Identifying Appropriate Adaptation Measures to Climate Change

Annex 6
ANNEX 6

Summary of Impacts and Adaptation Options

Excerpt from “Climate Change Adaptation in the Agricultural Sector: Challenges and Opportunities” (World Bank, Environment and Agriculture and Rural Development Dept.)

1. Water

1.1. Impact
Climate change is expected to reduce the supply of freshwater for irrigation, lead to increased variability and intensity of rainfall, prolonged dry spells and higher rates of evapotranspiration, placing increasing demand on irrigated production systems.

1.2 Adaptation responses
A range of water management practices are available to strengthen resilience to climate variability.

➢ Water-conserving technologies
Improving the access to and adoption of water conserving practices can help irrigated systems to cope with lower water supply. Water conserving technologies are an effective way to maintain cropping intensity, and can provide opportunities to diversify into high-value market crops, reducing reliance on rainfed field crops. Technologies for achieving higher water productivity include:
- Drip irrigation systems: low cost drop irrigation technologies exist in a price range affordable for smallholder farmers.
- Furrow- and deficit-irrigation methods
- Water management practices: altering amounts and timing of irrigation, managing water (including drainage) to prevent water logging, erosion, and nutrient leaching where rainfall increases.
- Improving the reliability of the water supply through support for the construction of diversionary structures and holding ponds for rainwater harvesting.

➢ Expanding use of marginal water sources
Use of marginal water sources (brackish water, treated and non-treated wastewater) can be an effective way to cope with lower rainfall. Strategies available include:
- Saline water irrigation: allowing high-value crops to be grown in rotation with lower-value salt-tolerant ones.
- Diversifying away from water-intensive crops towards salt-tolerant crops (eg agroforestry trees and shrubs)
- Seawater desalinization
- Blending good and poor-quality water to extend water supplies

➢ Rainwater harvesting and capture
Inter-annual storage of excess rainfall can be an effective way to maintain cropping intensity and smooth volatility in yield caused by climate variability. A range of methods is available:
- Capturing runoff through trenches and terraces (common in smallholder rainfed systems).
- Practicing conservation tillage and crop residue retention to increase water storage capacity
- Diverting rainwater into holding structures for subsequent use.

1.3. Institutional/Policy challenges

Despite the availability of water management practices to smallholders, farmer adoption of these technologies is low. Encouraging wider adoption of these practices, and more capital-intensive technologies, will require investments in:

**Infrastructure**
- Improve irrigation infrastructure to accommodate new pumping technologies
- Improve road draining systems for better market linkages
- Road investment to transport water more effectively where rainfall decreases.
- Design roads to serve the needs for runoff catchment

**Private sector/market development**
- Credit and cost sharing to enhance access to new production technologies, animal traction, drip irrigation equipment, foot pumps and other water delivery technologies
- Improvements to input/output markets

**Capacity building of local institutions**
- Training and outreach for farmers on rainwater harvesting and water management options
- Extension and training on drip irrigation
- Support for creation of water user associations
- Facilitation of farmer-to-farmer exchange mechanisms
- Strengthen the capacity of local institutions to coordinate water use
- Support for extension services
- Build capacity of community organizations around construction and maintenance of macro-catchments
- Strengthen management capacity of water user associations
- Support for farmers and local institutions affected by policy changes, including training, credit

**Improved knowledge and research**
- Research on breeding crops that are salt-tolerant
- Support for farmer field trials on irrigation water management
- Research on developing locally acceptable varieties of salinity-tolerant crops
- Support for farmer participatory varietal selection and plant participatory breeding programs
- Support for farmer-field trials on irrigation water management and improved varieties
- Enhance crop modeling capacity
- Support crop breeding programs for the development of varieties that fit conservation tillage systems
- Encourage research-to-use programs and capacity building of farmer organizations
- Building capacity to integrate climate projections into water resource planning models

**Policy reform**
- Policy reforms to encourage sustainable water use. Adapation-relevant measures include: ending subsidies for irrigation water pumping, property rights for irrigation water use, and targeting reform towards crops that are ill-suited to the environment (eg irrigated rice in semi-arid areas)

---

**2. Soil and Land Management**

**2.1 Impact**
Soil and land management will need to take measures to adapt to the impacts of climate change. Steps will be needed to increase the resilience of agricultural land to excess of water due to high intensity rainfall, which can result in soil erosion and flooding, and lack of water, which can lead to drought and damage crops. Climate change is projected to result in accelerated losses of soil carbon, which apart from contributing to global warming, is critical for improved soil nutrient and water dynamics and plant productivity.

