CHAPTER 1

Introduction and Reasons for Action

Agriculture has traditionally been an important part of the economies of the South Caucasus region. In 2011 agriculture contributed 28 percent of gross domestic product (GDP) in Armenia, 16 percent in Azerbaijan, and 22 percent in Georgia (World Bank 2013). Although the agriculture share of GDP has declined in the three countries over the past decade, all three are still agrarian societies. The main significance of the agriculture sector is its role in employment: it has provided 40 percent or more of total employment in recent years. However, the rural populations in these countries remain poor, with rural poverty rates in 2008 of 28 percent in Armenia, 19 percent in Azerbaijan, and 28 percent in Georgia. Although more recent data are not available for all countries, rates in the region appear to be on the rise (World Bank 2013). These rural populations are therefore highly vulnerable to any climatic event that affects the agriculture sector.

Climate change is a phenomenon that could trigger a greater severity and frequency of the types of events that currently challenge agricultural production, including heat waves, floods, and droughts, as well as changes in overall temperature and precipitation regimes that affect crop and livestock productivity. At the same time, climate change can also create opportunities, particularly in agriculture. Increased temperatures can lengthen growing seasons for some crops, higher carbon dioxide concentrations may enhance plant growth, and, in some areas, rainfall and the availability of water resources can increase as a result of climate change.

Adaptation planning is challenging because of uncertainties in climatic developments and their locally specific impacts, which makes it difficult to identify the optimal changes in agricultural systems. To be successful, adaptation planning should start early and be sufficiently flexible to address these variables. Accordingly, this work sets out to identify "win-win" or "no regrets" adaptation responses that are robust under a range of different future climate scenarios and contribute to increasing resilience to present day climate challenges, such as droughts, floods, and increased heat stress. Wherever possible, this work also tries

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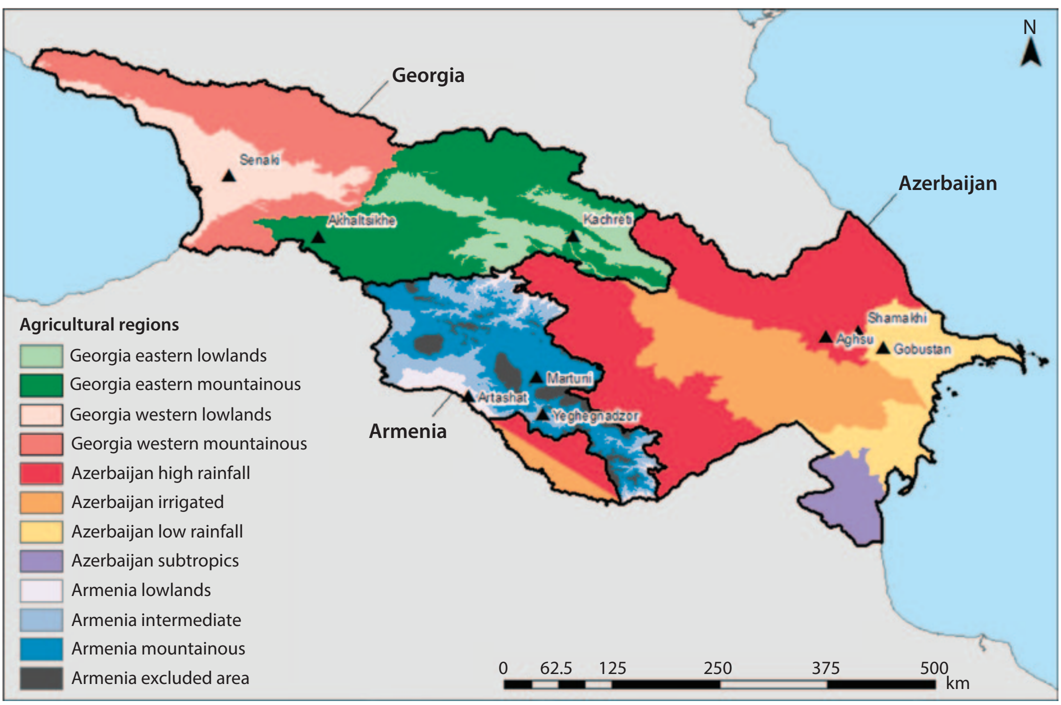
to identify "win-win-win" adaptation options that might also reduce greenhouse gas (GHG) emissions.

