# Adaptation Framework Thematic Brief: Irrigated Crops

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## Climate Change and Irrigated Crops

The impacts of climate change on irrigated crop production are complex, and vary according to both crop and location. It is important to note that the effects of climate change will not be a universal decrease in production, and that for some crops there may be an initial increase in productivity driven by higher temperatures.

Climate change is already affecting crop production and food security through increased temperatures, an increase in extreme events and changes to rainfall patterns and water availability. Recent studies indicate that at the global scale, observed climate change since 1980 has reduced yields of crops such as maize, wheat and soybeans, and that adaptation efforts so far have not been sufficient to offset these losses. The distribution of many pests and diseases has also already changed as a result of changing temperature and rainfall distributions affecting range and suitability.

While irrigated cropping systems are in general less vulnerable to changes in precipitation than their rainfed counterparts, climate change also poses a significant challenge. Shared challenges for both rainfed and irrigated cropping include shifts in areas suitable for growing different crops (e.g. higher temperatures can reduce lowland suitability for crops such as Potato), changes in seasonality (e.g. shorter rains, longer growing season), increases in extreme events, changing patterns of pests and diseases and shifts in the drivers of large-scale climate variability such as El Niño. Although increasing $CO_2$ levels will be beneficial for crop production at low levels of temperature rise (assuming no change in other factors such as rainfall, disease or extreme events), it will also reduce the nutritional quality of food produced, with negative impacts for food security.

Changes to irrigation demand for water will depend on the local interplay of changes in precipitation and water availability, changes to evaporation rates as temperatures rise, and changes to cropping cycles and shorter growing periods as a result of changes in temperature and the $CO_2$ fertilisation effect. Studies highlight significant uncertainty in calculations of irrigation demand, as well as the potential for different planting and cropping strategies to make the differences between increases or decreases in modelled crop yield.

Production losses under future climate change are expected to be greater at low latitudes than at high latitudes. As an example, assuming 4°C of warming, the modelled effect of climate change on vegetable production in warmer climates (>20°C) is a reduction in yield of around 30%, whereas cooler production areas are projected to see a smaller decrease of around 5%. Impacts will vary by region, crop, soil fertility and the exact nature of the $CO_2$ fertilisation effect. For some regions there is more confidence in these changes than others; for example for the Middle East and N. Africa there are significant declines in crop yield expected at all levels of warming.

Extreme events such as flooding are associated with the largest impacts on irrigation schemes. Climate change is likely to increase both the intensity and frequency of flood events in many areas, with implications for the design of irrigation intakes and other hydraulic structures. In addition to requiring changes to the design and protection of irrigation infrastructure itself, increased peak flows may increase the suspended sediment load, and impact on the performance of the irrigation system. An increase in extreme rainfall events will also affect drainage systems, and may require increased investment the re-engineering of spillways, culverts and canals, and designing systems to deal with larger peak flows and flood events.

Secondary impacts include; likely increases in food prices across most major crops, with subsequent negative effects on food access and security as well as malnutrition as substitute crops are found which are more reliable but less nutritious; reduced yields in rural areas fuelling migration and displacement; and the effect of extreme heat on the agricultural labour force.

The impacts of climate change will not be felt evenly, with women, marginalised indigenous groups and the poorest members of communities likely to be at greater risk. Poverty, lack of political power and marginalisation from decision-making processes interact to reduce the ability of these groups to adapt to a changing climate. Women and indigenous groups are more likely to be reliant on subsistence agriculture, and therefore are more exposed to negative impacts on crop production. Smallholder farmers are also consistently found to be more vulnerable to the impacts of climate change than commercial farmers with greater access to inputs and resources.

In summary, the specific impacts of climate change on irrigated cropping systems will be diverse, however, climate change has the potential to significantly reduce the yield of major crops (including cereals, fruit and vegetables), in the absence of effective adaptation strategies. The uncertainty in changes in irrigation water demand, and varied impacts by location and crop, highlight the importance of detailed regional and local assessments to inform adaptation strategies and project design. Climate change will pose a major challenge to food security, and to IFAD in achieving its strategic vision.