**2.2 Adaptation responses**

- **Conservation agriculture and organic agriculture**: Conserving soil organic matter, through low tillage and maintaining soil cover, improves and stabilizes the soil structure, allowing soils to absorb higher amounts of water without causing surface run off, which could result in soil erosion and flooding.
- **Maintenance of soil cover** enhances soil moisture: Maintenance of permanent soil cover through crop rotation, crop residues or cover crops can increase soil organic matter and reduce impacts from flooding, erosion, drought, heavy rain and winds.
- **Low tillage** of soil conserves the structure of soil, and allows fauna (earthworms, termites, root channels etc) to serve as drainage channels for excess water.
- **Soil erosion mitigation**: buffer strips, mulching and zero tillage to mitigate soil erosion where rainfall intensity increases
- **Conversion of marginal crop land to range land**
- **Altering the timing or location of cropping activities.**
- **Soil fertility replenishment**: Improvements to soil fertility can be an effective adaptation response to climate variability. Methods for this include:
  - Soil erosion control practices to enhance vegetative soil coverage and reduce soil disturbance
  - Altering fertilizer rates to maintain grain or fruit quality consistent with the prevailing climate.
  - Improving the retention of soil moisture through rainwater harvest methods. This reduces the risk of crop loss, which in turn improves soil fertility.
- **Integrated soil fertility management** (ISFM). The adoption of practices that enhance soil coverage and reduce soil disturbance are critical to strengthening the resilience of production systems. Practices such as green manure legumes, N-fixing agro-forestry trees, compost and animal manure serve this purpose. ISFM also provides a potential income source (through
products from green manure crops and agro-forestry trees) and is more flexible than the use of mineral fertilizer alone.

2.3 Technical and institutional challenges

Adoption of these adaptation measures requires investments in the following:

- **Rural infrastructure:** Improved input and output markets and rural infrastructure is important to provide incentives for on-farm investments in soil and land management
- **Access to credit:** Access to flexible credit programs, particularly targeted at women, will be needed to increase access to required inputs
- **Capacity building** of farmers and local institutions to use seasonal climate forecast information for land management decisions
- Shift the focus of **research and extension** from high-input fertilizer for yield maximization, to giving farmers information to allow them to make flexible adjustments in fertilizer use.
- **Education and extension** both through formal channels and through farmer organizations
- Promotion of **land tenure security** and resource ownership policies

3. Sustainable Agriculture

3.1 Agrobiodiversity

3.1.2 Adaptation responses

The capacity of crops and ecosystems to adapt to a changing climate, resist pests and diseases and tolerate stress requires continual input of genes from wild species. Genetically diverse populations and species-rich ecosystems have greater potential to adapt to climate change. Strengthening the diversity of genes, species and ecosystems is crucial to increase resilience to changing environmental conditions and stresses. Major adaptation needs include:

- **Access to improved crop varieties:** Developing and using new varieties/species with increased resilience to drought, flooding and increased resistance to heat shock is important for climate adaptation. Improving adoption and dissemination of short-duration crop varieties can enhance the ability of farmers to cope with variable climatic conditions. Measures to foster this include:
  - Informal seed networks
  - Participatory plant breeding and variety selection
  - Seed system recovery
  - Providing support to genebanks
  - Use of indigenous and locally-adapted plans and animals
  - Maintain strategic seed stocks locally as a hedge against disaster
- **Participatory plant breeding:** Participatory plant breeding and variety selection methods can increase the adoption of improved varieties. They can also reduce the time and costs of developing new varieties (conventional breeding programs typically take 10 or more years to deliver new varieties to farmers for testing, against 3 to 4 years through participatory methods).
Selection and multiplication of crop varieties resistant to adverse conditions: Selection of crops with tolerance to ‘abiotic stresses’ (high temperature, drought, flooding, high salt content in soil, pest and disease resistance etc.) is important to broaden the genetic base of new crop varieties.