Overview of Geography, Climate, and Crops in Study Countries

Map 1.1 presents an overview of the geographic scope of the study, identifying the key agricultural regions within each of the three countries. Baseline agricultural conditions, climate change impacts, and adaptive options are similar within each of the regions in ways that are important for developing a specific adaptation plan. The darker areas in map 1.1 are areas of high elevation (typically characterized by mixed livestock/cereal and some high-value fruit tree production), and lighter areas are low elevation (typically characterized by irrigated high-value vegetables and fewer cereals and in the case of Azerbaijan, potential for cotton production). Contiguous transboundary areas of high elevation are common throughout the region.

In each of the three countries, the study focused on selected crops (not more than seven due to resource constraints). The crops were different in each country but in all cases selection was based on the following criteria: (1) widely grown; (2) economically important to the country; (3) potentially sensitive

Map 1.1 Agricultural Regions of the South Caucasus



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(either positively or negatively) to temperature or water stress aspects of climate change; (4) well supported by data for domestic yield, cropping patterns, and phenology; and (5) broadly reflecting a mix of primarily irrigated and primarily rainfed crops. Furthermore, to ensure a wide variety, the list included one or two representatives from each of the following groups: (1) cereals, (2) tree crops, (3) vegetables, and (4) forage crops or natural pastures. As shown in table 1.1, wheat, grape, and potato were selected as focus crops by all three countries; corn, tomato, alfalfa, and pastures were selected by two countries; and mandarin orange, apricot, watermelon, and cotton were selected in one country.

The time frame of the study is the current period, 2013 through 2050. The logic for holding the time horizon to 2050 is that virtually all measures considered by the study, including newly constructed irrigation infrastructure, would have reached the end of their useful life by 2050. Nonetheless, because recent research suggests that the potential for dramatic climate change is greater after 2050, national institutes and ministries must periodically update this analysis as the mid-century approaches and climate change unfolds.

Stakeholder consultations, particularly those with farmers, were conducted throughout the region. Map 1.1 indicates the nine locations in the region (three in each country) where farmer stakeholder workshops were conducted to discuss

Table 1.1 Crops Selected for Modeling in Each Country

Irrigated/rainfed	*Crop*	*Armenia*	*Azerbaijan*	*Georgia*
Irrigated	Alfalfa	X	X	
	Apricot	X		
	Corn		X	X
	Cotton		X	
	Grape	X	X	X
	Mandarin orange			X
	Potato	X	X	X
	Tomato	X		X
	Watermelon	X		
	Wheat	X	X	X
Rainfed	Alfalfa	X	X	
	Apricot	X		
	Corn		X	X
	Cotton		X	
	Grape	X	X	X
	Mandarin orange			X
	Pasture		X	X
	Potato	X	X	X
	Tomato	X		X
	Watermelon	X		
	Wheat	X	X	X

