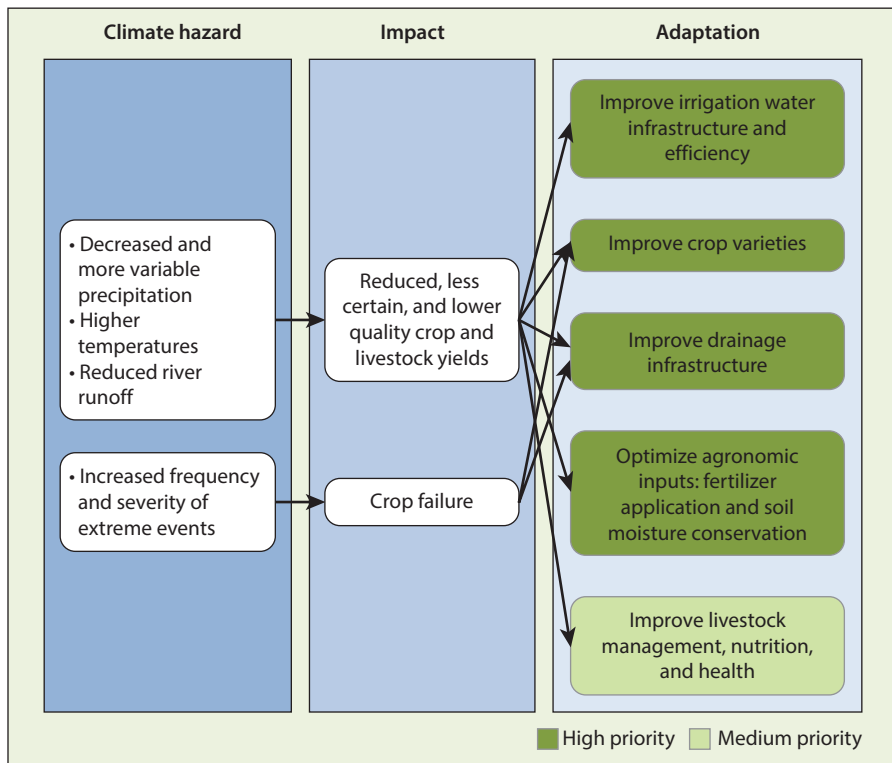


represent options that were identified by both the consultants’ assessment and the National Conference group, and represent the highest priority recommendations.

### Options for Specific AEZs

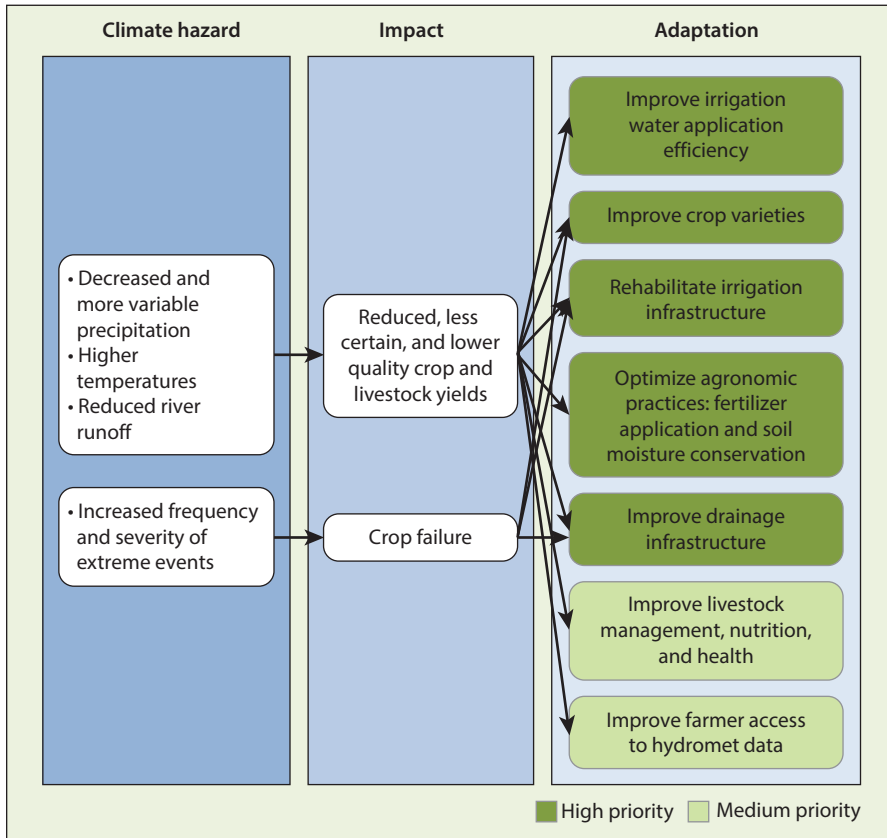
As summarized in figures ES.2 through ES.5, a number of options emerged from the quantitative analysis, farmer consultations, and National Conference evaluations of measures as most advantageous for adapting to climate change in each AEZ.

**Figure ES.2 Adaptation Measures for the Lowlands AEZ**

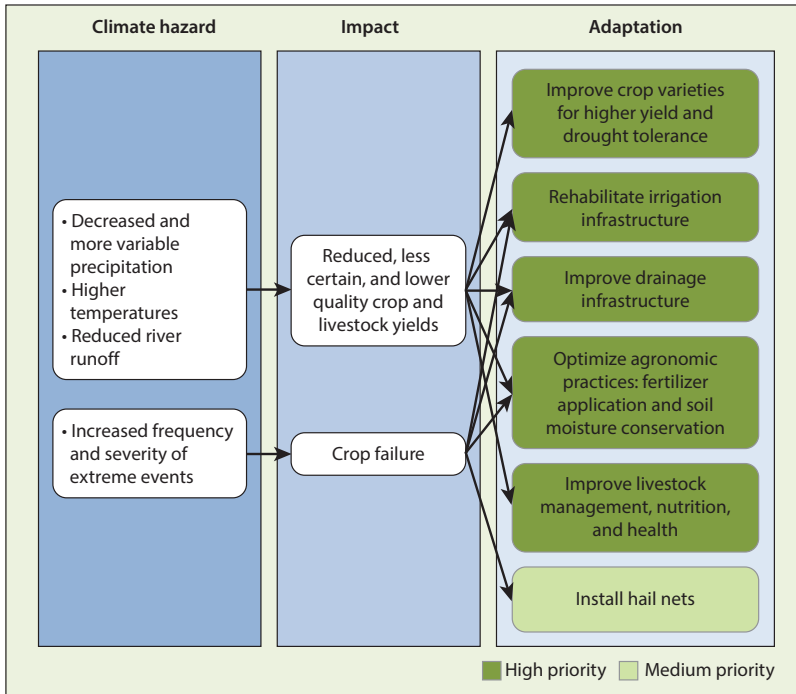




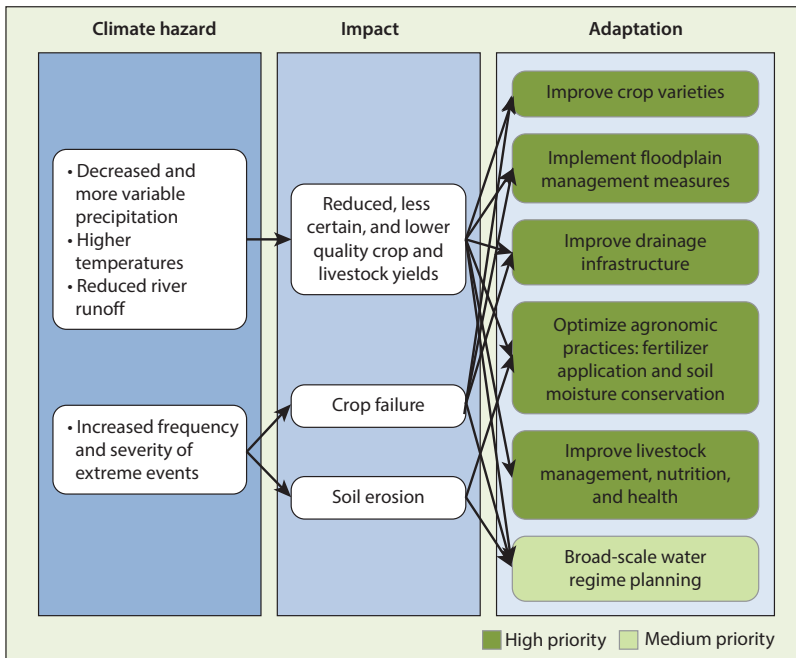
**Figure ES.3 Adaptation Measures for the Intermediate AEZ**



**Figure ES.4 Adaptation Measures for the Southern Highlands AEZ**



**Figure ES.5 Adaptation Measures for the Northern and Central Mountains AEZ**



# Current Conditions for Albanian Agriculture and Climate

## **The Agricultural Sector in Albania**

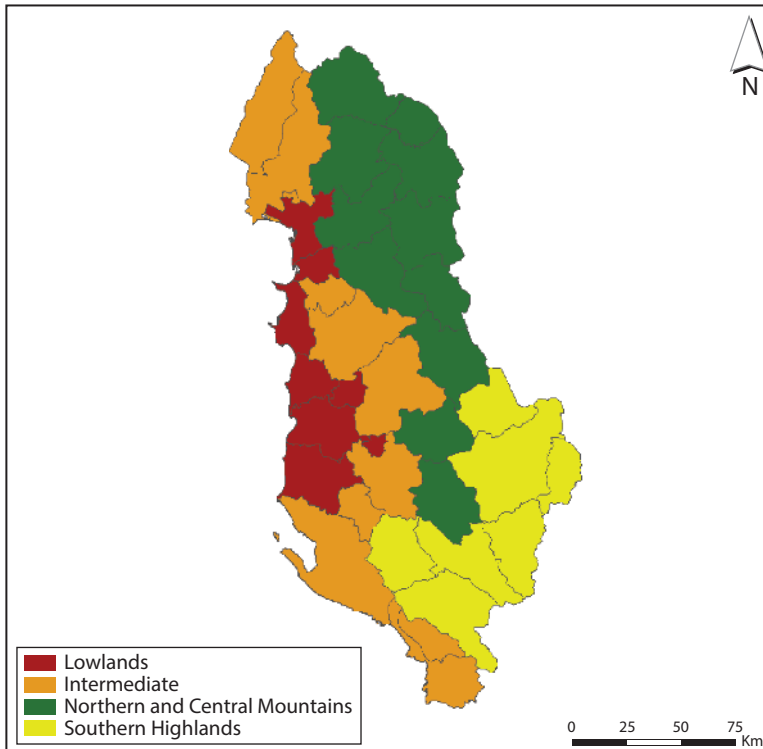
Albania is located in south-eastern Europe, on the western side of the Balkan Peninsula, with frontage to the Adriatic and Ionian Seas. It has a surface area of 28,745 km<sup>2</sup> and is bordered by Montenegro and Kosovo to the north, the Former Yugoslav Republic of Macedonia to the east, and Greece to the south. Administratively, Albania is divided into 12 prefectures, 36 districts, 315 communities, and 2,900 villages.

For the purposes of this study, Albania was divided into four agro-ecological zones, or AEZs, as shown in map 1.1. The area within each of these AEZs shares some of the same characteristics in terms of terrain, climate, soil type, and water availability, and as a result, baseline agricultural conditions, climate change impacts, and adaptive options will be similar within each AEZ, with differences between AEZs that are important for developing a specific adaptation plan.

The terrain of Albania is primarily mountainous, with 77 percent of the country's territory comprised of hilly or mountainous land. In map 1.1, these areas are shown in green, comprising the Northern and Central Mountains AEZ, and in yellow, comprising the Southern Highlands AEZ. There is also a highly productive coastal plain, however, shown in red, comprising the Lowlands AEZ, and parts of the Intermediate AEZ, shown in orange. Overall, the average elevation of the country is double the European average at 708 meters above sea level. The terrain and change in relief from the mountains to the coast result in high rates of soil degradation, and water resources are characterized by powerful, highly erosive river flows. This power has been converted into electricity, with over 95 percent of the country's power supply sourced from hydroelectric infrastructure.

## ***Recent Trends in Albanian Agriculture***

Agriculture has traditionally been the backbone of the Albanian economy and although the sector has been growing, the pace of growth has been outstripped

**Map 1.1 Agro-Ecological Zones in Albania**

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Note: AEZ = agro-ecological zone.

by other sectors such that the agricultural contribution to gross domestic product (GDP) has declined from 56 percent in 1997 to 21 percent in 2007. Although declining in economic importance, Albania is still an agrarian society with the agriculture sector providing between 55 and 60 percent of total employment between 2003 and 2005. However, with almost three-quarters of the rural population earning less than US\$5 per day, the vast majority are poor and highly vulnerable to any event that affects the agricultural sector.

The value of agricultural production in 2009 was a combined US\$1.7 billion, including livestock, field crops, and fruit production. As shown in table 1.1, more than half of the value of production is accounted for in the livestock sector. Field crops account for about one-third of the value of production, and fruit production makes up the remainder.

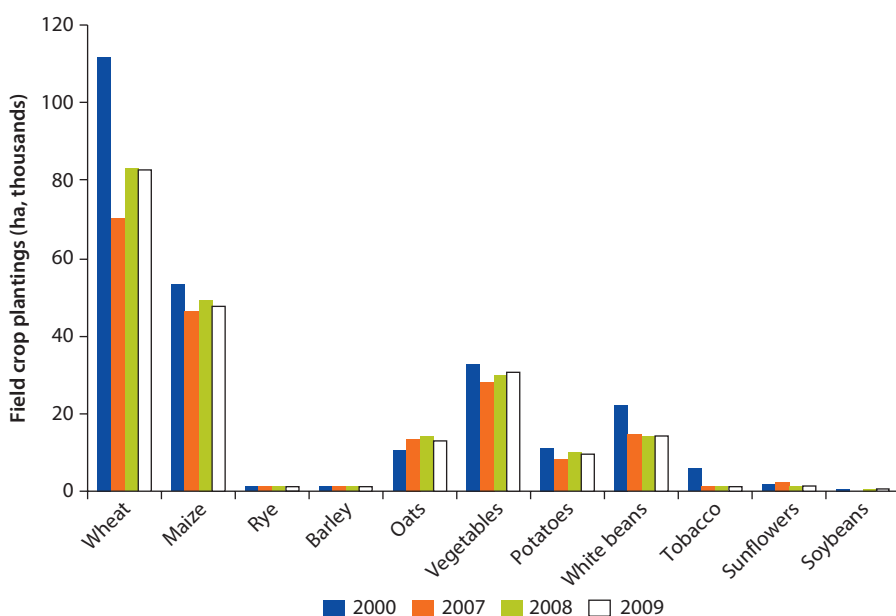
Although cereal field crops such as wheat and maize are grown extensively and occupy a larger percentage of the cropping land (see figure 1.1), their contribution by value is less than 50 percent of the contribution made by vegetable field crops, which garner a higher price. It should be noted that given the spatial variability of soils and climate, and access to water, infrastructure, and other

**Table 1.1 Value of Agricultural Products in Albania, 2008**

Description	Value (US\$ millions, 2008 <sup>a</sup> )	% of sectors listed
Cereals	546	28.6
Fibers	0	0.0
Fruit and tree crops	275	14.4
Livestock	1,036	54.3
Vegetables	51	2.7
Total	1,908	100

Sources: Food and Agriculture Organization Statistical Database; Albanian Institute of Statistics.

a. Used an exchange rate for 2008 of lek 83.842/US dollar.

**Figure 1.1 Area Planted by Crop in Albania, 2000–09**

Source: Ministry of Agriculture, Food and Consumer Protection, Republic of Albania, 2009.

Note: ha = hectare.

inputs, many areas of Albania outside of the coastal plain are unsuitable for high-value vegetable production and hence the reliance on more resilient, less input-intensive crops such as wheat, maize, and forage in the more mountainous areas.

Trends within the field crop sector over the last decade indicate an overall decline in areas planted, with a substantial decline in the area planted in wheat from the beginning of the current decade (see figure 1.1). Total crop area declined 4.2 percent from 2000 to 2009, while high-value vegetable crop areas remained roughly constant, with only a slight decline.

As noted above, livestock has long been an important component of the Albanian agricultural economy. After privatization of agriculture in the early 1990s, livestock numbers increased by 90 percent and reached its peak in 1995

**Table 1.2 Livestock Count, Gross Income, and Net Income by Agro-Ecological Zone**

	<i>Intermediate</i>	<i>Coastal Lowlands</i>	<i>Northern &amp; Central Mountains</i>	<i>Southern Highlands</i>
Beef cattle	68,200	63,800	60,100	49,500
Dairy cows	171,000	160,000	150,000	124,000
Goats	201,000	65,100	231,000	274,000
Sheep	552,000	164,000	681,000	370,000
Chickens	1,910,000	771,000	1,350,000	1,110,000
Gross income (000 US\$, 2009)	232,000	138,000	137,000	76,800
Net income (000 US\$, 2009)	4,710	2,840	12,200	2,710

Sources: Livestock counts from in-country sources. Data broken down to AEZ level using FAOSTAT gridded livestock data of the world (2005).

(with 840,000 cattle and 4.1 million sheep) due to growing demand for livestock products and low capital requirements. Consequently, the production of forage crops, especially alfalfa, increased throughout the country. Since 1995, number of livestock has started to decrease, partly as a result of people abandoning land in the mountainous parts of the country to move to urban areas. However, livestock production still contributes a large share of agricultural output and more than half of farmers' net income.

Table 1.2 shows that there is not much variation in livestock among AEZs with the exception that there are significantly fewer chicken, sheep and goats in the Coastal Lowlands than in the other three regions. Gross income from livestock is lowest in the Southern Highlands and highest in the Intermediate AEZ.

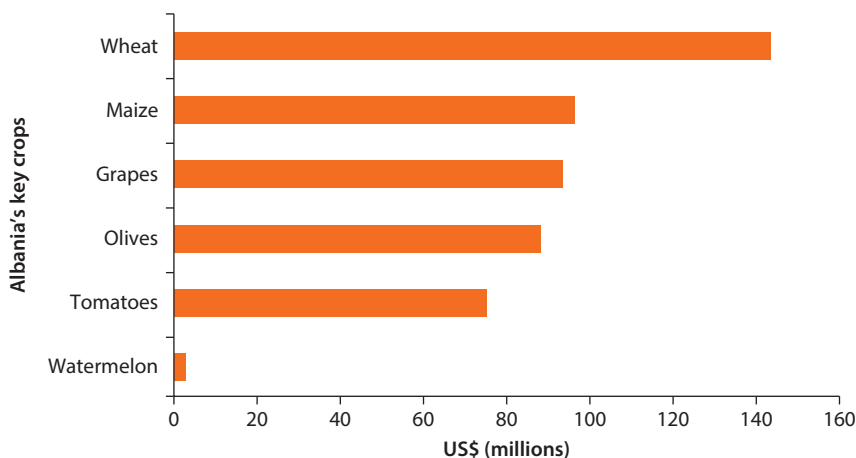
### ***Crop Focus for This Study***

For this study, based on extensive consultation with the Albanian steering committee and in particular the MoAFCP, there was a focus on eight crops, including four field crops (wheat, maize, tomatoes, and watermelons), two fruits (grapes and olives), and two crops used for livestock production (alfalfa and grassland pasture). Figure 1.2 provides estimates of the agricultural production value of six of these focus crops for this study (production estimates were not available for hay). With a total agricultural value (field crops plus fruit) in 2008 of US\$709 million, the key crops in figure 1.2 make up just over 70 percent of total agricultural value in Albania.

### **Exposure of Albania's Agricultural Systems to Climate Change**

Potential impacts of climate change on world food supply have been estimated in several studies (Parry et al. 2004). Results show that some regions and crops could improve production, while others could suffer yield losses. In Albania, the implications of climate change for Albanian agriculture could be substantial. Increased temperature accelerates crop phenology, which typically means there is less time for crops to develop the harvestable portions of the plant. High

**Figure 1.2 Estimated Value of Agricultural Production in 2008 at Producer Prices for Albania's Key Crops**



Source: FAOSTAT 2008 data.

temperatures and drought stress during critical growth periods can also reduce yields. Excess water from floods can also be damaging.

For some crops, (for example, winter wheat), increased temperatures can enhance yields. In the highland areas Albania, for example, winter wheat is cultivated at temperatures below the optimal temperature, and so climate change can enhance yields and extend the growing season.

Increased temperatures generally decrease livestock production potential and decrease water availability by lowering soil moisture, increasing evapotranspiration, and reducing the yield of water storage reservoirs through increased evaporation. The effect of precipitation on crops and water resources is generally more uniform than for temperature, at least for rainfed crops, with greater precipitation leading to higher yields and less precipitation reducing yields. The seasonal pattern of precipitation is critically important for rainfed crops, however. For example, in Albania, relatively low summer precipitation means rainfed maize cannot be profitably cultivated, and so maize in Albania is almost always irrigated.

### **Forecast Climate Changes for Albania**

The first step in understanding the exposure of Albania's agricultural systems to climate change is to understand the potential for changes in climate from the current baseline. This study attempts to capture a broad range of climate model forecasts by identifying high-impact, medium-impact, and low-impact scenarios through the year 2050. The scenarios are designed to represent a broad spread in the potential for climate to affect agriculture, as defined by a change in an indicator called the Climate Moisture Index (CMI; see box 1.1 for an explanation).

Maps 1.2 and 1.3 summarize the resulting forecast of changes in climate at the AEZ level from the current period baseline through 2050, by decade. Map 1.2 presents changes in temperature by AEZ from the baseline to the 2040s.

### Box 1.1 Developing a Range of Climate Scenarios

Climate change analyses require forecasts of how temperature, precipitation, and other climate variables of interest might change over time. Because there is great uncertainty in climate forecasts, it is best in a study such as this one to attempt to characterize a range of alternatives as well as a “central case” forecast.

The central concept used to select future climate scenarios was based on measures most likely to be relevant for the degree of impacts of climate to the agricultural sector. Because both temperature and precipitation affect agricultural productivity, scenarios were chosen based on a Climate Moisture Index or CMI. The CMI is based on the combined effect of temperature and precipitation, and as it is linked to soil moisture, it is believed to be well correlated with potential agricultural production.

Each scenario in our study corresponds to a specific global circulation model (GCM)/greenhouse gas (GHG) emissions scenario combination.

These scenarios were among those used by the Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment of the science of climate change (“Special Report on Emissions Scenarios,” or SRES) (IPCC 2007a, 2007b).

The study team relied on the three most commonly used GHG emissions scenarios: B1, A1B, and A2. A “wet” CMI scenario means that the location experienced the smallest impact (or change in) CMI—that is the “low impact” scenario. A dry scenario corresponds to high potential impact. The specific global general circulation model selected for the medium scenario is closest in consistency with the model mean CMI from a total of 56 readily available emission scenario–GCM combinations. An example of the GCM/emission scenario combinations chosen for Moldova is shown in the table.

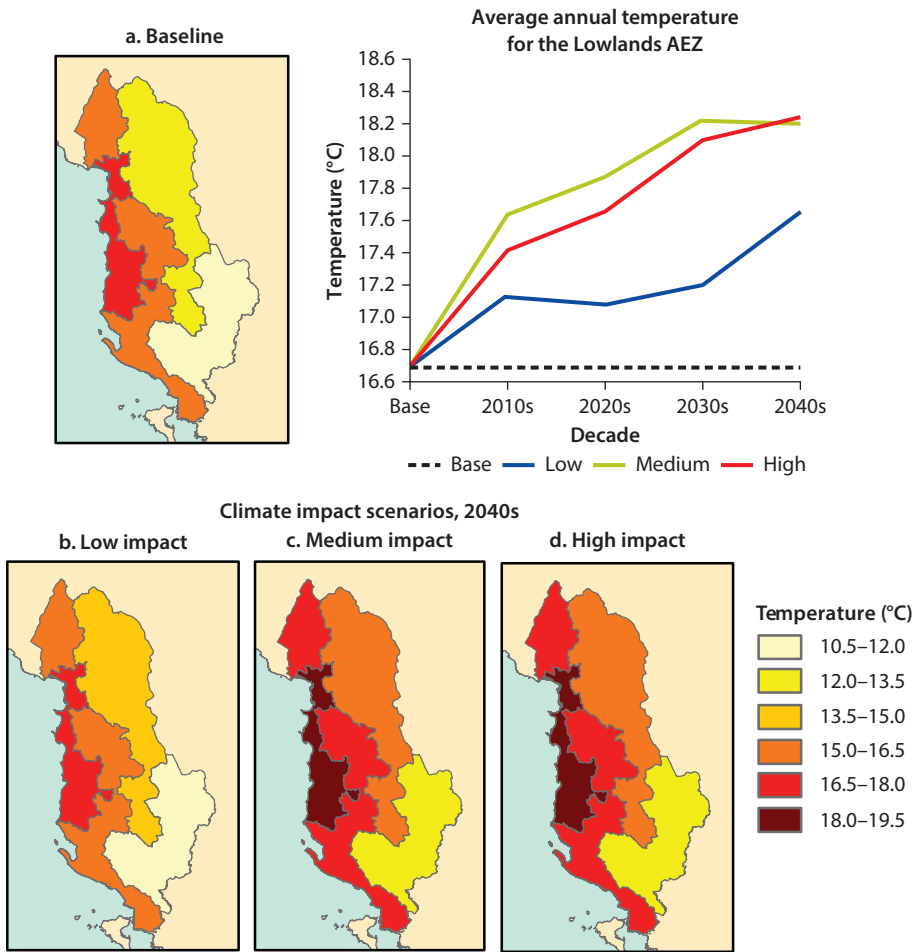
The advantages of this approach are that it provides a representation of a full range of available scenarios for future climate change in a manageable way, and that all climate scenarios are based on distinct GCM results. These results are themselves internally consistent in terms of the key GCM outputs the team used as inputs to the crop, livestock, and water resource impact modeling.

<i>This study's scenario</i>	<i>Global general circulation model basis for the scenario</i>	<i>Relevant IPCC SRES scenario</i>
High impact	Centre National de Recherches Météorologiques, Coupled Model 3 (France)	A1B
Medium impact	Center for Climate Modeling and Analysis, Coupled GCM 3.1.t63 (Canada)	A1B
Low impact	Goddard Institute for Space Studies, Model ER (US)	A2

Temperature under all scenarios increases gradually from the current base through 2050 with similar temperature increases under the medium- and high-impact scenarios and a lower increase under the low-impact scenario. This increasing trend in temperatures is consistent with the observed historical trend, and information gathered from farmer workshops conducted in Albania. In



**Map 1.2 Effect of Climate Change on Temperature through 2040s for the Three Climate Impact Scenarios**

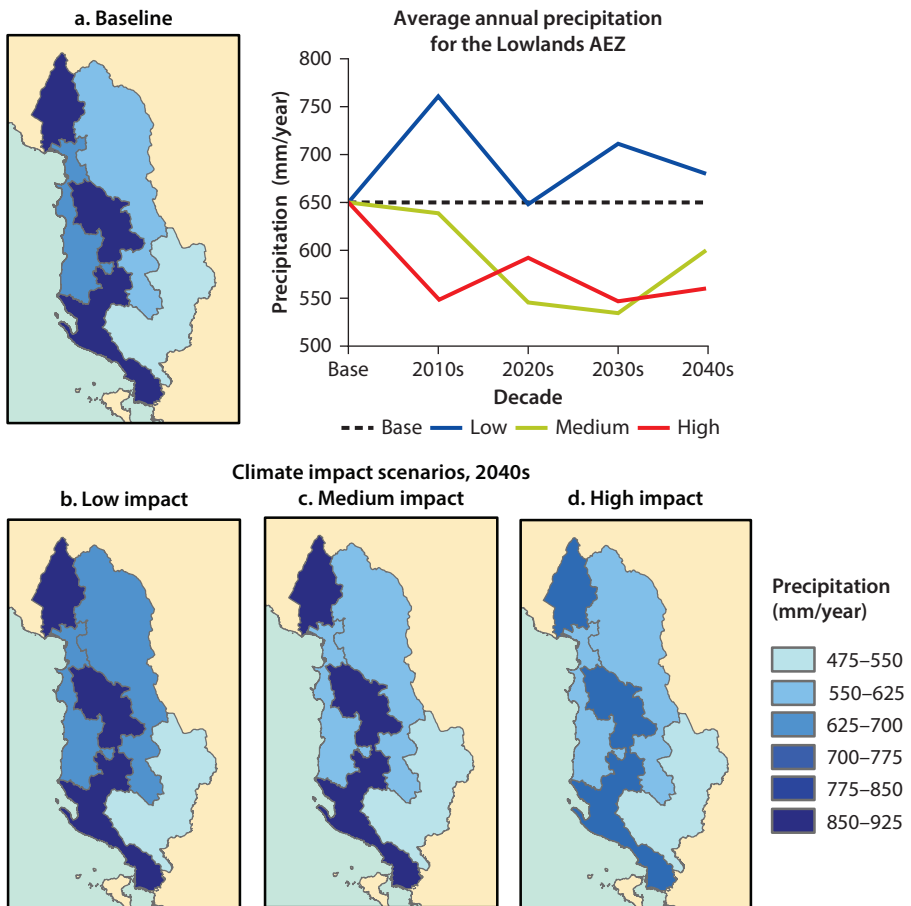


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addition to increases in average temperature, farmers also have observed an increasing trend in extreme heat events.