3.1.3 Technical and institutional challenges
Small farmers are often not serviced by formal plant breeding networks. This requires capacity and long-term support to implement plant breeding programs and develop locally adapted crops. Measures for this include:

Policy reform
- Strengthen decision-making tools and mechanisms to prioritize crops and identify alternative crops for specific ecologies
- Support policies to mainstream participatory plant breeding into national crop improvement programs
- Review regulations concerning seed distribution, breeding, variety release etc.
- Strengthen local property rights and intellectual property rights

Infrastructure
- Improve on-farm seed storage technologies and facilities to reduce losses to pests and diseases

Private sector/market development
- Improve access to credit to allow farmers to acquire improved seed

Capacity building of local institutions
- Build capacity for field-based variety testing in extension, NGO and farmer associations
- Creation of farmer seed enterprises targeted at local small-scale commercial seed production

Improved knowledge and research
- Build capacity for data gathering and applying climate scenarios to a range of crops
- Enhance plant breeding research capacity

3.2 Integrated Pest Management

3.2.1 Impact
Climate change is expected to lead to an increase in existing pests and invasion by new pests; accelerated pest lifecycles (leading to more pest cycles per season); loss of resistance of crops; and reduced efficacy of existing pest management practices.

3.2.2 Adaptation responses
Several practices are available to improve the effectiveness of pest, disease, and weed management:

Assess the risk
An initial assessment can identify which crops are vulnerable to pests, and the likely source of vulnerability (invasion of new pests, loss of host resistance etc.). This information could be used by agriculture policy makers and IPM researchers to decide where to invest resources in capacity building and technology development for pest management and surveillance.

Development and use of varieties and species resistant to pests and diseases
3.2.3 Technical and Institutional Challenges

Investments are needed in the following areas:

**Infrastructure**
- building capacity for surveillance and early detection of pest invasions through remote sensing and GIS capacity
- refurbish infrastructure such as laboratories and greenhouses

**Private sector/market development**

**Capacity building of local institutions**
- strengthening extension services into rural communities
- Support capacity building of farmer cooperatives and producer organizations as a means of technology adoption and information exchange
- encourage integrated participatory research and farmer field schools.

**Capacity building of national institutions**
- Strengthen national agricultural research and extension services in pest surveillance, plant breeding
- support institutional capacity for information sharing, coordination and planning across regions to build regional capacity to respond to new pests and diseases

**Improved knowledge and research**
- Expand the development and use of climate models to predict shifts in pests and develop risk maps to aid adaptation planning.
- broaden access to web-based research resources
- increase research support for crop biodiversity as an adaptation strategy
- support plant breeding research in international agricultural centers
- strengthening national agricultural research and extension services in pest surveillance, plant breeding

4. Generating and disseminating Climate Information and Knowledge

4.1 Impact
Access to data and information is a critical bottleneck for adaptation planning in low-income countries. Data sets are scarce, not readily shared or coordinated. Local-scale forecasts are needed to support local decision-making. However developing countries have poor spatial resolution of forecasts for local agricultural decision-making, a lack of information about intra-seasonal rainfall distribution and other climate parameters.

High climate variability in farming environments depresses crop productivity and constrains investments. Variability and risk decreases farmer investment in production. Knowledge and technology required for adaptation includes understanding the patterns of variability of current
and projected climate. Adaptation practices require extensive high quality data and information on climate, and on agricultural systems affected by climate.

### 4.2 Adaptation responses

- **Information and seasonal forecasts**
  Support for seasonal climate forecasts is needed in all regions. Information provided by seasonal climate forecasts can provide farmers with more flexibility to shift their coping strategies. Seasonal forecasts are aimed at enhancing responses to seasonal climate variability.