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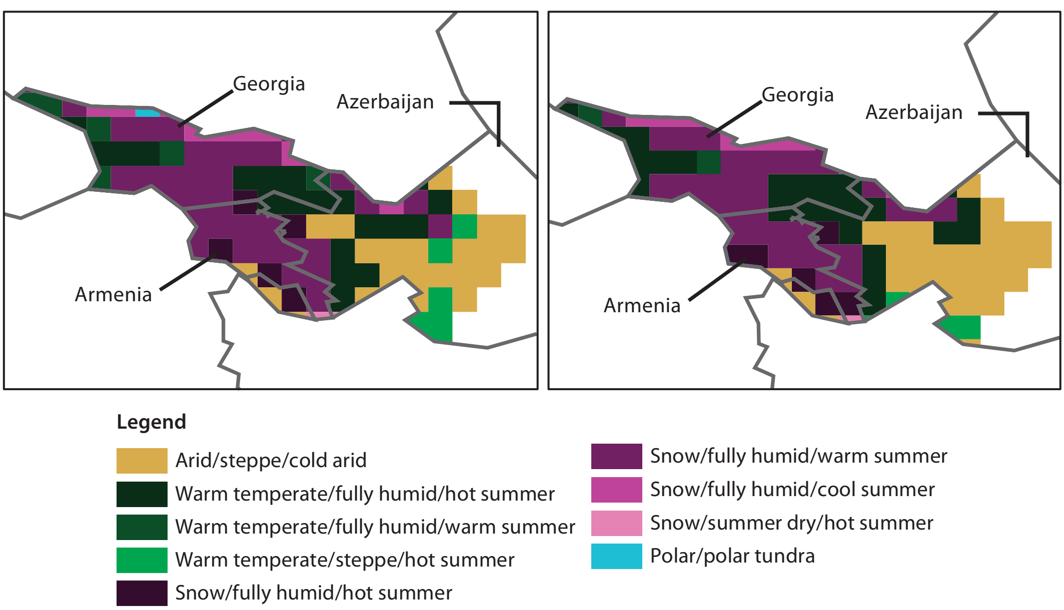
the challenges presented by climate change, to jointly identify viable adaptation measures, and to evaluate and prioritize these measures based on cost, feasibility, and potential of improving agricultural production in view of the challenges of climate change.

Current climate data show great variation within the three countries, owing mostly to wide variations in elevation and the effect of mountains on precipitation patterns (for example, rain shadow effects). While there is wide variation within each country, there are great similarities across the region; thus, most climate classification systems assign the three countries to a similar climate type. The Köppen-Geiger Climate Classification System (KGCCS),[1] which combines average annual and monthly temperatures and precipitation and the seasonality of precipitation in a single index, is one of these. Map 1.2 provides a summary of the KGCCS for the South Caucasus countries, for current (a) and projected (b) climate conditions, with resolution at roughly a 50 × 50 kilometer (km) grid. In map 1.2a the majority of the area is in the purple and black regions, which consists of a "snow" climate region that is "fully humid" with a "warm summer." Azerbaijan in the eastern area of the map is an exception, however, with the tan area (corresponding to lowland plains) representing an "arid steppe" region. Southwestern Armenia also has areas with this climate classification, in the highly productive Ararat Valley agricultural region. These similarities in current climate create opportunities for sharing results of agricultural research, particularly focusing on crop varieties that thrive in these climatic zones.

Map 1.2 Observed and Forecasted Köppen-Geiger Climate Classification for Azerbaijan, Georgia, and Armenia