## Adaptation and typical options available

Adaptation provides an important opportunity to reduce many of the negative effects described above, and in some cases avoid them entirely. Through the transformation of agricultural systems it also provides the opportunity to improve on current conditions and improve food security among poor and marginalised groups. Adaptation is highly context-specific, and influenced by the nature of local climatic, environmental and social systems. Adapting to climate change will require a combination of technological, social and policy responses.

Integrating a gender perspective in adaptation is critical, and it is clear that empowering women has positive outcomes in terms of capacity to adapt to climate change. Given the inequitable impacts of climate change, interventions need to be designed which specifically address the challenges faced by women, indigenous and marginalised groups, and poor people. Without this specific focus, there is a risk that adaptation can perpetuate and enhance existing inequalities.

Many interventions which increase the resilience of agricultural systems to climate change also have mitigation co-benefits. Agro-ecological, Conservation Agriculture and Climate-Smart Agriculture approaches can increase the amount of carbon sequestered through improved soil conservation, and reduce carbon-intensive inputs needed, while at the same time increasing soil moisture and reducing irrigation demand. For example, low or no-till approaches and the management of soil organic matter both increase water retention, as well as the amount of carbon sequestered.

Many of the options for adapting irrigation systems to climate change build on existing good practice in irrigation. Adaptation measures for irrigated cropping will require a combination of technical options such as improved infrastructure, and softer measures such as strengthening water management institutions, or reducing water demand. They can be broadly grouped into the following categories[1]:

### Agricultural Technology

Improved agricultural technologies can play an important role in adapting to climate change. Various measures to improve irrigation efficiency are well-established, and can be effective given the right supporting conditions. Drip irrigation systems can significantly reduce the amount of water required compared to traditional irrigation, while a suite of smart irrigation and precision farming solutions can be used to tailor watering strategies to respond to on-farm conditions and requirements. Measures to ensure that irrigation water supply can cope with potential decreases in water availability, or extreme drought conditions also increase the resilience of irrigation systems, including, for example, water harvesting and the use of dams, ponds and tanks (often based on traditional techniques). The development and adoption of crop varieties that are more resistant to heat, drought, or flooding can significantly increase the resilience of local cropping systems, and can include varieties developed through traditional breeding approaches, or genetically modified organisms. Switching from one crop to another crop more suited to changing conditions is also a viable adaptation strategy, however needs to be weighed against factors such as market demand and nutritional value.

### Infrastructure design

Changes in the design of irrigation infrastructure will be necessary in order to deal with changes in flood risk and intense rainfall in particular. Regional changes will vary, however, drainage systems need to be designed to with potential changes in rainfall intensity and flood frequency and magnitude, for example designing with a climate change allowance of +10-20% greater capacity. Flood protection measures for hydraulic structures may need to be strengthened, or designed to anticipate increases in flood magnitude. Structures such as dams used for water storage should also be designed to take into account potential changes in flow and water availability.

[1] For a comprehensive list of adaptation options for rainfed cropping please see the Adaptation Options database.

### Climate Information and risk management

The provision of climate information, in the form of seasonal forecasts, or early-warning systems, can, if well-tailored, significantly increase the resilience of farmers to climate change. Effective seasonal forecasts can allow farmers to adjust sowing and harvest dates, or choose a different combination of crops for the season, while flood or drought early-warning systems can reduce losses from extreme events. The integration of indigenous and local knowledge into climate information products is increasingly seen as important in increasing accuracy and uptake. Expanding both traditional, and index-based insurance schemes can be an effective risk transfer mechanism and allow farmers to better recover from climate impacts.

### Agro-ecological and Ecosystem-based Adaptation (EbA)

These approaches emphasise increasing the diversity of cropping systems, while enhancing local biodiversity and ecosystem services, and strengthening and empowering local communities. Diversification of food systems provides increased resilience against extreme events, while the maintenance and enhancement of local environmental services can provide a buffer against climate shocks. Examples include integrated crop-livestock systems, agro-forestry and conservation agriculture approaches aimed at maintaining soil fertility and improving water retention. Reducing water demand for irrigation in this way can help to adapt to reduced water availability.  In many cases there are existing good examples of these approaches with potential to be scaled up.

Catchment approaches to ecosystem-management can also be used to adapt to increases in flood risk, for example increasing floodplain connectivity to reduce downstream flood peaks, or managing valley slopes to increase water retention and slow through-flow.