Data analysis supports the conclusion that the historical trend in temperature will accelerate in Albania in the near future. Although there remains uncertainty as to the degree of warming that will occur in Albania, the overall warming trend is clear and evident in all four AEZs, with average warming over the next 50 years for the medium-impact scenario of about 1.5°C, much greater than the increase of less than 0.5°C observed over the last 50 years. Warming could be more modest, but average temperature changes for the low-impact scenario nonetheless represent an increase of about 1°C compared to current conditions. In all scenarios, the warming trend relative to current conditions is about the same magnitude across the four AEZs, but the range of current temperatures across AEZs is quite large, with average temperatures in the Coastal Lowlands AEZ being as

**Map 1.3 Effect of Climate Change on Precipitation through 2040s for the Three Climate Impact Scenarios**



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much as 6°C higher than those in the Southern Highlands, and 4°C warmer than the Northern Mountains AEZ.

Map 1.3 presents changes in precipitation by AEZ from the baseline to the 2040s. For precipitation, by 2050 the low-, medium-, and high-impact scenarios indicate uncertainty in the direction of effect as well as its magnitude, with the low scenario forecasting an increase in precipitation, and the medium- and high-scenarios forecasting decreases. The use of GCMs also means that the decadal trend in precipitation is not smooth over time—this is consistent with current climate science which suggests that short-term and long-term trends in precipitation can vary substantially, with some scenarios showing increases in precipitation in the short term and decreases in the long term, and vice versa.

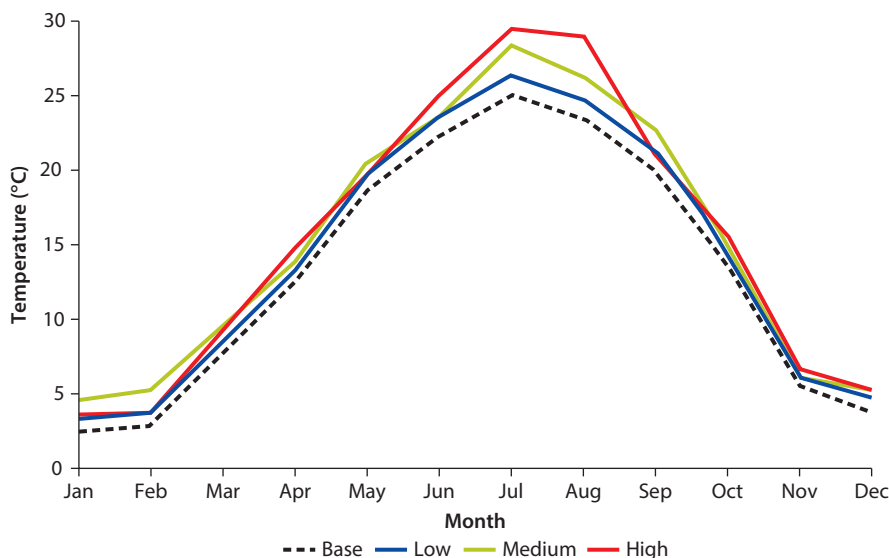
Precipitation changes are much more uncertain than temperature changes, as indicated by comparing map 1.2 with map 1.3. The medium-impact forecast

indicates a decline in precipitation nationally of about 50 mm per year, with most of this decline occurring in the Lowlands AEZ. The range of outcomes across the low- and high-impact alternative scenarios, however, is plus or minus 100 percent. Uncertainty at the regional level is even higher, and annual precipitation declines in the Lowlands and Intermediate AEZs, including areas around Lushnje, Vlores, Fushe-Kruje, and Shkodra, could be as large as 150 mm per year. Most models show that declines in precipitation in the mountainous areas of Albania, particularly around Korce, should experience only modest declines in annual precipitation.

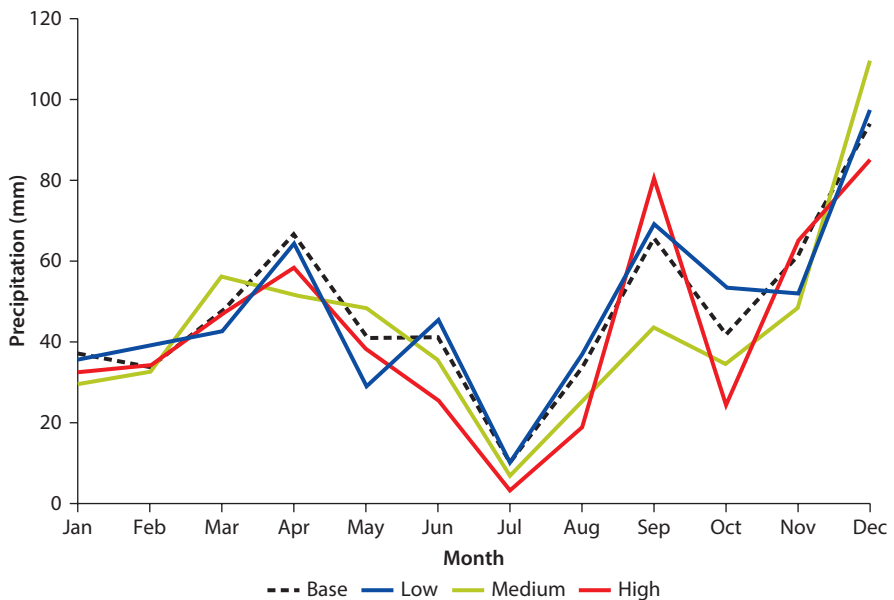
The national averages, however, are less important for agricultural production than the seasonal distribution of temperature and precipitation. For both temperature and precipitation, temperature increases are higher in July and August relative to current conditions; this summer temperature increase can be as much as 4–5°C in the northern mountains of Albania, when temperatures are already highest. In addition, forecast precipitation declines are greatest in the key May-to-September period, when precipitation is already lowest, particularly in the southern and northern mountains. Figures 1.3 and 1.4 present the monthly baseline and forecast temperatures and precipitation for the Northern Mountains AEZ.

Albania also has a history of relatively frequent flooding, especially in the last two decades. Flood events occur on a daily to weekly time-scale, and so the monthly data presented in the figures do not reflect the risk that climate change can lead to more extreme precipitation and flooding events. During the major flood of December 2010, 34,595 acres of Shkodra were submerged due to heavy rains and high levels of the Drin River (Lowen 2010). Flooding is particularly problematic in the northwest. This region has minimal watershed management and poor infrastructure. Flooding has worsened in recent decades most likely due

**Figure 1.3 Effect of Climate Change on Average Monthly Temperature for Northern Mountains AEZ, 2040s**



**Figure 1.4 Effect of Climate Change on Average Monthly Precipitation for Northern Mountains AEZ, 2040s**



to deforestation, overgrazing, and erosion, combined with a lack of maintenance of drainage canals and pumping stations. Additionally, river control programs were discontinued and reservoirs were silted. These disruptions led to a worsening of the hydroelectric and irrigation systems (Kodderitzsch 1999). In recent years, flooding has been most prevalent in the months of May through December.

Climate change could potentially increase the frequency and magnitude of flooding. While precipitation is only expected to increase in the low scenario by the 2040s (see map 1.3), rainfall events are expected to be larger and less frequent. Additionally, sea level rise and storm surge are expected to increase flooding in coastal areas. For the agriculture sector in Albania, floods are particularly problematic in the spring period, when they can delay or prevent planting of summer crops, and during late summer, when flooding can destroy the entire year's growth and prevent timely harvesting. Less serious flood events can reduce productivity through waterlogging of roots.

The results of detailed modeling of the effects of climate change on the key crops in Albania are included in chapter 3.<sup>1</sup> As described in greater detail in that chapter, the study concluded that the forecast changes in climate summarized in maps 1.2 and 1.3 present the following key vulnerabilities for Albania:

- Grapes and olives, which are rainfed crops in Albania, have a high potential for yield declines.
- Pasture, wheat, and irrigated alfalfa have a high potential for yield increases under all scenarios, due to beneficial effects of higher temperatures and a longer growing season.

- Tomato yields outside of greenhouses with climate controls may fall modestly. Given that tomatoes are mostly an irrigated crop in Albania, the main potential climate factor for tomatoes is temperature stress.
- Livestock are vulnerable to declines in productivity associated with higher temperatures.

### **Albania's Current Adaptive Capacity**

Assessing adaptive capacity in Albania's agricultural sector is challenging, because adaptive capacity reflects a very wide range of socioeconomic, policy, and institutional factors, at the farm, regional, and national levels. Some considerations in determining the variation in adaptive capacity across the country include current climatic exposure (described above), social structures, institutional capacity, knowledge and education, and access to infrastructure. Specifically, areas under marginal rainfed production will have less adaptive capacity than areas that are more productive and irrigated agricultural land. In addition, financial resources are one of the most important factors in determining adaptive capacity, as most planned adaptations are costly—by that measure, Albania ranks relatively low in overall adaptive capacity in the agriculture sector. Finally, agricultural systems that are poorly adapted to current climate are indicative of low adaptive capacity for future climate changes.

This section reviews three aspects of adaptive capacity: current agricultural policies and institutional capacities at the national level; evidence of adaptive capacity at the farm level based on consultations with Albanian farmers; and a brief review of evidence that Albanian agricultural systems for the crops studied here may be poorly adapted to current climate, reflecting a high current “adaptation deficit.”

### ***National Policies and Institutional Capacity***

At the national level, a high level of adaptive capacity in the agricultural sector is characterized by a high level of functionality in the provision of hydrometeorological and relevant geo-spatial data to farmers to support good farm-level decision-making; provision of other agronomic information through well-trained extension agents and well-functioning extension networks; and in-country research oriented toward innovations in agronomic practices in response to forecast climate changes. In addition, systems exist to ensure that collective water infrastructure is well maintained and meets the needs of the farming community. In addition, systems exist to resolve conflicts between farmers and other users over water provision. In Albania, some of these conditions exist, but most are currently inadequate, as outlined in the following:

- *The ability to collect, generate, and provide meteorological data to farmers is very low.* The main hydrometeorological institute in Albania is the Institute of Energy, Water and Environment (IoEWE), which is a center in the University of Tirana. This institutional arrangement has left the IoEWE with an acute

shortage of funding. Although the Institute has in the past provided some data to global data clearinghouses such as those maintained by the UN, they were unable to provide data to this study. They have very limited or no means of collecting and sharing data from electronic stations in real time; as a result, farmers rely solely on privately funded or neighboring country sources for meteorological information.

- *The current agricultural extension service is institutionally far-reaching but not oriented toward ameliorating risks from climate.* Extension in Albania employs 250 extension service personnel who work in 100 small offices throughout the country. The overall budget for extension is €1 million, but less than €200,000 is available for operations. While virtually all farmers are aware of the extension service, and roughly 70–80 percent make use of their services, the current extension service has little or no capacity to advise on adapting agricultural systems to the climate risks outlined in this study.
- *Agricultural research capabilities are expanding but have few connections to extension.* The Agriculture Technology Transfer Centers, or ATTTCs, conduct agricultural research and retain information. There is a clear and rational scheme to the division of research responsibilities by crop and region across these five institutions, and there is some effort devoted to livestock varieties as well. These agricultural research institutes, however, have yet to focus on climate change as a major risk to agricultural production, and are not as effectively coordinated with the extension service as they could be. Further, research could be better focused on leveraging advances in seed varieties and farming practices shown to be effective in other countries, and coordinating with the extension service to demonstrate these results locally, particularly for small-scale farmers.
- *Many farms are small and have limited resources for adaptation investments.* An early priority of transition period reforms in agriculture was land privatization. During 1990–2004, 564,000 hectares of agricultural land or 98.9 percent of land planned for distribution was privatized, resulting in the creation of about 450,000 private farms with an average size of 1.3 hectares. The total number of farms is gradually decreasing mainly due to migration and farm mergers, but the average size remains small and ownership of parcels can be fragmented. Production on most small farms cannot be mechanized due to financial constraints.
- *Agricultural markets are limited.* Farms in Albania are mostly subsistence farms that produce for family consumption and have no market links. Most farmers operate as individuals, and organized activities in marketing and other areas are very limited. A few entrepreneurial landowners are developing businesses (vegetable and fruit production, especially grapes) aimed at wholesale markets, and the number of such producers is gradually increasing.
- *Agricultural policy is well planned, but resources for implementing these plans are limited.* The Ministry of Agriculture, Food and Consumer Protection (MoAF-CP) oversees the agricultural sector. Farmland management, irrigation and drainage, and immovable property registration fall under the responsibility of

the Ministry. There are also local Land Administration and Protection (LAP) units in each district that report directly to the local government. A key strategic document, the National Environmental Action Plan (NEAP), was prepared in 1994 and revised in 2001 with the ultimate goal of meeting the constitutional right to live in an ecologically healthy environment. The plan identified several priority investment programs, including watershed management, forestry, and flood control. The National Strategy on Agriculture and Food and the National Strategy Plan for Rural Development, both covering the period 2007–13, were developed as part of the overall National Strategy on Social and Economic Development. These plans provide the framework for integrated rural development programs and are designed to enhance synergies among all related public institutions. Poverty reduction and sustainable management of natural resources (including land, water, and biodiversity) are among the objectives. However, strategies and legislation are not always translated into programs and projects, mainly because most of the activities included in these strategies require investments that are too high for the state budget. Implementation is also hindered by the limited professional capacities of relevant institutions. Hence, continuous international donors support is a crucial element for ensuring and expanding implementation.

### ***Adaptive Capacity Assessment from Farmer Consultations***

As described more fully in chapter 4, farmers at the AEZ level were twice consulted for the study. Both consultations included opportunities for farmers to share their concerns about the risks climate change posed for their crops, and to identify where they saw low current adaptive capacity. In the first consultation, farmers identified several climate stressors of concern, including temperature stress, water quality, drainage, and extreme weather events; they also expressed concerns that the current extension service was not adequate to help them address these problems. In the second consultation, the following questions were asked in an effort to identify the adaptive capacity of farmers in the region:

1. How have water quality issues affected you?
2. Do you have drainage issues? Do you have drainage systems on your farms? Why or why not?
3. How many farmers are reached by extension services?
4. What weather events are most difficult to adapt to now (that is, floods, droughts, heat waves)?

Some common themes emerged across all of the AEZ meetings, and other results were specific to AEZs. An overview of themes specific to each AEZ is given in box 1.2. The common themes in terms of current adaptive capacity were as follows:

- *Water infrastructure remains in poor repair.* Two World Bank Projects on irrigation (between 1993 and 2004) helped to rehabilitate irrigation and drainage

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**Box 1.2 Adaptive Capacity Assessment from Farmer Consultations**

As described more fully in chapter 4, consultations with farmers at the AEZ level were carried out within the context of this study. (For more details, see chapter 4.) Some common themes emerged across all of the AEZ meetings, and other results were specific to AEZs.

*Northern/Central Mountains and Intermediate AEZs.* In this region, farmers confirmed that climate change impacts have a present effect on agriculture. The most significant impact currently posing the greatest risk is flooding, as evidenced from recent events there that greatly reduced crop yields. Droughts are also a primary concern; farmers do not feel equipped to respond to either floods or droughts effectively. Although there are 32,000 hectares of irrigated farmland in this region, 10,000 hectares cannot currently access the irrigation network and are therefore highly susceptible to droughts. In addition, in higher elevation areas, accessing groundwater as an alternative irrigation source is considerably more difficult and costly. Heat waves were mentioned in the discussions as occurring roughly every 5–10 years, but these were not emphasized as a primary concern.

Drainage problems were a significant issue for those in the Intermediate AEZ, but not for those in the mountains. Water availability was also mentioned. Most farmers get water from wells, but each year they must dig deeper due to declining water levels. Water quality was not mentioned as a concern.

*Lowlands AEZ.* The primary climate issue in this region is drought. Because the irrigation and drainage infrastructure is often non-functional, farmers have very limited capacity to adapt to droughts. Heat waves are the next most significant issue. One farmer explained that he tries to cover his watermelons in hay to reduce sun and heat damage, but normally farmers cannot adapt to this issue and suffer yield losses and reductions in quality. Floods were not mentioned as a very significant issue in this AEZ.

Farmers confirmed that drainage of soils is a primary problem, as are water quality issues. In particular, both water from reservoirs and the upper groundwater layer are of low quality.

*Southern Highlands AEZ.* Farmers have very limited capacity to adapt to the regular droughts and heat waves that occur in this AEZ. Although floods and hail events also occur, these are not as much of a concern. During heat waves, hot, dry winds lasting as little as two to three days can be a major risk, and affect both the quality and quantity of production. As indicated in the first stakeholder meetings, the irrigation and drainage system is in need of rehabilitation. Water quality is not considered to be an issue in this AEZ.

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infrastructure; secondary and tertiary irrigation facilities were transferred to WUAs, and primary canals and head-works to the Federations. The two projects together have rehabilitated irrigation infrastructure on 180,000 ha and drainage on 120,000 hectares, or about 40 and 50 percent, respectively, of the area originally equipped for irrigation and drainage. Although these projects were success stories and have made Albania a model of decentralized irrigation management for the region, there remain problems with irrigation and drainage infrastructure. Depending on the specific climate related risk faced



by each AEZ, the priority infrastructure was for either irrigation or drainage. For example, a good deal of land in the Lowlands region lies below sea level. One farmer, who farms 10 hectares with a partner, says that the roots of his plum trees rot during especially wet seasons, a phenomenon that occurs with increasing frequency. If drainage channels were functioning properly this would not be an issue.

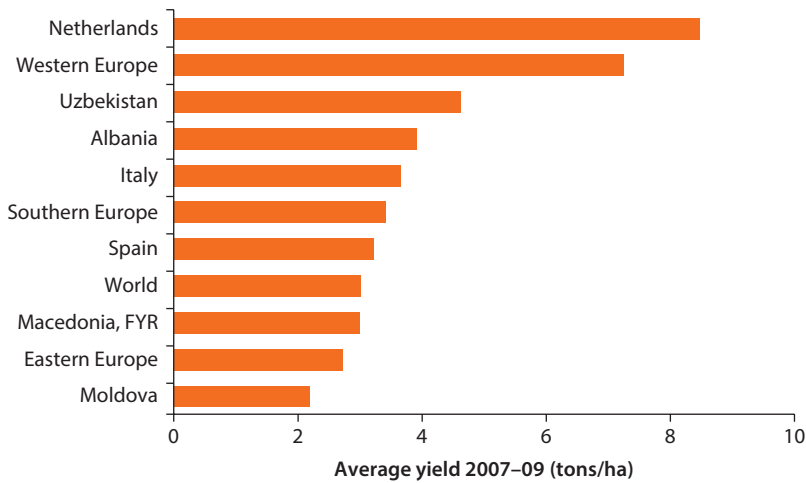
- *Extension and hydrometeorological institutional capacity are low.* The need for capacity building to enhance adaptive capacity was universally mentioned, especially in the suggestion to increase the reach of extension services. Other capacity building recommendations included technical training, seed and crop selection, and increasing the availability of region-specific hydro-meteorological information.
- *Market structure is inadequate.* Farmers emphasized that overall market effectiveness would assist in making farms more productive and provide a win-win adaptive response. Farmers expressed frustration in the absence of logistical support in the country, such as processing and storage facilities. They also expressed frustration at the small size of their farms.

### ***Crop Yields and Practices for Selected Crops***

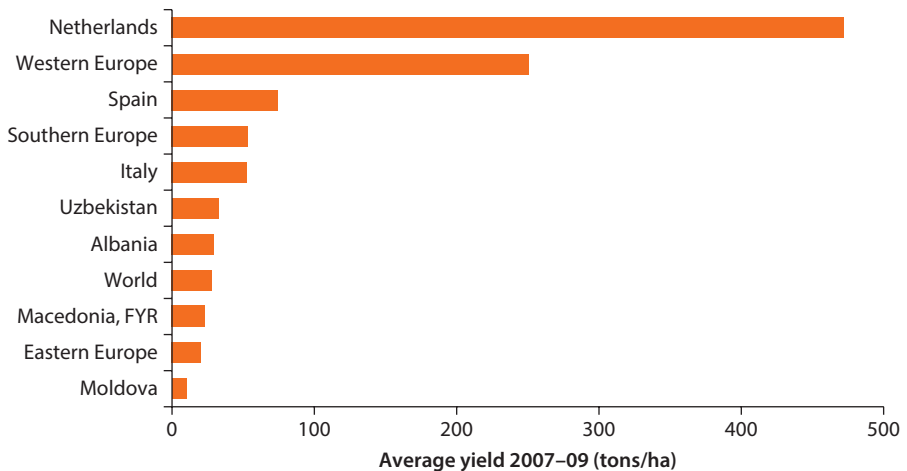
One observable indicator of adaptive capacity is the degree to which current agricultural crop yields and practices keep pace with those in other countries and international averages for key crops. The result of such an assessment gives a sense of what is sometimes termed an “adaptation deficit,” or the degree to which agricultural systems may not be adapted to current climate. If crop yields are relatively low by international standards, it suggests current marginal production may have little resiliency in the face of new climate stresses, and a high potential to be devastated by climate changes.

Relative yields for two important Albanian crops were reviewed through analysis of FAO data: wheat and tomatoes. For wheat, FAO statistics suggest that wheat production overall is close to four tons per hectare, reflecting a mix of rainfed and irrigated wheat. This is less, on average, than yields for other parts of Europe, but relatively high internationally and greater than for the United States (figure 1.5). One reason is that Albania has a relatively high portion of irrigated wheat, making their overall average wheat yield relatively high as well. Under irrigation, a good commercial wheat grain yield by international standards is 6–9 tons per hectare. In the lowlands of Albania, these values are reached, however, in the highlands, yields of 4–5 tons per hectare are more typical.

For tomatoes, Albania has a relatively low overall yield compared to other parts of Europe (figure 1.6). A good commercial tomato yield under irrigation is about 250 tons per hectare fresh fruit, of which around 90–95 percent is moisture. In Albania, where most of the tomatoes are irrigated, yields generally fall far short of this level. In the lowlands, yields usually reach about 30–60 tons per hectare. In the highlands, these values are around 20 tons per hectare. A major factor for high tomato yields is the use of greenhouses. A large part of the total

**Figure 1.5 Wheat Yield in Selected Relevant Countries, Average 2007–09**

Source: FAOSTAT 2007–09, Crop Production. Accessed December 2010 from <http://faostat.fao.org/site/567/default.aspx#ancor>.

**Figure 1.6 Tomato Fresh Yield in Selected Relevant Countries, Average 2007–09**

Source: FAOSTAT 2007–09, Crop Production. Accessed December 2010 from <http://faostat.fao.org/site/567/default.aspx#ancor>.

production in Albania comes from greenhouses, however, but the greenhouses vary in their quality and sophistication. More important factors are likely poorly optimized fertilizer and irrigation water application.

The overall conclusion of this review is that current wheat production enjoys a significant comparative advantage because of the widespread accessibility of irrigation capacity in Albania. For tomatoes, however, there remains significant room for enhancing adaptive capacity to current climate in Albania. As indicated later in this report, many of the options for adapting Albanian agriculture to

climate change have very high benefit-cost ratios for adaptation options that focus on improving tomato yield.

### **How This Study Can Assist Albania**

The need to adapt to climate change in all sectors is now clear. International efforts to limit greenhouse gases and, in the process, to mitigate climate change now and in the future will not be sufficient to prevent the harmful effects of temperature increases, changes in precipitation, and increased frequency and severity of extreme weather events.

At the same time, climate change can also create opportunities, particularly in the agricultural sector. Increased temperatures can lengthen growing seasons, higher carbon dioxide concentrations can enhance plant growth, and in some areas rainfall and the availability of water resources can increase as a result of climate change.

The risks of climate change cannot be effectively dealt with, and the opportunities cannot be effectively exploited, without a clear plan for aligning agricultural policies with climate change, for developing key agricultural institution capabilities, and for making needed infrastructure and on-farm investments. Developing such a plan ideally involves a combination of high-quality quantitative analysis and consultation of key stakeholders, particularly farmers, as well as in-country agricultural experts.

Another important motivating factor for Albania's development of an adaptation plan for agriculture is furthering Albania's work toward European Union accession. Albania has already begun the process of aligning laws that affect the agriculture sector to be in compliance with European requirements; along with these needed reforms, the EU encourages specific action toward climate change preparedness and adaptation. As outlined in a 2009 EU White Paper on the topic, these actions could include systematic assessment of climate risks, development of outreach initiatives to train farmers in such areas as improving water use efficiency, and identification of needs for financing of adaptation measures. These are the steps undertaken in this study.

This study provides a framework for evaluating alternatives for investment in adaptation, for the Albanian national government, potentially assisted by the donor community, and for the private agricultural sector. The framework has two critical components:

1. *Rigorous quantitative assessments, supplemented by expert opinions that considered not only the current climate outlook but also several scenarios of future climate change.* The quantitative analyses rely on local data to the extent possible to assess the risks of climate change to specific crops and areas of the country, but also to assess whether the costs of investments justify the benefits in terms of enhancing crop yield now and in the future. In addition, the study considers the specific water resource availability conditions at the basin level, now and in the future.

2. *Structured discussion with local experts and farmers to evaluate both the potential for specific adaptation strategies to yield economic benefits as well as the feasibility and acceptability of these options.* The input of Albanian farmers to this process was critical to ensuring that the quantitative analyses were reasonable and that the team did not overlook important adaptation actions.

Further, the study provides a ranking of the options based on both quantitative and qualitative results. The ranking can be used to establish priorities for policy-makers in enhancing the resilience of the Albanian agricultural sector to climate change. Two types of results from this study should therefore be most critical for Albanian policymakers:

1. *Specific infrastructure improvement actions, such as rehabilitating drainage and secondary irrigation capacity, should be high priorities for Albanian and international donor community investments.* It is important to remember, however, that this study maintained a broad focus, so the results do not represent project-level feasibility evaluations, but rather broad-scale scoping studies. As a result, pursuit of specific investments may require additional, more detailed feasibility studies.
2. *Creating conditions for farmers to make wise investments themselves to enhance their own adaptive capacity is important.* A number of the farm-level adaptive actions focus on changes in practices—such as better optimizing inputs and use of heat- or drought-tolerant seed varieties—that farmers can readily implement themselves. Policymakers should, however, be aware that many Albanian farmers currently lack the training or the information (for example, weather forecasts) to implement these practices wisely and effectively. National policymakers should therefore consider making these options focal points for expanding and improving extension services to farmers that explicitly consider adaptation to current climate and forecast changes in climate in the future.

The most effective plans for adapting the sector to climate change will involve both human capital and physical capital enhancements, but many of these investments can also enhance agricultural productivity immediately, under current climate conditions. These options, such as improving the accessibility to farmers of agriculturally relevant weather forecasts, will yield benefits as soon as they are implemented and provide a means for farmers to autonomously adapt their practices as climate changes.

## **Structure of the Report**

The remainder of this report consists of five chapters. Chapter 2 summarizes the design and methodology for the study, and chapter 3 reviews the results of the impact assessment. Chapter 4 describes the stakeholder processes employed to identify and evaluate adaptation options, and chapter 5 provides a benefit-cost

analysis of selected options. Finally, chapter 6 presents the overall recommendations for specific adaptation options at the national level and for each AEZ.

**Note**

1. A further factor in evaluating vulnerabilities is the fertilizing effect, for some crops, of increases in ambient CO<sub>2</sub> concentrations. Those results are reviewed in chapter 3.



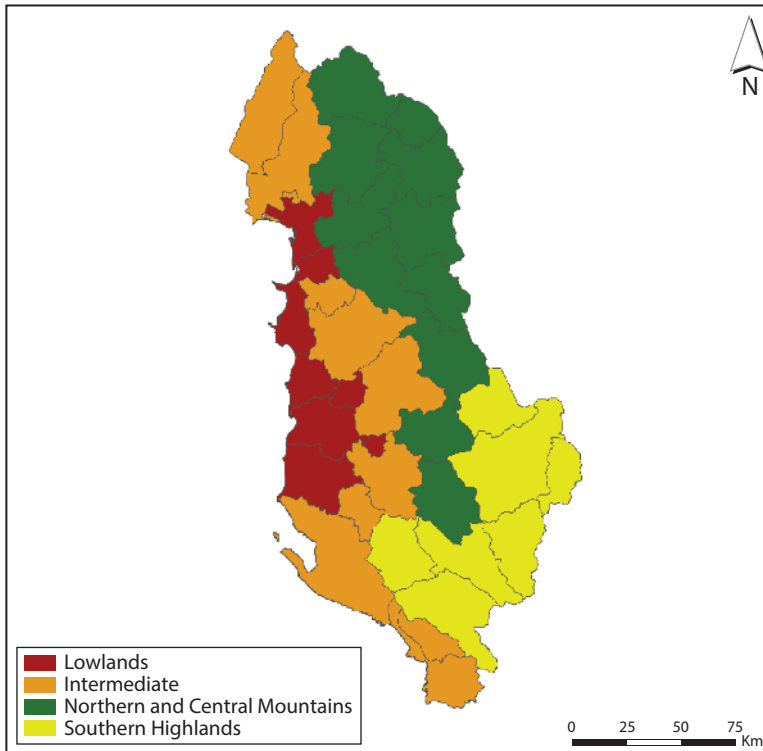
# Design and Methodology

### Overview of Approach

The overall scope of the assessment of adaptation options is as follows:

- *Geographic scope:* The analysis was conducted at the AEZ level, as indicated in map 2.1, using representative farms in each of the zones.
- *Crops:* Based on the abilities of existing crop models, consultation with Albanian counterparts, and the availability of appropriate data to support modeling, the following crops were evaluated quantitatively: wheat; maize; alfalfa; tomato; olive tree; grapes; watermelon; and rainfed pasture (grasslands).
- *Future climate:* Three future climate scenarios were created, based on projections of temperature and precipitation at the country level in 2050. The three scenarios (low-, medium-, and high-impact) were designed to reflect a range of GCM outcomes for agriculture. Climate scenarios were based on a country-level analysis, and were applied consistently across all four AEZ regions.
- *Time period:* Results were generated using decadal averages from 2010 to 2050 (that is, 2010s, 2020s, 2030s, and 2040s).
- *Economic assumptions:* Results were based on two economic projections: continuation of current conditions, prices, and markets; and an alternative crop price projection through 2050 as developed and recently published by the International Food Policy Research Institute (IFPRI).
- *Baseline for evaluation:* The benefits and costs of each of the options were evaluated relative to the “current conditions” baseline. As a result, in some cases the benefits and costs of adaptation options may reflect the benefits of both adapting to climate change and improving the current agricultural system; these options were regarded as “win-win” in nature.