a. Observed, 1976–2000 **b. Forecasted, 2001–25**

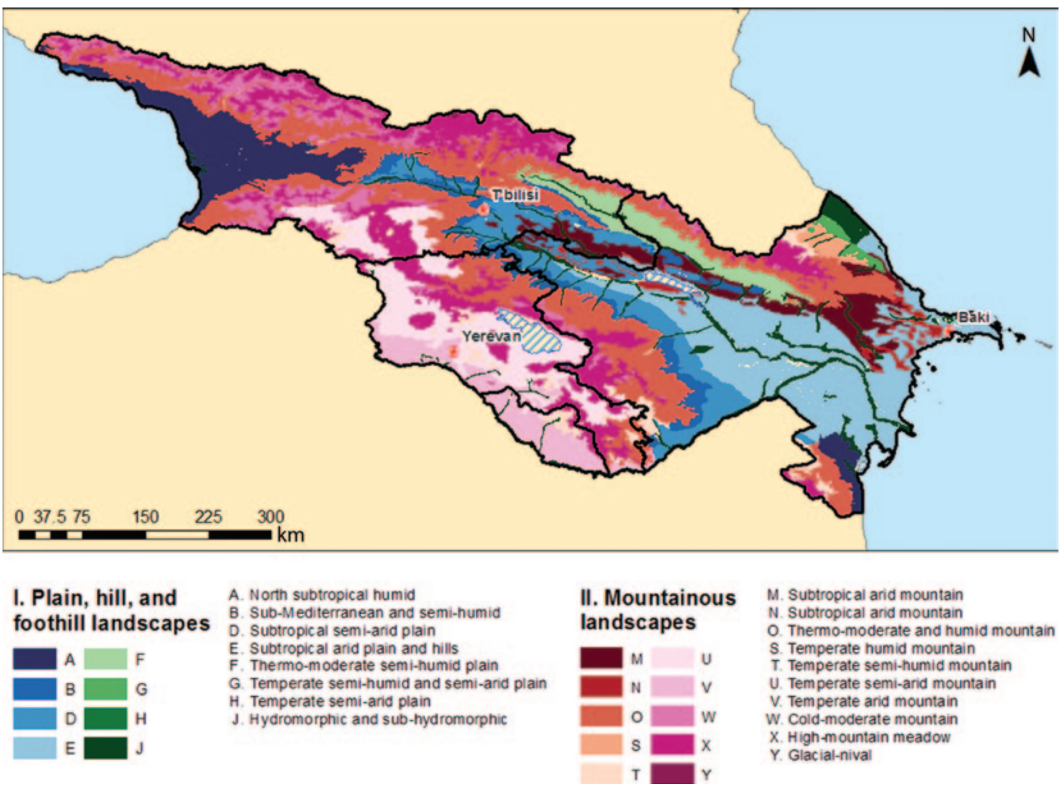


Sources: Author mapping of data described in Rubel and Kottek 2010; data provided at http://koeppen-geiger.vu-wien.ac.at/shifts.htm.

The implication of climate change, even when looking ahead only about 10 years to 2025 (map 1.2b), is for a dramatic expansion of the arid (tan) regime in Azerbaijan, particularly in the central area of the country, as well as changes in the temperature regime throughout Armenia and Georgia. The warm temperate and snow regimes largely cross national boundaries throughout the region, and these transitional areas with similar climate could be identified as good candidates for adaptation measures, for example, for variety adaptation trials.

These similarities in climate are also expressed in maps of landscape and ecology type. Map 1.3 shows the high elevation thermo-moderate and humid mountain landscape (classification O, in orange) is common to all three countries, including the northern and southern bands in Georgia; northern Armenia near the Georgia/Azerbaijan border; and the north, west, and extreme south portions of Azerbaijan. There is a high prevalence of the lower elevation subtropical and plain and hilly landscape (classification E, shown in light blue) in central and southern Azerbaijan, including the Absheron Peninsula, which corresponds well to the intensely irrigated areas; such landscape is not found in the other two countries. The high elevation temperate semi-arid mountain

Map 1.3 Landscape Types in Armenia, Azerbaijan, and Georgia



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landscape dominates in Armenia and has some prevalence in southern Georgia near the Armenian border, as well as small patches in Azerbaijan, in the northeastern portion of Nakhchivan, the far north central areas near the Russian border on the north slope of the Greater Caucasus, and the far southeast near the Iranian border.

The detailed maps provide an excellent basis for identifying areas with similar ecology (natural vegetation, climate, and soil characteristics) which parallel characteristics for crop suitability. These delineations were used as a guide in the study for agriculture sector climate change adaptation. As indicated in map 1.2 (climatic regions), these areas can also be used to identify "transnational regions" for testing and demonstrating promising varieties and also for developing site-specific agronomic practices to enhance productivity and profitability.