### Policy/Institutional measures

In order for adaptation measures to be effective, and move beyond site-specific interventions there is a need for climate change to be integrated into national and regional policy processes and plans. Identifying the barriers to scaling up different adaptation measures, many of which may not be specifically related to climate change, but revolve around access to affordable credit, for example, and working to overcome these barriers can create better enabling conditions for adaptation.

Irrigation systems need to be considered within the wider context of water management at the catchment-scale, and in relation to their total demand, and their effect on ecosystems, groundwater and other users. The interaction of water needed for the irrigation scheme with water needed for other uses, and for healthy ecosystems is critical. The combination of reduced availability, and increased demand may mean that the wider impacts of irrigation schemes become more negative, if steps aren’t taken to adjust the balance between water users. In this regard, strong institutions for water governance will be a critical component in developing well-adapted irrigation systems. Strengthening local institutions so that they are better able to deal with climate risks, for example by integrating climate risk management frameworks into organisational strategies, or training staff to use and act on climate information is also key in any adaptation strategy.

### Experience from the ASAP I programme

The Adaptation for Smallholder Agriculture Programme I (ASAP I) programme was launched in 2012, providing co-financing resources to scale up and integrate climate change adaptation into IFAD's investments. The programme reached eight million vulnerable smallholders in 43 countries, increasing their capacity to cope with climate change impacts and ability to build more resilient livelihoods.

Irrigation components are included in several ASAP I projects. The Fostering Agricultural Productivity Project (PAPAM) in Mali emphasised the need to contextualise irrigation within the broader context of landscape change. Addressing issues such as deforestation and land degradation at the same time as improving irrigation infrastructure can reduce the impact of extreme rainfall and flood events, and increase the resilience of the system overall. Equally important is that irrigation systems are designed in a participatory way so that they are appropriate for the communities targeted. The Ghana Agricultural Investment Programme (GASIP) worked with Water User Associations to improve irrigation water efficiency, at the same as time as demonstrating Conservation Agriculture approaches. Meanwhile the Programme for Rural Irrigation Development in Malawi also worked with farmers to strengthen water users associations to improve water governance across and effectively manage and maintain irrigation schemes.

## NDC Priorities

There is little distinction in the (Intended) Nationally Determined Contributions (INDC/NDC[2]) between rainfed or irrigated agriculture, and as such the figures here are for cropping as a whole unless specific reference to irrigation technology is made. Cropping is included in the NDCs of 90 IFAD partner countries. On a global scale, there is clearly recognition of the need for adaptation in the sector. However, at the national level, NDCs vary significantly in their depth and scope.

The most common adaptation priority in the NDCs is sustainable resource management (including organic farming, Conservation Agriculture and better use of soil and water resources), followed by Climate Smart Agriculture, including diversification, and the development of climate-resilient crop varieties. Mixed cropping approaches such as agro-forestry are cited as priorities by around a quarter of the countries that highlight cropping, as are social protection measures, and disaster risk reduction or disaster rick management approaches. Regionally, notable differences include a focus on harnessing Indigenous knowledge to improve agricultural systems in Latin America and the Caribbean, and West and Central Africa, while social protection measures are prioritised by more countries in East and Southern Africa, and pest management appears as relatively more important in Asia and the Pacific.

[2] In the following, NDCs is used to refer to both, NDCs and INDCs.

