CHAPTER 5. THE UNBUILT ENVIRONMENT: AGRICULTURE AND FORESTRY[39]

For ECA's productive environment—farms, commercially exploited forests, and fisheries—climate change is already happening. Moldova's drought-stricken agricultural sector and Central Europe's forest fires during the 2003 heat wave provide a harbinger of the challenges the farming and forestry sectors will face over the coming years (Fink et al. 2004).

However, the impact of climate change will vary across ECA countries, with some areas and sectors projected to experience significant new stresses, while others might see a positive impact. There are also variations in when and how directly different areas and sectors must cope with climate change impacts. The increased frequency of heat stress, drought, and flooding caused by climate change threaten to reduce crop yields and livestock productivity in many areas. Shorter and less harsh winters may result in potential productivity gains in others. In the forestry sector, increased risks of fires and pest outbreaks will negatively affect the health of forests (Easterling et al. 2007).

The agriculture and forestry sectors also can help mitigate further climate change and may offer opportunities for tapping into carbon finance. Forests, which play a critical role in absorbing carbon dioxide emissions, are cut in order to clear land for farming. Globally, agricultural production and deforestation account for up to 30 percent of greenhouse gas emissions, second only to the power sector (IPCC 2007c). These sectors therefore offer opportunities for carbon sequestration, such as through afforestation or minimum tillage agriculture. But mitigation strategies do not protect societies against the climate change impacts already in evidence, or those in the pipeline as a result of past greenhouse gas emissions.

Adaptation is essential to protect and enhance rural livelihoods in ECA. But adaptation is also critical to supply global food markets as global population soars, and as yields in many countries decline from the damaging physical impacts of climate change. Farms, forests and fisheries play a crucial role in rural poverty reduction, employment, economic growth, and food security. Indeed, the ECA countries that stand to benefit from moderate temperature increases (+1 to +3ºC in the global annual average) will play a vital role in meeting the world's growing demand for food.

But the benefits and risks of climate change are far outweighed by the costs of the region's comparative inefficiency and low productivity (Olesen and Bindi 2002). The recent crisis in global food prices revealed the inability of a number of ECA countries to respond to the changed environment, raising concerns about skewed incentives and the region's ability to adapt to the challenging shifts projected under climate change scenarios. To change this, ECA's leadership and farming community must be ready to address the productivity gap with Western Europe in both agriculture and forestry.

All governments in the region will need strategies that allow their countries to take advantage of potential gains from climate change, as well as minimize risks and threatened losses. But positive outcomes won't arrive automatically. A country or sub-region may be positioned to expand farm outputs under certain climate change scenarios, but if the physical infrastructure is failing, or if institutional or market barriers are a constraint, the benefits of increased farm outputs won't materialize.

[39] This chapter is based on "Adaptation to Climate Change in Europe and Central Asia's Agriculture" by William Sutton, Rachel Block, and Jitendra Srivastava, a background paper commissioned for this report.

Despite variations across countries, each one will need to remove barriers to efficiency and sustainability. In Central Asia, the unforgiving topography and hydrology will complicate adaptation strategies, even if institutions are functioning at optimum effectiveness. Southeast Europe, home to some of the most productive land in the region, is projected to suffer from drought, heat waves, and more frequent forest fires. In the north, there are potential benefits from climate change, but these will only be realized if countries adjust institutional frameworks to support new patterns of production. Even then, other barriers will persist, including in northern Russia's poor soil's, the lack of public services and infrastructure, and possible social dislocations and local environmental damage (Dronin and Kirilenko 2008).

In sum, countries should be ready to take advantage of potential benefits or to minimize threatened losses through assessment and well-structured adaptation programs. For those linked to the farm and forestry sectors, the need is urgent since climate change will affect them immediately and most directly. Countries will have to strengthen the capacity of institutions involved in the rural economy and to improve public services, particularly those that impart skills and understanding to farmers and foresters. Finally, infrastructures that affect production and institutions that support markets will require modernization.

The chapter reviews the impacts of climate change on farming and forestry in ECA, highlighting the region's inherent sensitivity and limited adaptive capacity, and what this implies for both winning and losing regions and sectors. It concludes with recommendations about possible adaptation measures. First, however, we discuss the continued importance of agriculture in many countries in the region—particularly for poverty concerns.

Climate impacts will exacerbate ECA's persistent problem of rural poverty

Despite the perception of ECA as an urbanized region, many livelihoods are still linked to the productivity of agriculture, even if those involved do not work directly on farms (Alam et al. 2005). Agriculture is a particularly important part of GDP in Central Asia, the South Caucasus, and Southeastern Europe (table 5.1).

Across ECA, roughly one-third to one-half of the population lives in rural areas with the figure approaching two-thirds in Central Asia. Even in Kazakhstan and Central and Eastern Europe, a significant share of the population remains rural, despite the fact that agriculture accounts for a smaller portion of the economy. And, in much of ECA, half or more of the poor live in rural areas, with three-fourths of extremely poor people in Central Asia living in the countryside. Thus, any forward-looking poverty strategy must take into account new stresses felt in rural areas as a consequence of global climate change.

Forestry and forests, though not as significant economically as agriculture, remain important for rural livelihoods both through direct employment and through ecosystem services (such as the provision of wood and food, or protection against erosion and flood) Forestry accounts for only about 0.1 percent of GDP in much of Central Asia and the Caucasus; but outside market systems, forest resources may be significant to rural communities, particularly with respect to the fuelwood. The market importance of forestry is somewhat higher in Central, Eastern, and Southeastern Europe.[40]

[40] Forestry as a share of GDP is 2.3% in Belarus, 0.8% in Russia, 1.2% in Ukraine, 2.2% in Bosnia-Herzegovina, 3.1% in Serbia and Montenegro, and about 0.8% in Bulgaria, Macedonia, and Turkey (all figures 2000; Sutton et al. 2008).

TABLE 5.1 AGRICULTURE MATTERS: POVERTY AND THE RURAL ECONOMY IN ECA

Region	Agricult. as share of GDP %	Rural pop %	Rural extreme poverty rate %	Rural poverty rate %	Of extremely poor, share in rural areas %	Of poor, share in rural areas %
Southeastern Europe	12.3	35.4	20 with Turkey, 9 without	61 with Turkey, 44 without	46	45
Central & Eastern Europe	8.7	36.1	10	44	54	48
Baltics	5.3	35.2	3	33	39	42
Russia	5.6	27.1	14	53	42	34
South Caucasus	12.0	45.9	30	80	49	48
Kazakhstan	6.7	42.2	31	79	64	52
Central Asia	27.0	64.1	62	94	73	69

Notes on Poverty: Extreme poverty line $2.15 or less per person per day. Poverty line $4.30 per person per day. Both poverty lines using purchasing-power parity dollars. 2002, 2003 or 2004 if available. For rural poverty, Central Europe is Ukraine, Romania, Moldova; Central Asia is Kyrgyzstan, Tajikistan, Uzbekistan; Southeastern Europe is Bulgaria, Serbia, Montenegro, Albania, FYR Macedonia, Bosnia-Herzegovina, +/- Turkey. *Notes on Agriculture and Population:* 2006 or 2005.
Sources: World Development Indicators (WDI) and Alam et al. (2005).

Rural poverty rates in ECA are significantly higher than national averages, and the share of rural people in poverty ranges from a low of one-third in Russia to a staggering 94 percent in Central Asia. In the rest of the region about half of the poor are found in rural areas. Thus, most ECA countries other than Russia have a poverty profile heavily influenced by conditions in rural areas, particularly with respect to agriculture.