The eco-region maps also provide insights concerning the opportunities for mitigating GHG emissions. A key factor in establishing the GHG mitigation potential of land is the ability of the soil to store carbon—for example, a healthy pasture is better equipped to sequester carbon, first in plant material and ultimately in storage of organic carbon in soils. With some exceptions, warmer and wetter areas are more ecologically productive, making them better able to capture and store atmospheric carbon. Therefore the maps provide a starting point for the design of national- and regional-scale mitigation strategies related to carbon storage, particularly in unmanaged or undermanaged ecosystems.

In addition to common climate and landscape regimes, a significant characteristic of the region is its shared water resources. Two major transboundary river basins—the Mtkvari/Kura and the Araks/Aras, both flowing to the Caspian Sea, as well as several smaller sub-basins within this larger basin—characterize the South Caucasus area. The transboundary nature of water resources provides an opportunity to examine regional water resource management among the riparians.

A series of smaller sub-basins are also important areas of shared transboundary water resources, in part because they are in high elevation areas that may have significant potential for reservoir construction, where such storage could be used for irrigation and hydropower development. These include the Alazani/Ganikh basin in Georgia and Azerbaijan, the Khrami-Debed in Georgia and Armenia, and the Aghstev in Armenia and Azerbaijan.

Climate change will further stress water resources in the South Caucasus region. Precipitation is projected to decline and temperatures to increase, resulting in runoff decline by 2050 or sooner. At the same time, crop water demands will increase due to the higher temperatures. The transboundary nature of water resources is coupled with the high likelihood that water flow and volumes in general will be reduced by climate change presenting the risk of conflicts over the ever-more precious water resources. However, coordinated regional water resource planning can alleviate these conflicts. For example, increased water storage is almost always more efficiently constructed in higher elevation areas, where natural terrain can be exploited to create reservoirs and where the steeper terrain creates greater potential for hydropower generation at the reservoir outlet.

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An added benefit is that higher elevations are cooler and evaporative loss from reservoirs is reduced. A well-structured multinational water management system holds promise for the higher elevation countries (mainly Armenia but also parts of Georgia) to develop these storage opportunities and sell both water and hydropower throughout the region, in exchange for other trade considerations. Managing the reservoirs as part of an integrated river basin system would provide benefits for all riparians.

Characteristics of the Agriculture Sector

The typical agricultural system in these countries is subsistence or semisubsistence mixed crop production integrated with small-scale livestock production. In fact, livestock production has long been an important component of the agricultural economies across the region. It is often dependent on communal grazing lands that are usually degraded in terms of both land and vegetation due to overgrazing and consequent soil erosion. Pastures dominate in the high-altitude regions, particularly along the southern face of the Greater Caucasus, which runs through northern Georgia and Azerbaijan, while in the lower altitude areas mixed farming dominates and is particularly prevalent in rainfed areas of Azerbaijan and Armenia.

The three countries also rely heavily on irrigation for high-value crop production, where, according to the Food and Agricultural Organization of the United Nations (FAO) AquaStat, the agriculture sector is by far the largest consumptive user of water (FAO 2013). Map 1.4 illustrates the current reliance on irrigation for all three countries. The irrigated lands are more extensive in Azerbaijan than in the other two countries, but this observation ignores important aspects of crop patterns. In Armenia about 80 percent of the overall value of crop production occurs on irrigated lands. In Georgia much of the high-value agricultural production (for example, grape) occurs in areas that are currently classified as semi-arid, but where precipitation and runoff are both expected to decline as a result of climate change. In addition, although many areas of Georgia are currently equipped for irrigation, on-farm water delivery still suffers mostly due to the need for rehabilitation of infrastructure.

