LESSONS LEARNED

IFAD
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Technical Note
Development of Irrigation Infrastructure

WATER AND RURAL INFRASTRUCTURE

Technical Note

Development of Irrigation Infrastructure

Originator:
Tarek Kotb
Lead Global Technical Specialist - Water and Rural Infrastructure
Sustainable Production, Markets and Institutions Division (PMI)
Email: t.kotb@ifad.org

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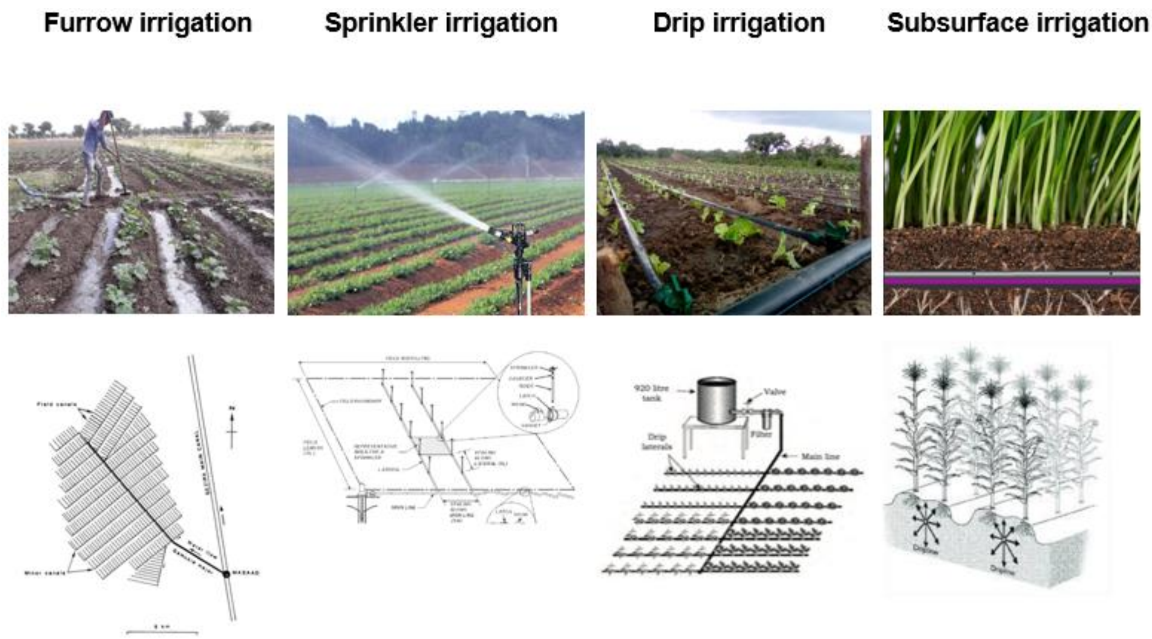
Acronyms

SDG	Sustainable Development Goals
SSI	Small-scale irrigation
FAO	Food and Agriculture Organization
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
ILO	International Labour Organization
IMWI	International Water Management Institute
O&M	Operation and Maintenance
SDG	Sustainable Development Goals
SECAP	Social, Environmental and Climate Assessment Procedures
SSI	Small-scale irrigation
WASH	Water Supply, Sanitation and Hygiene
WHO	World Health Organization
WUG	Water User Groups

Introduction

Over the past 40 years, the International Fund for Agricultural Development (IFAD) has been promoting investments in irrigation development, especially at the smallholder farm level, contributing to agricultural growth by creating opportunities for intensification and diversification, thereby increasing farmers' incomes. Investing in irrigation development contributes to food and nutrition security and, furthermore, has a multiplier effect on job creation in the construction, operation, maintenance and repair of system components such as pumps, canals, pipelines and valves. Irrigation also helps farm households extend the growing season and can be an effective risk management strategy through strengthening smallholder farmers' resilience to climatic shocks and stressors. Thus, irrigation development is able to stabilize yields in a changing climate, and is directly or indirectly linked to the achievement of several targets of the Sustainable Development Goals (SDGs), mainly those related to SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 5 (Gender equality and empowerment of women) and SDG 6 (Improving water use efficiency and integrated water resources management).

FIGURE 1: Different types of gravity and pressured irrigation systems



Technical definition of irrigation

Irrigation is “the process of artificially augmenting the amount of water available to crops. The water may be sprayed directly on to the plants or made available to their root systems through a series of surface channels or ditches”.[1] It entails the mobilization, storage, distribution and application of water to plants and requires support in the form of infrastructure, services and

[1] Oxford Reference: https://www.oxfordreference.com/view/10.1093/oi/authority.20110803100011577?rskey=DZ7xv1&result=7

socioeconomic factors. Irrigation covers not only supplying additional water to agricultural land to augment rainwater for crop growth but also agricultural drainage, flood control and rainwater run-off harvesting.