The overall study was conducted in three stages, as outlined in figure 2.1. The first stage focused on awareness-raising and on developing an overall methodology and scope for the study. This phase began in October 2009 with an Awareness Raising Workshop organized by the World Bank, Ministry of

**Map 2.1 Agro-Ecological Zones in Albania**

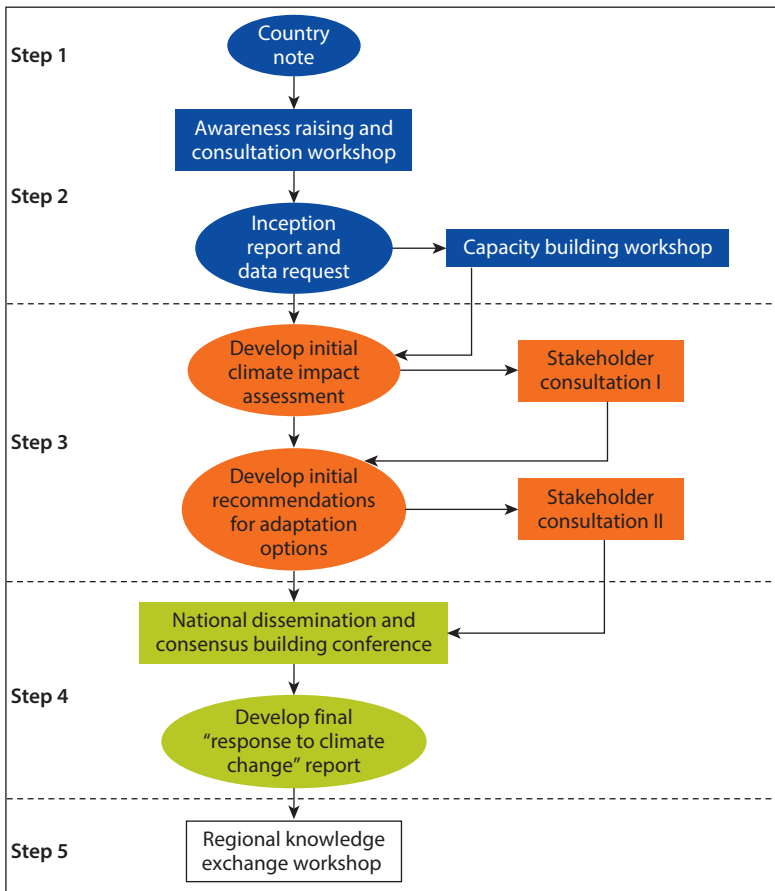
Sources: © Industrial Economics. Used with permission; reuse allowed via Creative Commons Attribution 3.0 Unported license (CC BY 3.0). AEZs adapted from Shundi 2003; administrative boundaries based on GADM databases of Global Administrative Areas and used via CC BY 3.0.  
 Note: AEZ = agro-ecological zone.

Agriculture, Food and Consumer Protection (MoAFCP), and Ministry of Environment, Forests and Water Administration (MoEFWA). It continued in March 2010 with an initial mission and concluded with the acceptance of an inception report and work plan by the Albanian counterparts.

The second stage was the climate impact assessment for the agricultural sector, beginning with data collection, and culminating in a capacity building session. At the conclusion of the impact assessment an initial stakeholder outreach was conducted, which involved a participatory process with farmers to continue awareness-raising, establish a reasonable baseline for the analysis, and gather ideas for adaptive measures to assess in the third stage. A team travelled to each of the agro-ecological zones to report on the results of the initial climate impact assessment modeling and collect input on adaptation options that might be pursued in response to these projected impacts.

The third stage involved refinement of the impact assessment and additional analysis to develop the quantitative analysis, a qualitative expert assessment, and recommendations from Albanian farmers for the adaptation menu. In January 2010, a second stakeholder workshop was conducted with farmers to afford them



**Figure 2.1 Flow of Major Study Action Steps**

an opportunity to review and comment on the draft menu of options. The study culminated in the Albanian National Dissemination and Consensus Building Conference in March 2010, and revision of this report reflected those outcomes.

The remainder of this chapter describes three key steps in the quantitative analysis. The next section describes how future climate scenarios were developed and applied to conduct an agricultural sector climate impact assessment, modeling a baseline of effects of changed climate on the current agricultural system, before adaptation. "Development of Adaptation Menu" provides details on the assessment of the effect of specific adaptation options on crop yields and farm revenues. "Assessing Risks to Livestock" provides an overview of assessment of risks to livestock.

This chapter focuses on the methods used in the quantitative analysis. The final set of options in chapter 6, however, includes elements of quantitative modeling, qualitative assessment, and participatory strategies among farmers. The other elements of the approach are described in chapter 4.

## Climate Scenarios and Impact Assessment

Overall, there are four steps in the development of the impact methodology: (1) identify major agricultural growing regions in Albania, (2) gather baseline data, (3) develop climate projections, and (4) use baseline and climate projection data to conduct the impact assessment.

### **Step 1: Identify Agricultural Growing Regions of Albania**

Results were generated for “representative farms” in each of the major agricultural production regions of Albania, at least one of which must be in each of the four agro-ecological zones (AEZs). Presenting the results at this spatial scale allows the use of baseline data from meteorological stations that are co-located with agricultural regions, and avoids needing to either interpolate data between stations or rely upon global sources of gridded data (which have already used interpolation). Note that this approach focuses the analysis on regions that are currently in agriculture and does not evaluate regions that may become newly suitable for agriculture as the climate changes.

Information on rainfed and irrigated crop coverage across Albania was collected based on remote sensing data from several international sources (for example, MIRCA dataset for 26 irrigated and rainfed crops at ~5 minute resolution, McGill dataset for 175 crops at ~5 minute resolution, and SPAM [Spatial Production Allocation Model] dataset of detailed global crop maps from IFFPRI). Unfortunately, local meteorological data were not available.

### **Step 2: Gather Baseline Data**

Baseline meteorological, soil, and water resource data were provided from in-country and global sources. While station-level meteorology is preferred, it was not provided in Albania. As a result, global sources were relied on for the meteorological and soils data inputs. In-country data were obtained for the water resources requirements. These requirements include:

- *Meteorological.* Because AquaCrop is a daily model, the crop modeling methodology requires at least 10 years of daily historical data in the major agricultural regions of Albania.
- *Soil characteristics.* Crop modeling requires data on soil type, suitability, erosion potential, and hydrology characteristics.
- *Water resources.* Water resource modeling requires at least 10 years of average daily (preferably) or monthly historical river flow data for gauging stations along the main stem rivers of each major drainage basin in Albania. These were provided by in-country sources. In addition, locations and active storage volumes of each major reservoir were obtained from in-country sources.

Where global sources of data, available at a grid-cell level were used, gridded meteorological data are translated to the agricultural production regions, and spatially average daily data for grid cells covering that region.

### **Step 3: Develop Climate Projections**

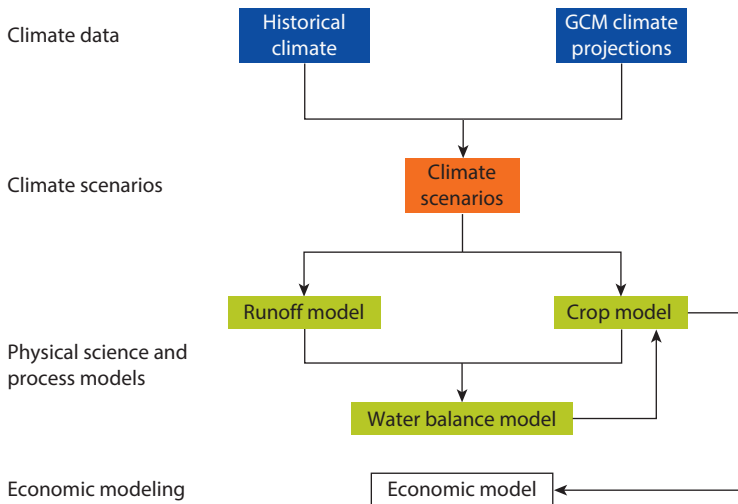
The climate projections combine information from the baseline datasets with projections of changes in climate obtained from global circulation model (GCM) results prepared for the United Nations Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. As noted in box 1.1, three climate scenarios were developed for Albania. The scenarios are defined by the Climate Moisture Index (CMI), which is an indicator of the aridity of a region.<sup>1</sup> Based on the average of CMI values across Albania, three scenarios (the driest, the wettest, and medium) were created from among the 56 available GCM combinations deployed by IPCC for 2050. The following two subtasks were conducted:

- *Decadal monthly changes in precipitation and temperature were generated.* Monthly changes in climate were generated based on differences between future projections of temperature and precipitation and twentieth-century baseline outputs for each GCM. Following the literature, absolute changes in temperature and relative changes in precipitation are presented.
- *These monthly decadal changes were translated to daily changes.* Crop modeling under future climate change also requires daily data for the period 2010–50, but the GCMs only produce 12 monthly outputs for each decade between 2010 and 2050 (that is, four sets of 12 monthly values). Therefore, decadal monthly changes are used, combined with the earliest decade of available in-country daily station data, to scale the future projections.<sup>2</sup>

### **Step 4: Conduct Impact Assessment**

The impact assessment uses the process-based crop model AquaCrop to analyze changes in crop yields across Albania, and the CLIRUN model to analyze changes in water runoff. The WEAP (Water Evaluation and Planning System) model is then applied, using the inputs from CLIRUN to analyze potential basin-level shortages in water available to agriculture. Any estimated water shortage is fed back to the biophysical step to estimate the net effect of the shortage on irrigated crop yields. As outlined in the next chapter, however, water appears to be abundant in Albania, and will likely remain so as climate changes. Accordingly, there were no water shortages for agriculture identified for this country.

The interactions between these tools are presented in figure 2.2. Note that this figure also includes an economic model that is applicable to the adaptation assessment (described below). The AquaCrop, CLIRUN, and WEAP tools are briefly described in box 2.1. As indicated in the box, these tools are well suited to climate change impact and adaptation analyses. The AquaCrop tool addresses the effects of changes in temperature and water stress on crop growth and yields, but it does not consider the impacts of pests on these outcomes, either in the base case or with altered pest activity that might result from climate change.

**Figure 2.2 Analytic Steps Action Step 3: Quantitative Modeling of Adaptation Options**

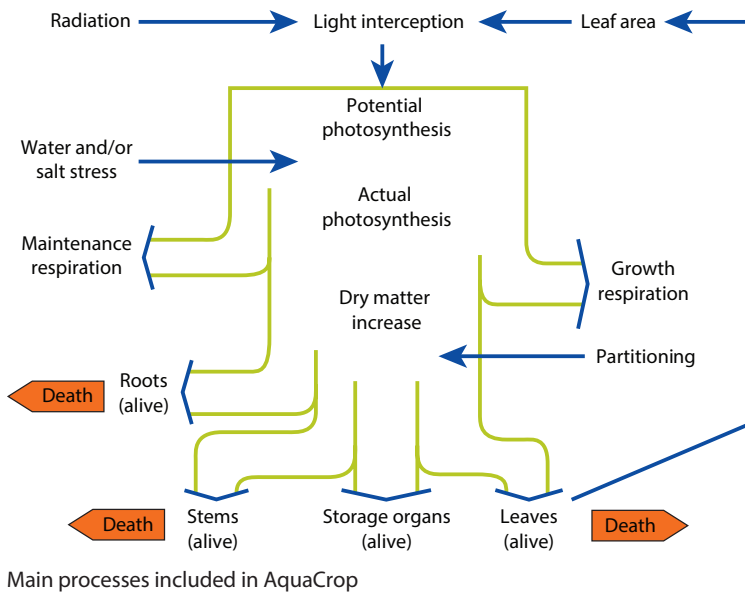
Note: GCM = global circulation model.

### Box 2.1 Brief Description of Modeling Tools

The three models used in this study are AquaCrop, CLIRUN, and WEAP. Below is a brief description of each of these models. All are in the public domain, have been applied worldwide frequently, and have a user-friendly interface:

- *AquaCrop*: The strengths of this process model are in its simplicity to evaluate the impact of climate change and evaluation of adaptation strategies on crops, and also in its ability to evaluate the effects of water stress and estimate crop water demand, both key issues in Albania currently and with climate change. The model was developed and is maintained and supported by the Food and Agriculture Organization (FAO) and is the successor of the well-known CropWat package. Other advantages of the model are its widespread use and straightforward analysis. The model is mainly parametric-oriented and therefore less data demanding. The diagram included in this box illustrates some of the main crop growth processes reflected in AquaCrop.
- *CLIRUN*: Monthly runoff in each catchment can be estimated using this hydrologic model that is widely used in climate change hydrologic assessments. CLIRUN models runoff as a lumped watershed with climate inputs and soil characteristics averaged over the watershed simulating runoff at a gauged location at the mouth of the catchment. CLIRUN can run on a daily or monthly time step. Soil water is modeled as a two-layer system: a soil layer, and a groundwater layer. These two components correspond to a quick and a slow runoff response to effective precipitation. A suite of potential evapotranspiration models is available for use in CLIRUN. Actual evapotranspiration is a function of potential and actual soil moisture state following the FAO method. CLIRUN can be parameterized using globally available data, but any local databases can also be used to enhance the data for the models. CLIRUN produces monthly runoff for each watershed.

*box continues next page*

**Box 2.1 Brief Description of Modeling Tools** (continued)

- **WEAP:** The Water Evaluation and Planning System (WEAP) is a software tool for integrated water resources planning that attempts to assist rather than substitute for the skilled planner. It provides a comprehensive, flexible, and user-friendly framework for planning and policy analysis. River basin software tools such as WEAP provide a mathematical representation of the river basin encompassing the configuration of the main rivers and their tributaries, the hydrology of the basin in space and time, existing as well as potential major schemes and their various demands of water. The WEAP application proposed for this study would model demands and storage in aggregate, providing a good base for future more detailed modeling. WEAP was developed by the Stockholm Environment Institute (SEI) and is maintained by SEI-US. Although it is proprietary, SEI makes the model available for a nominal fee for developing country applications.

## Development of Adaptation Menu

Building on the four steps of the impact assessment, there are three additional steps necessary to develop the adaptation menu: (5) select and categorize a set of adaptation options to be considered for Albania, (6) conduct qualitative and quantitative assessments of those options, and (7) develop a ranked order menu of adaptation options.

### **Step 5: Select and Categorize Adaptation Options for Each Country**

A set of adaptation alternatives was defined and categorized. This list was supplemented by stakeholder recommendations from the consultation workshops. The adaptation options fall into four categories:

- *Indirect*. Broad investments in programs, policies, and infrastructure that indirectly benefits agriculture (for example, road improvements)
- *Programmatic*. Investments in programs and policies that are targeted specifically at agriculture (for example, research and development [R&D], extension services)
- *Farm management*. Non-infrastructure farm management improvements aimed at improving farm productivity (for example, changing planting dates or crop varieties)
- *Infrastructural*. Infrastructure investments that improve farm productivity and/or reduce variability. These may include farm-level investments such as rainwater harvesting, or sector investments such as irrigation infrastructure or reservoir storage.

The initial list of categorized adaptation options for Albania is provided in chapter 5.

### **Step 6: Conduct Adaptation Assessment**

The adaptation options are evaluated based primarily on four criteria: (1) net economic benefits (quantified where possible, based on expert assessment otherwise); (2) robustness to different climate conditions; (3) potential to aid farmers with or without climate change, otherwise referred to as “win-win” potential; and (4) favorable evaluation by stakeholders. Because of data limitations, not all options are evaluated quantitatively. Methodologies for addressing each of the criteria are described below.

#### **Criterion 1: Net Economic Benefits**

The net economic benefit model evaluates a subset of the adaptation options in terms of both their net present value (NPV; total discounted benefits less discounted costs) and their benefit-cost ratio (B-C ratio; total discounted benefits divided by discounted costs) over the time period of the study. Ranking based solely on NPV would tend to favor projects with higher costs and returns; considering the B-C ratio highlights the value of smaller scale adaptation options suitable for small-scale farming operations. The economic model produces the optimal timing of adaptation project implementation by maximizing NPV and the B-C ratio based on different project start years. This is of particular relevance to infrastructural adaptation options such as irrigation systems and reservoir storage, whose high initial capital expenses may not be justified until crop yields are sufficiently enhanced. Lastly, the model estimates NPV and B-C ratios for yield outputs under each dimension of the analysis, namely: (1) climate scenarios, (2) AEZs or river basins, (3) crops, (4) CO<sub>2</sub> fertilization, and (5) irrigated versus rainfed.

Generating these metrics requires several key pieces of information, including the following:

- *Crop yields* with and without the adaptation option in place. These are derived from AquaCrop modeling.

- *Management multiplier* to convert from experimental to field yields. These estimates were developed in consultation with local experts as part of capacity building work.
- *Crop prices through 2050*. National crop price data from FAO for current conditions were used, and price projections under two scenarios were developed—one with constant prices and one based on an IFPRI global price change forecast.
- *Exchange rate* between global and local crop prices
- *Discount rate* to estimate the present value of future revenues and costs. All analyses in this report employ a 5 percent discount rate, consistent with recent World Bank Economics of Adaptation to Climate Change analyses.
- *Capital and operations and maintenance (O&M) costs of each adaptation input* (for example, irrigation infrastructure). Local data were requested to characterize costs of adaptation options, and in some cases they were provided. Overall, these can be difficult to obtain or generalize, and as a result, in many cases, estimates derived from prior work are used.

The general approach for estimating the net benefits of two of the farm management options (optimizing fertilizer application, and changing crop varieties) is outlined in table 2.1. Details of these analyses are provided in chapter 5. Note that not all options are amenable to such quantitative analysis. In addition to optimizing fertilizer application and changing crop varieties, a quantitative assessment of the following options was undertaken:

- Expanding extension services
- Expanding agricultural research and development activities
- Improving drainage capacity
- Developing new irrigation capacity

**Table 2.1 Approach for Two Quantifiable Farm-Level Adaptation Options**

<i>Adaptation option</i>	<i>Description</i>	<i>Crop modeling approach</i>	<i>Economic methodology</i>
<b>Optimize fertilizer application</b>	Additional application of fertilizer may partly offset impacts of climate change on crop yields.	Redeploy AquaCrop to optimize levels of fertilizer inputs and provide resulting crop yields for each of these dimensions.	<ol style="list-style-type: none"> <li>1. In the economic model, estimate the per hectare revenue increase (that is, market price times increased yield) due to implementation of the adaptation alternative, and the per hectare increase in costs, then convert these to net present value and benefit-cost ratios for each start year between 2011 and 2050.</li> <li>2. Assess whether the farm management adaptation option is net beneficial, and if so, identify the optimal start year(s).</li> </ol>
<b>Switch to more suitable crops or crop varieties</b>	As climate conditions change, another option would be for farmers to switch to more suitable crops or crop varieties.	The economic model employs estimates of crop yields under climate change in each of the AEZs.	

- Rehabilitating irrigation capacity
- Improving irrigation water application efficiency
- Adjusting livestock holdings in response to climate stress.

Finally, farmers in the Korce region noted that hail damage was a significant problem for them. Indeed, there is research that indicates that hail events could be more frequent and/or damaging with climate change. An existing study that evaluates the cost-effectiveness of hail nets for apple crops was therefore identified and applied for relevant Albanian crops.

### ***Criterion 2: Robustness to Different Future Climate Conditions***

All options are assessed relative to climate conditions in three alternative climate scenarios. Benefit-cost ratios and net present value calculations are developed for each of the three scenarios, both with and without the effect of carbon fertilization, providing a means for assessing robustness to future climate conditions.<sup>3</sup>

### ***Criterion 3: “Win-Win” Potential***

The study also analyzed whether adaptation options would be beneficial even in the absence of climate change. For options amenable to economic analysis, the net benefits of the adaptations were analyzed relative to the current baseline—as a result, the benefits estimates implicitly incorporate both climate adaptation and non-climate related benefits of adopting the measure. For other alternatives, the win-win potential is assessed based on expert judgment.

### ***Criterion 4: Stakeholder Recommendations***

Adaptation measures that stakeholders recommended during the stakeholder consultation workshops carry significant weight in the menu of adaptation options. Stakeholders also provided information on impacts that they had already experienced and adaptation options that address those impacts. Adaptation options that address those impacts, such as drainage improvements to enhance adaptation to flooding, even if those measures were not specifically mentioned in the stakeholder workshops, are also given a higher priority.

### ***Step 7: Develop Menu of Adaptation Options***

The menu of adaptation options presented in chapter 6 synthesizes the results of the three components of the adaptation assessment: quantitative analysis (described in chapter 5); qualitative assessment of potential net benefits to farmers (also summarized in chapter 5); and farmer recommendations (summarized in chapter 4). Tables in chapter 6 provide a prioritized list of national and AEZ-level options, with a justification for the option based on these three components of the assessment. In addition, the tables identify whether the option has win-win potential.

Other components of the option include a qualitative assessment of the time needed to implement each of these adaptation options. This characteristic of the option may be a key consideration for farmers and potential investors. For example, reservoir construction requires much more time than changing crop varieties



from one season to the next. This information is not used to assign priority, but instead is designed to provide guidance about measures that could have an immediate versus delayed impact. The assessment is based on available information on each option along with expert judgment.

A key consideration in the quantitative analysis is assessing whether the option yields benefits across the range of possible future climate outcomes. These include the quantitative and qualitative projections of net benefits of adaptation options across three climate change scenarios, two CO<sub>2</sub> fertilization scenarios, multiple crops, and four decades. For some adaptation options, robustness is assessed based on expert evaluation.

### **Assessing Risks to Livestock**

Although the direct effects of heat stress on livestock have not been studied extensively, warming is expected to alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton et al. 2009).

In an effort to assess the effects of climate change on livestock, a broad literature review was conducted to identify existing models on the effect of climate change, particularly changing temperature, on livestock. Ideally, a “process” model similar to the AquaCrop crop model would be employed. A model of this type could be deployed to simulate effects on livestock for various climate scenarios, and also evaluate the impact of taking adaptive actions. The only extensive analysis of this type was a structural Ricardian model of livestock developed by Mendelsohn and Seo based on studies in 10 countries in Africa (2006). This model measures the interaction between temperature and livestock and considers the adaptive responses of farmers by evaluating which species are selected, the number of animals per farm and the net revenue per animal under changes in climate. The study relies on a survey of over 5,000 livestock farmers in 10 African countries. In this dataset, the variation in livestock productivity and expected incomes in different regions demonstrates a clear relationship to regional climate, which provides a mechanism, through spatial analogue, to statistically analyze how climate change may affect livestock incomes.<sup>4</sup>

The general results of the study are that, relative to the baseline, the probability of choosing beef cattle and chickens will decline with rising temperatures, but that the probability of selecting dairy cattle, goats, and sheep will increase. Expected income per animal falls across all livestock types, but changes are most dramatic for beef cattle, goats, and chickens, which fall 19 percent, 21 percent, and 29 percent respectively with an increase of 2.5°C. Rising temperatures, in general, lead to a response to reduce the predicted number of beef cattle and chickens on each farm, but increase the number of the other livestock types.

Mendelsohn and Seo’s results are consistent with other work in this area. In prior studies, beef cattle have been found to experience increases in mortality,

reduced reproduction and feed intake, and other negative effects as temperatures rise (for example, Adams et al. 1999). Butt et al. (2005) found that small ruminants (that is, goats and sheep) are more resilient to rising temperatures than beef cattle. Chickens are particularly vulnerable to climate change because they can only tolerate narrow ranges of temperatures beyond which reproduction and growth are negatively affected. Further, increases in temperature caused by climate change can be exacerbated within enclosed poultry housing systems.

Ultimately, however, the Mendelsohn and Seo model was not applied in the Albanian analysis. The main reason is that the current climate, and in particular the effect of current climate on existing management practices and current livestock varieties in the 10 African countries they studied, differs markedly from those in Albania. The Ricardian approach does not accommodate reliable adjustment for those differences. Instead, a qualitative evaluation of both the risk of climate to livestock, and adaptive measures to consider in responding to those risks is provided.

### Uncertainty and Sensitivity Analysis

A study of this breadth, conducted under time and data constraints, is necessarily limited. In particular, in order to look broadly across many crops, areas, and adaptation options—especially options that may be relatively new to Albania—in many cases this study had to rely on general data and characterizations of these options. While care was taken to use the best available data as well as state-of-the-art modeling and analytic tools, an analysis of outcomes 40 years into the future, across a broad and varied landscape of complex agricultural and water resource systems, involves uncertainty. As a result, this study attempts to evaluate the sensitivity of the options to one of the most important sources of uncertainty, which is how future climate change will unfold across Albania.

A potentially more significant question that was not addressed at this time involves projecting the evolution and development of agricultural systems over the next 40 years, with or without climate change. The future context in which adaptation will be adopted is clearly important, but very difficult to project. Other important limitations involve the necessity of examining the efficacy of adaptation options for a “representative farm.” The results of this study should not be interpreted as in-depth analysis of options at the farm-scale. Instead, these results may be viewed as an important initial step in the process of evaluating and implementing climate adaptation options for the agricultural sector, using the current best available methods.

### Notes

1. The CMI depends on average annual precipitation and average annual potential evapotranspiration (PET). If PET is greater than precipitation, the climate is considered to be dry whereas if precipitation is greater than PET, the climate is moist. Calculated as  $CMI = (P/PET) - 1$  {when  $PET > P$ } and  $CMI = 1 - (PET/P)$  {when  $P > PET$ }, a CMI of  $-1$

is very arid and a CMI of +1 is very humid. As a ratio of two depth measurements, CMI is dimensionless.

2. For example, if a selected GCM projects that the change in January temperatures in the 2030s is two degrees and the earliest available station data are from 1994 to 2003, the January 1–31 temperatures for every year in the 2030s will be the temperatures during Januarys between 1994 and 2003 plus two degrees.
3. As noted in chapter 5, in most cases it was found that quantitative results for adaptation options are less sensitive to uncertainties in climate forecasts than to uncertainties in future prices.
4. Because the raw data from this survey were not available, it was not possible to compare the climatic conditions observed in the Seo and Mendelsohn survey to the conditions in Albania.



# Impacts of Climate Change on Agriculture in Albania

This section describes the results of the climate impact assessment for the Albanian agriculture sector. The impact assessment is an important component of developing an adaptation plan. It reflects impacts of forecast changes in temperature and precipitation, outlined in the “Exposure of Albania’s Agricultural Systems to Climate Change,” from 2010 to 2050 on crop yields and water resources available for agricultural irrigation if no actions were taken to adapt to these changes. As such, it represents a baseline from which the effects of individual adaptation options can be measured. It also provides a clear picture of the risks and opportunities presented by climate change at a detailed level, by crop, AEZ, and river basin.

This chapter reviews the forecast impacts of climate change on crops and horticulture, then summarizes the results of the screening-level assessment of the direct effects of climate change on livestock, and finally reviews the effects of climate change on water available for agricultural irrigation.

In general, the results suggest the following:

- *Overall, the effects of climate change on crops in Albania could be relatively modest, especially for wheat, alfalfa, and pasture.* There is potential for more substantial effects on vegetable and fruit crops, such as tomatoes, watermelons, and grapes, which could suffer from heat and drought stress, particularly during critical periods of their growth. One reason for the relatively modest effects is the widespread use of irrigation in Albania. However, to the extent that irrigation infrastructure is in poor repair, water may not be available at critical times of the growing season, which would mean that the severity of effects of future climate change for irrigated crops may be underestimated.
- *The direct effect of temperature on livestock, reducing their productivity and farm revenues, could be large, especially for cattle and chickens.* The results, however are based on a relatively simple method that may over- or underestimate this effect.

- *Climate change will increase irrigation water demand.* However, even with projected increases in demand from agriculture and other sectors through 2050, it is estimated that water supply in Albania will be more than adequate to meet the increased demand.

### Climate Impacts on Crops and Horticulture

The detailed results of the impact assessment for individual crops, for each AEZ and climate scenario, are summarized in tables 3.1 and 3.2. Table 3.1 shows the results for the medium scenario, and table 3.2 shows the range of results for the low-, medium-, and high-impact scenarios. As shown in table 3.1, most crops are affected negatively by climate change, except for alfalfa and winter wheat. The

**Table 3.1 Effect of Climate Change on Crop Yield 2040–50 Relative to Current Yields under Medium-Impact Scenario, No Irrigation Water Constraints and without New Adaptation Measures**

% change

<i>Irrigated/rainfed</i>	<i>Crop</i>	<i>Intermediate</i>	<i>Lowlands</i>	<i>Northern Mountains</i>	<i>Southern Highlands</i>
Irrigated	Alfalfa	6	4	6	13
	Maize	-3	-4	-11	1
	Tomatoes	0	-11	-8	-4
	Watermelon	N/A	-6	N/A	N/A
Rainfed	Alfalfa	-6	-3	-2	7
	Grapes	-17	-20	-21	-18
	Grassland	-5	-3	-7	10
	Olives	-3	-21	N/A	N/A
	Wheat	10	7	24	20

*Note:* Results are average changes in crop yield, assuming no effect of carbon dioxide fertilization, under medium-impact scenario (no adaptation and no irrigation water constraints). Declines in yield are shown in shades of orange, with darkest representing biggest declines; increases are shaded green, with darkest representing the biggest increases. N/A = crop is not grown in that AEZ, according to local stakeholders.