Agriculture is uniquely effective in reducing poverty in all country types.[41] The inverse, of course, is that setbacks in agriculture—whether losses or missed opportunities—will be disproportionately damaging to the rural poor. Thus, even if climate change has only a small impact on the overall economy, it could have a profound effect on the portion of the population living below the poverty line, or the population of a particular district or locality. Moreover, at the local or household level, the impact could go beyond income to affect human health and nutrition (Randolph et al. 2007).

Livestock activities are important to many vulnerable groups in the ECA region and may be undergoing structural shifts as the demand for meat, eggs, and dairy products increases in Asia's fast-growing economies. The delicate balance of grain allocation as a staple food or as animal feed may become more difficult to maintain in the context of changing global demand. Shocks from climate change could add to an already uncertain mix of factors, potentially exacerbating the current global food and feed crisis (Sirohi and Michaelowa 2007). Untangling the interplay of shifting global demand, climate change, and patterns in livestock-related land use—and teasing out the policy implications—is a continuing endeavor worldwide.

Models predict that there will be winners and losers in ECA

Beyond the undisputed conclusion that climate change will add to the vulnerability of most if not all rural populations already living in poverty, the effects of changing weather patterns on ECA's agriculture and forestry are hugely varied. In addition, projections build on uncertain

[41] This point, which was highlighted in the *World Development Report 2008* on agriculture, is well illustrated by the fact that GDP growth originating in the agricultural sector reduces poverty twice as much as growth driven by other sectors (World Bank 2007).

factors, including the ways that private interests or institutions might respond to the new opportunities and risks that come with warmer, wetter, or drier weather.

Adaptation will be essential not only to protect the poorest but also to realize potential benefits. However, adaptation strategies carry costs and face barriers that must be factored into any calculation about net gains in ECA. And the scope of opportunities is partly a function of world food markets, which are subject to fluctuation and uncertainty.

Still, climate and agroeconomic information, while far from comprehensive, provides sufficient data to illustrate the scope of climate shifts already underway, along with some future changes and their potential impacts.

Insights from observed climate changes and impacts

Changes in climate and their impacts on agricultural systems and rural economies are already evident throughout ECA. The growing season has lengthened in locations stretching from Germany to European Russia (Maracchi et al. 2005). Chapter 2 noted that extreme events have occurred with greater frequency and intensity in Europe, most recently in the 2003 summer heat wave over much of the continent, and more intense flooding in Central and Southeastern Europe. A decline in precipitation along the northeastern coast of the Mediterranean has caused significant drought-related damages in the agricultural economies of Southeastern Europe (Alcamo et al. 2007, p545). Drought-induced economic losses in all sectors have been calculated for the region, and are in some cases large.[42] Successive weather extremes add to stresses: Moldova's resilience was already weakened by past storms and droughts when a major drought arrived in 2007, bringing greater economic disruption.

In Central Asia, Kazakhstan, Asian Russia, and the Arctic, twentieth century increases in temperature have surpassed the worldwide warming average, rising by as much as +3ºC (Cruz et al. 2007 p475; Kattsov 2007 p8). The frequency and intensity of extreme events has increased, including heat waves, extreme cold days and winter storms, heavy rains and floods, and droughts (Alcamo et al. 2007; Cruz et al. 2007).

In the mountainous South Caucasus, observed changes have exhibited geographic variation in both direction and magnitude; so while average temperature has increased slightly and average precipitation declined slightly, localized impacts have been larger (Hovsepyan and Melkonyan 2007). Severe droughts have become increasingly common in the North and South Caucasus and Central Asia, worsened by poor land management, soil degradation, and reduced rain or river runoff (World Bank 2005).

Impacts: the agronomic view

ECA as a whole, as well as individual ECA countries, is unique in encompassing both warm, dry areas where agriculture and forests are projected to experience significant damage from climate change, and colder areas where agriculture and forestry could benefit from warmer temperatures and increased precipitation (see table 5.2 for a summary of changes in agricultural potential; detailed regional information on impacts is in box 5.1).

[42] Albania (1989–1991: $25m), Macedonia (1993: $10m), Moldova (2000: $170m, 2007: $1 billion), Romania (2000: $500m), Croatia (2003: $330m), Bosnia-Herzegovina (2003: $410m) (UNISDR / World Bank 2007; WMO 2007).

Small-holder farms in Albania that depend on irrigation may be hard hit by droughts and heat waves, while in parts of Poland, a longer growing season and warmer winters may allow greater crop diversity and increased productivity.

Large countries such as Kazakhstan incorporate various climate zones, and will be home to both winners and losers as climate change impacts play out. Areas projected to see increasing rainfall could see expanding opportunities for rain-fed, high-yielding winter wheat, while other parts of the country face reduced water availability, sporadic drought, and lower cotton yields.

Ideally, countries could embark on a smooth adaptation (as illustrated by the arrows in table 5.2), with cereal cultivation shifting northward in Russia and Kazakhstan, and longer growing seasons allowing for increased diversification into high-yield or high-value crops in the cool, temperate areas of Central Europe and European Russia. Of course, it takes planning, investment, and effective knowledge services to take advantage of climate-induced opportunities.

TABLE 5.2 CROP POTENTIAL IN THE ECA REGION TODAY AND POSSIBLE SHIFTS BY 2100

General climate class	Average temperature of warmest months (°C)	Crop-growing period (days)	Crop potential	ECA regions in 2009	ECA regions in 2100
Very cold	8.5–11	<90	Quick maturing green root vegetables (lettuce & radishes)	Parts of Arctic Region, Siberia & Far East (Russia)	
Cold	10.5–16	<100	Early varieties of vegetables (cabbage, spinach, turnips), early varieties of barley, oats, buckwheat, flax, hardiest local varieties of apples & pears	Northern parts of Urals, Western Siberia & Far East	
Moderately cold	15–20	100–150	Winter wheat, spring wheat, rye, barley, oats, legumes, flax, potatoes, cabbage, beets, locally adapted winter-hardy varieties of apples, pears, plums.	Baltics, northern parts of Central Russia & Volga Region & Southern Siberia, Northern Kazakhstan	
Moderate	18–25	150–180	Grain, corn, sunflower, soybeans, rice, wheat, melons, early cotton, vegetables, walnuts, peaches, apricots, apples, grapes, cherries, plums.	Ukraine, southern parts of Central Russia & Volga Region, Northern Caucasus, Central Europe	
Warm	>25	>180	Cotton, citrus, figs, grapes, olive, wheat, corn, rice, vegetables during winter, subtropical perennials (tea), nuts and a variety of fruit crops	Central Asia, Caucasus, Southeastern Europe, Turkey, Southern Kazakhstan	Compare to South Mediterranean & Middle East in 2009

Source: Sutton et al 2008.

BOX 5.1 ESTIMATED AGRONOMIC IMPACTS OF CLIMATE CHANGE IN ECA TO 2050—A SUMMARY

SOUTHEASTERN EUROPE including Turkey

Decreased precipitation in all seasons, yet more storms, floods • Soil erosion from wind, storms, and floods* • increased evapotranspiration, soil salinization • increased irrigation demand, stress on water supply • especially severe water stress in southern Turkey.