Agriculture in the region is predominantly carried out by rural households where some land has been distributed from former state-run farms and collectives after the Soviet breakup. These smallholder farmers usually have fragmented land holdings of 1–3 hectare (ha) in several plots, thus facing constraints of small areas, limited profits, and scarce financial means. Having been former employees of the state farms where they were delegated with specific and often nonagricultural tasks, many farmers lack farming backgrounds. They need tailored advice; however, no effective and efficient extension system is in place to provide the service on required scale and quality.

Similarities in agricultural land characteristics and the prevalence of irrigated and mixed livestock/crop production patterns across the region present important opportunities for collaboration. In particular, as all three countries seek to address development and adaptation deficits in their agricultural land management

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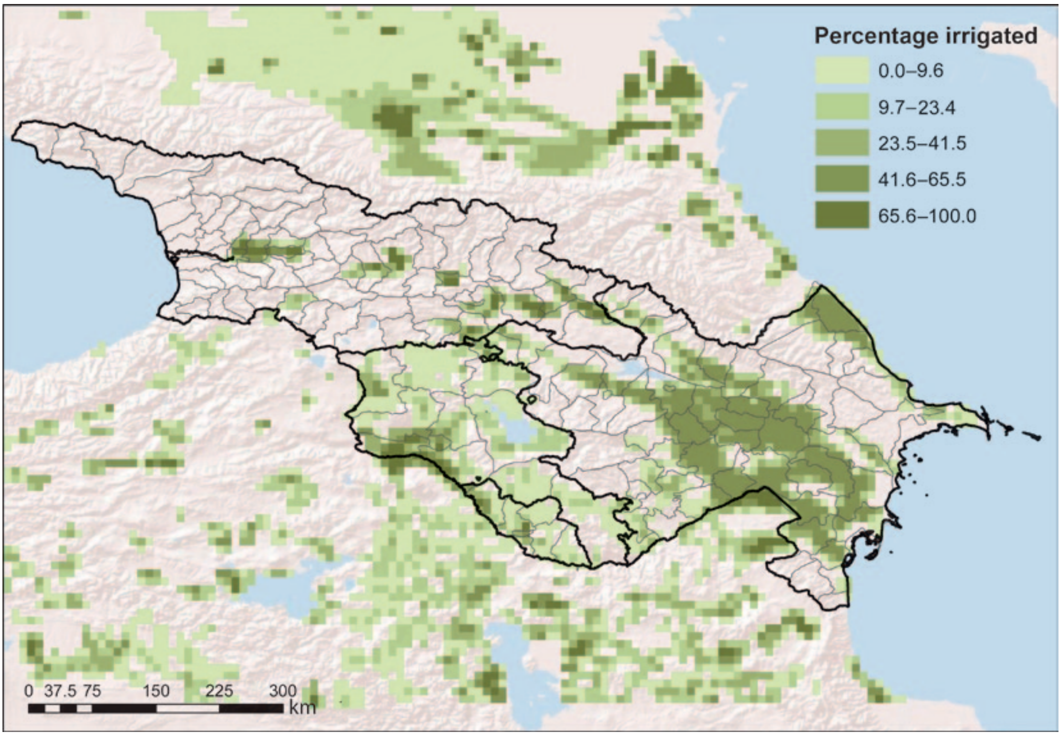
Map 1.4 Irrigated Lands in the South Caucasus



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practices—for example, by learning and applying modern agronomic practices and improving water-use efficiency—a cooperative approach can yield cost savings and significant transboundary spillover benefits compared to each nation pursuing these agriculture sector improvement measures independently.