| NDC priority | Asia and the Pacific | Latin America and the Caribbean | Near East, North Africa and Europe | East and Southern Africa | West and Central Africa | Total |
|---|---|---|---|---|---|---|
| Number of countries | 19 | 16 | 14 | 19 | 22 | **90** |
| Sustainable resource management (soil, water, manure, biological pest prevention, organic farming) | 10 | 8 | 8 | 17 | 13 | **56** |
| Climate smart agriculture and adapted agricultural practices (e.g. planting times, diversify varieties, new agricultural areas) | 5 | 7 | 8 | 12 | 14 | **46** |
| Agroforestry, agro-pastoralism and integrated agro-forest-livestock systems | 3 | 4 | 1 | 7 | 9 | **24** |
| Development and introduction of resilient seed and crop varieties; use of native crop varieties; conservation of germplasm | 8 | 5 | 10 | 8 | 15 | **46** |
| Social protection (insurance, livelihood diversification, access to finance) | 3 | 2 | 5 | 8 | 6 | **24** |
| Enhance food security | 1 | 1 | 2 | 1 | 5 | **10** |
| Rainwater harvesting technology and improved efficiency of water use | 2 | 2 | 5 | 6 | 7 | **22** |
| Improve performance and increase resilience of agricultural production systems & value-chains; based on indigenous/local and new knowledge | 4 | 8 | 6 | 8 | 11 | **37** |
| Pest management (prevention, monitoring, control, response) | 5 | 1 | 1 | 3 | 1 | **11** |
| DRR/M for agriculture, incl. climate information, forecasts, early warning | 4 | 3 | 4 | 4 | 6 | **21** |
| Extension services; education on CC for farmers and agricultural staff; raise awareness of CC impacts | 1 | 1 | 2 | 5 | 1 | **10** |
| Research into CC impacts on agriculture and resilient agricultural production | 2 | 0 | 2 | 3 | 4 | **11** |

## Accessing the Green Climate Fund (GCF)

The GCF invests in adaptation and mitigation projects and programmes in developing countries, with the objective of limiting or reducing greenhouse gas emissions and supporting vulnerable people to adapt to climate change. Key to GCF access is ensuring that projects have a strong climate rationale – the justification for how the project addresses specific climate impacts and vulnerabilities. While there are lots of other GCF assessment criteria, in this brief we summarise how to craft a strong climate rationale. A strong climate rationale must first set out the need for adaptation, and then clearly describe the rationale for planned adaptation interventions and why they have been selected.

*Step 1: Adaptation Evidence*

The project team must describe the project context, namely expected climate change impacts, risks and vulnerabilities. Expected climate impacts should be based on scientific evidence, and thus the project team needs to demonstrate clear use of climate data in the assessment of impacts and vulnerabilities. Demonstrating clear risks from climate change, including, where possible estimates of economic damage and number of people affected, is key if a project is to qualify for GCF funding.

Assessment Criteria – project should answer:

- What are the climate risks, vulnerabilities, and impacts related to climate variability and change relevant to the project context?
- What aspects of climate vulnerability will be targeted?
- Which climate-related risks might prevent project objectives being achieved?
- What is likely business-as-usual development and what are climate change related vulnerabilities?

*Step 2: Prioritization of Interventions*

The second step is to identify and describe adaptation measures for the project that are clearly linked to the previously identified climate risks and vulnerabilities. Adaptation measures should be consistent with national priorities for adaptation and sustainable development. The Adaptation Options System provides a foundation for identifying and prioritising appropriate adaptation options for the project. Transparency of decision-making around project interventions, including assumptions and uncertainty behind the choice of options strengthens a climate rationale. A theory of change should describe how the adaptation interventions are expected to contribute to the project objective.

Assessment Criteria:

- What options are available to address identified climate related vulnerabilities and are the proposed adaptation options realistic?
- Are the options robust and within an appropriate envelope of uncertainty?
- What type of adaptation is being pursued: reducing adaptation deficit, incremental, or transformational adaptation?
- With the investment, what are the specific adaptation activities to be implemented to increase the climate change resilience of the business-as-usual activity or baseline?
- Project states intent to address outlined vulnerabilities and risks through the proposed interventions.
- Does this project respond to national adaptation and sustainable development priorities?

## Tools available to support project design

Various tools are available to help integrate adaptation into project design. In this note three main tools are highlighted, with a selection of additional data sources and tools provided under the resources section. Together, these tools provide support to IFAD staff to identify the relevant climate risks during project design, and integrate appropriate adaptation measures. They also provide the evidence base needed for the climate finance contribution from adaptation projects to be reported.

### Climate Adaptation in Rural Development (CARD) Assessment Tool:

CARD is an IFAD tool that has been developed to help integrate climate risks into project design. The tool assesses the impact of climate variability and change on the yield of 17 major crops, and is implemented for 54 African countries. CARD uses the RCP8.5 scenario and allows users to select between Median, Optimistic and Pessimistic scenarios, corresponding to different percentiles in the ensemble of climate models used. The tool allows users to assess the likely impacts on crop yield, which can provide justification for adaptation options, or be used as the basis for cost-benefit analyses.