Higher average temperature, very hot summers, heat waves, and droughts • Faster maturation, shorter development period, with water shortage and heat stress, grain sterility, lower yields of many cereals, oilseeds, and pulses (i.e., determinant crops)* • decreased yield or quality of onions,** cool-weather vegetables* • longer season for warm-weather vegetables • possible shifts to higher altitude of some crops (esp. mountainous Turkey) • increased variability of grape quality, quantity, and vulnerability to pests, but potential benefit from CO_2 fertilization • expansion of drought-tolerant olive, citrus, fig*,*** • but tree crops highly vulnerable to storms, pests** • winter survival and subsequent proliferation of pests.[†]

Increased variability in yields of cereals, other crops.*,***

Livestock • Heat stress and both indigenous and non-indigenous disease in livestock threaten milk and meat production.[**,***] Heat, water scarcity decrease forage production leading to shortage in late summer. ***

CENTRAL & EASTERN EUROPE

Right on line between north (wetter, milder winter) and south (drier, hotter), so not yet clear if climate and thus impacts will be similar to the neighbors to the north or to the south. Potential yield increases projected by models mostly shown in Alps, Carpathians,[††] where significant agriculture not actually feasible. Disagreement among sources, including range from benefits to large losses around Black Sea (E. Romania, Moldova, S. Ukraine—hot and dry), little agreement for all of Ukraine.[**,††]

Increased storms, but ambiguous magnitude and direction of precipitation change • Tree crops vulnerable to storms • even if no change in region overall, possible yield decline if too wet in the north (see Baltics) or even slightly drier in the south (see Southeastern Europe).

Equal amount of warming in winter and summer • Faster maturation, shorter development period, may lower yield of many cereals, oilseeds, and pulses (i.e., determinant crops)* • potential for northward expansion of warm weather crops like oilseeds, pulses, vegetables** • potatoes more variable, possibly limited by low soil moisture* • winter survival and subsequent proliferation of pests • too warm, dry for rain-fed cereals in parts, but suitable for more tree crops, including fruit, nuts and more natural pasture biomass for animals; possible increase in area of winter wheat and rye.

BALTICS

Increased precipitation, floods • Risk of soil erosion • excess soil moisture limits days suitable for machinery use* • spring planting disrupted by April/May rains • harvest disrupted, damage from water-logging, or molding of harvested grain if excess rain in autumn.*

Milder winters and higher average temperature • Faster maturation, shorter grain-filling period, lower yield of winter wheat,* but now possible to use higher yielding spring-wheat • potential for northward expansion of warm-weather crops like oilseeds, pulses, vegetables* • either no or favorable changes in potato, sugar-beet yields, but increased variability* • winter survival and subsequent proliferation of pests* • more varieties of apples, plums, pears.

Increased variability in yields of cereals, other crops. [†††, ‡]

Potential yield gains require more fertilizer and pesticides.** No consensus on strongly positive nor strongly negative yield projections overall; generally small, positive for initial moderate warming, becoming unpredictable and possibly negative as mean temperature increases further.[†,††]

Livestock • Increased survival, reduced winter feed requirements for livestock.** Forage, grassland may benefit but only with proper drainage.[†,††]

RUSSIA: Baltic & Western Arctic

Marked increase of precipitation, especially in winter, and of surface water • Risk of soil erosion and nutrient leaching from excess rain • excess soil moisture limits days suitable for machinery use* • spring planting disrupted by April/May rains • harvest disrupted, damage from water-logging, or molding of harvested grain if excess rain in autumn.*

Much milder winters and higher average temperature • Potential for northward expansion of temperate cereals, vegetables, pulses in Baltic, and of hardiest crops into uncultivated land** • longer growing season[‡] • potato yields more variable, though with average increase.**

Large change, especially in Arctic, and thus large uncertainty.

Expansion of leaf-bearing and steppe range into current tundra, taiga.** Change in composition of forests, and possible increase in value for timber production.

Livestock • Increased survival, reduced winter feed requirements for livestock.** Forage, grassland may benefit but only with proper drainage.[**,†]

RUSSIA: Central & Volga

Small increase of precipitation, mostly in winter, and of surface water • Given small change, unclear if there will be sufficient moisture, given temperature increases and faster evaporation, in some months • extreme low runoff events threaten output[†] due to drought.

Much milder winters and hotter summers, higher average temperature • Potential for northward expansion of winter cereals and crops like oilseeds, pulses, vegetables, as well as fruit crops currently grown in N Caucasus** • longer growing season • winter survival and subsequent proliferation of pests.[†]

Increased variability in yields of cereals, other crops.[†††, ‡]

Livestock • Increased survival and reduced feed requirements for livestock in winter.** Possible heat stress, drying up of grassland in summer. [**,†,‡] Possible expansion, intensification of indigenous and non-indigenous disease.[†] In southern part, productivity of grassland to decline, will need to shift northward. Lower grass production, heat stress, dry summers lead to reduced milk, vulnerability to disease.[†] *(continued)*

RUSSIA: North Caucasus
Decreased precipitation in all seasons, yet more storms, floods, and soil erosion.
Higher average temperature, very hot summers, heat waves, and droughts.
Very similar changes, on average, to South Caucasus, though even higher heat wave risk. See agronomic impacts information for South Caucasus. The area with the greatest potential damages within Russia, given current agricultural importance and nature of projected changes. Plant and animal diseases to become more recurrent.

RUSSIA: Urals & W. Siberia, S. Siberia, E. Siberia & Far East
Marked increase of precipitation, especially in winter, and of surface water, high flood risk • Excess precipitation may limit expansion of cereals otherwise possible from temperature increase alone • risk of soil erosion • excess soil moisture limits days suitable for machinery use* • spring planting disrupted by April/May rains • harvest disrupted, damage from water-logging, or molding of harvested grain if excess rain in autumn.*
Much milder winters and higher average temperature • Shift of agro-ecological zones on a diagonal gradient towards the northeast, so currently forested or uncultivated land warm enough for winter cereals, short season vegetables, • expansion of cereals would entail major changes in land use over time.
Livestock • Increased survival, reduced winter feed requirements for livestock.** Forage, grassland may benefit but only with proper drainage.[**,†]
Expansion of leaf-bearing and steppe range into current tundra, taiga.** Change in composition of forests, and possible increase in value for timber production.
South Siberia has a different climatic and agricultural baseline, though projected climate *changes* are similar to the rest of Asian Russia. See impacts in Kazakhstan for more relevant agronomic impacts.

SOUTH CAUCASUS
Decrease in surface water; droughts and floods; decline in spring and summer precipitation, small increase on sea coasts in winter • High risk of summer droughts • salinization, desertification, and soil degradation[‡‡] • yield declines for cereals, vegetables, potatoes from water shortage and excess heat in many areas • widespread crop failures during droughts • strain on water supply for irrigated agriculture. [‡‡]*Especially hotter in summer, also milder winters* • Despite milder winters, more crop-destroying frosts (tree crops, fruits) because of absence of heat-retaining humidity[‡‡] • longer growing season may allow multiple harvests[‡‡] • expanded area for cultivation of warm-weather tree crops (figs, nuts) in plains, and expanded area for vegetables (tomato, peppers) and cool-weather tree crops (apples) at high altitudes, but limited by steepness and risk of increased erosion[‡‡] • potential yield increase and geographic expansion for hot-weather perennials like grapevine, olive, citrus, but with risk of high variability[‡‡,**] • tree crops vulnerable to storms, pests** • winter survival and subsequent proliferation of pests.[†]
Livestock • Increased heat stress and disease, but less stress from cold in winter.** Outcomes for forage, grassland not clear.[‡‡]

KAZAKHSTAN
More rainfall, surface water year-round in north, with very dry summers in south • Despite CO_2 fertilization, increased heat and water shortage cause decline in cotton, rice, fodder, vegetable and fruit crop production in irrigated south[†] • potential expansion of grazing land northwards and in formerly virgin marginal lands, that were later ploughed for wheat cultivation. Note, greater water demand for rice production with higher temperatures.[†]
Much warmer throughout year, slightly more in summer • Potential increase in cereal, legume and oil crop production in cooler, wetter north • increased fodder production • increased water demand of plants and drying of soils in warmer months because of higher temperatures, causing drought risk and water scarcity to persist or worsen.
Livestock • Initial warming good for livestock, provided sufficient water availability, but after first few degrees, increased heat stress and disease.[†]

CENTRAL ASIA
Unchanged or increased winter rainfall, decrease in rainfall and surface water in spring, summer, fall, with droughts • Major stress on water resources for irrigation • decline in cereal yield from water shortage from spring to fall, and from thermal stress[†] • drought, desertification, soil erosion, salinization • widespread crop failures during droughts • increased suitability for drought-resistant tree crops. Note, greater water demand for rice production with higher temperatures.[†]
Hotter summer, milder winter • Greater water demand for rice production with higher temperatures[†] • despite CO_2 fertilization, increased heat and significant water shortage cause decline in cotton yields.[†]
Livestock • Marginal grasslands at risk for aridization, desertification. Heat stress reduces milk production.