Irrigation technologies (water application in fields) include water application by gravity flow to the surface of the field (e.g. basin, furrow or border irrigation), pressurized irrigation systems providing overhead irrigation (e.g. sprinkler irrigation) and localized irrigation (e.g. drip irrigation, including subsurface irrigation in which a network of pipes are located just under the ground's surface to apply water to the root zone of plants). Small-scale irrigation (SSI) equipment – as used, for example, by many smallholder farmers in sub-Saharan Africa – includes buckets, watering cans and treadle pumps; it tends to have lower unit costs and better performance than the equipment managed by government agencies (FAO, 2020).

In general terms, irrigation infrastructure refers to the physical infrastructure for water collection, conveyance, storage, delivery, application and drainage, including dams, canals, pumping plants, aqueducts, drains and flow-regulating structures. However, irrigation also includes soft infrastructure – the support systems that are more focused on institution-building and capacity development, services, regulations and governance systems to make the physical infrastructure functional, efficient and sustainable.

Irrigation versus rainfed contributions to food production

Pressure on agricultural land and water resources is growing, as the global population is expected to reach 9.7 billion people by 2050. The remaining agricultural land must double its production to meet the world population's growing need for food and fibre. At the same time, climate change poses significant risks owing to unpredictable dry and wet shocks and rising temperatures (IFAD and IFC, 2022). This makes reliable and suitable water supply through irrigation even more vital to ensure effective and efficient cropping and food production. Although irrigation is fundamental in arid and semi-arid settings, in relatively humid areas it helps to ensure that there is more than one cropping season or that supplemental water is supplied to crops when needed in order to improve and stabilize yields.

Farmers, particularly smallholder farmers, have limited influence over the amount and timing of water. Rainwater harvesting and on-site storage structures have been and still are examples of smallholders' efforts to cope with these limitations (IFAD, 2021) (more information can be found in. The main challenge is to manage and adapt to weather variability, unpredictable temperatures and rainfall patterns. Global analyses estimate that extreme weather events affecting rainfall and temperature can explain 18-43 per cent of yield variation for key crops, including maize, rice, soybean and wheat. As water shortages increase and population and economic growth accelerate, there will be pressure placed on all agricultural systems, especially rainfed ones, to use water more productively (FAO, 2020).

Globally, agriculture is predominantly rainfed, limiting production to two to six months of the rainy season, making it highly vulnerable to rainfall variation. Outputs are typically low, as farmers limit their risk by underinvesting in fertilizer and seeds, and periodic droughts affect yields. However, irrigation can double or triple agricultural yields compared with those from rainfed agriculture. Although rainfed agriculture supplies more than 60 per cent of the world's food from about 80 per cent of cultivated land, irrigated land provides 40 per cent of the world's food from only 20 per cent of cultivated land. Depending on the crops under consideration, and particularly in the case of high-value crops, the cost of investment in irrigation development may be largely outweighed by the incremental income arising from productivity gains. Typically, SSI systems may be considered financially and commercially feasible when system costs, crop values and the demand for crops would allow farmers to retain some profit, in addition to covering the repayment of SSI capital (interest), and the purchase costs, operating costs and replacement costs within three years. It should be noted that irrigation also facilitates the introduction of new crops to areas where they could not be cultivated owing to lack of rainfall, as irrigation enables an additional harvest during dry seasons (IFAD and IFC, 2022).

Global potential for increased irrigation

Worldwide, over 324 million hectares of cropland are equipped for irrigation, or about 21 per cent of the total cropland area. As the world population continues to increase, and hence so does the demand for food, the areas equipped for irrigation will have to expand to produce the food needed. However, there are obvious limitations to equipping new areas for irrigation to meet the target of doubling global production, most notably the availability of a water source within a reasonable distance. To this effect, the development of irrigation does not exclude converting rainfed agriculture to or supplementing it with fully or partially irrigated agriculture to double food production in humid areas as well. The Food and Agriculture Organization of the United Nations (FAO) estimates the global irrigation potential of approximately 515 million hectares based on the biophysical suitability of the land and availability of water. Estimates of the level of investment required to realize this potential through turning rainfed areas into irrigated areas over different time horizons are available; the maximum investment is set at US$50 billion per year over 40 years (IFAD and IFC, 2022).