**Table 3.2 Effect of Climate Change on Crop Yields through 2040s across the Three Climate Scenarios**

% change

<i>Irrigated/rainfed</i>	<i>Crop</i>	<i>Intermediate</i>	<i>Lowlands</i>	<i>Northern Mountains</i>	<i>Southern Highlands</i>
Irrigated	Alfalfa	5 to 7	5	6 to 7	14 to 16
	Maize	-7 to -5	-17 to 2	-24 to -7	1 to 3
	Tomatoes	-1 to 0	-11	-14 to -7	-7 to -5
	Watermelon	N/A	-6 to -5	N/A	N/A
Rainfed	Alfalfa	-10 to 6	-6 to 6	-1 to 4	7 to 10
	Grapes	-25 to -10	-23 to -17	-28 to -18	-24 to -22
	Grassland	-14 to 5	-7 to 8	-2 to 4	9 to 14
	Olives	-6 to -2	-20 to -11	N/A	N/A
	Wheat	6 to 7	4 to 5	11 to 16	13 to 24

*Note:* N/A = the crop is not grown in the AEZ.

high-impact climate scenario has the strongest impact, with less rainfall and higher evapotranspiration due to the higher temperature projection. For the medium-climate scenario the impact of climate change is a little less severe than the high-impact scenario, as this scenario is less pessimistic in terms of rainfall projections.

In general, the results indicate that: grape and olive yields decline under two of the three scenarios; pasture and wheat yields increase under all scenarios (but wheat yield analysis did not consider the effects of pests, which may underlie recent historical declines in wheat yields); tomato yields fall modestly under all scenarios; and irrigated alfalfa yields increase significantly under climate change. As expected, irrigation increases yields and reduces yield variability.<sup>1</sup>

The low-impact scenario shows a net positive impact for most crops, as the increased rainfall amounts increase the water available to the plants. The higher temperatures result in a higher evaporative water demand, but only a part of the increased rainfall is lost through non-productive soil evaporation and therefore most of the crops are affected positively by the increased water availability also under the medium- and high-impact scenarios. The yield of rainfed crops especially is enhanced by the increased rainfall amounts, as in the current situation they experience a certain amount of water-stress and growth is water-limited.

The results presented above do not incorporate the effects of higher CO<sub>2</sub> concentrations that are expected as a byproduct of increased CO<sub>2</sub> emissions. Higher CO<sub>2</sub> concentrations can enhance growth for some crops with a photosynthesis process that can benefit from additional ambient CO<sub>2</sub>. The effect is difficult to accurately estimate, however, because of the challenge in designing field experiments, and the inability in most studies to account for the counter-vailing effects of CO<sub>2</sub> on competing weeds.<sup>2</sup>

For the high-impact scenario, some of the crops experience an increase in production due to the assumed CO<sub>2</sub> fertilization effect. This effect compensates part of the negative impact of the increased water stress caused by the higher temperatures and evaporative demand. For other crops (grapes, grassland) the impact under this scenario remains negative and the impact on crop yields are considerable. For the medium- and low-impact climate scenario, CO<sub>2</sub> fertilization is positive and enhances yields by about 7 percent on average.

For the irrigated crops, the climate impact on irrigation water demand was also assessed, as a key input to the water resources analyses. In table 3.3, orange indicates an increase in crop irrigation water requirements, while green indicates a decrease. For the medium- and high-impact scenarios, the overall trend is that more water is required to maintain the current yields. Especially tomatoes and maize will need substantial increased amounts of water. The low-impact scenario forecasts more rainfall, including during the cropping period, which results in a slight decrease in water demands.

### **Climate Impacts on Livestock**

Effects on alfalfa and rainfed pasture crops summarized in the previous section present one type of climate change risk to livestock, an indirect effect. Effects of

**Table 3.3 Irrigation Water Requirement Changes Relative to Current Situation to 2040s under the Three Climate Scenarios, for Each Crop and AEZ (Assuming No CO<sub>2</sub> Fertilization)**

% change

Scenario	Crop	Intermediate	Coastal Lowlands	Northern Mountains	Southern Highlands
High	Alfalfa irrigated	5	0	-7	-23
	Maize	46	25	36	16
	Tomatoes	100	61	14	61
	Watermelon	N/A	31	N/A	N/A
Medium	Alfalfa irrigated	-2	-5	-12	-16
	Maize	22	14	24	6
	Tomatoes	46	83	7	41
	Watermelon	N/A	23	N/A	N/A
Low	Alfalfa irrigated	-12	-7	-12	-21
	Maize	7	7	5	3
	Tomatoes	32	103	8	60
	Watermelon	N/A	16	N/A	N/A

Note: N/A = the crop is not grown in the AEZ. Orange indicates an increase in crop irrigation water requirements, while green indicates a decrease.

climate change on maize yields may also be linked to effects on livestock. As noted above, for the medium scenario, rainfed alfalfa and grassland yields are expected to increase in the Northern Mountains and Southern Highlands AEZs, where livestock makes up a larger percentage of overall agricultural productivity. Even under the high-impact scenario, effects on these crops in the higher-elevation regions of Albania are relatively modest, with temperature effects being a boost to yield that generally balances or outweighs the negative effects of less precipitation. As a result, the indirect effects of climate change in areas where livestock are most important would range from relatively modest in the worst case, to beneficial in the best case.

The direct effect of climate change on livestock is also important, and is linked to higher-than-optimal temperatures for livestock, in which heat can affect animal productivity and, in the case of extreme events, may lead to elevated mortality rates related to extreme heat stress. As outlined in chapter 2, there is limited information to characterize the direct effects of climate on livestock; the methodologies currently available are far less sophisticated than the crop modeling techniques applied in the prior section, or the water resource modeling techniques applied in the following section, and are generally not applicable to Albania.

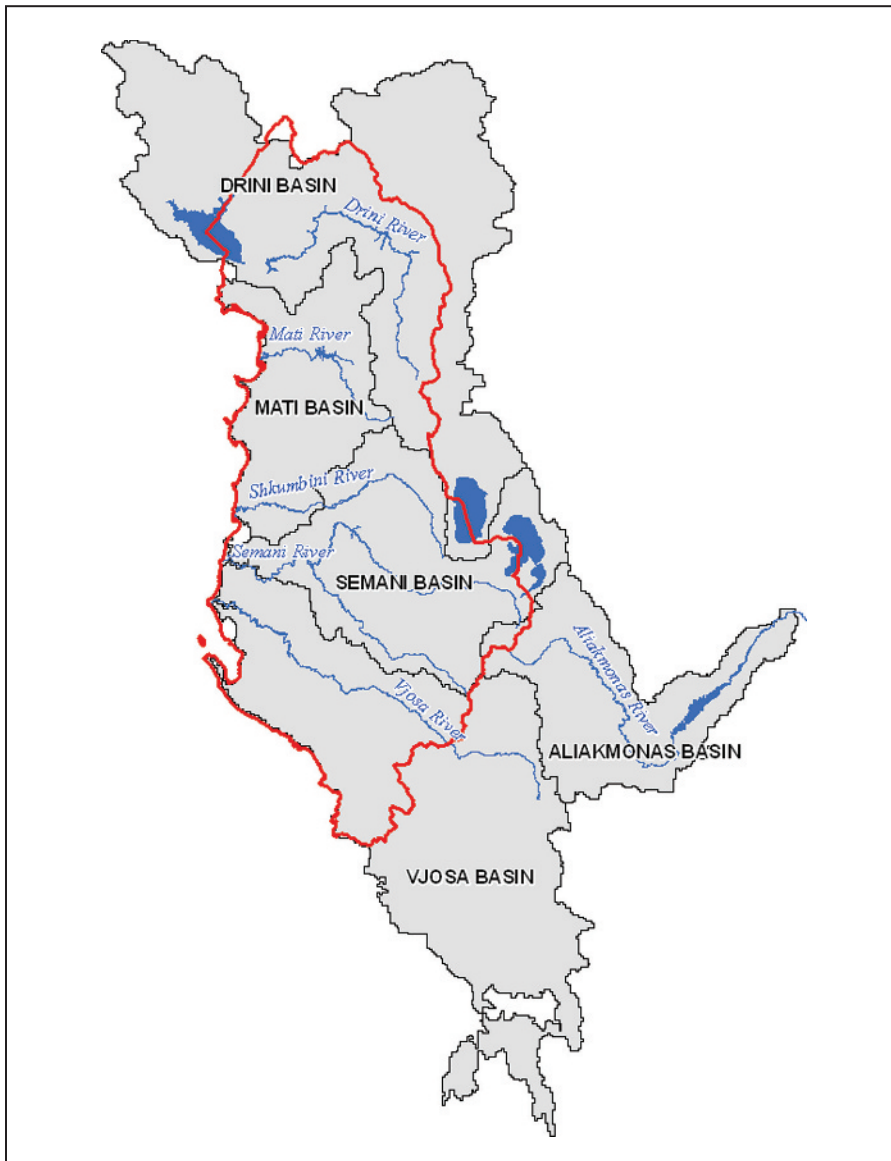
A screening analysis suggests that the direct effects of climate change on most livestock, in the absence of adaptation, could be negative and potentially large. For many livestock type/AEZ combinations, climate change is a major risk, with potential for as much as 35 percent loss in net revenue by the 2040s, with effects on goats and sheep being less than those for chickens and cattle.



## Climate Impacts on Water Availability for Agriculture

A water availability analysis was conducted at the river basin level. The four major river basins are shown in map 3.1. They include, from north to south, the Drini, the Mati, the Semani, and the lower Vjosa basins. Each of these basins extends beyond Albania's border, indicated by the red line in the figure, but the

**Map 3.1 Water Basins in Albania**



Sources: © Industrial Economics. Used with permission; further permission via Creative Commons Attribution 3.0 Unported license (CC BY 3.0). Country boundaries are from ESRI and used via CC BY 3.0. Basin data available from the U.S. Geological Survey Hydro1k River Basins.

analysis focuses on changes in water supply and demand within Albania's territory. The CLIRUN model used here estimates the effect of climate change on runoff in rivers for each basin. Runoff is the difference between precipitation and evapotranspiration; as a result, runoff is affected by both the temperature and the precipitation forecasts.

The WEAP model then compares these water supply results from CLIRUN with forecasts of water demand for all sectors, including agriculture. Agricultural water demand for irrigation is derived from the AquaCrop model results described above; agricultural water demand is also affected by both temperature and precipitation, as water demand is directly linked to both crop yield and evapotranspiration. This comparison of water demand and water supply (or runoff) identifies the potential for shortages of water to meet future demands.

Overall results suggest that water supply decreases under the high- and medium-impact scenarios, and increases under the low-impact scenario. Irrigation water demand is higher for all scenarios, however, particularly in the summer months. Nonetheless, in each of the four river basins, the WEAP analysis indicates that there is no unmet water demand through 2050, meaning that there will continue to be ample water available for both current levels of irrigation and any expansion of irrigated areas, as necessary.

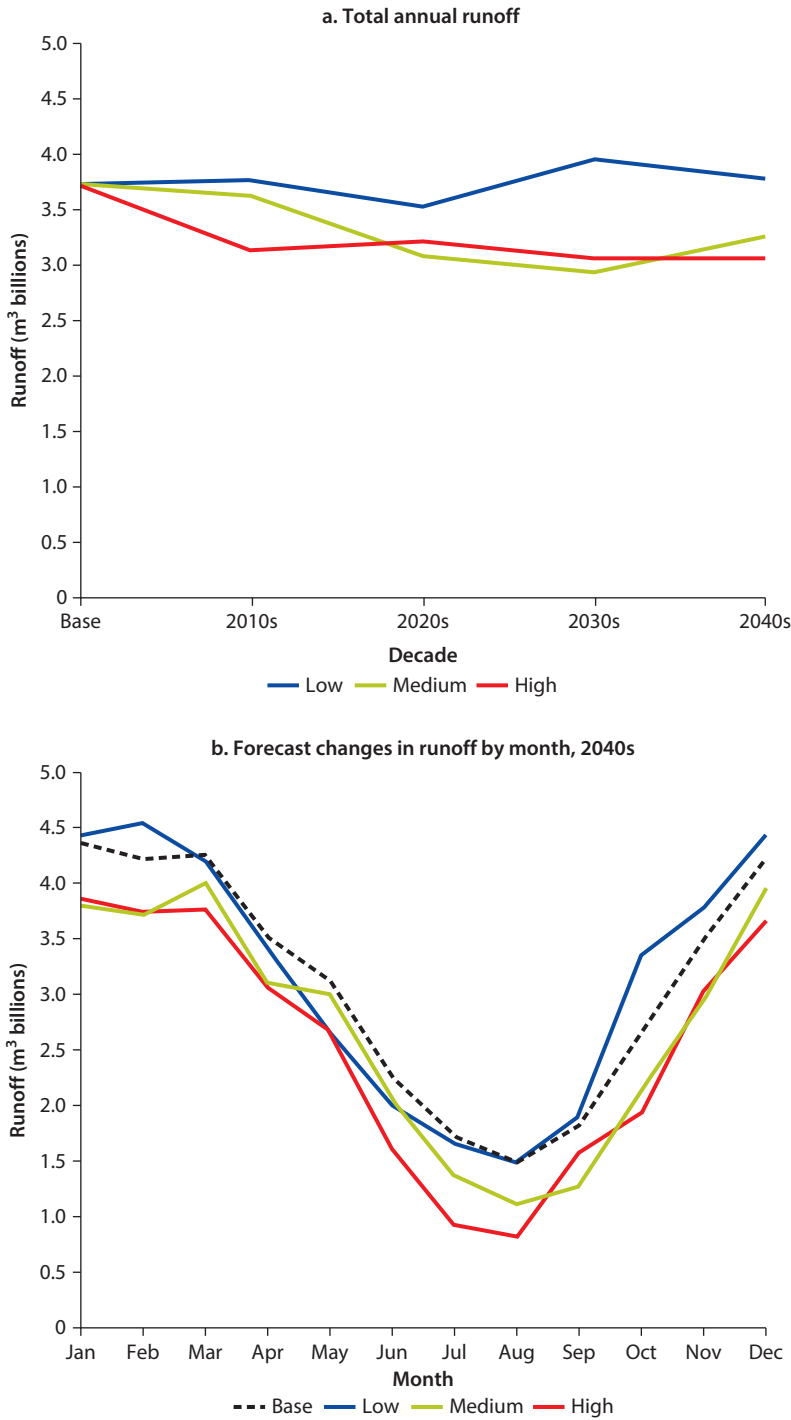
The national level CLIRUN results are presented in the two panels of figure 3.1. Panel a shows total annual water runoff in all basins under each scenario, with current, base runoff of  $3.7 \times 10^{10}$  cubic meters indicated on the vertical axis. The figure shows that, with climate change, runoff increases slightly under the low-impact scenario, but decreases as much as 20 percent under the other scenarios.

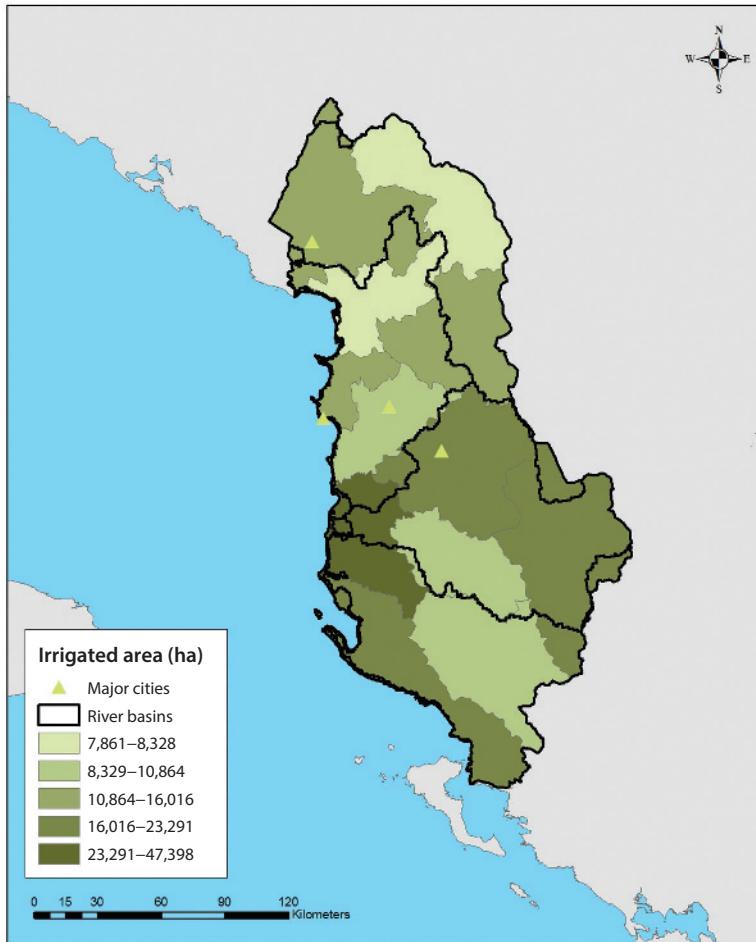
Panel b of the figure shows forecast changes in runoff by month for the decade of the 2040s. As indicated in the figure, the low-impact scenario shows very modest differences in runoff during the summer growing season, when agricultural irrigation demand is typically highest, but under the medium- and high-impact scenarios, runoff is particularly affected during this growing season.

Demand for irrigation water is widespread throughout Albania. The currently irrigated areas are indicated in map 3.2. The most intensively irrigated area is in the Lowlands AEZ, but some of the more mountainous areas also have high concentrations of irrigated land.

Figure 3.2 shows the results of comparing annual river runoff, or water supply, with annual water demand from all sources, for the current baseline conditions and the forecast effects under the high-impact scenario in the 2040s, on an annual basis, for all four major Albanian river basins analyzed. Figure 3.3 provides similar information for the same scenario, but on a monthly basis. Although the impact of climate change on runoff is substantial, and demands for water are projected to increase substantially with climate change, water resources are so abundant in Albania that there is a wide gap between supply and demand. Thus, it is unlikely that climate change will decrease irrigated agricultural production, and there exists ample capacity to pursue increased irrigation where and when needed, provided that current water storage facilities operate at or near their stated capacities.

**Figure 3.1 Estimated Effect of Climate Change on National Water Runoff**



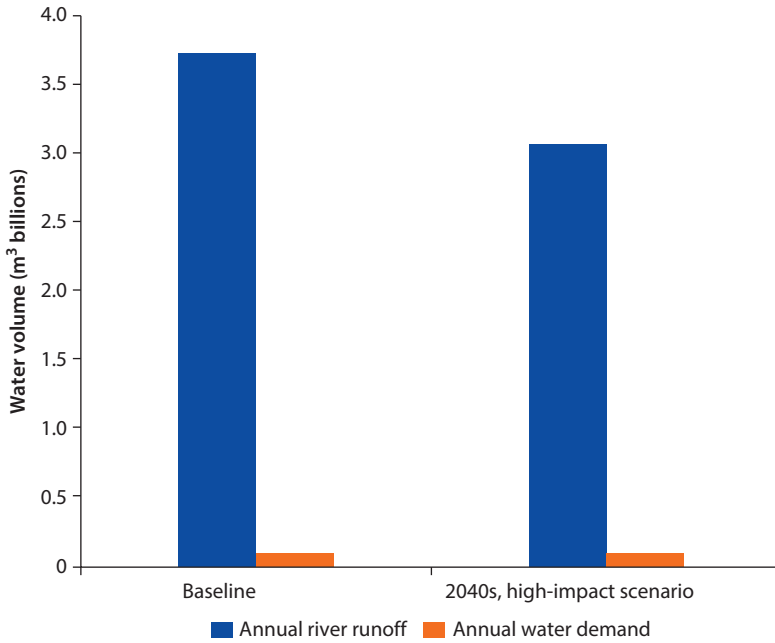
**Map 3.2 Irrigated Areas in Albania**

1:1,817,761

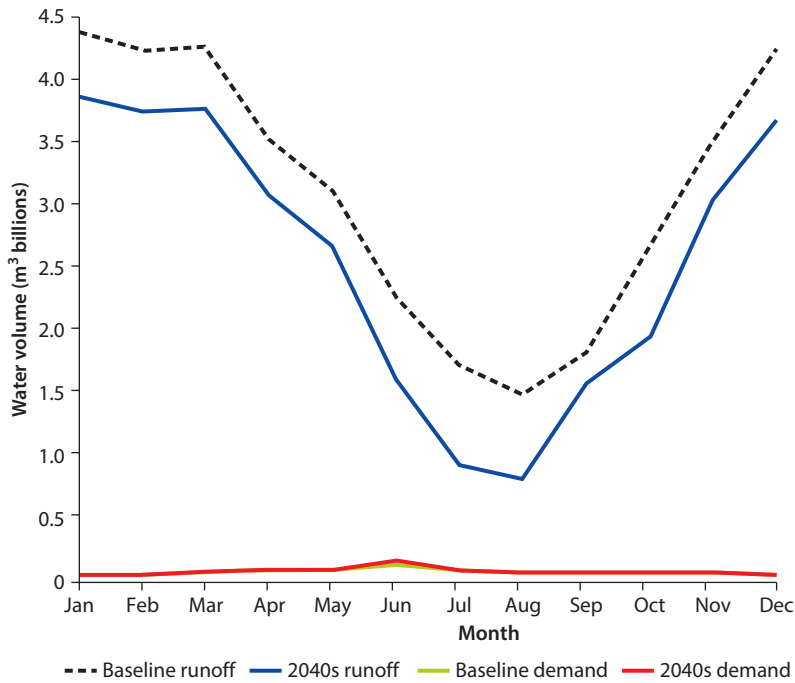
Projected Coordinate System:  
Europe Albers Equal Area Conic;  
European 1950

Sources: © Industrial Economics. Used with permission; further permission via Creative Commons Attribution 3.0 Unported license (CC BY 3.0). Country boundaries are from ESRI and used via CC BY 3.0. FAO 2011, Global Map of Irrigated Areas.

**Figure 3.2 Annual Forecast Water Balance for 2040s in Albania**



**Figure 3.3 Monthly Forecast Water Balance for 2040s in Albania**



**Notes**

1. The results in tables 3.1 and 3.2 provide summary yield changes relative to current yields, expressed as percent change for the full 40-year study period. In table 3.1, orange indicates a decrease in yield, compared to the current situation, while green indicates an increase in yield.
2. A full accounting of indirect effects of climate change on crops would also incorporate the effects of higher ambient ozone, which also limits most crop yields.

# Identification of Adaptation Options for Managing Risk to Albania's Agricultural Systems

### Options for Consideration

This chapter describes the qualitative approach to identifying and evaluating adaptation options, with a focus on those adaptation options that are not amenable to the quantitative assessment. The qualitative analyses are based on the expert judgment of three sets of individuals: Albanian in-country agricultural experts who have been consulted throughout the study process; farmers who shared their insights in two sets of consultation workshops in each agro-ecological zone (AEZ); and a team that conducted the analytical work for this study.

This chapter attempts to apply the same overall framework for identifying options that is used in the quantitative analyses (see chapter 5). In practice, that means attempting to identify options for which economic benefits (to farmers, primarily) seemingly exceed the costs (regardless of who bears the costs: the Albania government, donors, cooperatives, farmers themselves, or some combination). A clear rationale and a time frame for implementing the options are also identified. Finally, to the extent possible, the recommendations are specific to the individual AEZs in Albania.

Table 4.1 provides the overall scope for the adaptation assessments in this chapter and in the quantitative analysis. From this list, a ranked list tailored to each AEZ was created, with indications of whether the measure should be implemented in the short term (1–3 years), medium term (3–9 years), or long term (10 years from now or longer). The list includes four categories of options: (1) infrastructural adaptations, which are “hard” adaptation options, improvements of agriculture sector infrastructure, including water resources infrastructure improvements or expansions that are specifically targeted toward water available for irrigation; (2) programmatic adaptations, which strengthen existing programs or create new ones; (3) farm management adaptations, which

**Table 4.1 Adaptation Options for Consideration**

<i>Category</i>	<i>Adaptation measures and investments</i>	<i>Adaptation option reference number</i>
<b>A. Infrastructural adaptations</b>		
Farm protection	Hail protection systems (cloud seeding, nets)	A.1
	Install plant protection belts	A.2
	Lime dust on greenhouses to reduce heat	A.3
	Vegetative barriers, snow fences, windbreaks	A.4
	Move crops to greenhouses	A.5
	Smoke curtains to address late spring and early fall frosts	A.6
	Build or rehabilitate forest belts	A.7
Livestock protection	Increase shelter and water points for animals	A.8
	Windbreak planting to provide shelter for animals from extreme weather	A.9
Water management	Enhance flood plain management (for example, wetland management)	A.10
	Construct levees	A.11
	Drainage systems	A.12
	<b>Irrigation systems: new, rehabilitated, or modernized</b>	A.13
	<b>Water harvesting and efficiency improvements</b>	A.14
<b>B. Programmatic adaptations</b>		
Extension and market development	Demonstration plots and/or knowledge sharing opportunities	B.1
	Education and training of farmers via extension services (new technology and knowledge-based farming practices)	B.2
	National research and technology transfer through extension programs	B.3
	Private enterprises, as well as public or cooperative organizations for farm inputs (for example, seeds, machinery)	B.4
	Strong linkages with local, national, and international markets for agricultural goods	B.5
Livestock management	Fodder banks	B.6
Information systems	Better information on pest controls	B.7
	Estimates of future crop prices	B.8
	Improve monitoring, communication and distribution of information (for example, early warning system for weather events)	B.9
	Information about available water resources	B.10
Insurance and subsidies	Crop insurance	B.11
	Subsidies and/or supplying modern equipment	B.12
R&D	Locally relevant agricultural research in techniques and crop varieties	B.13
<b>C. Farm management adaptations</b>		
Crop yield management	Change fallow and mulching practices to retain moisture and organic matter	C.1
	Change in cultivation techniques	C.2
	Conservation tillage	C.3
	Crop diversification	C.4

*table continues next page*



**Table 4.1 Adaptation Options for Consideration** (continued)

Category	Adaptation measures and investments	Adaptation option reference number
	Crop rotation	C.5
	Heat- and drought-tolerant crops/varieties/hybrids	C.6
	<b>Increased input of agro-chemicals and/or organic matter to maintain yield</b>	C.7
	Manual weeding	C.8
	More turning over of the soil	C.9
	Strip cropping, contour bunding (or plowing) and farming	C.10
	<b>Switch to crops, varieties appropriate to temp, precipitation</b>	C.11
	<b>Optimize timing of operations (planting, inputs, irrigation, harvest)</b>	C.12
Land management	Allocate fields prone to flooding from sea level rise as set-asides	C.13
	Mixed-farming systems (crops, livestock, and trees)	C.14
	Shift crops from areas that are vulnerable to drought	C.15
	Switch from field to tree crops (agro-forestry)	C.16
Livestock management	Livestock management (including animal breed choice, heat tolerant, change shearing patterns, change breeding patterns)	C.17
	Match stocking densities to forage production	C.18
	Pasture management (rotational grazing, etc.) and improvement	C.19
	Rangeland rehabilitation and management	C.20
	Supplemental feed	C.21
	Vaccinate livestock	C.22
Pest and fire management	Develop sustainable integrated pesticide strategies	C.23
	Fire management for forest and brush fires	C.24
	Integrated pest management	C.25
	Introduce natural predators	C.26
Water management	Intercropping to maximize use of moisture	C.27
	<b>Optimize use of irrigation water (for example, irrigation at critical stages of crop growth, irrigating at night)</b>	C.28
	<b>Use water-efficient crop varieties</b>	C.29
<b>D. Indirect adaptations</b>		
Market development	Physical infrastructure and logistical support for storing, transporting, and distributing farm outputs	D.1
Education	Increase general education level of farmers	D.2
Water management	Improvements in water allocation laws and regulations	D.3
	Institute water charging or tradable permit schemes	D.4

Note: Adaptation options in bold are those that are evaluated quantitatively in chapter 5.

are farm-level measures that make up the largest portion of this list; and (4) indirect adaptations, which are options not directly aimed at the agriculture sector, but which would still benefit the sector. Options that were evaluated quantitatively in chapter 5 are highlighted in bold in the table.

## Options from Farmers

An important component of this study was to inform and consult stakeholders, farmers, and farmers' associations, on the impact of climate change on agriculture and water resources. Farmers attended structured workshops in four locations: Shkodra, representing both the Northern Mountains and Intermediate AEZ; Fushe-Kruje, representing the Intermediate AEZ; Lushnje, representing the Lowlands AEZ; and Korce, representing the Southern Highlands AEZ. The purpose of these meetings was to review and discuss draft climate change adaptation options with local stakeholders. The meetings were held at the Agriculture Technology Transfer Center (ATTC) in each city, and were attended by farmers, ATTC staffers, and extension service workers.

Stakeholders were presented with a series of adaptive responses to climate change. The quantitative and qualitative analysis of each strategy was also presented to explain each option. Farmers were then asked to give feedback on the options as well as the criteria used for evaluation.<sup>1</sup> Farmers confirmed that climate change has already affected their agricultural practices. Many had already taken some actions to adapt to these changes, mostly by altering planting dates but also by attempting to improve the provision of water to their farms.

Though responses from each AEZ were nuanced, the following is a summary of how local stakeholders ranked the options.