Sources: Olesen and Bindi 2002;* Maracchi et al. 2005;** Branczik 2007;*** IPCC 2007c;[†] European Commission 2007;[††] Alexandrov 1997;[†††] Sirotenko, Abashina, and Pavlova 1997;[‡] Hovsepyan and Melkonyan 2007.[‡‡]

Further south, hotter, drier summers pose new risks, with more frequent, intense droughts in Southeastern Europe and Turkey, the North and South Caucasus, and Central Asia. The net effect could well be new limits on output, and far greater volatility in crop yields from year to year. In fact, as illustrated in the last row of table 5.2, the model for agriculture in the already warm, dry areas of ECA eventually will be drawn less from local experience than from current practices in the Middle East and North Africa (MENA). Today's management challenges and conflicts over water in MENA offer a sobering picture of what some in ECA must adapt to.

The projected increase in weather extremes presents challenges for agriculture across all parts of ECA. Inundating rains in Russia and the Baltics may interrupt sowing and harvesting of cereals. Storms in Central and Southeastern Europe could destroy tree crops. Alternating drought and intense rain and snowmelt could cause erosion and landslides in the densely cultivated slopes of the Caucasus. Drought combined with the scarcity of irrigation water could accelerate soil degradation; and as vegetation withers, local climate feedback effects result in less precipitation and worsening drought. Climate change will worsen this long-term spiral of intensifying aridity in Central Asia and the Southern Caucasus (Easterling et al. 2007; Cruz et al. 2007; Alcamo et al. 2007; Olesen and Bindi 2002; Maracchi, Sirotenko, and Bindi 2005; Branczik et al. 2007; Hovsepyan and Melkonyan 2007).

Livestock production, also sensitive to weather patterns, could benefit in the north from increased forage production, lower feed requirements, and less threat of extreme cold. But in the warmer, drier areas changing rainfall patterns and extreme heat will affect livestock both directly—through heat stress, lack of drinking water, and changed reproductive patterns—and indirectly—through reduced forage and feed yields. The unwelcome arrival of infectious diseases, such as brucellosis or rabies, because of warmer temperatures, would add to stresses on herds.

Livestock production can add to the climate change problem—through overgrazing and local climate feedback effects and, globally, through methane emissions. All told, livestock activities now contribute 80 percent of all agricultural greenhouse gas emissions (FAO 2006a). If producers respond to declines in the productivity of livestock by enlarging their herds, the result could be overgrazing, pasture degradation, and erosion of watershed catchments, causing devastating local climate feedback effects (Kokorin 2008). This scenario of grasslands becoming dry and barren is already a concern in water-scarce Central Asia, where many people depend on traditional agro-pastoral grazing systems.

ECA's forests face tree loss and degradation from extreme events and from the combination of earlier snowmelt and hot, dry summers. Regional droughts and shifting wind patterns have already increased the frequency and intensity of wildfires, notably in Serbia, Bosnia and Croatia in 2007, and Russia, where some 20 million hectares were lost to fires in 2003 alone. Strong winds, which are projected to increase as climate changes, can not only spread wildfires but also spark the initial conflagration. Many suspect that strong winds near electrical wires were the culprit in the 2008 fires in the Turkish province of Antalya, where, in addition to taking life and destroying trees, the fires devastated vast stretches of productive farmlands.

A changing climate can redistribute tree species, with warming causing shifts to higher latitudes. The new patterns can also provoke outbreaks of insect infestations, as seen in the northern march of damaging pests in boreal forests around the world (Easterling et al. 2007).

Similarly, a changed climate sets the stage for an invasion of non-native, harmful plant species into already disrupted forest ecosystems. Plant and pest species will move to higher altitudes in response to global warming, a trend already observed in the expanded northward range of birch (*Betula pubescens*) into the tundra of Sweden over the last half of the twentieth century.

Impacts: the economic models

The model estimates

The economic effects of climate change on agriculture include direct yield impacts, which are the most easily estimated, as well as ripple effects across sectors and markets. We take the initial shock to potential crop yields as our starting point before subsequently considering market forces and feedbacks, with particular focus on the international food market. Based on our analysis and estimates available in global synthesis studies, primarily Cline (2007), which are discussed further in box 5.2, we have also attempted to identify potential winners and losers in agricultural output markets.

BOX 5.2 ECONOMIC AGRICULTURAL IMPACT MODELS AND THEIR LIMITATIONS

The Cline estimates have been chosen here because they incorporate both main types of models, agronomic and Ricardian, to arrive at consensus estimates. (For further discussion, see Sutton et al. 2008.) However, there are a number of reasons to interpret the results with caution. Five major limitations of the estimates are (i) the lack of ECA-specific data, particularly important in mountainous and water-constrained areas, in the initial design of the models; (ii) the reliance on averages to determine yields, when in fact variability, extremes, and non-linear tipping points may be equally or more important; (iii) oversimplification of hydrology, and thus failure to consider realistic constraints on water availability; (iv) a partial equilibrium view of resource allocation and production, i.e., omission of trade-offs in the allocation of land and water and of market feedback effects; (v) the lack of consideration of the barriers to adaptation, from the geographic, technological, and infrastructural to the institutional, informational, and financial; (vi) highly optimistic assumptions about a positive supply response from ECA in the face of global shifts in food production potential, demand, and prices, which would in fact require currently absent complementary institutions and investments.

The results show that there is the potential for the following changes in the agricultural economies of the region:

- Net losses in Southeastern Europe and Turkey, the North and South Caucasus, and Central Asia;
- Gains in the Baltics and Siberia, Urals, Far East, and Baltic & Western Arctic regions of Russia;
- Mixed or uncertain outcomes in Central and Eastern Europe, Kazakhstan, and the Central and Volga regions of Russia (table 5.3).

The sub-regional summaries are not meant to be definitive because uncertainties remain, but they can help identify potential conditions that farmers and policymakers can shape and respond to based on current climate change knowledge. While precise impacts can’t be gauged, a pattern does emerge in which southern areas, already water-stressed, will be vulnerable to the projected higher temperatures and lower precipitation, while higher latitudes could benefit from improved conditions for agriculture. (The economic impact models for forests are less developed.)