In addition, the governments of Armenia, Azerbaijan, and Georgia have recently developed agricultural policy documents that outline some of the primary challenges facing the sectors. These documents identify the following key issues, suggesting that the countries of the South Caucasus face many of the same challenges (World Bank 2007; Azerbaijan Republic 2008; Urutyan and Thalmann 2011; FAO 2012; Georgia Ministry of Agriculture 2012; IFAD 2012):

- Lack of effective extension and research services
- Insufficient and inadequate use of fertilizers and pesticides
- Lack of mechanization and/or outdated agricultural machinery and equipment
- Inadequate irrigation coverage or inefficient irrigation practices
- Soil erosion, land degradation, salinization, and/or limited land resources
- Natural disasters
- Limited water resources
- Lack of market access

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Agriculture Sector Capacity to Adapt to Climate Change

A country's capacity to adapt to climate change reflects a wide range of socioeconomic, policy, and institutional factors, at the farm, national, and regional levels. Considerations in determining the variation in adaptive capacity across a country or a region also include the current climate, social structures, institutional capacity, knowledge and education, and access to functioning infrastructure. Specifically, marginal areas under rainfed production will have less adaptive capacity than areas that are irrigated and more productive. In addition, financial resources are key in determining adaptive capacity, as most planned adaptations require investment. Currently, the region's countries rank low in their agriculture sectors by many factors that determine a country's overall adaptive capacity.

In any country the level of adaptive capacity in the agriculture sector is characterized by a number of factors: (1) high level of functionality in the provision of hydrometeorological and relevant geospatial data to farmers to support good farm-level decision making, (2) provision of other agronomic information through trained extension agents and effective extension networks, (3) in-country research oriented toward innovations in agricultural practices in response to forecasted climate changes, (4) well-maintained and managed water collection and distribution infrastructure that meets the needs of the farming community, and (5) systems in place to resolve conflicts between farmers and other users over water allocation.

Some of these conditions exist in the study countries, but most are inadequate or lacking in the following ways: (1) inefficient and ineffective extension service, (2) weak agricultural research-extension linkage, (3) limited access to rural finance, (4) limited crop insurance, (5) poor access to meteorological data, and (6) poor market access. These conditions are described as follows.

The current agricultural extension service is not oriented toward ameliorating risks from climate. While many farmers are aware of the extension service, only a few have access to these services or can make use of them. Furthermore, the current extension service has limited capacity to advise on adapting agricultural systems to the climate risks outlined in this study. Farmers in the region indicate that they would benefit highly from a well-functioning, effective extension service. In agriculture, climatically (as in weather) induced risks are inherent to the system. Farmers may be risk-averse but they need knowledge and skills to manage their risks.

Agricultural research-extension linkages, if not lacking, are weak and erratic. Agricultural research institutes remain an important part of the agricultural bureaucracy in these former Soviet countries, but these institutions have not yet given priority to and focused on climate change as a major risk to agricultural production, and their research is not coordinated with the extension service as it should be. Further, research could be better focused on leveraging advances in crop varieties and farming practices proven to be effective in other countries, as well as coordinating with the extension service to carry on-farm adaptation trials and then demonstrate these results locally.

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Farmers' access to rural credit is limited. Farmers note difficulty in obtaining long-term, low-interest bank loans for agriculture. These financial constraints limit mechanization of production on most small farms. While government-sponsored credit subsidy programs exist or are being planned, farmers consistently emphasized that even if they want to invest in equipment and agricultural inputs to improve their practices, financial issues are the major bottleneck. Many of the credit issues in the region are also linked to weaknesses in land policy and land markets.

Crop insurance is either not affordable or not available. Both hail and spring frost are major issues for farmers in the region, with estimates of annual losses on the order of 10 percent of annual production for some crops, which may account for as much as US$100–150 million in annual losses in Armenia alone.[2] Even where insurance is available, farmers are generally unable to afford it. Subsidized disaster relief programs, including insurance, would greatly stabilize their incomes and improve their capacity to re-invest in farming.

The ability to collect, generate, and disseminate meteorological data to farmers is either inadequate or lacking. Current capacity in hydrometeorological institutions needs improvement, as farmers lack basic climatic and meteorological data for their regions—except weather forecasts on public TV—that they can utilize in operational farm management. Specifically, most farmers do not have the financial means to buy specific hydrometeorological services or related equipment.