1. *Rehabilitate infrastructure*: Depending on the specific climate related risk faced by each AEZ, the priority infrastructure was for either irrigation or drainage.
2. *Increase institutional capacity*: Capacity building was universally mentioned, especially in the suggestion to increase the reach of extension services. Other capacity building recommendations included technical training, seed and crop selection knowledge transfer, and increasing the availability of region-specific hydrometeorological information.
3. *Improve market structure*: Farmers emphasized that overall market effectiveness would assist in making farms more productive and provide a "win-win" adaptive response. Farmers expressed frustration in the absence of logistical support in the country, such as processing and storage facilities. They also expressed frustration at the small size of their farms.

### **Northern Mountains/Intermediate AEZ—Shkodra ATTC**

The most significant impact currently posing the greatest risk in this AEZ is flooding, although droughts are also a primary concern. Farmers commented that they do not feel equipped to respond to either floods or droughts effectively. Heat waves were mentioned in the discussions as occurring roughly every 5–10 years, but these were not emphasized as a primary concern. Drainage problems were a significant issue for those in the Intermediate AEZ, but not for those in the mountains.

The following represents farmers' ranking of the top three adaptation options for these AEZs, as well as a list of non-ranked options that were mentioned as important.

1. Improve drainage.
2. Rehabilitate irrigation infrastructure.
3. Increase capacity for new technologies through extension services.
  - Improve region-specific hydrometeorological forecasting.
  - Improve access to higher yield and drought-tolerant varieties.
  - Improve groundwater management.
  - Improve market orientation.
  - Improve fertilizer application, and move toward organic fertilizers.
  - Improve flood plain land management.
  - Establish windbreaks.
  - Improve pest and fire management.

Participants disagreed with the draft option that livestock herders modify their flocks from the more climate-sensitive cattle and chickens to goats and sheep, saying that this would be impossible from a cultural perspective. Instead, they suggested a transition to heat-tolerant cattle and chicken breeds.

### ***Intermediate AEZ—Fushe-Kruje ATTC***

Thirteen farmers attended a workshop at the Fushe-Kruje ATTC, about half of whom considered themselves owners of small farms. Farmers at this meeting were most concerned about changes in temperature; this was viewed as most important for vineyards, and was associated with increased pest occurrences and yield losses of an estimated 10–15 percent. To adapt to this and other climate-related risks, farmers believed the following measures would be most effective:

- Introduce temperature-tolerant seed varieties. Farmers have already tried this measure but many say they need more information to implement it effectively.
- Alter planting dates.
- Provide for drainage, both within plots and on a larger scale.
- Improve irrigation. Farmers shared that the current irrigation systems do not work well, are old, or take water from polluted rivers. Pesticide contamination was cited.
- Improve capacity of research institutes, especially around seed varieties. Farmers' experience was that seed varieties used by them are not well-adapted and productive.
- Provide better meteorological information. For example, provide 10-day forecasts for extreme events.
- Mainstream and provide extension service advice on how to mitigate for climate change.
- Mobilize financial resources to use for small investments.

### ***Lowlands AEZ—Lushnje ATTC***

The primary climate issue in this region is drought. Because existing irrigation and drainage infrastructure is often non-functional, farmers have very limited capacity to adapt to droughts. Heat waves are the second-most significant issue. In addition, farmers reconfirmed the messages from the first stakeholder meeting, that drainage of soils is a primary problem along with water quality issues. In particular, both water from reservoirs and the upper groundwater layer are of low quality.

Attendees provided the following ranking of the top three adaptive responses; other options are provided in bulleted form.

1. Rehabilitate drainage systems (especially at primary and secondary levels).
2. Rehabilitate irrigation systems (primary and secondary levels). There have been attempts to establish water users associations for 12 years, but these have not been successful.
3. Develop domestic seed production system for locally adapted and improved varieties.
  - Improve quality of irrigation water.
  - Increase capacity of extension services and hydrometeorological institutions.
  - Improve quality of inputs such as seeds, fertilizers, and chemicals.
  - Shift crops to greenhouses (assuming they can cover the costs with access to a reliable export market).

As in Shkodra, participants in this meeting did not agree with the option to gradually switch livestock types. Participants also felt that market enhancement strategy should be one of the national-level policy options. The policies should include a national export strategy, processing and storage infrastructure, and land consolidation.

### ***Southern Highlands AEZ—Korce ATTC***

Farmers have very limited capacity to adapt to the regular droughts and heat waves that occur in this AEZ. Although floods and hail storms also occur, these are not as much of a concern. During heat waves, hot, dry winds lasting as little as two to three days can be a major risk and affect both the quality and quantity of production. The irrigation and drainage system is in need of rehabilitation. The discussion yielded the following list of adaptation measures, where the top three are ranked:

1. Rehabilitate irrigation systems.
2. Improve access to seed varieties, especially pest-resistant varieties.
3. Include hail nets as an option, especially for apple trees.
  - Reestablish windbreaks.
  - Increase the involvement of ATTC in advising farmers to reduce the risk of impacts of climate change.

- Improve capacity of extension service and hydrometeorological institutions.
- Improve pest and fire management.
- Improve application of inputs such as fertilizer.

## Options from the Team

The team arrived at a general conclusion that the adaptation deficit, or the difference between current Albanian yields and potential yields for current climate, is larger than the incremental gains that can be made to better adapt the Albanian system to the projected effects of climate change. Closing the adaptation deficit, however, should be accomplished with future climate change explicitly considered, especially for larger capital or infrastructure projects such as drainage infrastructure construction or rehabilitation. As the recent floods in Albania demonstrate, an investment in improved drainage in agricultural areas is justified on benefit-cost criteria in the current climate, but a marginal increase in drainage area is likely justified when climate change is considered.

Nonetheless, every large investment project should include analyses of climate change in the design phase, because it is much less expensive to incorporate adjustments in such parameters as the capacity of the drainage pipes in design phase than as a retrofit option after the system is built. Climate change may also alter the geographic focus of these areas: for example, coastal areas of Albania are projected to experience a relative drying trend, while the highland areas are forecast to become wetter. The team's specific results are summarized below.

### High-Priority Options

- *Improve drainage infrastructure and educate on drainage practices at farm level (Options A.12, B.2, and C.13).* The team strongly suggests that analyses be performed in the short term to increase the capacity of in-process/planned drainage infrastructure projects to include explicit consideration of climate change. The most critical need is in the coastal lowlands areas. Drainage infrastructure is evaluated quantitatively in chapter 5, but to realize the full benefits of that infrastructure option better farmer education is needed.
- *Improve soil water management (Options A.12 and B.10).* There is an existing new capacity at the Fushe-Kruje ATTC to analyze soil information throughout Albania. This information should be better disseminated to farmers, particularly as it concerns the potential for drainage problems at the farm level. Sandy and loam soils are not an issue for drainage, but any soils greater than 40 percent clay are susceptible to periodic waterlogging, which reduces yields. This option involves modifying the existing data collection and analysis system to provide this type of soils information to farmers, along with know-how to address drainage problems for those soils at greatest risk.
- *Enhance flood plain management and construct levees in lowlands areas (Options C.13, A.10, and A.11).* These are additional options that can contribute to better management of acute drainage issues.

- *Increase general education level of farmers (Options B.1, B.2, and B.3; possibly coupled with B.14).* More specifically, this option involves improving the existing extension agency capacity overall to support better agronomic practices at the farm level, and strategic implementation of a plan for more widespread demonstration plots. This option could also be coupled with investment in research focused on the testing of varieties that are better tuned for future climate.
- *Improve capacity of hydrometeorological institutions (Option B.9).* The current lead hydrometeorological institution in Albania, the IoEWE, is inadequately funded to maintain and access important climatological information, and is not currently engaged in generating and analyzing archival and real-time temperature and precipitation data. Those capabilities are acutely needed to support both better farm-level and better policy-level decision-making in Albania.
- *Switch to crops and varieties appropriate to future climate regime (Options C.11, C.6, and B.2).* This option, partially analyzed in chapter 4, requires a combination increased knowledge at the national level and effective extension to advise farmers on those varieties best suited to the emerging temperature and precipitation trends. This option has both a medium-term and a long-term component.
- *Consider policy and/or private sector options to encourage more cooperative farming (Option B.4, as a step to more widespread adoption of all measures in Category C).* Smallholder plot owners are faced with significant obstacles in making yield-enhancing investments. For smaller farms, these investments are difficult to justify. In larger cooperatives, there is a much greater likelihood that substantial economies of scale can be realized in implementing farm-level management improvements.
- *Provide better information for policy-makers (Options B.7 to B.11).* There is a need to improve the capacity in Albania to use globally available remote sensing data and Global Information Systems (GIS) tools to analyze these data to better target extension demonstrations at farm level. One reason this measure is likely to be cost effective is that much of the remote sensing data and information is available freely from global sources, and MoAFCP has already made some investments in GIS capabilities. What is needed to fully realize these options are capacity building sessions and one or more demonstration projects to illustrate how the information can be used to enhance policy-makers' decisions.
- *Improve fallow and mulching practices to retain moisture and organic matter (Options C.1 and C.2).* This measure is relatively low-cost but could yield a substantial closure of the adaptation deficit and, in the process, improve the resiliency of the agricultural sector to climatic shifts and extremes (such as drought).
- *Introduce strip cropping and contour bunding (plowing) (Option C.10).* This option is designed to improve water management and reduce soil erosion.

- *Move tomatoes to greenhouses (Option A.5)*. FAO data suggests that about 25 percent of the area devoted to tomato farming currently employs greenhouses, although information gathered in Albania suggests the percentage is higher. Simple plastic greenhouse technology (called “plastic tubes”) provides protection from extreme climate events, suggesting this option may have great potential, but the team has yet not been able to obtain data on yields in greenhouses versus field-grown, or costs for various types of greenhouses, to assess whether benefits might exceed costs.
- *Introduce conservation tillage and other soil moisture conservation measures (Option C.3)*. Conservation tillage has great potential for reducing certain types of input yields, for conserving soil resources, and for improving yields. In addition, soil erosion is a major issue in Albania. However, soil erosion was not mentioned as a key concern by farmers, in-country experts, or the team. As a result, this measure was not analyzed quantitatively. The team did note that costs to implement the measure in the current Albanian context might be substantial, owing to a current lack of equipment, the difficulty in controlling weeds, and the increased need for expensive pesticides that currently may not be widely available in Albania.

### **Greenhouse Gas Mitigation Potential of Adaptation Options**

Many of the adaptive measures that are recommended to improve the climate resilience of Albania’s agricultural sector also have the potential to mitigate climate change now and in the future. Particular adaptive practices, like conservation tillage, present promising opportunities to lower greenhouse emissions by either increasing the carbon stored in agricultural soils or reducing the greenhouse gases emitted in agricultural production processes. This section discusses the potential for greenhouse gas mitigation in Albania’s agricultural sector and highlights the specific adaptive measures that demonstrate the greatest opportunities for emissions reductions. A summary of the mitigation potential of various adaptive measures is provided in table 4.2.

The relative mitigation potential of the various adaptive measures described in table 4.2 is primarily based on each measure’s contribution to climate change as described in Albania’s Second National Communication (SNC) to the Conference of Parties under the United Nations Framework Convention on Climate Change (Islami et al. 2009). In particular, the SNC estimates a score for each adaptive measure according to its potential to reduce greenhouse gas emissions and mitigate the economic impacts of climate change. The measures were grouped by these scores and assigned a high potential (three checks in table 4.2, a medium potential (two checks), and a low potential (one check).

The adaptive practices discussed in the SNC were then mapped to the adaptive measures listed in table 4.2 based on similarities across qualitative descriptions. To supplement the analysis, a comprehensive review was also conducted of the economic and scientific literature related to the mitigating impacts

**Table 4.2 Greenhouse Gas Mitigation Potential of Adaptation Options**

<i>Adaptation measure</i>	<i>Adaptation option reference number</i>	<i>Mitigation impact</i>	<i>Mitigation potential</i>
Irrigation systems: new, rehabilitated, or modernized (including drip irrigation, irrigation using less power, and the better use of local water sources)	A.13	Minimize CO <sub>2</sub> emissions from energy used for pumping while maintaining high yields and crop-residue production.	✓
Change fallow and mulching practices to retain moisture and organic matter	C.1	Increases carbon inputs to soil and promotes soil carbon sequestration; Reduces energy used in transportation; Reduces energy consumption for production of agrochemicals.	✓✓
Conservation tillage	C.3	Minimizes the disturbance of soil and subsequent exposure of soil carbon to the air; Reduces soil decomposition and the release of CO <sub>2</sub> into the atmosphere; Reduces plant residue removed from soil thereby increasing carbon stored in soils; Reduces emissions from use of heavy machinery.	✓✓
Crop rotation	C.5	Rotation species with high residue yields help retain nutrients in soil and reduces emissions of GHG by carbon fixing and reduced soil carbon losses. Also increase carbon inputs to soil and fosters soil carbon sequestration.	✓✓✓
Strip cropping, contour bunding (or plowing) and farming	C.10	Increases carbon inputs to soil and fosters soil carbon sequestration.	✓✓✓
Optimize timing of operations (planting, inputs, irrigation, harvest)	C.12	More efficient fertilizer use reduces N losses, including NO <sub>2</sub> emissions; More efficient irrigation minimizes CO <sub>2</sub> emissions from energy used for pumping while maintaining high yields and crop-residue production.	✓✓
Allocate fields prone to flooding from sea level rise as set-asides	C.13	Increases soil carbon stocks; especially in highly degraded soils that are at risk of erosion.	✓✓
Switch from field to tree crops (agro-forestry)	C.16	Retains nutrients in soil and reduces emissions of GHG by fixation of atmospheric N, reduction in losses of soil N, and increased carbon soil sequestration.	✓✓
Livestock management (including animal breed choice, heat tolerant, change shearing patterns, change breeding patterns)	C.17	Reduces CH <sub>4</sub> emissions.	✓
Match stocking densities to forage production	C.18	Reduces CH <sub>4</sub> emissions by speeding digestive processes.	✓
Pasture management (rotational grazing, etc.) and improvement	C.19	Degraded pastureland may be able to sequester additional carbon by boosting plant productivity through fertilization, irrigation, improved grazing, introduction of legumes, and/or use of improved grass species.	✓✓

*table continues next page*



**Table 4.2 Greenhouse Gas Mitigation Potential of Adaptation Options** (*continued*)

<i>Adaptation measure</i>	<i>Adaptation option reference number</i>	<i>Mitigation impact</i>	<i>Mitigation potential</i>
Rangeland rehabilitation and management	C.20	Degraded rangeland may be able to sequester additional carbon by boosting plant productivity through fertilization, irrigation, improved grazing, introduction of legumes, and/or use of improved grass species.	✓✓
Intercropping to maximize use of moisture	C.27	Increases carbon inputs to soil and fosters soil carbon sequestration.	✓✓✓
Optimize use of irrigation water (for example, irrigation at critical stages of crop growth, irrigating at night)	C.28	Minimize CO <sub>2</sub> emissions from energy used for pumping while maintaining high yields and crop-residue production.	✓
Use water-efficient crop varieties	C.29	Minimize CO <sub>2</sub> emissions from energy used for pumping while maintaining high yields and crop-residue production.	✓

Sources: Islami et al. 2009; Medina and Iglesias 2010; Paustian et al. 2006; Smith et al. 2005, 2008; Weiske 2007.

Note: CH<sub>4</sub> = methane, CO<sub>2</sub> = carbon dioxide, GHG = greenhouse gas; ✓✓✓ = high potential, ✓✓ = medium potential, ✓ = low potential.

of agricultural adaptation in Europe (Medina and Iglesias 2010; Paustian et al. 2006; Smith et al. 2005, 2008; Weiske 2007). The results of this review were used to corroborate the mitigation potentials identified in the SNC and to provide additional mitigation potentials for adaptive measures that were not explicitly quantified in the SNC.

Each year Albania's agricultural sector emits approximately 1.4 million tons of CO<sub>2</sub> equivalent of greenhouse gas emissions, which are generated by CO<sub>2</sub>, nitrous oxide, and methane (Islami et al. 2009). Mitigation of CO<sub>2</sub> emissions is primarily enabled by adaptive crop yield and cropland management practices that increase soil carbon content. Soil carbon content is augmented by either enhancing the uptake of atmospheric carbon in agricultural soils, or by reducing carbon losses from agricultural soils. Specific adaptive practices that promote carbon soil sequestration include changing fallow season and mulching practices to retain moisture and organic matter and introducing cropping systems that promote high residue yields (that is, crop rotation, strip cropping, intercropping, cover cropping, etc.). Adaptive practices that slow rates of soil decomposition and reduce soil carbon losses include reduced till and no till farming.

Adaptive practices also have the ability to significantly reduce nitrous oxide and methane emissions. Nitrous oxide emissions are largely driven by fertilizer overuse and misuse, which increases soil nitrogen content and generates nitrous oxide losses. By improving fertilizer application techniques, specifically through more efficient allocation, timing, and placement of fertilizers, nitrous oxide emissions can be reduced while maintaining crop yields. Mitigation of methane emissions, on the other hand, is largely enabled by increasing the efficiency of livestock production. Optimizing breed choices, for example, serves to increase

livestock production per animal, thereby reducing overall methane emissions. Proper use of animal manure—for example, biogas production and improved feed quality—quickens digestive processes and also leads to reduced methane emissions. Finally, adaptive measures may also reduce the emissions associated with agricultural production processes. In particular, conservation tillage and manual weeding will reduce emissions generated by heavy machinery use. Similarly, increased irrigation efficiency reduces energy required to pump groundwater.

The potential for adaptive agricultural practices to simultaneously mitigate climate change has already garnered attention in Albania. Initiatives related to sustainable land management, soil protection, and irrigation efficiency and improvement have already been implemented across the country. While no actions have yet been taken to improve crop mixtures, species selection, or fertilizer use, the potential benefits of these practices have been both analyzed and publicized (Islami et al. 2009).

### **Note**

1. Questions on adaptive capacity were asked first—the questions and a summary of farmers' answers are included in chapter 1.

# Cost-Benefit Analysis

### Scope and Key Parameters

The quantitative cost-benefit analyses of adaptation options described in this chapter address seven of the most important adaptation options in a detailed fashion.

1. Adding new drainage capacity
2. Rehabilitating existing drainage infrastructure
3. Adding new irrigation capacity
4. Rehabilitating existing irrigation infrastructure
5. Improving water use efficiency in fields
6. Changing crop varieties and species
7. Optimizing fertilizer use

These options may include costs for extension programs, as appropriate, if enhanced extension is necessary to achieve the full benefits of the adaptation option. This is true for two of these options, namely improving water use efficiency, and changing crop varieties. It is expected that farmers would incur relatively small costs from these changes in farming practices. Currently, these good farming practices are not pursued because of inadequate capacity and knowledge at the farm level. This was confirmed by at least some of the farmers during consultations. Therefore, the costs that would be incurred to enable these measures are to improve the capacity of extension services and the availability of new varieties and breeds.

In addition, less detailed analyses of three other options was conducted: improving the hydrometeorological network; installing hail nets for selected crops; and expanding the use of plastic greenhouses for tomato cultivation.

The assessments are conducted at the farm level, on a per hectare basis, and consider available estimates of the incremental cash costs for implementing the option as well as the revenue implications of increasing crop yields. All estimates are conducted for representative “model” farms, located in each of the four Albanian AEZs, for farms that cultivate each of the key crops. With seven key

crops (one of which is farmed in both irrigated and rainfed areas), and four AEZs, there are a total of 28 model farms in the analyses.

The results presented here are useful as a first order assessment of actions that are likely to yield positive returns for farmers. No conclusions are, however, made in this analysis about farmers' ability to pay for these measures. For example, while it may be concluded that irrigation infrastructure would increase farm-level revenue for certain crops and in certain locations, and the revenue increase would be greater than the per hectare cost, that does not mean that the study recommends that farmers attempt to construct and pay for this infrastructure themselves. In fact, few farmers would actually be able to obtain individual farm-level irrigation infrastructure at the per hectare price used, which reflects construction of a broader irrigation infrastructure project with potentially significant economies of scale. In many cases, national policies and/or funding are needed to enable these adaptations to occur.

While some measures (for example, additional fertilizer) could be pursued with limited or no government or donor involvement, most could be more cost-effectively pursued as sector- or regional-scale programs. The results are therefore useful for decision-making at the national or regional scale, with the target decision-making audience being Albanian government policy-makers and donor communities with interest in financing agricultural sector investments.

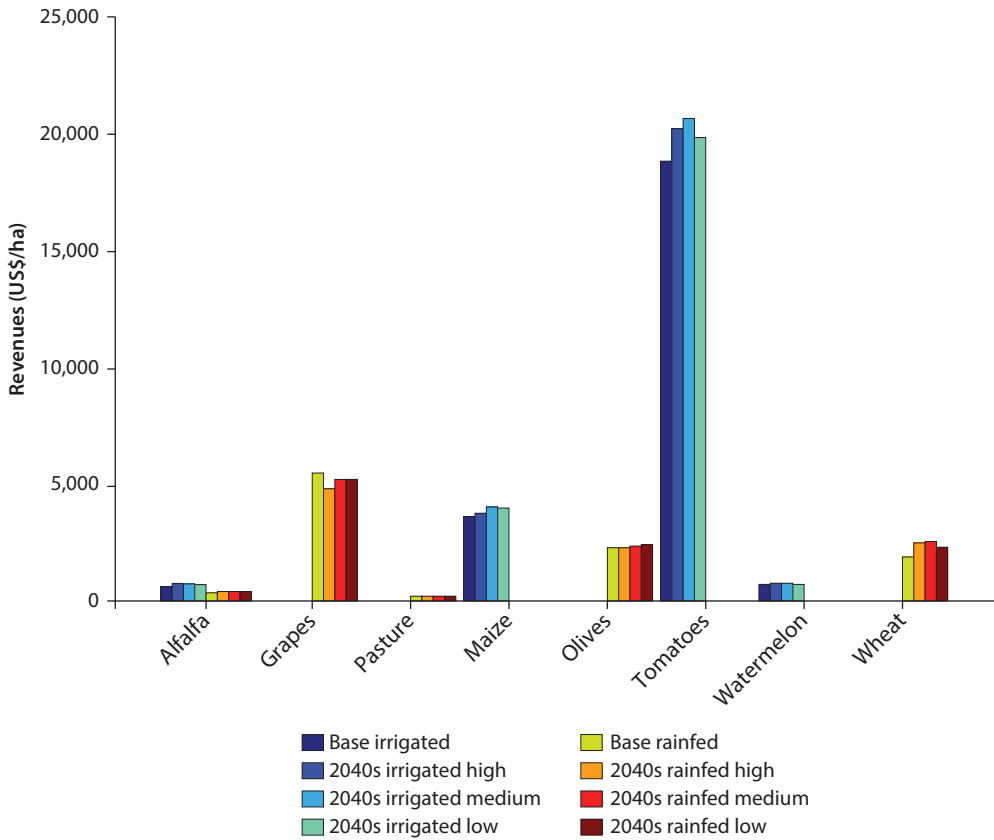
The analyses reported here have a limited scope and not all adaptation options considered with the Albanian farmers and in-country experts could be assessed quantitatively for their effects on crop yields (the key element of the benefits side of the cost-benefit analysis). Also, for some options it was difficult to assess the overall costs. For those options that were not amenable to quantitative cost-benefit analysis, a qualitative assessment of benefits and costs was provided based on evaluation by the team and summarized in chapter 4.

Other costs and benefits that do not affect farm expenditures or revenues were excluded from the quantitative analysis, mainly due to lack of available data. For example, while increasing fertilizer use may lead to social costs in terms of negative effects on nearby water quality, it is difficult to quantify those effects without consideration of the site-specific characteristics that may be unique to individual farms. While excluding those costs from the scope of the quantitative cost-benefit assessment, and focusing only on cash expenditures and revenues, social costs and other considerations were brought back into consideration qualitatively in the final chapter, as part of the overall options.

Figure 5.1 presents the revenue per hectare for crops, comparing current conditions with those of the 2040s with climate change, but before adaptation actions are taken. For comparison purposes across years, the price forecasts incorporated in this figure are current prices rather than "high" 2040 price forecasts.

In this figure it is clear that tomatoes provide the greatest yield per hectare. What is not apparent is that tomato production requires appropriate terrain, suitable soil, relatively intensive inputs of labor and nutrients, and readily available irrigation water to achieve these yield levels. A general conclusion from

**Figure 5.1 Estimated Crop Revenues per Hectare for the 2040–50 Decade before Adaptation Actions Are Taken**



examination of figure 5.1 is that climate change alters yields and revenue estimates for all crops examined, in the range of up to about a 10 percent decline in yields in the worst cases. As can be seen in the next section, however, adopting adaptation options has the potential for yield enhancement of greater than 10 percent, because adaptation can both address current yield deficits relative to full yield potential (closing the adaptation deficit), and enhance farmers’ abilities to both minimize risks and exploit opportunities presented by climate change.

**Results of Quantitative Analyses—Cost-Benefit and Present Value Assessments**

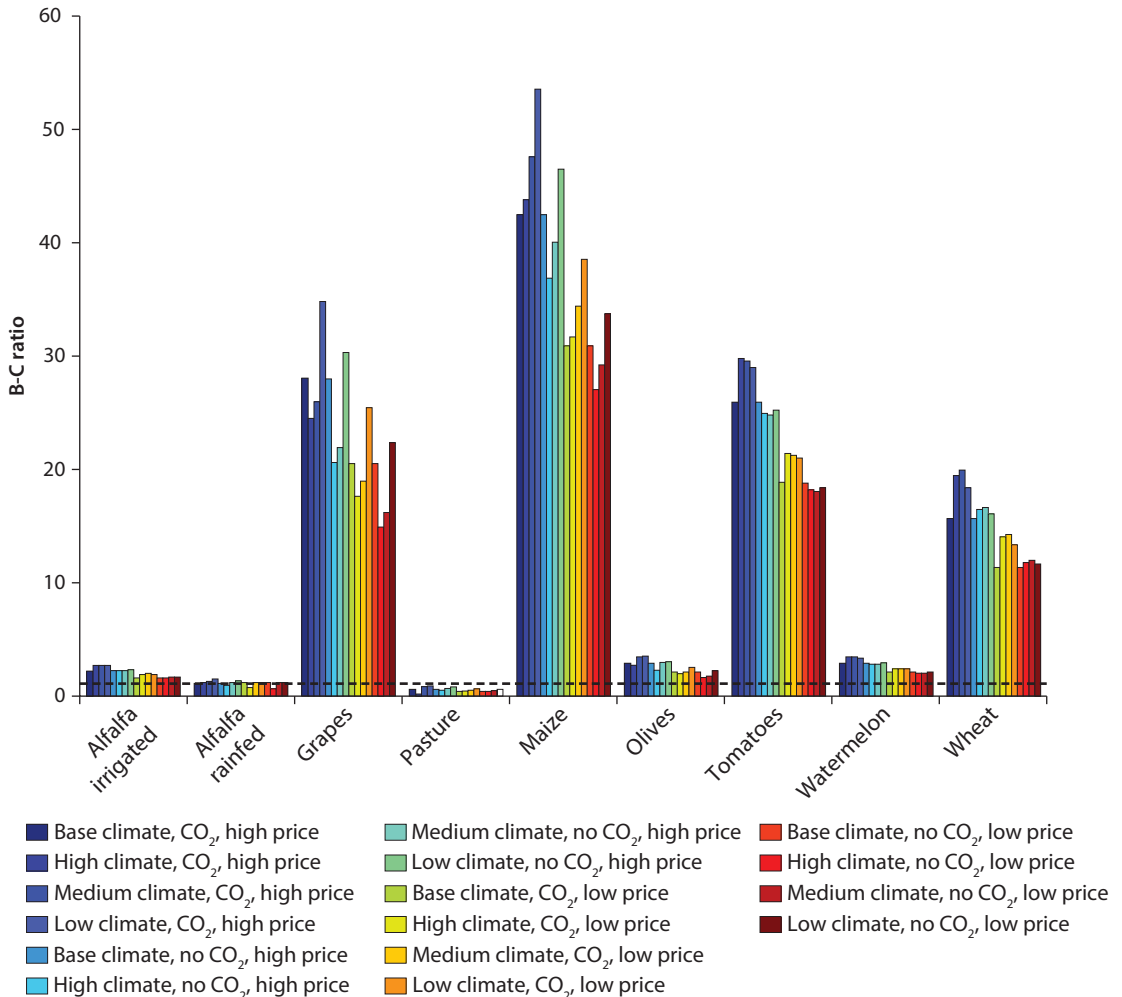
This section presents results for each of the options analyzed, focusing on the Lowlands AEZ. Later in the chapter, the quantitative results for each AEZ are summarized and ranked.