TABLE 5.3 ECA'S POTENTIAL WINNERS AND LOSERS IN AGRICULTURE FROM CLIMATE CHANGE

Region	Based on annex 5.1, Cline, authors' analysis	Yield impacts 2080s without CO_2 fertilization (%)	Yield impacts 2080s with CO_2 fertilization[43] (%)
South Caucasus	Likely loser	–17	–5
Central Asia	Likely loser	–9	+4.6
Southeastern Europe & Turkey	Likely loser	Eur: –8.6 Turk: –16.2	Eur: +5.1 Turk: –3.6
Central & Eastern Europe	Mixed/ indeterminate	–5	+8.5
Kazakhstan	Mixed/ indeterminate	+11.4	+28.1
Russia: North Caucasus	Likely loser		
Russia: Central and Volga	Mixed/ indeterminate		
Russia: Baltics	Potential winner		
Russia: West Arctic	Potential winner		
Russia: South Siberia	Potential winner	–7.7	+6.2
Russia: Urals & W.Sib, E.Sib & FarEast	Potential winner		
Baltics	Potential winner	–5 to +5	+9.5 to +27.9

Source: Sutton et al. 2008. *Notes:* Relative to the other parts of ECA, Kazakhstan's yield increases are probably an overestimate. More details are in box 5.2.

Interpretation and caveats

At first glance, the impact on ECA's farm economy appears manageable, particularly when compared to South Asia or the Sahel, where yields are projected to decrease by more than 25 percent. Because the models all have weaknesses, and because country level economic projections are rudimentary, decision-makers should see the projections as indicative. To date, very little analytical work has been done at the country level in ECA to estimate the economic costs and benefits of climate change impacts and agricultural adaptation, and even less to address the intra-country distributional implications of climate change.

The estimates are limited in the sense that they can only include trends; but not all climate changes follow a simple trajectory. A key example of climate change complexity is the Syr Darya and Amu Darya Rivers, which draw on mountain snowmelt in the spring and early summer and glacial melt in late summer, and which provide much of the water for Central Asian farms before eventually draining into the Aral Sea in western Kazakhstan and Uzbekistan. The crucial glaciers of the Tien Shan Mountains of Northern China and Kyrgyzstan, a critical source of water, have declined sharply in the past 50 years, with an accelerated retreat in the past two decades (Niederer et al. 2008).

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[43] Carbon fertilization refers to an expected increase in yield of many crops in an environment of higher CO_2 concentrations, because i) CO_2 is an input into photosynthesis, and more CO_2 means more photosynthesis and thus growth; and ii) higher concentrations can reduce respiration, i.e., water loss from the "pores" in leaves, thereby increasing water use efficiency. There is still debate about the magnitude of the CO_2 fertilization effect, so both estimates with and without it are considered here (Cline 2007).

As warming continues and winter snowfall is replaced by rainfall, river flow will increase in the winter but decline in the spring and summer when it is most needed. This is because there will be little accumulated snow. Up to the year 2050, water from the melting glaciers will increase substantially: estimates range from an increase of one-third (Agaltseva 2008) to a tripling (Cruz et al. 2007). But after these few decades, the flow from the diminished glaciers will slow to the point where Central Asian farms won't have enough water for irrigation. As a result, the Aral Sea will likely shrink further, possibly reversing recent successes in restoring its ecosystems (Savoskul et al. 2003).

The state and sensitivities of ECA's agriculture today

For any region the capacity to manage climate change will depend on its demonstrated ability to address a broader category of problems related to the environment and national resource base. The institutional and economic conditions of countries will shape the ways that countries respond to the challenges posed by shifting weather patterns.

Stakeholders engaged in adaptation assessments and planning will need to understand how land is used, which population groups are vulnerable, as well as the diversity of agricultural practices. A map of the region's land use categories appears in map 5.1, while ECA's agricultural characteristics appear in table 5.4.

Climate change is complicated by environmental management weaknesses

Independent of climate change, environmental problems have presented substantial challenges to ECA countries, many of which lack management practices needed to protect the natural resource base on which critical economic activities depend (Sutton et al. 2007). Shortcomings are evident in soil fertility management, water use, pest control, nutrient conservation, forest health, and illegal logging. Projecting current management practices into an era of accelerating climate change raises concerns not only about social and economic setbacks in farming and forestry, but also about ecosystem stresses including biodiversity loss, and damage to watersheds and rural landscapes.

Failure to address soil erosion is particularly worrisome, since climate change could make present problems worse through a pattern of alternating droughts and extreme rains. Turkey stands out for its progress in managing soil erosion, motivated in part by concrete estimates of lost output, which helped to motivate stakeholders. This highlights the importance of monetary estimates to empower champions advocating for change (Sutton et al. 2007).

Institutional and management weaknesses in ECA stem mainly from the wrenching transition from centrally planned, Communist-era governance models. Though the bleakest decade is past, a legacy of distorted specialization and rigid, resource-poor institutions remains. The emphasis on inputs that characterized the region's thinking on agriculture for decades—more fertilizer, more seeds, more irrigation—have left the sector unprepared to adapt to knowledge-based farming better suited to a world of constrained resources.

TABLE 5.4 CHARACTERISTICS OF CURRENT AGRICULTURAL PRODUCTION IN ECA

Region	Distribution, Ownership, and Productivity of Agricultural Land	Major Crops & Products	Cropland Irrigation and Water Supply
South-eastern Europe and Turkey	Farms of Bulgaria now privatized; Croatian and Macedonian farms privately owned. Albania, Serbia and Montenegro mostly private but unclear ownership rights, and some inefficient collectives remain. Excessive fragmentation of holdings throughout region limits efficiency. In Turkey, farms are small and privately owned.	Highly diversified. Cereals, fruits, vegetables, orchards, vineyards, oilseeds, nuts, sugar beets; dairy, pork, sheep, poultry. In Turkey, cotton, olives, figs in addition to above.	Northwestern part of Balkans entirely rainfed. Albania: 50% irrigated. Macedonia, Bulgaria: 15%. Turkey: 20%. Drought-prone, hot desiccating winds, intense rain, soil erosion.
Central & Eastern Europe	Current yields low relative to potential. Moldova especially poor and agriculture-based; moderate privatization but highly fragmented private holdings and some remaining inefficient collectives. Privatization also incomplete in Ukraine. In Romania, mix of small family and commercial farms, all privately owned.	Moderately diversified. Wheat, barley, fodder, fruit & vegetables, orchards, potatoes, oilseeds, sugar beets. Livestock, though smaller share than rest of ECA.	Mostly rainfed, around 10% irrigated, except in Romania 30%. Moderately drought-prone, Moldova more drought-prone.
Baltics	Farms are privately owned.	Little diversification. Barley, rye, wheat, potatoes (especially Belarus). Livestock, pork and poultry. Oilseed in Poland. Limited fruits and vegetables.	Entirely rainfed, abundant precipitation.
Russia	Farms mostly in Central & Volga, N. Caucasus, some in Baltic, and in southern Urals and South Siberia. About one-third of agricultural land in private hands, the rest public. Few subsistence farms. Family, joint stock company farms, and public owned farms; low yields, poorly run.	Little diversification except in N. Caucasus. Barley, rye, potatoes, fodder in north & west. Spring wheat in north & east, some winter wheat in south. Diverse fruits, vegetables, vineyards in Volga & N. Caucasus. Some rice in N. Caucasus. Livestock.	Mostly rainfed. Some irrigation in N Caucasus, southernmost part of Urals and Siberia, small amount in Central & Volga. Moderately drought prone in south.
South Caucasus	Most productive arable land now under private ownership, but pasture still communal in places. Small, fragmented holdings. Subsistence and family farms with low productivity.	Highly diversified. Fruits & vegetables, orchards including apple, pears, cherries and some citrus, vineyards, dairy, sheep. Cereals, forage, corn, tea.	Armenia, Azerbaijan: 20–30% of cropland irrigated. Georgia: 40%. Highly drought-prone, but rainfall more abundant in Black Sea coastal area of Georgia.
Kazakhstan	Privatization progressing but incomplete. Small family farms in irrigated south but large farms in the north are better-run, private joint stock companies growing wheat.	Moderate diversification. Cotton, rice, wheat, fruits & vegetables. Forage, livestock, poultry in south. In the north monoculture of wheat, some oil crops, pasture.	Rainfed pasture. Just 10% irrigated. Highly drought-prone, especially in south.
Central Asia	Little privatization, with land ownership and distribution policies distortionary except in Kyrgyzstan, which is implementing privatization. Subsistence/family farms, inefficient low-productivity collective farms.	Highly diversified. Cotton, rice, wheat, corn, large number of fruits, vegetables, livestock, poultry, sheep, pasture. Especially reliant on livestock.	Kyrgyz, Turkmen, Uzbek mostly rainfed pasture. 75–90% of region's cropland irrigated. Extremely drought-prone, water-stressed.