CARD allows users to specifically model the impacts of climate change with or without irrigation, allowing for a quantification of the benefits of including irrigation systems within a project.

### Adaptation Options Prioritisation System

A database of adaptation options, and system for the assessment and prioritisation of adaptation options have been developed as part of IFAD's Adaptation Framework. The prioritisation comprises two main elements. First, the adaptation options in the database are filtered based on project sector, and the climate risks identified during the climate screening process. A multi-criteria analysis is then carried out on the shortlist of adaptation options to assist IFAD staff in choosing measures to integrate into the project using the following criteria:

- Technical feasibility
- Cost-benefit ratio
- How well the option addresses risks in the project context
- Complementarity to other IFAD themes
- Flexibility (i.e avoids lock-in)
- Mitigation co-benefits
- Transformative potential
- Accessibility for small-holder farmers

The Adaptation Options System uses a simple scoring system based on the eight criteria above. The first four criteria require a minimum score of 2; options which score lower than 2 on any of these criteria do not meet the minimum requirements and are not deemed to be suitable. Adaptation options which are scored the highest are most suitable for a project. The guidance below sets out how users of the system should score assign scores to the adaptation options for each of the criteria in the multi-criteria assessment.

**Technical feasibility**
The technical feasibility criterion is important in assessing which adaptation options are practical, given the skills, experience and capacity of the organisations tasked with implementing the project. If there is no prior experience with an adaptation option then the barrier to implementation may be too high, and there is an increased risk that it fails to meet its objectives.

1: Executing Agency has no experience implementing this type of adaptation option and there are no project partners with this experience.

2: Executing Agency does not have direct experience with this adaptation option, but partners are available who can provide technical expertise and experience with this type of option.

3: Executing Agency has previously implemented this type of adaptation option, and there is technical expertise within the organisation itself.

**Economic case**
The economic case includes a cost-benefit analysis and other instruments to establish the business case for public investment. The benefits must exceed the costs: the ratio of benefits to costs is greater than 1 in a cost-benefit analysis. Comparing the costs and benefits of different options allows for a comparison of the efficiency of different options, but requires costs and benefits to be calculated over the lifetime of the option and therefore requires a discount rate to be applied. The choice of discount rate for the analysis has an important bearing on the overall ratio of benefits to costs. Cost-benefit analysis for adaptation should also make some allowance for benefits that are hard to value in a traditional assessment, such as the benefits arising from improved environmental goods and services.

1: The benefits are less than the costs (BCR < 1) over the lifetime of the option, even with indirect benefits included

2: The benefit-cost ratio is in the range of 1-2. Benefits of implementing the option are higher than the estimated costs over the lifetime of the option although the benefits are not large and may be distributed unevenly among beneficiaries.

3: The benefit-cost ratio is greater than 2. Benefits of implementing the option are significantly higher than the estimated costs over the lifetime of the option and should be readily achieved.

**Addresses climate risks**
The extent to which an adaptation option increases resilience to the climate risks facing the project is a key consideration in prioritising options. All other things being equal, an option which increases resilience to several of the identified risks (e.g. livelihood diversification) should be prioritised over options that only address a single risk (e.g. increased flood protection). In the final consideration of which options to include in the project, care should be taken to select a package of options which address the different risks identified in the climate screening process.

1: Adaptation option is not relevant or may not be effective for the risks identified for the project.

2: Adaptation option effectively addresses at least one of the identified risks.

3: Adaptation option is relevant for all of the major climate risks identified for the project.

**Accessibility for project beneficiaries**

Adaptation options for IFAD projects should be appropriate for the project beneficiaries. This means ensuring that the adaptation option is affordable for target groups such as rural smallholders, youth or indigenous populations, or will not exacerbate existing gender inequalities (for example an insurance product that is only accessible to heads of the household, who may be predominately men).

1: Adaptation option is inaccessible for the main project beneficiaries (e.g. unaffordable, requiring regular complex maintenance), or exacerbates existing inequalities.

2: Adaptation option is accessible for the majority of the project's target beneficiaries.