Agricultural marketing is a common problem. More must be done to improve markets if the agriculture sector potential is to be realized. Several projects that targeted marketing were financed by international donors, but the problem still prevails in the region where a large portion of farmers practice subsistence and semi-subsistence farming with poor market links and outdated varieties. The farming community as a whole complains about the following interlinked problems, some of which extend beyond but are related to marketing: (1) low commodity prices, (2) inability to market the produce even though the market is not saturated, (3) distance to the markets, and (4) lack of access to agro-processing. The underlying reasons include poor quality of the products due to poor production and post-harvest practices, timing of marketing, lack of storage facilities, lack of adequate information related to production and marketing, and problems regarding transportation.

An Approach for Adapting to Climate Change in the South Caucasus

The key insights from the study related to land, water, climate, ecological conditions, and development and adaptation capacity throughout the South Caucasus region are as follows:

- ***Land.*** Crop suitability of land resources, as evaluated by FAO and the World Bank, is quite similar across the three countries: Irrigation is important for

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high-value crop production in the region, with Azerbaijan having the largest irrigated area.

- ***Water.*** The key Kura-Araks river system is transboundary, so issues of management of water resources, both quantity and quality, demand a supranational approach. Reflecting this insight, in this study the transboundary river system was modeled as a multicountry unit, encompassing water demand and supply in the agriculture, urban/municipal, and hydropower sectors.
- ***Climate.*** Climate is diverse within the countries due to undulated topography and large variability in elevation. However, the climatic regions in these three countries are very similar, as is the projection of climate change.
- ***Ecology.*** Ecological regions are transboundary in nature, with a high degree of common landscape types, particularly across the mountainous regions. All three countries exhibit similar ecotypes with elevated areas of low and high rainfall, including both steeply sloping areas and elevated meadows and plains.
- ***Adaptive capacity.*** As noted, all three countries have common development and adaptation deficits in the agriculture sector. The development deficit refers to a low level of adoption and knowledge of modern agricultural practices, as well as prevailing financial and market constraints. The *adaptation deficit* refers to inadequate adjustment to current climate conditions, including high vulnerability to extreme weather events, poor access to weather and climate information, and poor uptake of new technologies and information that can ameliorate impacts of climate. Addressing *both* is critical to improving the resilience of the region's agriculture to climate shifts.

The key insight of this book is that the regional nature of the natural resources and current adaptive capacity of the countries makes a multicountry transboundary approach to management advantageous to neighboring countries. There is great potential for cost savings and significant spillover benefits to accrue to each country if measures addressing these deficits are pursued as part of a collective program with direct reference to their shared geographies and natural resources, rather than in isolation within each country's national programs. At present, natural resources are managed with a rather narrow, national perspective. The impact of climate change in the region is likely to make suitable land and high-quality water resources more scarce for all, putting new pressures on ecological resources and presenting more risks than opportunities. Neighboring countries stand to gain in the agriculture and water resources sectors from cooperation, much more so than if national interests are pursued without regard for transboundary implications.

Notes

1. The effort is described and applied to the globe in Rubel and Kottek (2010). The Köppen-Geiger system classifies land areas based primarily on their climate characteristics, and the system is based on the concept that native vegetation is the best

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expression of climate. Therefore climate zone boundaries are made with vegetation distribution in mind. The results can be generated for both historic and projected climate conditions, and both historic and projected results are readily available for the globe via a website, http://koeppen-geiger.vu-wien.ac.at/shifts.htm. The key advantages of the Köppen-Geiger system are that it is well known and often cited within the climate change and other literatures and that it is widely available and readily replicable.

2. Estimates of annual losses are from World Wildlife Fund Norway (WWF 2009) and from discussion during the first farmer consultation of the study with independent consultant Tigran Kalantaryan, who facilitated the farmer consultations.

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