Notes: Central Europe is Ukraine, Moldova, and Romania**.** *Sources: World Development Indicators*. Alam et al. 2005. FAO 2006b. Csaki et al. 2006. World Bank 2005.

Building the capacity to adapt will be crucial for ECA's Agricultural Knowledge and Information Systems, which were designed to assist large, public-sector, collective farms in meeting pre-determined production targets for crops and livestock commodities. These systems remain ill-suited for meeting the needs of smaller, private farmers who constitute a large share of the sector today.

Years of over-specialized production have also taken a toll. Under the command economy, collective farms, sub-national regions, and even entire countries specialized in an often small number of goods that may or may not have been appropriate to the local natural and human resource endowment. One of the most damaging examples was the concentration of cotton production in Central Asia, which led to overexploitation of water for irrigation, held in place by an institutional framework resistant to diversification.

In the first decade of the region's transition to markets, agriculture, like most sectors, experienced major upheavals, with sometime severe declines in output, and a drying up of government financial support (World Bank 2007). The new private farmers lacked experience in modern management or in operating in a market economy. They had little training support from institutions that had either collapsed or remained geared towards the old system. Knowledge gaps combined with a shortage of inputs, equipment, storage facilities, and market structures continue to weaken the farm sector throughout the region (Swinnen and Rozelle 2006).

The agricultural sector is gradually adjusting to policy reforms. Farm economies have begun to recover, with harvests and heads of livestock increasing toward 1990 levels. Private agriculture based on market principles is now predominant. But serious problems persist in the sector's institutional foundations. Environmental laws protecting agriculture, forestry, and biodiversity are weakly or unevenly enforced (Sutton et al. 2007). Research, education, training, and technology transfer systems suffer from neglect.

Turkey stands out, since it isn't emerging from Communist-era central planning. Private farms have always dominated agriculture in Turkey, though the small farm size limits the country's productivity gains. There is diversity in farm production within the country, and agriculture in western Turkey has generally been more progressive and export-oriented than in eastern Turkey. The research, extension, training, information, and technology transfer institutions function relatively well, and cross-ministry cooperation on environmental issues is promising (Sutton et al. 2007).

The capacity to monitor the impact of climate change has largely broken down in Russia as well as in other Eastern European and Central Asian countries, along with services for monitoring baseline weather conditions (see chapter 7). The ability to track pests, watch for forest fires, and provide warning of flash floods and other extreme events will increase the risks for farms and foresters as climate change plays out over time. Because fires pass unchecked across borders, they can spark transboundary political disagreements in addition to causing physical and economic damages. The fires of the summer of 2007 in Southeastern Europe offer a sobering example of the human, economic, and political cost of insufficient cooperation and coordinated planning at the national and international level.

Farm type and adaptive capacity

Different types of farms have varying advantages and disadvantages in adapting to the challenges posed by climate change.

Broadly, the ability to adapt to a changing climate depends on the elements of a functioning agricultural system: (i) timely climate information and weather forecasts, and the skills needed for their interpretation; (ii) locally relevant agricultural research in techniques and crop varieties; (iii) training in new technologies and knowledge-based farming practices; (iv) private enterprises, as well as public or cooperative organizations for inputs, including seeds and machinery, and affordable finance for such inputs; (v) infrastructure for water storage and irrigation; (vi) physical infrastructure and logistical support for storing, transporting, and distributing farm outputs; and (vii) strong linkages with local, national, and international markets for agricultural goods.

Different types of farms have different levels of access to these critical elements. Although smaller private farms would seem to be the most nimble in responding to changing conditions, larger farms generally would have superior climate information and expanded access to credit; and government-owned farms would have better access to state sources of information and finance.

All told, diversified operations are better positioned to respond to stresses that might hit one set of crops or one type of activity. Any farms already dealing with stressed water supplies will face new hardships in the more uncertain and extreme times that may lie ahead.

Corporate farms in Bulgaria, Romania, Russia, and northern Kazakhstan represent the largest type of farm and have the greatest physical and human capital resources. Next are the cooperative or group farms, generally managed by a few individuals using the pooled land of many smallholders, who may also be hired to provide farm labor. While these farms can exploit economies of scale, their managers typically lack the technological know-how and financing of the corporate farms, making them more vulnerable.

The largest and fastest growing group is the small, family farm, which produces for the commercial market but at a small scale. These farms make up the bulk of agricultural income and output in the Balkans, Turkey, the Caucasus, and Central Asia, and remain important in Central and Eastern Europe and Russia. These farms will likely continue to serve as the engine of the rural economy in the coming decades, but they may be highly vulnerable to climate change given their size, the farmers' limited technical knowledge, and poor access to public and private information and financial services.

Small farmers in particular will face climate change as yet one more stress compounding many others, including fragmented holdings, marginal land, poor environmental management, ill-defined property rights, increasing demand for standardized and safety-controlled products, declining health and vitality of the rural poor (in ECA, due to aging and outmigration of the young), protectionist food policies abroad, and unpredictable world food prices (Easterling et al. 2007).

The final type of farm is the low-productivity subsistence farm, with aging proprietors supported in part by urban remittances, which have little resilience to shocks. The transition out of agriculture will not be easy for these people since they often have no other options. Safety nets will be needed to assist them.

Potential climate change winners face their own challenges

Potential winners will not benefit automatically without making substantial investments in the future. They must take significant actions if they are to reap the potential benefits of climate change. Producers and policymakers in northern latitudes have begun to anticipate longer growing seasons and improved farm outputs.

However, any complacency would be misplaced, since adaptation investments will be required to take advantage of any potential gains (Parry, Rosenzweig, and Livermore 2005). The potential winners need to be aware of the specific changes projected and how best to take advantage of them. Moreover, most countries will have a mix of losing and winning producers, and will require adaptation strategies across sectors and sub-regions.

Some new challenges will emerge as producers take advantage of new farming opportunities. Northern areas will see intense competition between forestry and agriculture for land. The relative feasibility of field crops, tree crops, and livestock may further alter land-use patterns. As seen in the case of the Aral Sea, overexploitation of water resources for irrigation, as well as overuse and resulting runoff of polluting fertilizers, can have devastating consequences on fisheries and other water-dependent activities.

The question of whether ECA's potential winners can realize the benefits of favorable climatic conditions has important implications not just for the countries themselves, but for world food markets in general. In particular, Kazakhstan, Russia, and Ukraine (KRU), it is often said, have the most unrealized grain production potential, and they could benefit from climate change (at least in their northern regions).

But a recent report notes that, since the breakup of the Soviet Union, these three countries combined have removed 23 million hectares of arable land from production, the largest such withdrawal in recent world history (FAO & EBRD 2008). Almost 90 percent of this land had been used to produce grain.