### Adding New Drainage Capacity and Rehabilitating Existing Drainage Infrastructure

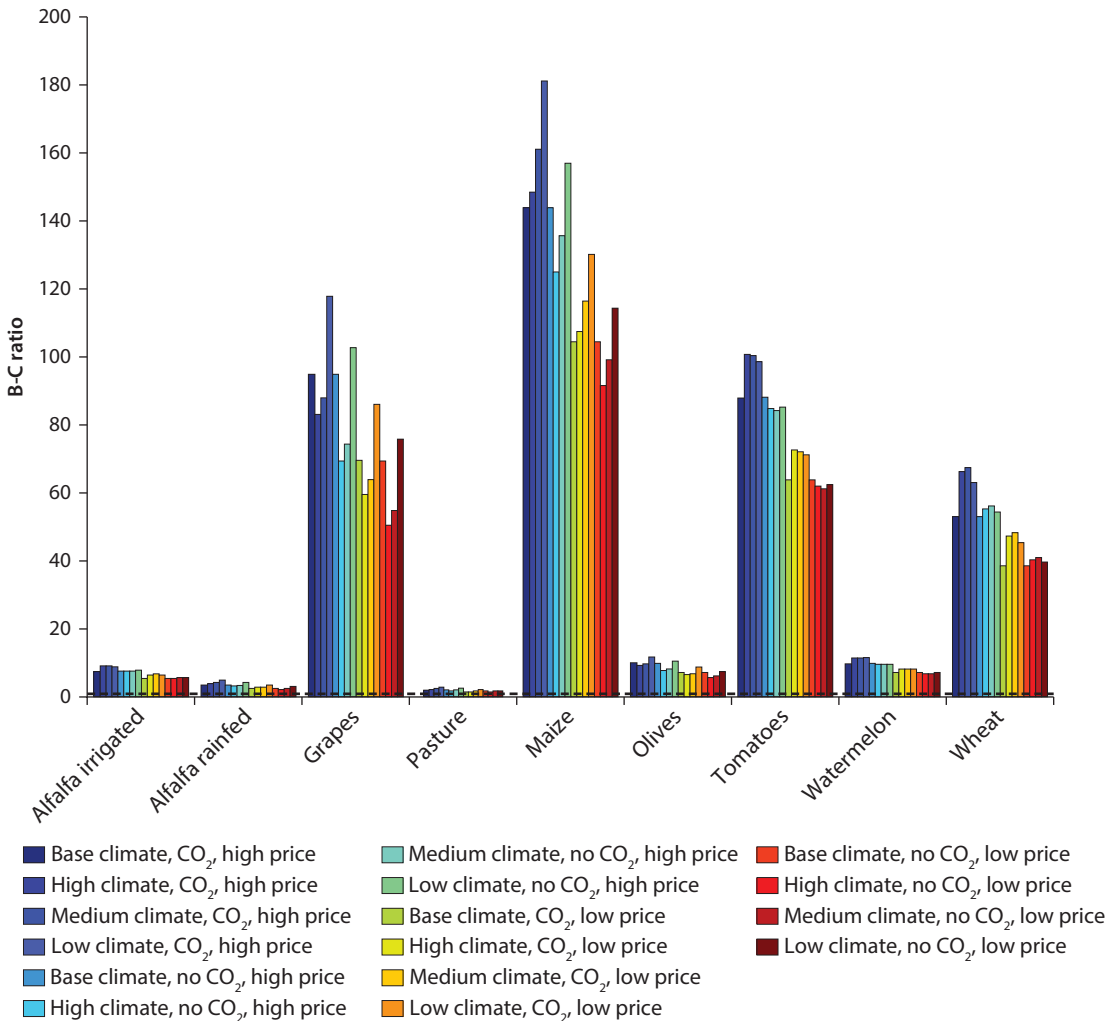
The results of an analysis that considers improved drainage for the Lowlands AEZ are presented in figures 5.2 and 5.3. Figure 5.2 is for new drainage infrastructure, and figure 5.3 is for rehabilitated drainage infrastructure.

This option involves a farm-level improvement of drainage conditions similar to that which would result from the difference between poorly drained and well-drained soils and entails both capital and ongoing maintenance costs, estimated on a per hectare basis. Costs are higher for new drainage infrastructure than for rehabilitated infrastructure, but the estimated yield increase is the same, so benefit-cost ratios are higher where it is possible to rehabilitate existing infrastructure. The yield effect in the calculations likely underestimates benefits,

**Figure 5.2 Benefit-Cost Analysis Results for Improved Drainage in the Lowlands AEZ—New Drainage Infrastructure**



**Figure 5.3 Benefit-Cost Analysis Results for Improved Drainage in the Lowlands AEZ—Rehabilitated Drainage Infrastructure**



because the AquaCrop modeling reflects only the continuous yield improvements, and does not reflect additional yield changes that might result from improved drainage during extreme flood events.

The figures show benefit-cost ratios for all crops, under each of the climate scenarios, for both assumptions regarding carbon dioxide fertilization (with and without the yield effect), and for two alternative future price forecasts. The dashed horizontal line in each graph shows a B-C ratio of one. Bars that extend above this line represent crop/condition combinations where benefits exceed costs.

The results for all four AEZs are similar in that enhanced drainage is most advantageous for the higher-value crops. The tallest bars are for maize, tomatoes, and grapes. B-C ratios for wheat and olives are lower than for maize, tomatoes,

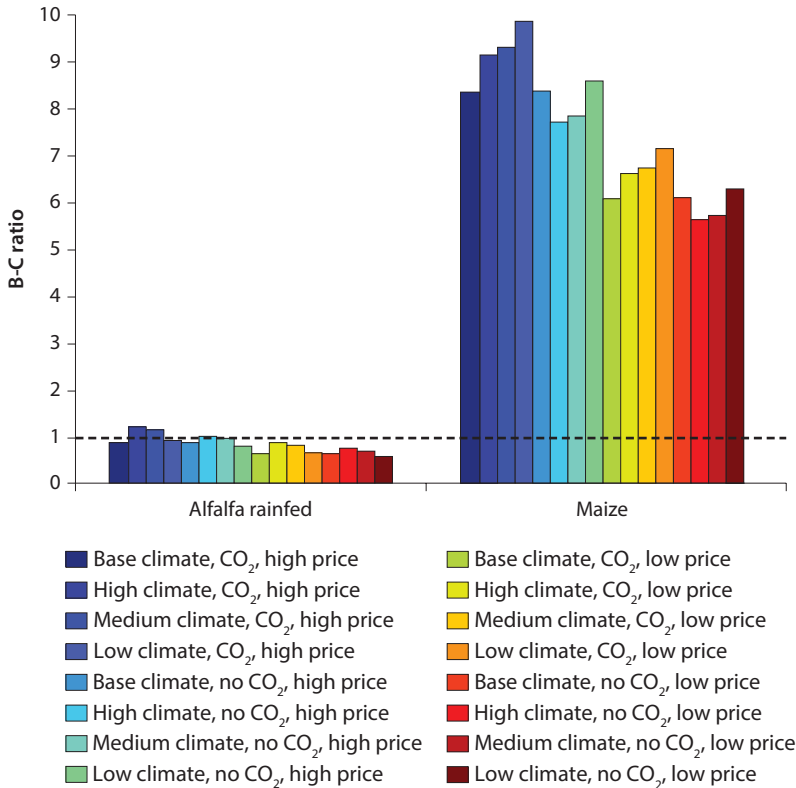
and grapes, but for all climate scenarios they remain above a B-C ratio of one. B-C ratios for the drainage adaptation option for alfalfa (rainfed or irrigated), pasture, and watermelon are consistently below one, or, in the case of irrigated alfalfa, below one under at least some climate scenarios. As a result, drainage for those crops should be a much lower priority.

**Adding New Irrigation or Rehabilitating Existing Irrigation Infrastructure**

Figures 5.4 and 5.5 illustrate the results for adding irrigation capacity, or rehabilitating existing irrigation capacity. Among the crops that are the focus of this work, only alfalfa and maize are currently grown in Albania under both rainfed and irrigated conditions, so in this case B-C ratios are only estimated for these two crops. There are also only a few hectares of rainfed maize. The option is modeled as a switch from rainfed to irrigated for the model farms in each of the four AEZs and the graph therefore presents B-C ratios for the Lowlands AEZ for these crops.

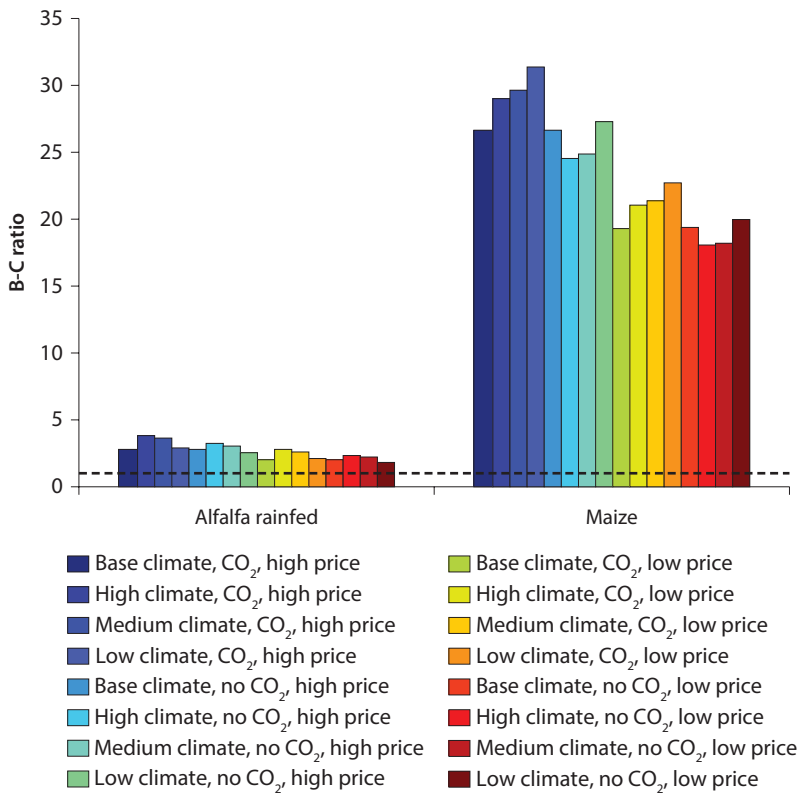
The results in these figures indicate that B-C ratios are relatively high in the Lowlands AEZ for maize, and lower for alfalfa. Because rehabilitating irrigation infrastructure is less expensive than new infrastructure, but the benefits are the

**Figure 5.4 Benefit-Cost Analysis Results for Newly Irrigated Alfalfa and Maize in the Lowlands AEZ**





**Figure 5.5 Benefit-Cost Analysis Results for Rehabilitated Irrigation Infrastructure for Alfalfa and Maize in the Lowlands AEZ**



same, B-C ratios for rehabilitated infrastructure are higher than for new infrastructure. In other AEZs, B-C ratios for alfalfa are less than one, even for rehabilitated infrastructure. For alfalfa, as expected, both the new and rehabilitated irrigation capacity options have the lowest B-C ratio for the low-impact scenario, which has the highest precipitation and therefore the lowest estimated incremental yield benefit for increased irrigation water. On the other hand, maize shows the opposite pattern because precipitation during key months of the maize growing season is projected to be lowest under the low-impact scenario. In all cases, B-C ratios under the high-, medium-, and low-climate scenarios are significantly higher than if the adaptation options are adopted under base climate conditions.

**Changing Crop Varieties**

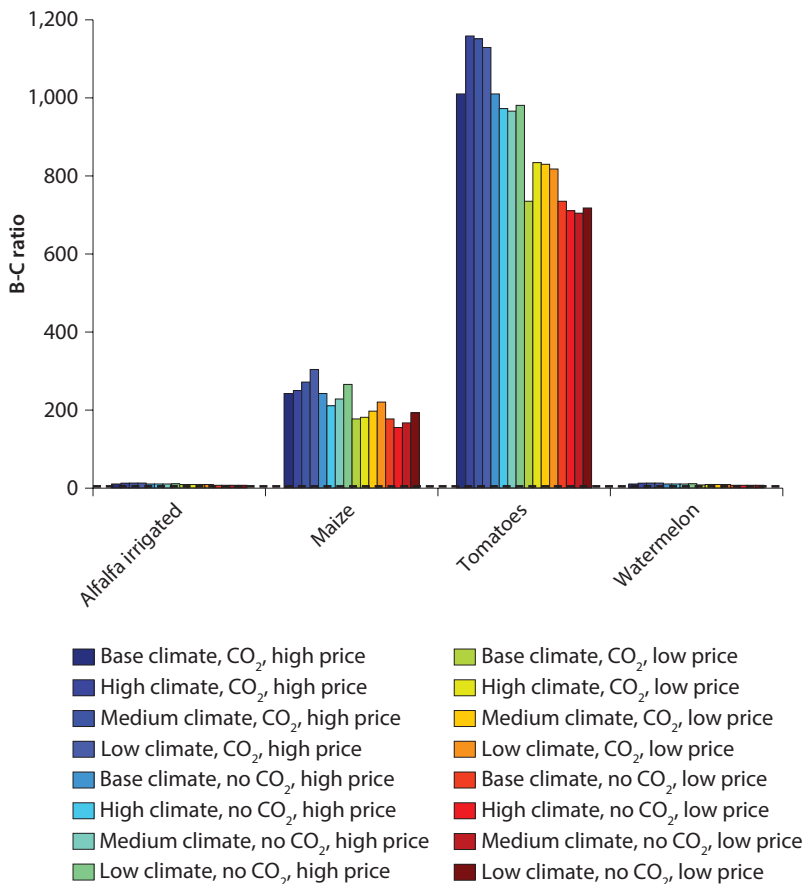
For changing crop varieties, it is estimated that the main cost is in enhanced research and development at the regional level, likely funded by national expenditures but potentially funded privately by farmer cooperatives or agribusiness concerns. For changes in crop variety, only the results for the Lowlands AEZ are discussed but results from other AEZs are similar. For this option the value of yield is estimated to benefit for a change from current to optimal crop varieties,

as feasible within the options available within the AquaCrop database of crop varieties. B-C ratios are highest for tomatoes, with extraordinarily high ratios of up to 350 to 1. B-C ratios for other crops are lower but still significantly greater than one for grapes, maize, olives, and wheat, and closer to one for other crops. In most cases, the benefits of optimizing crop varieties reflects the adaptation deficit, in that better varieties could result in substantial yield gains regardless of the change in climate. Costs may, however, be underestimated for this adaptation option, as there may be additional costs to farmers for more expensive varieties, and possibly other direct costs for fertilizer and water inputs to achieve the highest yields.

**Improving Water Use Efficiency in Fields**

Figure 5.6 shows the B-C ratios for improving water use efficiency in fields, for the Lowlands AEZ. The main costs for this option are an enhanced hydrometeorological network, to provide better precipitation forecasts for farmers, coupled with enhanced extension to provide better training for farmers to make better

**Figure 5.6 Benefit-Cost Analysis Results for Improved Water Use Efficiency in the Lowlands AEZ**

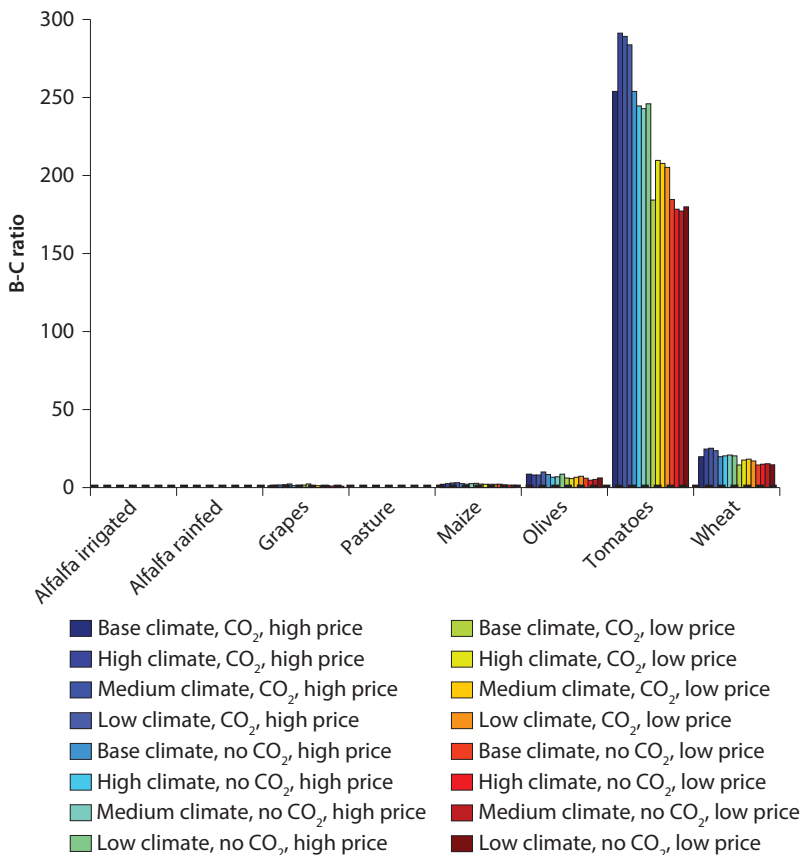


use of existing water resources to optimally irrigate. The results for the Lowlands AEZ indicate high B-C ratios for tomatoes and maize, but ratios near zero for alfalfa and watermelon. In general, the results across scenarios appear to be most sensitive to price projections and the presence or absence of carbon dioxide fertilization effect, and less sensitive to the climate scenario

**Optimizing Agronomic Inputs, Fertilizer Application**

Figure 5.7 illustrates the results for optimized organic fertilizer application, relative to current use of fertilizer, for the Lowlands AEZ. The graph shows a very wide range of B-C ratios by crop, as high as 250 to 1 for tomatoes, and ratios of about 20 to 1 for wheat, but with much lower ratios for other crops. As noted above, however, the costs for fertilizer in this framework include only the direct expenditures, and do not reflect indirect costs and effects of fertilizer application for the surrounding environment, or the possibility that enhanced fertilizer application could in some cases also increase greenhouse gas emissions that contribute to climate change.

**Figure 5.7 Benefit-Cost Analysis Results for Optimized Fertilizer Use in the Lowlands AEZ**



## Other Economic Analyses

In addition to the detailed economic analyses described above, additional analyses were undertaken on the potential benefits and costs of the four additional options that were of interest to farmers, but for which data were sparse: improving the hydrometeorological network, expanding extension services, and installing hail nets for selected crops. These other economic analyses are informative for ranking options but provide less certainty than the more detailed analyses in the prior section.

### *Improving the Hydrometeorological Network*

The costs of improving hydrometeorological data collection and institutions in Albania were estimated and compared to the yield increases that would be necessary to achieve yield benefits equal to the estimated costs. Although one of the benefits of this option is improved timing of irrigation water application (analyzed above), it was not possible to monetize several other benefits of this alternative, some of which include flood forecasting, improved forecasting of crop life stages, and less frequent and more precise pesticide application. Because direct comparison of costs and benefits is not possible, this option was instead evaluated by considering how much crop yields would need to increase in order to justify the costs of improving hydrometeorological capacity. This is sometime referred to as a break-even analysis.

Information on costs of improved hydrometeorological services was derived from several sources:

- *Number of stations.* The Ministry of Agriculture in Tirana indicated that approximately six automated stations would be required to meet the needs for agriculturally relevant hydrometeorological services.
- *Cost per station.* Capital and O&M costs for an average station were obtained from a World Bank project in Moldova that purchased 24 automated stations and necessary infrastructure (for example, computers), provided staff training, and helped develop necessary institutions. All of these cost categories were included in the estimate of average station costs. In total, per station capital and annual O&M costs were US\$18,500 and US\$1,340 respectively.
- *Hectares that benefit.* In order to distribute these costs to the per hectare level, it was assumed that these benefits would accrue only to irrigated hectares, and only to farmers that currently make use of extension services. For extension reach, the Ministry of Agriculture and ATTC representatives estimate that approximately 70 percent of farmers use extension services. The Albanian Institute of Statistics indicates a total of 117,800 irrigated hectares in Albania, so it was assumed that benefits would accrue to a total of 82,500 hectares.

In total, these annualized capital and annual O&M improvements in hydrometeorological capacity cost 21 US cents per irrigated hectare per year. The cost would be considerably lower if rainfed hectares were included.

For the break-even analysis, the present value (over the 2015–50 period) per hectare costs of hydrometeorological services was divided by the present value revenues for a typical hectare of each crop in each AEZ across each of the price, CO<sub>2</sub>, and climate scenarios. This reveals the percentage increase in per hectare yields (that is, yields are linear with respect to revenues) necessary to cover the per hectare costs. Across all crops, AEZs, and scenarios, yields would need to increase an average of 0.03 percent to justify the costs. The maximum necessary increase in yields necessary to justify this measure would be about 0.3 percent, but this high estimate is not reasonable because it assumes that all hectares that would benefit from hydrometeorological investment are in the lowest revenue crop (pasture).

Based on these results, it was found that expanding the hydrometeorological network with a program such as that contemplated by the Ministry would very likely yield benefits substantially greater than its costs.

### ***Expanding Extension Capabilities and Services***

The costs of enhanced extension services are already included in B-C analyses of the optimized fertilizer application and improved irrigation water application options presented above. A break-even analysis was also conducted for expanding extension services.

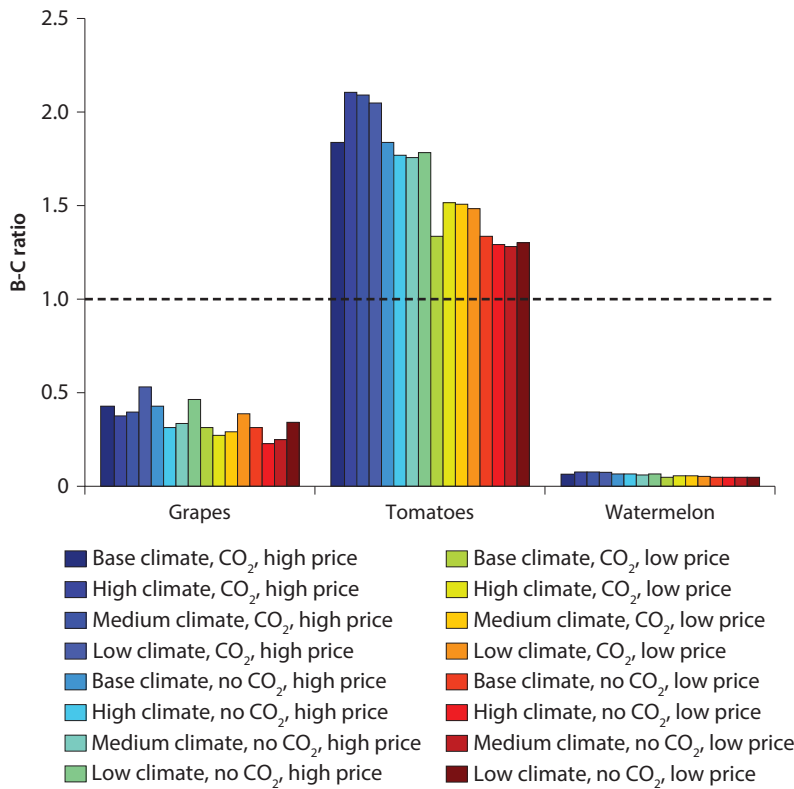
The total cost for an enhanced extension service is estimated by the Ministry to be just over US\$500,000 per year. It can be assumed that the total number of hectares of farmland that could benefit from enhanced extension is the same number as estimates for the hydrometeorological service enhancement described above, or 82,500 hectares. The result would be an annual cost per hectare of US\$6.44. The average break-even yield increase required to justify this cost, across all crops, AEZs, and scenarios is 1.03 percent.

The yield increase required to justify the program seems plausible when compared with other estimates in the literature on the likely yield benefits of enhanced extension. For example, a meta-analysis of 294 studies of research and development rates of return (IFPRI 1998) found a 79 percent rate of return to extension services. The Inter-American Development Bank also found enhanced extension services increase yields by the lowest-producing grape farmers, and increase grape productivity (2008). Another study (Pesticide News 2007) found that farmer field schools reduced pesticide use on cotton by 34–66 percent. In a project to reform the Indian agriculture extension system, IFPRI found that Farmer Field Schools increased graduates' cotton yields by 4–14 percent (2010).

### ***Installing Hail Nets for Apple Orchards and Other Crops***

Apples were not included in the list of focus crops for this analysis, therefore crop modeling for apple orchards was not conducted. Hail nets were mentioned by farmers in the Korce region as a measure that they believed would be beneficial. There is some emerging literature that indicates that climate change will lead to more frequent and more severe hail storms and thunderstorms (Trapp et al. 2007). In addition, a recent study for Northeastern Spain estimates the costs of hail nets for apple crops relative to crop insurance (Iglesias and Alegre 2006). The

**Figure 5.8 Benefit-Cost Analysis Results for Hail Nets to Protect Grapes, Tomatoes, and Watermelon**



study finds slight benefits of hail nets relative to crop insurance, but implicitly assumes that crop insurance is already a wise investment, and does not evaluate the baseline risk of hail damage each year relative to insurance premiums.

Hail nets have both capital costs and yield implications—they reduce sunlight infiltration which reduces yield, but they also moderate extreme low and high temperatures to some extent, which can increase yield. In this analysis, capital costs from Iglesias and Alegre and their estimates of net yield decrements from their field studies of gala apples were applied to tomatoes and grapes in the Southern Highlands AEZ. The result is illustrated in figure 5.8. Benefit-cost ratios for tomatoes are greater than one, but less than one for grapes. The Iglesias and Alegre analysis provides some justification for the measure Korce region farmers believe would be beneficial for their orchards, but the analysis is inconclusive, and further analysis is needed to evaluate this option.

### Sensitivity Analyses

As indicated above, the sensitivity of the B-C ratio and present value of benefits across 12 (3×2×2) scenarios was examined, including the three climate scenarios (low-, medium-, and high-impact); two carbon dioxide fertilization assumptions

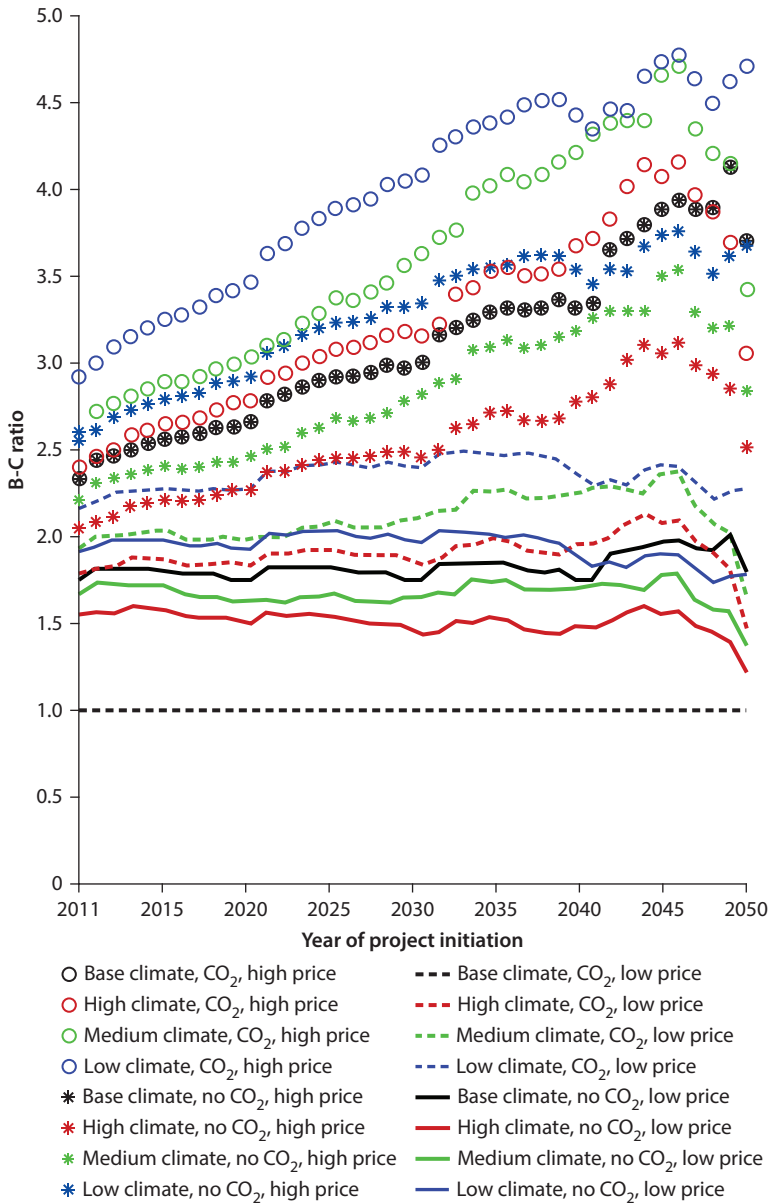
(no effect and full effect); and two price projections (low forecast, which holds prices constant, and high forecast, which incorporates a gradual upward trend in prices based on IFPRI published projections). The results in general are most sensitive to the price projections, which yield relatively larger changes in revenues in later years of the period of analysis, near 2050, though some of those differences are tempered by application of a 5 percent discount rate.

Overall, use of a higher discount rate (10 percent rather than 5 percent discount and cost-of-capital rate) results in present value benefits of the adaptation options falling by between 44 and 54 percent (across crops, AEZs, and climate/ $\text{CO}_2$ /crop price scenarios). This narrow range reflects the fact that increases in revenue over the 2015–50 time period are relatively constant, particularly in the near term when the majority of present value benefits accrue. On the other hand, present value costs fall between 29 and 47 percent, where the low end of the range reflects adaptation options with large initial loans for capital expenditures and relatively low O&M costs (for example, new irrigation or drainage infrastructure). The effect on present values varies and depends on relative magnitudes of the costs and benefits, but the overall average effect on present values is a reduction of 48 percent. In approximately 3 percent of instances, the use of a 10 percent discount rate causes NPVs of the adaptation options to change signs. The vast majority of these sign changes (99 percent) are from positive NPVs to negative NPVs, and occur under adaptation scenarios with near-zero NPVs at a 5 percent discount rate (for example, many options for alfalfa and pasture). Because options are not recommended unless B-C ratios are much greater than one or NPVs are much greater than zero, the higher discount rate does not alter the options or priority ranking.