- **Climate change scenario generation**
  Training is needed to operate climate models and interpret climate model output. Using a range of methods to generate climate change scenarios. Many developing countries lack resources or capacity to support downscaling of general circulation models. However there are several techniques that would create a foundation for adaptation planning in countries where capacity is weaker. A range of techniques are available for generating climate change scenarios that can inform impact assessment and adaptation planning in agriculture. These include:
  - weather generators
  - Trend extrapolation
  - Sensitivity analysis etc.
  These tools are relatively easy to apply, and provide good information on regional patterns of climate change suitable for agriculture. Education, training and equipment are needed to build capacity to use these techniques.

- **Integrate local and traditional knowledge and practices**
  The availability of science-based climate prediction information needs to be tailored to farmer needs by matching it with traditional knowledge and practices and incorporating existing local knowledge.

### 4.3 Technical and institutional challenges

Technical and institutional challenges to improving and scaling up seasonal climate forecasts include:

- **Skill and coverage of forecasts needs improvement**
- Technical: lack of data and skills
- Institutional: lack of coordination among government agencies, inadequate capacity to act on information etc.
- Communication infrastructure - stations
- Education and sensitization of public eg through participatory forecast workshops
- Data collection
- Policies
- Training

**Greater support and investment is needed for the following:**

- Skills for forecasts
- generation and transfer of knowledge and information
- institutional capacity building and coordination
- Indigenous knowledge – how to integrate new climate data with indigenous knowledge
- Using climate forecasting to reduce production risk.
- Building a communication infrastructure to support forecast dissemination.
- Education and sensitization of the public about the seasonal climate risks to society.
- Building local capacity through participation in forecast workshops.

5. Diversifying Rural Livelihoods

5.1 Impact
In areas where climate change threatens rural livelihoods dependent on agriculture and natural resources, it is important to build capacity to diversify.

5.2 Adaptation responses

- **Assessing Livelihoods Options**
  A livelihoods approach to promoting climate change adaptation at local level involves:
  - assessing and understanding current livelihood systems, adaptive capacities and vulnerabilities.
  - Identifying and promoting options to adapt to climate variability, jointly with local producers, research institutes and extension agencies.
  - Enhancing local adaptive capacities by linking multiple stakeholders.

- **Diversification to climate resilient agricultural production systems**
  Diversification of sensitive agricultural production systems (eg rainfed agriculture) into less sensitive agricultural microenterprises (small-scale vegetable and fruit production, livestock rearing, bee keeping etc.) can enhance adaptation to short- and medium-term impacts from climate change. Diversifying income through altering with other farming activities such as livestock-raising, tree-farming (agroforestry), pond aquaculture, agroforestry, silvicultural practices.

- **Strengthening risk-coping production systems:** Production systems that are resilient to land and water modifications incorporate crop rotations, agroforestry, crop-livestock associations, crop-fish systems, use of hedges and buffer strips. These require diversified structures in space and time [? What does he mean?].

- **Strengthen capacity of rural institutions to use tools such as:**
  - Participatory identification of vulnerabilities.
  - Implementation of community-based disaster risk reduction activities (eg sub-national early warning systems).
  - Strengthening the capacity of communities to manage their resources, eg through savings, credit schemes, agricultural inputs, agricultural production, land use etc.
  - Enhancing the use of technological options to manage climate variability associated risks (eg disaster information management systems).
  - Raising awareness of farmers and building capacities of local institutions in support of national disaster management policy.
- partnership between regional and national research institutions, extension services and farmers

**Investments:**
- R&D in horticultural crops
- Enhance the capacity of extension services and NGOs to transfer technology and knowledge
- Improve the enabling conditions for smallholder farmers to enter into horticulture: credit, matching funds for smallholder investments, programs targeted to women, improved crop marketing, capacity building of producer organizations
- Improve market information systems
- Post-harvest facilities and market chain improvements
- Increase household access to productive assets, education and skill development