Bringing large parts of this land back into production could increase world grain supplies and help solve the current global food prices crisis. Meanwhile, a number of global studies (e.g. Cline 2007) project a substantial increase in agricultural output for the KRU countries as a result of climate change (see the caveats in the discussion of table 5.3 above). These projected increases contribute to the relatively sanguine attitude of many towards climate change's impact on world food supplies.

The key question is whether the potential ECA winners will be able to provide the supply response that many expect of them. There are two possibilities for increasing production in the KRU countries: (i) raise yields on currently cultivated agricultural land; and/or (ii) expand the areas under cultivation. Because the latter would require large investments in land-clearing, production, marketing, and transport infrastructure, moves to improve productivity of existing farms are more attractive.

Productivity depends not only on the climate conditions, but also on technology, investment, support services, and crop management. Analysis has shown that the current gap between potential and actual yields in Central and Eastern Europe and the European parts of the former Soviet Union are significantly higher than any potential gains from climate change. In particular, the current yield gap for the former Soviet countries in Europe (including Ukraine and European Russia) is 4.5 times higher than the potential increase in production from climate change by 2050 (Olesen and Bindi 2002).

While world grain yields have been rising on average by about 1.5 percent per year since 1991, yields in Ukraine and Kazakhstan have fallen, and Russia's have increased only slightly. Yields in all three countries are far lower than those in Western Europe or the US. The fact that the KRU countries and other ECA countries have not been able to take advantage of this potential for productivity gains suggests fundamental weaknesses in the agricultural sectors of these countries, which does not bode well for their capacity to adapt to and benefit from climate change. Indeed, the key challenge would be to close the existing productivity gap rather than expecting to ride the climate change trends to a new era of prosperity.

Forests show a similar pattern to agriculture. Estimates indicate that the largest share of potential forest stock increases in Europe would be due to improved management (60–80%) rather than climate change (10–30%) (Easterling et al. 2007). Improved management requires strong forest institutions, which are often lacking in the transition countries.

Adaptation in the productive environment

Adapting the productive environment to challenges of climate change will demand technologies to monitor and measure conditions in the productive environment, institutions to facilitate change, and policies that encourage reform. Managers will need to show resilience and flexibility if they are going to be less vulnerable to changing weather patterns. A number of sustainable, appropriately chosen adaptation initiatives would yield measurable benefits regardless of climate factors. Policies and technologies for more efficient distribution and on-farm use of water make economic sense—by lowering costs to government in the form of water subsidies—and make adaptation sense—by equipping farmers to cope with reduced water availability as well as drought events.

But adaptation is a national effort not limited to individual farmers or foresters. For example, increased water-use efficiency will not be implemented without adoption of irrigation technologies and management strategies. But institutional components are equally important: water-user associations might aid in knowledge sharing, and advisory services can equip farmers with waste-reducing techniques. At the policy level, governments can invest in advisory services and awareness campaigns, while setting water prices to give users incentives to reduce waste and thereby lower government spending on subsidies.

Given the uncertainty about the exact spatial and temporal distribution of climate changes, a cautious approach is to pursue adaptations that would be worthwhile even without climate change. Following are examples from areas where adaptation measures hold the greatest promise, independent of climate change scenarios:

Technology and management (see annex table 5.1): Conservation tillage for maintaining moisture levels; reducing fossil fuel use from field operations, and reducing CO_2 emissions from the soil; use of organic matter to protect field surfaces and help preserve moisture; diversification of crops to reduce vulnerability; adoption of drought-, flood-, heat-, and pest-resistant cultivars; modern planting and crop-rotation practices; use of physical barriers to protect plants and soils from erosion and storm damage; integrated pest management (IPM), in conjunction with similarly knowledge-based weed control strategies; capacity for knowledge-based farming; improved grass and legume varieties for livestock; modern fire management techniques for forests.

Institutional change (see annex table 5.2): Support for institutions offers countries win-win opportunities for reducing vulnerability to climate risk and promoting development. Key institutions include: hydromet centers, advisory services, irrigation directorates, agricultural research services, veterinary institutions, producer associations, water-user associations, agro-processing facilities, and financial institutions.

Policy (see annex table 5.3): Non-distorting pricing for water and commodities; financial incentives to adopt technological innovations; access to modern inputs; reformed farm subsidies; risk insurance; tax incentives for private investments; modern land markets; and social safety nets.

ANNEX TABLE 5.1 TECHNOLOGICAL ADAPTATION PRACTICES AND INVESTMENTS FOR VARIOUS CLIMATE, WEATHER AND AGRICULTURAL PHENOMENA

Technological adaptation measures and investments	Climate / weather / agricultural phenomena								
	Drought	Need for soil moisture conservation (rain-fed)	Need for water use efficiency (irrigated)	Land degradation, soil infertility, erosion	Heat stress	Pest and disease control	Excess rain, flooding, storms	Milder winters, longer growing season	Emissions mitigation, carbon sequestration
Land use management	x	x	x	x	x	x	x	x	x
Mixed farming systems (crops, livestock, and trees)	x	x	x	x	x	x	x	x	x
Conservation tillage	x	x	x	x					x
Nutrient management and use of organic matter	x	x		x					x
Watershed management	x	x		x			x		x
Water harvesting techniques, storage, reduction of runoff	x	x	x	x	x			x	
Drainage systems				x		x	x	x	
Rehabilitation and modernization of irrigation infrastructure, canals	x		x		x		x		
Develop new irrigation facilities	x				x			x	
Use of marginal water	x		x						
Dams for water storage, flood control	x	x		x	x		x		
Supplemental irrigation	x		x		x				
Irrigation at critical stages of crop growth	x		x		x				
Sprinkler irrigation	x		x						
Drip irrigation	x		x						
Furrow and flat-bed irrigation	x		x						

Technological adaptation measures and investments	Climate / weather / agricultural phenomena								
	Drought	Need for soil moisture conservation (rain-fed)	Need for water use efficiency (irrigated)	Land degradation, soil infertility, erosion	Heat stress	Pest and disease control	Excess rain, flooding, storms	Milder winters, longer growing season	Emissions mitigation, carbon sequestration
Crop diversification	x	x	x	x		x		x	
Use water-efficient crops, varieties	x		x	x				x	
Heat- and drought-resistant crops/varieties/hybrids	x	x	x		x			x	
Switch to crops, varieties appropriate to temp, precipitation	x		x	x	x	x	x	x	
Crop rotation (sequencing)	x	x				x			
Switch from field to tree crops (agro-forestry)	x	x	x	x	x	x	x		x
Timing of operations (planting, inputs, irrigation, harvest)	x	x	x		x	x	x	x	
Strip cropping, contour bunding and farming	x	x		x			x		
Vegetative barriers, snow fences, windbreaks	x	x	x	x	x	x			x
Rangeland rehabilitation and management	x	x		x	x	x	x	x	x
Pasture management (rotational grazing, etc) and improvement	x	x		x	x	x	x	x	x
Supplemental feed	x			x					
Fodder banks	x			x					
Watering points	x			x	x			x	x
Livestock management (including animal breed choice)				x	x	x	x	x	
Fire management for forest and brush fires				x					x
Response farming (using seasonal forecasts)	x		x	x	x	x		x	
Integrated Pest Management	x					x		x	

Source: authors; Padgham (forthcoming).