More detailed sensitivity analyses are possible, including analysis of the optimal start date for specific options for each crop and AEZ, as illustrated in figures 5.9 and 5.10.<sup>1</sup> Figure 5.9 shows that under all scenarios and start dates, optimal fertilizer application for maize in the Lowlands AEZ has a B-C ratio greater than one. Figure 5.10, on the other hand, shows that only some ratios and start dates yield B-C ratios greater than one. For figure 5.10 the price trajectory is critical, with low-price scenarios exhibiting B-C ratios less than one, and high price ratios exhibiting B-C ratios greater than one. In this case, price is clearly more important than climate in determining the B-C ratios. One conclusion from figure 5.10 might be that, rather than ruling out implementation of new irrigation for alfalfa crops in the Lowlands AEZ, it would be prudent to wait to implement this option, and to monitor price trends as well as the unfolding of climate scenarios.

A general finding across almost all option, crop, and AEZ combinations is that there are upward sloping B-C ratio curves. That in turn suggests that implementation of these options grows more beneficial over time, either because of changes in prices, changes in climate that widens the increment in yield (that is, increasing resiliency over time), or both. For options with B-C ratios greater than one in the early part of the period of analysis, short-term implementation is warranted, and benefits can be expected to grow over time. For others, the option can be part of a long-term plan, or at least a wait-and-see approach can be

**Figure 5.9 Detailed Sensitivity Analyses: Optimized Fertilizer Application for Irrigated Maize in the Lowlands AEZ**



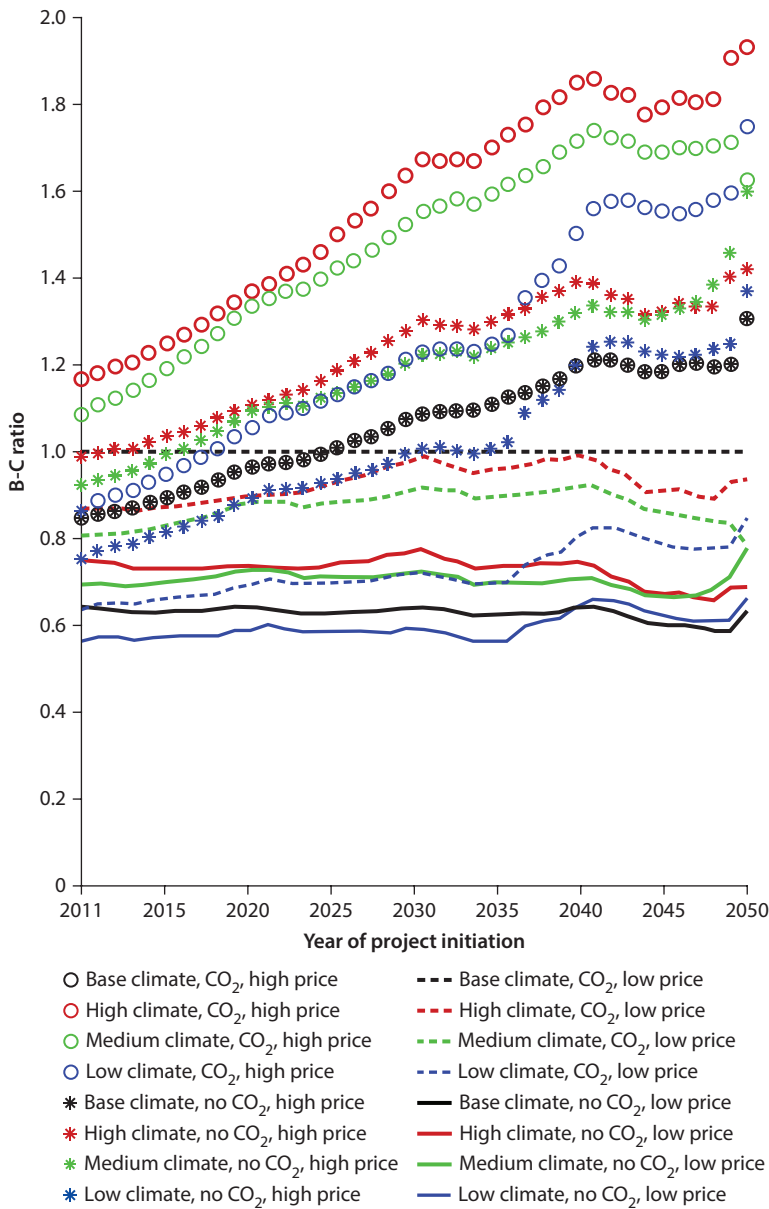
adopted, with monitoring of both price and climate outcomes to assess whether uncertainty in these parameters narrows as time progresses.

**Analysis of Livestock Sector Adaptation**

In the absence of a process model that can simulate the effects of climate change and adaptation measures on livestock productivity, it is difficult to evaluate



**Figure 5.10 Detailed Sensitivity Analyses: New Irrigation Capacity for Rainfed Alfalfa in the Lowlands AEZ**



livestock sector adaptation options. As a result, the livestock sector options are based on the literature review and qualitative analysis. These include options such as providing better protection for livestock during heat waves (ranging from better shade to air-conditioned barn space) improving overall management, nutrition, and health, and transitioning livestock to heartier types.

## Summary of Quantitative Results in AEZs

The previous section highlights selected results for benefit-cost ratios for the Lowlands AEZ. Benefit-cost ratios are useful, but another useful measure is net present value benefits, which indicates the per hectare benefits minus the per hectare costs over the full period of analysis, starting in 2015 and ending in 2050. Ranges of results reflect variation across the climate, CO<sub>2</sub> fertilization, and price scenarios.

Tables 5.1 and 5.2 summarize the net benefit estimates for two AEZs: the Lowlands and Southern Highlands. The results for the Intermediate AEZ are similar to those for the Lowlands, but generally somewhat lower; results for the Northern and Central Mountains AEZ are similar to those for the Southern Highlands. The tables list what are considered the five adaptation measures with the highest overall net benefits. Detailed results indicate that the same five measures have the highest overall rankings in all AEZs, but the crop emphasis differs in low-elevation AEZs from those for high-elevation AEZs. Net benefits are higher in low-elevation AEZs, except for a few crops (for example, wheat). Only those crops with a positive net benefit are listed; for all other crops not listed in the table, there is a negative or very near zero net benefit for the measure.

The ranking of benefits also considers that some benefit and cost estimates are incomplete, as indicated in the “notes” column. For example, the estimated costs

**Table 5.1 Five Adaptation Measures with High Net Benefits: Lowlands AEZ**

<i>Illustrative present value economic results per hectare (in thousands 2009 US\$)</i>					
<i>Adaptation measure</i>	<i>Crop focus for Lowlands AEZ</i>	<i>Estimated revenue gain</i>	<i>Estimated costs</i>	<i>Net revenues</i>	<i>Notes</i>
1) Improve varieties	Tomatoes:	\$79 to 129	\$0.35	\$78 to 129	Costs are for R&D
	Grapes:	\$13 to 31		\$13 to 31	
	Wheat:	\$4 to 7		\$4 to 7	
	Maize:	\$5 to 10		\$5 to 10	
2) Use irrigation water more efficiently	Tomatoes:	\$71 to 116	\$0.1	\$71 to 116	Costs are extension & hydromet
	Maize:	\$15 to 31		\$15 to 31	
3) Rehabilitate existing drainage infrastructure	Maize:	\$29 to 56	\$0.31	\$28 to 56	Benefits do not reflect increased risk of floods with climate change
	Grapes:	\$16 to 37		\$15 to 37	
	Tomatoes:	\$19 to 31		\$19 to 31	
	Wheat:	\$12 to 21		\$12 to 21	
4) Install new drainage infrastructure	Maize:	\$29 to 56	\$1.0	\$28 to 55	
	Grapes:	\$16 to 37		\$15 to 36	
	Tomatoes:	\$19 to 31		\$18 to 30	
	Wheat:	\$12 to 21		\$11 to 20	
5) Optimize agromorphic inputs: fertilizer and soil moisture	Tomatoes:	\$215 to 353	\$1.2	\$213 to 351	Costs do not include environmental damages
	Wheat:	\$18 to 30		\$17 to 29	
	Olives:	\$6 to 12		\$4 to 11	
	Maize:	\$2 to 4		\$1 to 3	

**Table 5.2 Five Adaptation Measures with High Net Benefits: Southern Highlands AEZ**

Adaptation measure	Crop focus for Southern AEZ	Illustrative present value economic results per hectare (in thousands 2009 US\$)			Notes
		Estimated revenue gain	Estimated costs	Net revenues	
1) Improve varieties	Tomatoes:	\$42 to 69	\$0.35	\$42 to 69	Costs are for R&D
	Grapes:	\$19 to 34		\$18 to 34	
	Wheat:	\$0.7 to 1.3		\$0.4 to 1	
	Maize:	\$10 to 17		\$9 to 16	
2) Use irrigation water more efficiently	Tomatoes:	\$6 to 10	\$0.1	\$6 to 9	Costs are extension & hydromet
	Maize:	\$20 to 33		\$20 to 33	
3) Rehabilitate existing drainage infrastructure	Maize:	\$23 to 40	\$0.31	\$23 to 39	Benefits do not reflect increased risk of floods with climate change
	Grapes:	\$21 to 38		\$21 to 38	
	Tomatoes:	\$19 to 31		\$19 to 31	
	Wheat:	\$6 to 12		\$6 to 11	
4) Install new drainage infrastructure	Maize:	\$23 to 40	\$1.0	\$22 to 39	
	Grapes:	\$21 to 38		\$20 to 37	
	Tomatoes:	\$19 to 31		\$18 to 30	
	Wheat:	\$6 to 12		\$5 to 11	
5) Optimize agronomic inputs: fertilizer and soil moisture	Tomatoes:	\$172 to 284	\$1.2	\$171 to 283	Costs do not include environmental damages
	Wheat:	\$11 to 20		\$10 to 18	
	Maize:	\$17 to 28		\$15 to 27	

for optimizing fertilizer application include only the costs for the fertilizer input and extension service to advise farmers and leave out the potentially very significant environmental costs to surface and ground water quality, as well as potential greenhouse gas emissions, that could result from added fertilizer loads on fields. For this reason, fertilizer application is the fifth of the five options listed here.

This ranking of measures by their net benefits is carried through to the next chapter, where the results of the quantitative and qualitative evaluations are combined to arrive at an overall menu of climate adaptation options for Albanian agriculture.

## Note

1. Benefit-cost ratios over time, however, are influenced by the inability to estimate benefits after 2050. In many cases, benefits of options that have a continued useful life after 2050 may be underestimated, and may have higher benefits as climate changes accelerate after 2050.



# Options to Improve Climate Resilience of Albania's Agricultural Sector

This chapter combines a review of current adaptive capacity (chapter 1), identification of the risk of climate change to agriculture (chapter 3), results of the farmer and expert evaluations of adaptation options (chapter 4), the quantitative evaluation of adaptation measures (chapter 5), and the results of the National Dissemination and Consensus Building Conference held in Tirana on March 3, 2011, to arrive at an overall set of high-priority policy, institutional capacity building, and investment measures for improving the resiliency of Albanian agriculture to climate change.<sup>1</sup>

Below is a summary of high-priority options at the national level, followed by high-priority options specific to each AEZ. The discussions below include summaries of the ranked lists developed at the National Conference.

### Options at the National Level

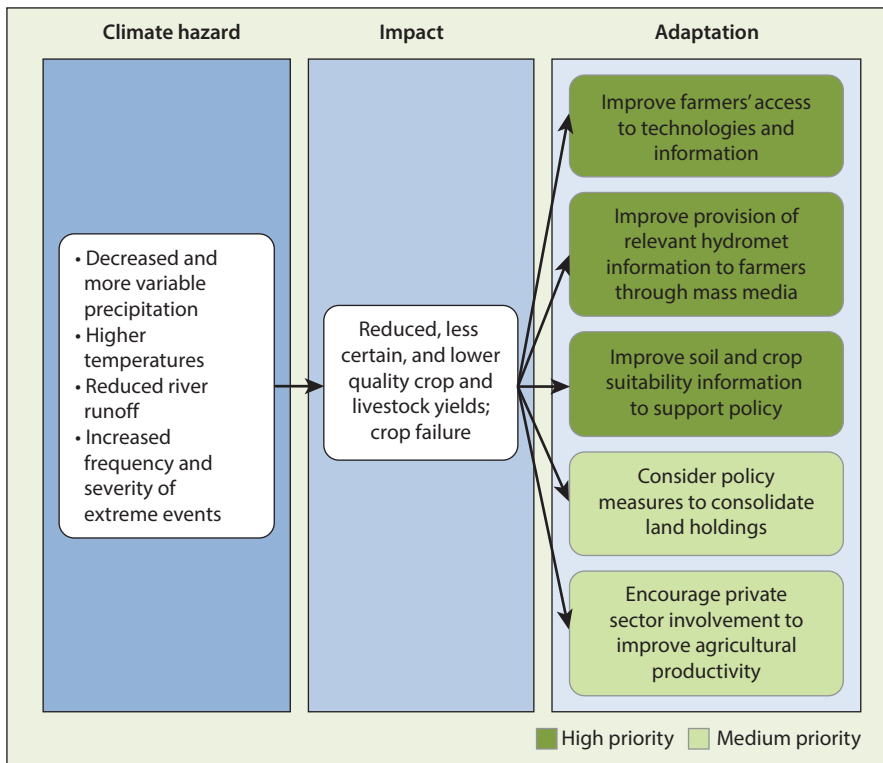
Measures for consideration at the national level focus on policy and institutional capacity that have value on their own, or which are essential to ensure that farm-level and private sector actions are applied to their best advantage. The basis for the ranking of these options is in most cases the qualitative analysis of potential net benefits, combined with suggestions from the farmer consultations. These national-level recommendations include the following:

1. *Increase the access of farmers to technology and information, both generally and for adapting to climate change.* The team recommends that the capacity of the existing extension agency be improved in two areas: (1) to support better agronomic practices at the farm level, including implementation of more widespread demonstration plots and access to better information on the availability and best management practices of high-yield crop varieties; and (2) to support the same measures but with a focus on maintaining yields during extreme water stress periods that are likely be more frequent with climate change. The

first part of this recommendation is a measure to close the adaptation deficit, and the second part is a measure to ensure yield gains are not undermined by future climate change. As outlined in chapter 5, the economic analysis suggests that expansion of extension services is likely to yield benefits in excess of estimated costs.

2. *Improve the dissemination of hydrometeorological information to farmers.* In every farmer meeting held, and again at the National Conference, participants noted the need for better local capabilities for hydrometeorological data, particularly for short-term temperature and precipitation forecasts. The current lead hydrometeorological institution in Albania, the IoEWE, is inadequately funded to collect and disseminate climatological information to farmers. Those capabilities are acutely needed in the short term to support better farm-level decision-making and, in the medium term, better policy-level decision-making in Albania. The economic analysis of the costs and benefits of a relatively modest hydrometeorological station investment, which includes training and annual operating costs, suggests that benefits of such a program are very likely to exceed costs.
3. *Improve information collection and dissemination on soil types, drainage potential, and crop suitability.* It is recommended that the existing capacity at the Fushe-Kruje ATTC (Agriculture Technology Transfer Centers) to analyze soils information throughout Albania, for the purposes of crop suitability analyses, be enhanced and better linked to both policy initiatives at the national level and local farmer education efforts. This measure would work in concert with measures to improve drainage infrastructure, focusing drainage efforts on those areas with the greatest potential for yield increases. Crop modeling at a more specific level, linked to spatially explicit soils information, could be a powerful tool for targeting these infrastructure investments. If possible, these efforts should also be linked with a comprehensive mapping of existing drainage capacity, which should include an assessment of its current functional state.
4. *Consider national policy measures to further consolidate farm holdings.* Both the team and at least one farmer group noted that on-farm adaptive capacity is limited by the generally small size of Albanian farms. The consequence of small farms is an inability to provide sufficient economies of scale to invest in adaptive measures, such as tertiary irrigation systems and equipment that might both increase yields and reduce soil erosion. In other countries, efforts to consolidate holdings have involved the national government facilitating transfers of land among smallholders to create contiguous plots, efforts to facilitate farmer organization around collective crop marketing efforts, or efforts to facilitate large equipment sharing (for example, tractors, harvesters) among smallholders.
5. *Encourage private sector involvement to most efficiently adapt to climate change.* There may be a tendency to assume that adaptation to climate change is necessarily a public sector function, but as the economic analysis in chapter 5 demonstrated, there is strong private sector incentive, with economic benefits

**Figure 6.1 Adaptation Measures at the National Level Based on World Bank and National Conference Assessments**



greatly exceeding costs, for measures that will improve the resiliency of Albanian agriculture to climate change. The national government should focus on putting in place policies that enable the private sector to effectively assist in adaptation. For example, public service conducting testing of seed and livestock varieties for their suitability for Albanian climate, terrain, and soil conditions, and making recommendations of the best varieties, but allowing the private sector to produce and sell seeds to farmers.

Figure 6.1 links the climate change exposures to impacts, and then these impacts to the national-level adaptation options. Measures shaded in darker green represent options that were recommended highly by both the experts' assessment and the National Conference groups.

### Options at the AEZ Level

Tables 6.1 through 6.4 present the results of the adaptation modeling (chapter 5), qualitative analysis, and farmer consultations (chapter 4), which form the basis for overall options to improve the resilience of Albania's agricultural sector to climate change. Each table reflects four ranking criteria, and

**Table 6.1 National-Level Adaptation Options**

<i>Adaptation measure</i>	<i>Specific focus areas</i>	<i>Ranking criterion</i>			
		<i>Net economic benefit: Quantitative analysis</i>	<i>Net economic benefit: Expert assessment</i>	<i>“Win-win” potential</i>	<i>Favorable evaluation by local farmers</i>
<b><i>Improve farmer access to technology and information</i></b>	<i>Seed varieties; more efficient use of water</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>High</i>
<b><i>Improve farmer access to relevant hydro-meteorological information</i></b>	<i>Short-term temperature and precipitation forecasts</i>	<i>High (based on “break-even” analyses)</i>	<i>High</i>	<i>High</i>	<i>High</i>
<b><i>Improve agricultural information for policy support</i></b>	<i>Soils (types and drainage qualities), General crop suitability</i>	<i>Not evaluated</i>	<i>High</i>	<i>High</i>	<i>Not mentioned</i>
<b><i>Provide incentives to consolidate farm holdings</i></b>	<i>None identified</i>	<i>Not evaluated</i>	<i>Not mentioned</i>	<i>Potentially High</i>	<i>High</i>
<b><i>Encourage private sector involvement in efficient adaptation</i></b>	<i>Seeds, livestock options, particularly on international market</i>	<i>Not evaluated</i>	<i>Potentially High</i>	<i>High</i>	<i>Not mentioned</i>

Note: Rows in italics indicate measures that were prioritized both by the expert analysis and by the stakeholders participating in the National Conference. The measures not in italics were prioritized only by the expert analysis.

assessment of the measure on a five-point scale for net economic benefits, with all measures on that scale representing a favorable economic evaluation, but the scale providing a rank order; and a three-point scale (high, medium, or low) for other criteria:

- *Net economic benefits* (benefits minus costs)
- *Expert assessment of ranking* for those options that cannot be evaluated in economic terms
- *Win-win potential*: A measure with a high potential for increasing the welfare of Albanian farmers, with or without climate change
- *Favorable evaluation by the local farming community*: In this draft, these results are based on the results of two stakeholder consultations at the AEZ level, with farmers and local agriculture sector experts.

These sections summarize the results of the individual and AEZ-specific small groups that met at the National Conference on March 3, 2011. The purpose of those groups was to rank adaptation options most advantageous for each AEZ. The synthesized menus of high- and medium-priority adaptation options for each AEZ are summarized in figures 6.2 through 6.5.



### Lowlands AEZ

The National Conference group noted that this AEZ includes 20 percent of the surface area of the country, but accounts for 70 percent of the value of agricultural products. The groups ranking of priorities included the following:

1. Improve drainage, specifically rehabilitation and improvements to the existing drainage infrastructure that will result in an increase in subsurface drainage.
2. Improve the on-farm efficiency and the quality of water for irrigation use; the group concluded that average water use in irrigated areas is approximately 1,000 cubic meters per hectare, much more than should be needed.
3. Improve crop varieties.
4. Practice optimal feeding and fertilization of crops (the former refers to organic soil amendments), and optimize the use of pesticides.
5. Research agriculture by increasing investment in agricultural centers that can provide new means of adapting farms to climate change.

As summarized in table 6.2, five options emerge from the quantitative, qualitative, and farmer evaluations of measures as most advantageous for adapting to

**Table 6.2 Adaptation Measures for the Lowlands AEZ**

Adaptation measure	Crop and livestock focus	Ranking criterion			
		Net economic benefit: Quantitative analysis	Net economic benefit: Expert assessment	Potential to aid farmers with or without climate change	Favorable evaluation by local farmers
<b>Improve drainage infrastructure</b>	Tomatoes, Maize, Grapes, Wheat	3 for rehabilitation 4 for new drainage	High	High	High
<b>Optimize agroeconomic inputs: fertilizer and soil moisture conservation</b>	Tomatoes, Olives, Wheat	5	Not mentioned	High	Medium
<b>Improve irrigation water quality</b>	Tomatoes, Maize, Watermelon	2, but only indirectly evaluated	Not mentioned	High	High
<b>Improve crop varieties</b>	Tomatoes, Grapes, Wheat, Maize, Watermelon	1	Medium	Medium	High
<b>Research and improve livestock management, nutrition, and health</b>	Beef cattle, Chickens	Unknown	Not mentioned	Low to Medium	High

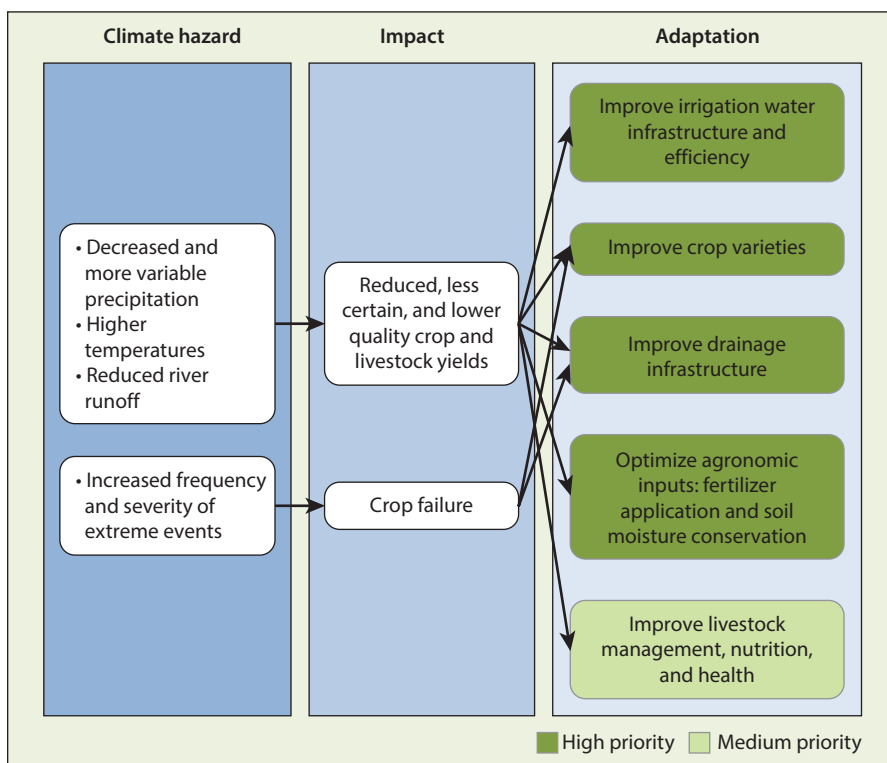
Note: Rows in italics indicate measures that were prioritized both by the expert analysis and by the stakeholders participating in the National Conference. The measure not in italics was prioritized only by the expert analysis.

climate change in the Lowlands AEZ, with the top four also recommended at the conference, as indicated in italics in the table:

- *Improve access to higher yield and drought-tolerant crop and livestock varieties.* In this study, possible yield increases by changing varieties to higher yield alternatives were evaluated. To achieve the higher yields, this measure needs to be combined with extension on management practices (the costs for this is also reflected in the analysis). These measures represent some of the potentially most cost-effective measures to improve resiliency, they provide benefits both with and without climate change, and they were strongly supported by Lowlands farmers.
- *Improve drainage infrastructure.* The quantitative analysis suggests that economic benefits to farmers of improved drainage are 10–20 times higher than estimated costs, and B-C ratios exceed one by a wide margin across climate scenarios, with and without carbon fertilization, and across alternative future price projections for tomatoes, maize, grapes and wheat. In addition, improving drainage could improve yields today, and is evaluated favorably by farmers. The team also noted the need to improve drainage infrastructure and, perhaps more important, to properly size drainage capacity to take account of the effect of future climate change on the variability of water flows, which could contribute to higher extreme flow episodes in the future.
- *Improve irrigation water quality and repair irrigation infrastructure.* This measure was not directly evaluated in this study, but was strongly advocated by farmers. Lowlands farmers noted that some irrigation infrastructure is in disrepair, which has the effect of lowering its effective capacity. The water drawn from the reservoir at a lower level has a high mineral content, rendering it inadequate for irrigation. The specific measure discussed in the Lowlands AEZ meeting envisaged the repair of a dam to ensure that bottom sediment is not re-suspended at times of low flow. The analysis of a measure to repair irrigation infrastructure finds a very high B-C ratio, providing support for this measure.
- *Optimize agronomic inputs, including fertilizer application and soil moisture conservation.* High-to-very high B-C ratios were found for optimizing fertilizer application, based on the enhanced yields indicated by the crop modeling. In the Lowlands AEZ, the highest B-C ratios were found for tomatoes, olives, and wheat. Smaller B-C ratios were found for maize and grapes; when combined with omission of other costs of fertilizer application, such as reduced water quality, there is the potential that a full cost analysis could yield costs in excess of yield benefits. The sensitivity analysis suggests that yield benefits associated with this measure do not necessarily change with climate change.

The last option is to improve livestock management, nutrition, and health. Figure 6.2 provides climate change exposures, impacts, and adaptation options for the Lowlands AEZ. Measures shaded in darker green represent options that were identified by both the consultants' assessment and the National Conference group.

**Figure 6.2 Adaptation Measures for the Lowlands AEZ Based on World Bank and National Conference Assessments**



### **Intermediate AEZ**

Many of the measures in the Intermediate AEZ are similar to those in the Lowlands AEZ, but with a somewhat different crop focus. Switching to existing, higher yield varieties has greatest value where there is already irrigation. There is less impact from the higher yield varieties when the crop is rainfed, because water application cannot be timed to achieve the best results from these varieties. Most farmers in this AEZ advocated for the employment of drought-tolerant varieties, however, which currently have limited availability and therefore are difficult to evaluate quantitatively.

During the National Conference, participants from the Intermediate AEZ developed the following ranking of options:

1. Improve drainage and other management of high water flows. As part of this discussion, the group noted that a key priority is tertiary (on-farm) drainage, where they believe no investor is interested in funding that adaptation.
2. Pursue irrigation rehabilitation and more efficient on-farm irrigation.
3. Improve crop varieties combined with better agronomic practices and smarter use of fertilizers.

**Table 6.3 Adaptation Measures for the Intermediate AEZ**

Adaptation measure	Crop and livestock focus	Ranking criterion			
		Net economic benefit: Quantitative analysis	Net expert assessment	Potential to aid farmers with or without climate change	Favorable evaluation by local farmers
<b>Improve drainage infrastructure</b>	Maize, Wheat, Grapes, Tomatoes	3 for rehabilitation 4 for new drainage	High	High	High
<b>Optimize agromomic inputs: fertilizer application and soil moisture conservation</b>	Tomatoes, Wheat, Maize	5	Not mentioned	High	Medium
<b>Improve irrigation water application efficiency</b>	Maize	2	Not mentioned	High	Medium
<b>Rehabilitate existing irrigation system</b>	All irrigated crops	May be high in certain sites	Not mentioned	High	High
<b>Improve crop varieties</b>	Grapes, Tomatoes, Maize	1	High	High	High
<b>Research and improve livestock management, nutrition, and health</b>	Beef cattle, Chickens	Unknown	Not mentioned	Low	High

Note: Rows in italics indicate measures that were prioritized both by the expert analysis and by the stakeholders participating in the National Conference. The measure not in italics was prioritized only by the expert analysis.

4. Improve management of livestock under climate change.
5. Improve provision of meteorological information to farmers.

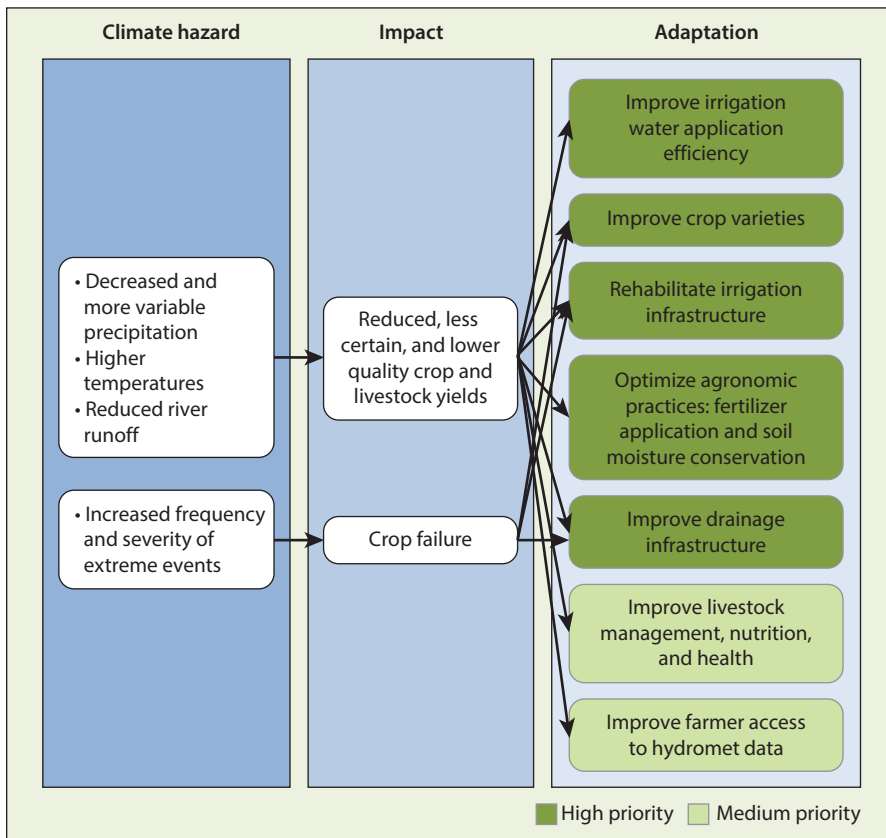
Where these overlap with the original team priorities in table 6.3, they are listed in italics.