3: Adaptation option is accessible to project beneficiaries and specifically benefits women or other marginalised groups.

**Flexibility**

Flexible and agile strategies for dealing with the uncertainty inherent in predictions of climate change ensure that adaptation options and strategies are developed in response to pressing needs and opportunities. This includes allowing for changes in approach as new information becomes available, or certain impacts start to pose a major risk. Flexibility in adaptation options is a function of the timeframe being considered, the design of the option, and the approach to managing change in the options being considered.

1: The adaptation option has a long life-time (>10 years) and its design does not allow for any adjustment. For example, a flood defence designed to cope with an additional 1m of flooding, and which would have be completely replaced if greater protection was required.

2: The adaptation option being considered has a short lifetime (<10 years) meaning that considerations of flexibility are not as relevant.

3: The adaptation option is low or no regrets or is part of an adaptive management approach. Low regrets mean the option has benefits across a wide range of conditions. Thresholds and trigger points identified in adaptation strategies support adjustments in response to new information, risks or opportunities.

**Mitigation co-benefits**

Where possible we should prioritise those options which also have emissions reductions potential. For example, the reforestation to stabilise slopes prone to landslides has clear mitigation benefits, while a reduction in the use of fertilizer resulting from the implementation of low or no-till agricultural practices would decrease the emissions used in food production.

1: No mitigation co-benefits or adaptation significantly increases greenhouse gas emissions.

2: Adaptation option leads to emissions reductions, either at present or in the future.

3: Adaptation option involves reforestation, restoration of carbon sinks, or the substitution of fossil fuels for renewable energy sources.

**Transformative potential**

An adaptation option may enable fundamental change in the target system so that it becomes more resilient to climate change. Key attributes of transformative adaptation are that it addresses underlying barriers to change, and that it operates at scale; for example enabling access to insurance products amongst smallholders may create knock-on effects in risk-taking and ability to invest in productive assets and thus create transformative change in livelihoods and significantly increase resilience to climate change at a large scale.

1: Adaptation option is limited to small increases in the resilience of target group, but does not involve changes in wider systems.

2: Adaptation option operates at scale or enables wider implementation of the option, for instance with a declining marginal cost.

3: Adaptation option enables change in the system in question which significantly increases opportunities for target beneficiaries to adapt to climate change.

**Complementarity to IFAD themes**

Where possible the adaptation options selected should complement the other IFAD cross-cutting themes (Gender, Youth and Nutrition). For example, a drought-resistant crop variety may be introduced which is nutritionally superior to existing varieties.

1: No complementarity

2: Complements at least one other cross-cutting theme that is directly relevant to adaptation outcomes.

3: Complements more than one other cross-cutting theme to support systemic resilience.

## Resources

### IFAD Guidance

- How to do: Climate Change Risk Assessments in Value Chain Projects
- How to do: Measuring Climate Resilience
- How to do: Design of gen
- IFAD Climate Finance Tracking guidelines
- Scaling up note: Climate-resilient agricultural development
- Gender in Climate-Smart Agriculture
- Climate change mitigation potential of agricultural practices supported by IFAD investments
- Climate Adaptation in Rural Development (CARD) User Manual

### Adaptation Framework:

- Adaptation Options prioritisation system
- Access climate finance from the Green Climate Fund
- NDC Priorities database

### Useful reports

- IPCC (2019) Special Report on Climate Change and Land
- FAO (2019) Good practices for integrating gender equality and women's empowerment in climate-smart agriculture programmes.
- FAO (2019) Climate-Smart Agriculture in Action: from concepts to investment
- GACSA (2018) Compendium on Climate-smart Irrigation.
- Copernicus Climate Change Service. *Climate-proof Irrigation Strategies*
- FAO (2016) Climate Change and Food Security: Risks and Responses
- UNDP (2015) Climate Resilient Irrigation Training Manual
- UNEP (2013) Climate-Resilient Irrigation Guidance Paper.

### Data & Tools

**Climate data portals:**

World Bank Climate Portal
KNMI Climate Explorer
Climate Information Portal
COPERNICUS Climate Change Service
CCAFS Downscaled Climate Data Portal

**Climate hazards data**

ThinkHazard
Global Flood Risk Analyzer