ANNEX TABLE 5.2 INSTITUTIONS CRITICAL FOR ADAPTATION

Institution	Importance for Adaptation	Status in ECA
	NATIONAL AND LOCAL GOVERNMENTS	
Hydromet & Forecasting Centers	Essential information for planning, understanding changing climate, providing farmers with long-term, seasonal, and daily weather forecasting for knowledge-based response farming.	USSR was served well, has since crumbled. Improving in European Russia but still unsatisfactory in Central Asia and the rest of ECA. Poor capacity for local monitoring, local data interpretation, and forecasting.
Advisory Services (incl. Agricultural Extension) i. Agronomic Info ii. Financial Advice iii. Market Info	i. Interpret hydromet output for practical advice to farmers; convey information on trends of climate change and risk; recommend and train in new and off-the-shelf technologies and in new/different locally-adapted crops and varieties; demonstrate new farming practices. ii. Provide information on sources of finance for adaptive investments. iii. Provide information on market prices and channels of distribution for crops and livestock. Key to ensure that services reach small and medium family farms.	Generally poor state of both public and private sector advisory services. Challenge to reach small farmers. Lack of capacity for interpretation of climate forecasts, interpretation of probabilistic climate data, and thus communication of probabilistic and not deterministic forecasts. In Turkey, advisory services are better developed but lack capacity to effectively advise farmers in an environment of increased challenges.
Irrigation Directorates	Maintain, rehabilitate, expand, and replace old and new irrigation facilities, which will be more important in water-stressed areas. Intermediary between managers of water resources and farm users.	
Forestry Departments / Agencies	Maintain health of forests and respond to pests and risks of fire. Observe changes in forest ecosystems in response to changing climate. Participate in planning related to forest-agriculture land trade-offs.	In much of ECA, often among the best-functioning of those institutions that will be relevant for climate adaptation.
Agricultural Research Institutes	Bring knowledge of locally-relevant needs to research networks from local to international level, develop varieties and technologies suitable for changing climate and local endowments.	After the disintegration of the Soviet Union, research systems collapsed and are not effective in meeting the current demands. In Turkey, the situation is better.
Agricultural Education at Vocational Schools, Technical Colleges	Important conduit for information about implications of climate change for farmers and managers, including adaptation measures and technologies and guidance on how and when to implement them. Key in move towards more knowledge-based rather than input-based farming.	
Quality Control, Phytosanitary, & Veterinary Services	Provide standards information and enforcement consistent with national and international regulation, monitor and control livestock health and provide timely information on disease risks.	Strong in some countries, in others not up to challenge of global food market.

Institution	Importance for Adaptation	Status in ECA
	CIVIL SOCIETY	
Producer Associations & Farmer Organizations	Share information about outcomes and challenges of adaptation, serve as locus for absorbing new information from and communicating farmer concerns to government bodies and private enterprises, allow shared investment in new machinery by small farmers.	Producer associations and farmer organizations are starting to grow and their effectiveness varies across countries. There is potential for further expansion to more areas and for deepening of activities.
Water User Associations	Encourage more sustainable water use.	Relatively recent institution, not fully developed, just beginning to function.
NGOs	Provide information, funding, and institutional support at small scale for pilot adaptation efforts by farmers, offer microcredit to enable adoption, share knowledge of local experiences, advocate farmers' concerns.	Moderate presence, increasing in ECA client countries. Face the usual challenges, e.g. interventions not sustained after projects end, struggle to reach the neediest, lack of coordination with other institutions.
	PRIVATE ENTEPRISES	
Private & Public Seed Companies & Nurseries	Ensure production and availability of seeds/seedlings of appropriate varieties, e.g., with improved drought- and pest-resistance, to take advantage of agricultural research and development and facilitate adoption.	In Europe, available but currently inadequate. Limited presence, efficacy in Caucasus, Central Asia. Good in Turkey.
Grain Storage and Drying Facilities	Will be needed in currently unserved newly cultivated areas, and areas with intense rainfall or heat which cause rot, spoilage.	Not present or inadequate in areas that will need them as cropping, livestock zones shift, and as rainfall increases during cereal harvesting time in the Baltics, Central Europe, Russia, northern Kazakhstan.
Agroprocessing Facilities	Offer processing of livestock products in expanded pasture areas, processing of horticulture crops in new areas.	Not present or inadequate in areas that will need them as cropping, livestock zones shift northwards.
Marketing Enterprises	Exploit economies of scale by buying produce of family farms and selling at market, mitigates risk to farmers of adopting unfamiliar crops or varieties with uncertain demand locally.	Variable and with scope for improvement. Generally stronger in Turkey and Europe than the Caucasus, Central Asia.
Financial Services i. Banks ii. Microloans iii. Agricultural Insurance	i. Provide necessary finance for implementation of adaptations. ii. Reach out to small farmers with limited access to formal banks. iii. Mitigate risks of crop failure from unpredictable weather, unproven adaptations, market uncertainties.	Poor access of small farmers to banks. Limited presence, effectiveness of microcredit organizations. Weather-indexed insurance does not exist in most of ECA client countries.

ANNEX TABLE 5.3 POLICIES CRITICAL FOR ADAPTATION

Policy	Importance for Climate Change Adaptation and implementation challenges
Non-Distortionary Water Pricing	Reduce subsidies to increase incentives for better management of water resources, allocation of water, and efficiency of its use. Difficult because removing subsidies often meets political resistance.
Non-Distortionary Commodity Market Policies	Reduce distortions in markets for cereals and oilseeds, including setting price caps, or taxing or otherwise restricting exports. Letting prices pass through will increase incentives for producers to invest and expand production of these crops over time. Export restrictions become contagious, significantly reducing agricultural trade and the ability of world food markets to respond to climate change. Also, manage state grain reserves transparently and effectively to ensure supply during short-term shocks, not to keep prices low.
Financial Incentives for Adoption of Technological Adaptations	Provide tax incentives for, e.g., farmers' purchase of machinery required for conservation tillage, planting of drought-resistant seedlings. Provide financing, coordination for hiring of machines and labor for reforestation projects.
Access to Modern Inputs	Remove restrictions on imports of modern seeds and seedlings to allow farmers access to modern varieties (e.g., with increased drought resistance or longer maturation).
Invest in Support Institutions (identified in previous table)	Those institutions have been underfunded for a long time, some governments pay attention to it and some don't, some have the resources to invest there and some don't.
Reform Farm Subsidies	Subsidies targeted at production of specific crops may be counterproductive as comparative advantages change. Avoid trying to "pick winners," e.g., subsidies for cereals rather than the fruits and vegetables which may become more appropriate due to warming. Recurrent production subsidies also reduce scope for investments in public services and farm investment subsidies.
Promote Private Investments	Promote investments by the private sector in new technologies by providing tax incentives, matching grants, technical assistance, etc. Not only for primary production, but also for inputs, processing, logistics, warehousing, and other related sectors.
Risk Insurance	Explore opportunities for developing system of weather index insurance (as opposed to traditional multi-peril crop insurance). For smaller countries especially, spread risk across countries.
Improve Land Markets	Ensure land tenure security, improve land registration and cadastre systems, and reduce market transaction costs. This will help to increase the flexibility of farmers, reduce fragmentation, increase access to finance, and encourage investment.
Calculate Economic Costs and Benefits	Calculate the economic costs and benefits of policy changes and investments decisions as rigorously as possible to ensure the most efficient and effective use of public resources. This will often require capacity building.
Encourage Livelihood Diversification	In some areas, and for some rural residents, agriculture and forestry may become unviable. Provide training and financial support to encourage the development of non-farm rural employment or skills for urban employment.
Strengthen Social Safety Nets	Provide targeted income support for poor and vulnerable segments of the population that may have difficulty affording food, who may live in areas where agriculture becomes unviable, may not be able to easily change livelihoods (elderly, sick).