Figure 6.3 links the climate change exposures to impacts, and these impacts to the intermediate AEZ adaptation options. Measures shaded in darker green represent options that were identified by both the team and the National Conference group.

### **Southern Highlands AEZ**

Table 6.4 summarizes the adaptation measures for the Southern Highlands AEZ. While many of the recommended measures are similar to those in other AEZs, a key challenge unique to the Southern Highlands AEZ is adapting fruit tree crops to higher temperatures, and possibly to hailstorms. Unfortunately, it was not possible to include apples in the scope of the crop modeling. Improvement in apple varieties to increase drought and heat resistance seems likely to have positive net

**Figure 6.3 Adaptation Measures for the Intermediate AEZ Based on World Bank and National Conference Assessments**



benefits. At least one study shows positive benefits to apple crops of hail nets, but it was possible to confirm those results with the modeling in this study.

The Southern AEZ group developed the following ranked list of adaptation options:

1. Improve drainage.
2. Rehabilitate irrigation infrastructure.
3. Improve crop varieties.
4. Optimize fertilizer use and crop nutrition more generally.
5. Improve livestock management, nutrition, and health.
6. Install hail nets.
7. Develop forest wind-breaks, using short-cycle tree species that also produce biomass.
8. Ameliorate soil erosion on steep slopes, possibly by planting trees selectively in pasture areas.
9. Develop a simple meteorological forecasting system for farmers, with early warning for extreme events.

**Table 6.4 Adaptation Measures for the Southern Highlands AEZ**

<i>Adaptation measure</i>	<i>Crop and livestock focus</i>	<i>Ranking criterion</i>			
		<i>Net economic benefit: Quantitative analysis</i>	<i>Net economic benefit: Expert assessment</i>	<i>Potential to aid farmers with or without climate change</i>	<i>Favorable evaluation by local farmers</i>
<b><i>Improve drainage infrastructure</i></b>	<i>Tomatoes, Maize, Grapes, Wheat</i>	<i>3 for rehabilitation, 4 for new drainage</i>	<i>High</i>	<i>High</i>	<i>High</i>
<b><i>Optimize agronomic inputs: fertilizer application and soil moisture conservation</i></b>	<i>Tomatoes, Wheat</i>	<i>5</i>	<i>Not mentioned</i>	<i>High</i>	<i>Not mentioned</i>
<b><i>Rehabilitate irrigation system</i></b>	<i>Tomatoes, Maize</i>	<i>May be high in certain sites</i>	<i>Not mentioned</i>	<i>Unknown</i>	<i>High</i>
<b><i>Improve varieties for higher yield and drought tolerance</i></b>	<i>Tomatoes, Grapes, Maize</i>	<i>1</i>	<i>High</i>	<i>Medium to High (focus on drought-tolerance)</i>	<i>High</i>
<b><i>Improve varieties for drought tolerance</i></b>	<i>Apples</i>	<i>Not evaluated</i>	<i>High</i>	<i>Unknown, but likely High</i>	<i>High</i>
<b><i>Research and improve livestock management, nutrition, and health</i></b>	<i>Beef cattle, Chickens</i>	<i>Unknown</i>	<i>Not mentioned</i>	<i>Low</i>	<i>High</i>

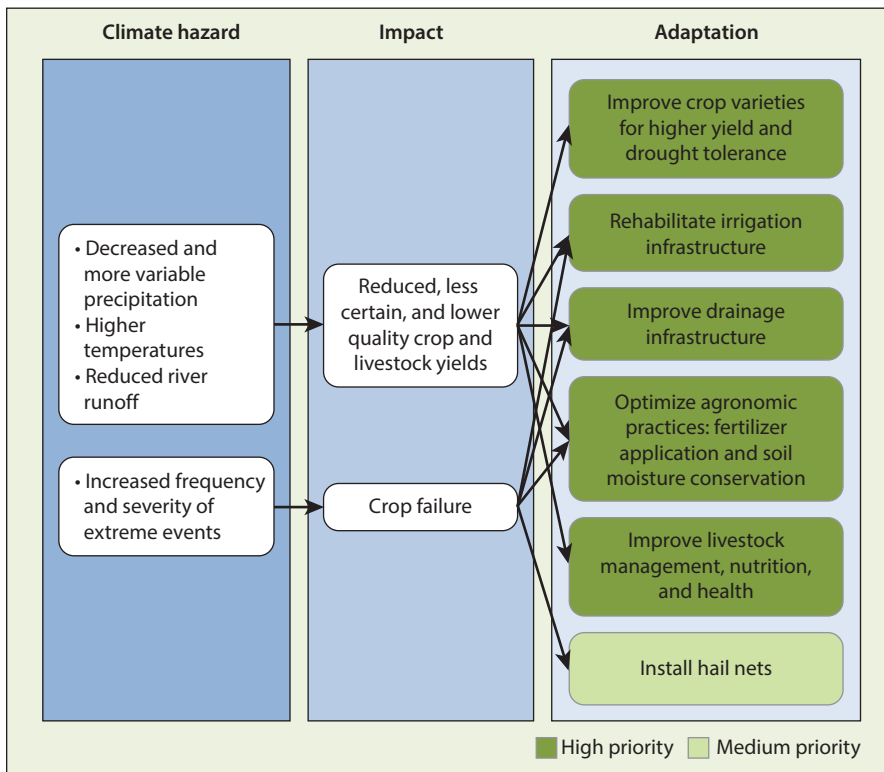
Note: Rows in italics indicate measures that were prioritized both by the expert analysis and by the stakeholders participating in the National Conference.

Figure 6.4 summarizes the full set of adaptation options from the team and the National Conference group. Measures shaded in darker green represent options that were identified by both the team and the National Conference group.

### **Northern and Central Mountains AEZ**

Table 6.5 summarizes the adaptation measures for the Northern and Central Mountains AEZ. The original draft of this work identified a key issue in parts of the Northern and Central Mountains AEZ as the frequency of flooding of agricultural areas. This issue is only prevalent in the Shkodra region, however. The National Conference group agreed with the results of in-country work suggesting that there may be a need for new initiatives in floodplain land-use management, which could include levee construction but may simply involve better identification of lands at high-risk for flooding, and restrictions on agricultural practices for those lands. Extreme water flow events, which are expected to increase with more variable precipitation under climate change, would further increase the need for those measures.

**Figure 6.4 Adaptation Measures for the Southern Highlands AEZ Based on World Bank and National Conference Assessments**



Overall, the National Conference group favored a broader focus on the impact of high water flow events, to include incidence of these events in the mountainous regions, where torrents can cause severe soil erosion. As a result, this group had the following ranking of adaptation options:

1. Examine the water regime in this region more broadly, incorporating analysis of the effects of high flow on drainage, irrigation, and soil erosion.
2. Provide land-use management in frequently flooded areas.
3. Improve crop structure (for example, rotations) and varieties.
4. Research and improve livestock management, health, and nutrition.
5. Improve and optimize the use of agronomic inputs, including fertilizer and soil moisture conservation.

Figure 6.5 provides climate change exposures, impacts, and adaptation options for the Northern and Central Mountains AEZ, summarizing the options from both the team and the National Conference group. Measures shaded in darker green represent options that were identified by both the team assessment and the National Conference group.

**Table 6.5 Adaptation Measures for the Northern and Central Mountains AEZ**

<i>Adaptation measure</i>	<i>Crop and livestock focus</i>	<i>Ranking criterion</i>			
		<i>Net economic benefit: Quantitative analysis</i>	<i>Net economic benefit: Expert assessment</i>	<i>Potential to aid farmers with or without climate change</i>	<i>Favorable evaluation by local farmers</i>
<b><i>Improve drainage infrastructure</i></b>	<i>Maize, Grapes</i>	<i>3 for rehabilitation, 4 for new</i>	<i>Medium</i>	<i>High</i>	<i>High</i>
<b><i>Optimize agronomic inputs: fertilizer application and soil moisture conservation</i></b>	<i>Tomatoes, Wheat, Maize</i>	<i>5</i>	<i>Not mentioned</i>	<i>High</i>	<i>Medium</i>
<b><i>Improve crop varieties</i></b>	<i>Grapes, Tomatoes, Maize</i>	<i>1</i>	<i>Not mentioned</i>	<i>High</i>	<i>High</i>
<b><i>Floodplain land-use management measures</i></b>	<i>All</i>	<i>Not evaluated</i>	<i>High</i>	<i>High</i>	<i>Not mentioned</i>
<b><i>Research and improve livestock management, health, and nutrition</i></b>	<i>Beef cattle, Chickens</i>	<i>Unknown</i>	<i>Not mentioned</i>	<i>Low</i>	<i>High</i>

*Note:* Rows in italics indicate measures that were prioritized both by the expert analysis and by the stakeholders participating in the National Conference.

### **Categorization of Short-, Medium-, and Long-Term Options**

The measures outlined above will need to be implemented over differing time scales to ensure they have maximum effect and cost-effectiveness. As part of the quantitative analysis, several sensitivity tests were conducted to assess whether, as the climate changes, certain of the options analyzed in this study might be more cost-effectively implemented at a certain point in time. However, for the options analyzed here, it was found that time was not an important factor in determining B-C ratios. In other words, options with B-C ratios greater than one exhibited positive net benefits from the start of the simulations, in 2015, and exhibited continued net benefits throughout the period of analysis, through 2050, regardless of the simulated start date. The opposite was also true; options with B-C ratios less than one exhibited low B-C ratio values for all simulated start dates.

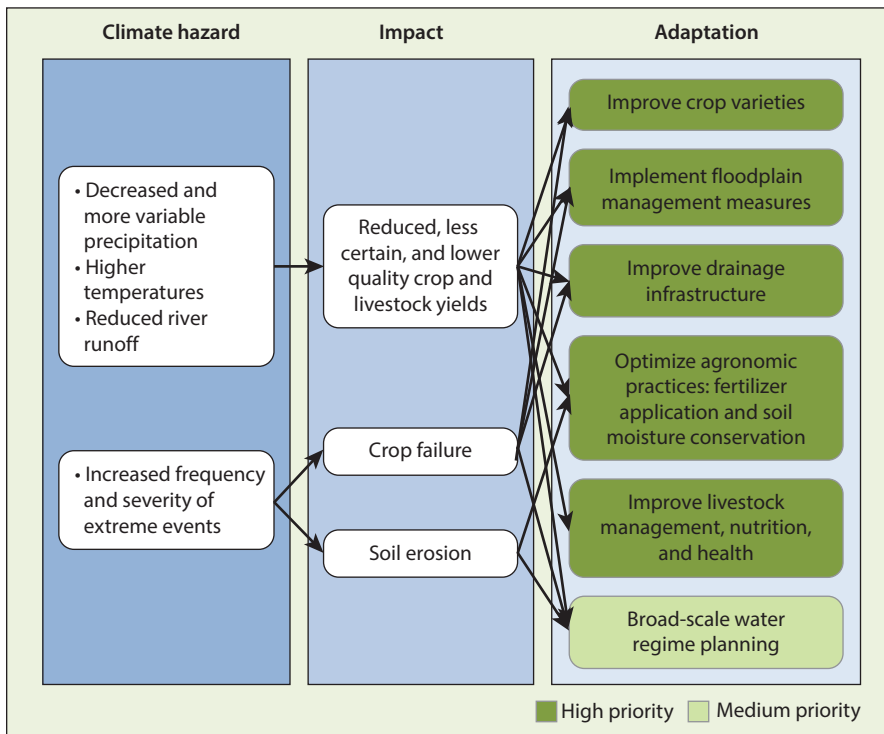
As a result, categorization of short-, medium-, and long-term options is mainly based on qualitative assessment. Short-term options are those that would be implemented within 1–3 years; medium-term options would be implemented in 4–10 years; and long-term options in 10 years or more.

#### **Short-Term Options**

The following should be implemented or at least initiated within one to three years of the completion of the study:



**Figure 6.5 Adaptation Measures for the Northern and Central Mountains AEZ Based on World Bank and National Conference Assessments**



- Provide weather forecasts tailored to farmers.
- Improve farmer access to the best internationally available information and technologies.
- Provide better agricultural information for policy-makers.
- Develop land-use management measures in the Northern and Central Mountains AEZ.
- Optimize agronomic inputs, including fertilizer application and soil moisture conservation.

### **Medium-Term Options**

The following measures should be implemented or at least initiated within four to 10 years of the completion of the study. These measures will require sufficient lead time to ensure they are designed with consideration of the effects of future climate change on the potential for episodic flooding, for example. Prior to implementing these options, therefore, more detailed engineering feasibility studies will be needed for these long-term investments, but those studies must consider the effects of climate change. These measures are not long-term options, however, as they clearly will yield benefits based on current climate conditions, even before the climate changes significantly:

- Improve drainage infrastructure.
- Improve irrigation water infrastructure and, in the process, irrigation water quality.

### ***Long-Term Options***

The following options require long lead time to implement, and also are best pursued as climate scenarios unfold:

- Develop farmer education in the management of drought-tolerant varieties. (Note: a possible exception is heat-tolerant apple varieties in the Southern Highlands AEZ, where farmers report that they have already experienced losses at harvest from extreme heat events.)
- Transition to more heat-tolerant livestock varieties.

In conclusion, a study with this broad scope necessarily involves significant limitations. These include the need to make assumptions about a wide range of aspects of agricultural and livestock production in Albania, the limits of simulation modeling techniques for forecasting crop yields and water resources, and time and resource constraints. Some of the options will require more detailed examination and analysis than could be accomplished here, to ensure that specific adaptation measures are implemented in a manner that maximizes their value to Albanian agriculture.

It is hoped, however, that the awareness of climate risks and the analytic capacities built through the course of this study provide not only a greater understanding among Albanian agricultural institutions of the basis of the options presented here, but also an enhanced capability to conduct the required more detailed assessment that will be needed to further pursue these actions.

### **Note**

1. The National Conference was structured so that participants could first learn more about the work presented in this report, and then work in small groups to develop AEZ-level rankings of options identified here, determine if some of the options were infeasible or not needed, and add new options for consideration. Ultimately, each of the small breakout groups, one for each AEZ, made a specific recommendation to the conference with a ranked list of adaptation options, including in some cases national-level policy and institutional strengthening needed to successfully implement those options.

# Glossary

The source of these definitions is the IPCC AR4 Working Group II report, Appendix I: Glossary, unless otherwise noted. Italics indicate that the term is also contained in this glossary.

**Adaptation.** Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation:

- *Anticipatory adaptation*—Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
- *Autonomous adaptation*—Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in human systems. Also referred to as spontaneous adaptation.
- *Planned adaptation*—Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

**Adaptation assessment.** The practice of identifying options to adapt to *climate change* and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.

**Adaptation—“hard” vs. “soft”.** “Hard” adaptation measures usually imply the use of specific technologies and actions involving capital goods, such as dikes, seawalls and reinforced buildings, whereas “soft” adaptation measures focus on information, capacity building, policy and strategy development, and institutional arrangements. (World Bank 2011)

**Adaptive capacity (in relation to climate change impacts).** The ability of a system to adjust to climate change (including climate variability and extreme to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

**Agroforestry.** A dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (World Agroforestry Centre 2011).

**Aquaculture.** The managed cultivation of aquatic plants or animals, such as salmon or shellfish, held in captivity for the purpose of harvesting.

**Arid region.** A land region of low rainfall, where “low” is widely accepted to be less than 250 millimeters precipitation per year.

**Baseline/reference.** The baseline (or reference) is the state against which change is measured. It might be a “current baseline,” in which case it represents observable, present-day conditions. It might also be a “future baseline,” which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines. Economic baselines reflect current conditions, and climate baselines reflect the decade 2000–09.

**Basin.** The drainage area of a stream, river, or lake.

**Benefits of adaptation.** The avoided damage costs or the accrued benefits following the adoption and implementation of *adaptation* measures.

**Biophysical model.** Biophysical modeling applies physical science to biological problems, for example, in understanding how living things interact with their environment. In this report, biophysical modeling is used in conjunction with economic modeling.

**Capacity building.** In the context of *climate change*, capacity building is developing the technical skills and institutional capabilities in developing countries and economies in transition to enable their participation in all aspects of *adaptation* to, *mitigation* of, and research on *climate change*, and in the implementation of the Kyoto Mechanisms.

**Carbon dioxide (CO<sub>2</sub>).** A naturally occurring gas fixed by photosynthesis into organic matter. A by-product of fossil fuel combustion and biomass burning, it is also emitted from land-use changes and other industrial processes. It is the principal anthropogenic *greenhouse gas* that affects the Earth’s radiative balance. It is the reference gas against which other greenhouse gases are measured, thus having a Global Warming Potential of 1.

**Carbon dioxide fertilization.** The stimulation of plant photosynthesis due to elevated CO<sub>2</sub> concentrations, leading to either enhanced productivity and/or efficiency of primary production. In general, C<sub>3</sub> plants show a larger response to elevated CO<sub>2</sub> than C<sub>4</sub> plants.

**Catchment.** An area that collects and drains water.

**Climate.** Climate in a narrow sense is usually defined as the “average weather,” or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

**Climate change.** Climate change refers to any change in *climate* over time, whether due to natural variability or as a result of human activity. This usage differs from that in the *United Nations Framework Convention on Climate Change* (UNFCCC), which defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” See also *climate variability*.

**Climate model.** A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity (that is, for any one component or combination of components a hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions; the extent to which physical, chemical, or biological processes are explicitly represented; or the level at which empirical parameterizations are involved. Coupled atmosphere/ocean/sea-ice *General Circulation Models* (AOGCMs) provide a comprehensive representation of the climate system. More complex models include active chemistry and biology. Climate models are applied, as a research tool, to study and simulate the climate, but also for operational purposes, including monthly, seasonal, and interannual climate predictions.

**Climate Moisture Index (CMI).** CMI is a measure of aridity that is based on the combined effect of temperature and precipitation. The CMI depends on average annual precipitation and average annual potential evapotranspiration (PET). If PET is greater than precipitation, the climate is considered to be dry, whereas if precipitation is greater than PET, the climate is moist. Calculated as  $CMI = (P/PET) - 1$  {when  $PET > P$ } and  $CMI = 1 - (PET/P)$  {when  $P > PET$ }, a CMI of  $-1$  is very arid and a CMI of  $+1$  is very humid. As a ratio of two depth measurements, CMI is dimensionless.

**Climate projection.** The calculated response of the *climate system* to *emissions* or concentration *scenarios* of *greenhouse gases* and aerosols, or radiative forcing scenarios, often based on simulations by *climate models*. Climate projections are distinguished from climate predictions, in that the former critically depend on the emissions/concentrations/radiative forcing scenarios used, and therefore on highly uncertain assumptions of future socio-economic and technological development.

**Climate risk.** Denotes the result of the interaction of physically defined hazards with the properties of the exposed systems—that is, their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences—that is, risk equals the probability of climate hazard multiplied by a given system’s vulnerability (UNDP 2005).

**Climate (change) scenario.** A plausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use

as input to climate change impact models. A “climate change scenario” is the difference between a climate *scenario* and the current climate.

**Climate variability.** Climate variability refers to variations in the mean state and other statistics (such as standard deviation, statistics of extremes, and so on) of the *climate* on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variation in natural or anthropogenic external forcing (external variability). See also *climate change*.

**Costs of adaptation.** Costs of planning, preparing for, facilitating, and implementing *adaptation* measures, including transition costs.

**Crop modeling.** Determines characteristics of crops such as yield and irrigation water requirements. Examples of inputs to crop models include changes in conditions, such as soil type, soil moisture, precipitation levels, and temperature, and changes in inputs, such as fertilizer and irrigation levels.

**Deficit irrigation.** A type of irrigation meant to maximize water-use efficiency (WUE) for higher yields per unit of irrigation water applied: the crop is exposed to a certain level of water stress either during a particular period or throughout the whole growing season. The expectation is that any yield reduction will be insignificant compared with the benefits gained through diverting the saved water to irrigate other crops. The grower must have prior knowledge of crop yield responses to deficit irrigate (Kirda 2000).

**Desert.** A region of very low rainfall, where “very low” is widely accepted to be less than 100 millimeters per year.

**Discount rate.** The degree to which consumption now is preferred to consumption one year from now, with prices held constant, but average incomes rising in line with GDP per capita.

**Drought.** The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.

**Evaporation.** The transition process from liquid to gaseous state.

**Evapotranspiration.** The combined process of water evaporation from the Earth’s surface and transpiration from vegetation.

**Exposure.** A description of the current climate risk within the priority system (that is, the probability of a climate hazard combined with the system’s current vulnerability; UNDP 2005).

**Extreme weather event.** An event that is rare within its statistical reference distribution at a particular place. Definitions of “rare” vary, but an extreme weather event would normally be as rare or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called “extreme weather” may vary from place to place. Extreme weather events typically include floods and *droughts*.

**Food security.** A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an

active and healthy life. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level.

**Forecast.** See climate projection.

**Global circulation model (GCM).** Computer model designed to help understand and simulate global and regional climate, in particular the climatic response to changing concentrations of greenhouse gases. GCMs aim to include mathematical descriptions of important physical and chemical processes governing climate, including the role of the atmosphere, land, oceans, and biological processes. The ability to simulate subregional climate is determined by the resolution of the model.

**Greenhouse gas (GHG).** Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapor (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>), and ozone (O<sub>3</sub>) are the primary greenhouse gases in the Earth's atmosphere. As well as CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub>, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

**Hydrometeorological data.** Information on the transfer of water between land surfaces and the lower atmosphere, especially in the form of precipitation. This type of data can provide insight on effects on agriculture, water supply, flood control, and more.

**(Climate change) Impact assessment.** The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of *climate change* on natural and human systems.

**(Climate change) Impacts.** The effects of *climate change* on natural and human systems. Depending on the consideration of *adaptation*, one can distinguish between potential impacts and residual impacts:

- *Potential impacts*—all impacts that may occur given a project change in climate, without considering adaptation.
- *Residual impacts*—the impacts of climate change that would occur after adaptation.

**Index-based insurance.** A type of crop insurance that uses meteorological measurements to determine indemnity payments, as opposed to assessing damage at the individual farm level, allowing for a lower premium cost. This type of insurance is particularly useful for damages that affect areas relatively uniformly (Roberts 2005).

**Infrastructure.** The basic equipment, utilities, productive enterprises, installations, and services essential for the development, operation, and growth of an organization, city, or nation.

***Integrated water resources management (IWRM).*** The prevailing concept for water management which, however, has not been defined unambiguously. IWRM is based on four principles that were formulated by the International Conference on Water and Environment in Dublin in 1992: (1) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment; (2) Water development and management should be based on a participatory approach, involving users, planners, and policy makers at all levels; (3) Women play a central part in the provision, management, and safeguarding of water; and (4) Water has an economic value in all its competing uses and should be recognized as an economic good.

***Irrigation water-use efficiency.*** Irrigation *water-use efficiency* is the amount of biomass or seed yield produced per unit of irrigation water applied, typically about 1 tonne of dry matter per 100 millimeters water applied.

***Mitigation.*** An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce *greenhouse gas* sources and emissions and enhancing greenhouse gas sinks.

***Multiple-peril crop insurance (MPCI).*** A type of insurance that is geared toward a level of expected yield, rather than to the damage that is measured after a defined loss event. MPCI policies are best suited to perils where individual contribution to a crop loss are difficult to measure and peril impacts last over a long period of time. Yield shortfall may be determined on either an area or individual farmer basis (Roberts 2005).

***Net present value (NPV).*** Total discounted benefits less discounted costs.

***Projection.*** The potential evolution of a quality or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions—concerning, for example, future socioeconomic and technological developments, that may or may not be realized—and are therefore subject to substantial uncertainty.

***Rangeland.*** Unmanaged grasslands, shrublands, savannas, and tundra.

***Reservoir.*** A component of the climate system, other than the atmosphere, that has the capacity to store, accumulate, or release a substance of concern (for example, carbon or greenhouse gas). Oceans, soils, and forests are examples of carbon reservoirs. The term also means an artificial or natural storage place for water, such as a lake, pond, or aquifer, from which the water may be withdrawn for such purposes as irrigation or water supply.

***Resilience.*** The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

***Runoff.*** That part of precipitation that does not *evaporate* and is not transpired.

***Scenario.*** A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from *projections*,



but are often based on additional information from other sources, sometimes combined with a “narrative storyline.” See also (*climate change*) *scenario*.

**Sector.** A part or division, as of the economy (for example, the manufacturing sector, the services sector) or the environment (for example, water resources, forestry) (UNDP 2005).

**Semi-arid regions.** Regions of moderately low rainfall, which are not highly productive and are usually classified as *rangelands*. “Moderately low” is widely accepted as 100–250 millimeters precipitation per year. See also *arid region*.

**Sensitivity.** Sensitivity is the degree to which a system is affected, either adversely or beneficially, by *climate variability* or change. The effect may be direct (for example, a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (for example, damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

**Silviculture.** Cultivation, development, and care of forests.

**Special Report on Emissions Scenarios (SRES).** The storylines and associated population, GDP, and emissions scenarios associated with the Special Report on Emissions Scenarios (SRES; Nakićenović et al. 2000) and the resulting *climate change* and sea-level rise scenarios. Four families of socioeconomic scenarios—A1, A2, B1, and B2—represent different world futures in two distinct dimensions: a focus on economic versus environmental concerns and global versus regional development patterns.

**Stakeholder.** A person or organization that has a legitimate interest in a project or entity or would be affected by a particular action or policy.

**United Nations Framework Convention on Climate Change (UNFCCC).** The convention was adopted in 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community; it entered in force in March 1994. Its ultimate objective is the “stabilization of *greenhouse gas* concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.” It contains commitments for all “parties, which under the convention, are those entities included in Annex I that aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000.

**Vulnerability.** Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

**Water stress.** A country is water-stressed if the available freshwater supply relative to water withdrawals acts as an important constraint on development. Withdrawals exceeding 20 percent of renewable water supply have been used as an indicator of water stress. A crop is water-stressed if soil-available water, and thus actual *evapotranspiration*, is less than potential evapotranspiration demands.

**Water-use efficiency (WUE).** Carbon gain in photosynthesis per unit water lost in *evapotranspiration*. It can be expressed on a short-term basis as the ratio of photosynthetic carbon gain per unit transpirational water loss or on a seasonal basis as the ratio of net primary production or agricultural yield to the amount of available water.

**Win-win options.** “Win-win” options are measures that contribute to both *climate change mitigation* and *adaptation* and wider development objectives; for example, business opportunities from energy efficiency measures, sustainable soil, and water management, among others. They constitute *adaptation* measures that would be justifiable even in the absence of climate change. Many measures that deal with *climate variability* (for example, long-term weather forecasting and early warning systems) may fall into this category (World Bank 2011).

**Win-win-win options.** “Win-win-win” options are measures that contribute to *climate change mitigation*, development objectives, and *adaptation* to *climate change*.

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*Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options* is part of the World Bank Studies series. These papers are published to communicate the results of the Bank's ongoing research and to stimulate public discussion.

Agriculture is one of the most climate-sensitive of all economic sectors. Albania is one of the many countries where the majority of the rural population depends on agriculture—directly or indirectly—for their livelihood. The risks associated with climate change pose an immediate and fundamental problem in the country.

The study proposes a clear and comprehensive plan for aligning agricultural policies with climate change; developing the capabilities of key agricultural institutions; and making needed investments in infrastructure, support services, and on-farm improvements. Developing such a plan ideally involves a combination of quality quantitative analysis; consultation with key stakeholders, particularly farmers and local agricultural experts; and investments in both human and physical capital. The experience of Albania, highlighted in this work, shows that it is possible to develop an initiative to meet these objectives, one that is comprehensive and empirically driven as well as consultative and quick to develop.

The approach of the study is predicated on strong country ownership and participation, and is defined by its emphasis on “win-win” or “no regrets” solutions to the multiple challenges posed by climate change for farmers in Albania. The solutions are measures that increase resilience to future climate change, boost current productivity despite the greater climate variability already occurring, and limit greenhouse gas emissions—also known as “climate-smart agriculture.”

*Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options* applies this approach to Albania with the goal of helping the country mainstream climate change adaptation into its agricultural policies, programs, and investments. The study projects impacts of climate change on agriculture across Albania's four agro-ecological zones through forecast variations in temperature and rainfall patterns so crucial to farming. It offers a map for navigating the risks and realizing the opportunities, outlined through a series of consultations with local farmers. A detailed explanation of the approach is provided for those who want to implement similar programs in other countries of Europe, Central Asia, and anywhere else in the world.

The study is one of four produced under the World Bank program “Reducing Vulnerability to Climate Change in European and Central Asian Agricultural Systems.” The other countries included in this series are the former Yugoslav Republic of Macedonia, Moldova, and Uzbekistan. The results from the four studies are consolidated in the book *Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia*.

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