Between 2010 and 2050, the harvested irrigated area is projected to increase by 12 per cent in East Asia and the Pacific, by 35 per cent in Latin America and the Caribbean, by 22 per cent in the Near East and North Africa, by 30 per cent in South Asia, and by more than 100 per cent in sub-Saharan Africa (FAO, 2020). The African Union Framework for Irrigation Development recognizes that smallholder irrigation has not only higher returns than large-scale irrigation but also greater resource potential for sustainable expansion (IFAD and IFC, 2022). The financing gap for SSI is significant, but it is expected that a substantial proportion of the 500-million-person global market represented by smallholder farmers could benefit from introducing irrigated crop production and increase their net incomes if financially viable projects can be developed. However, there are some risks to expanding irrigation that we need to be aware of and ready to address: it could come at large environmental costs, including groundwater overdraft, agricultural water pollution, associated environmental degradation and human health impacts.

Purpose of this note

The aim of this note is to provide a quick overview of how IFAD projects are designed to serve irrigated smallholder farming, and to raise awareness of the different assessments and interventions needed to make sustainable investments in SSI. The note aims to inform government officials, project teams and other relevant stakeholders involved in designing and supporting the implementation of irrigation projects of the steps and arrangements that need to be put in place to reach the full potential of irrigation development, while endorsing environmental and smallholders' climate resilience. This note is particularly relevant to arid regions, where agricultural production is fully dependent on irrigation, as is the case, for example, in Egypt, southern Iraq, Tajikistan, Turkmenistan and Uzbekistan.

IFAD support for irrigation

Since its foundation in 1977, IFAD has funded more than 800 projects in developing countries around the world, of which more than 200 (25 per cent) included a component on irrigation development. The average share of irrigation in the total base costs of these projects was over 30 per cent (about US$1.42 billion from IFAD5 to IFAD11). Lending for irrigation development has therefore formed a significant part of IFAD's operations. Given that strategic objective 2 of the IFAD Strategic Framework 2016-2025 specifically provides for the construction, redesign, and modernization or rehabilitation of irrigation and water-management systems, IFAD's interventions in this subsector are likely to be as important in the future as they have been in the past, if not more so.

Focus on smallholder producers

IFAD focuses on smallholder irrigation. This ranges from individual households' microscale irrigation mainly used for household food security on a landholding of usually less than 0.5 hectares, to community-driven and small-scale irrigation schemes, which are usually developed on landholdings of less than 200 hectares in a participatory manner by households organized into Water User Groups (WUGs) with varying levels of legal status (IWMI, 2018).

IFAD has explored numerous interventions to meet the needs of small-scale farmers, including techniques for water harvesting and storage, making more efficient use of water and incorporating renewable energy, which has the additional advantage of reducing women's workload regarding water collection (IFAD, 2010). There are pros and cons of each technology and they have varying levels of overall suitability to a specific context. Water harvesting during rainfall is an important source of water for operating models, which may be designed to maximize harvests in areas with excess water – that is, an amount beyond the soil's water-holding capacity – while preventing flooding of those fields. Conjunctive use of water (surface water, groundwater and rainfall) can provide additional flexibility for operating models designed to benefit from a variety of sources across the season and the combined surface area of the system. In the use of groundwater, areas lacking access to alternative, surface water sources require more attention than areas where pumping facilities are used to compensate for inadequate or unreliable water deliveries (IFAD and IFC, 2022). In addition to incorporating renewable energy, and particularly the replacement of diesel pumps with solar pumping, investments in smallholder irrigation infrastructure may be designed to be climate smart in different ways: (i) providing water storage to overcome longer dry spells, (ii) increasing overall irrigation efficiency to meet increased demand from the crops and (iii) being able to withstand extreme weather events.

IFAD's comparative advantage lies in engaging communities in irrigation development interventions and participatory operation and maintenance (O&M) through strengthening the technical and organizational capacities of the rural poor, and improving their access to markets and financial services. It provides technical training and support to ensure that irrigation equipment is maintained and operated to reach its full potential, and that conventional and unconventional water resources are used in an efficient and environmentally friendly manner (IFAD and IFC, 2022).

When considering new investments in irrigation schemes, project implementation teams should focus on not only necessary physical upgrades, but also “soft” measures to address poor performance. Such measures include the following:

- **Introducing institutional reforms (policy and legal frameworks) to create a more conducive environment for irrigation (e.g. by providing more secure land and water rights, or enhancing the legal status of WUGs).** In several countries, there are multiple agencies engaged in the governance of water, which often leads to legal contradictions, gaps and overlaps. Assessing the impact of these inefficiencies in the policy, legal and regulatory frameworks can increase understanding of the core barriers to improving service delivery performance. This assessment can help governments implement institutional hybrid policy frameworks that acknowledge statutory and customary land and water tenure, and take a flexible approach that does not marginalize the most vulnerable (IFAD and IFC, 2022). In this context, projects may work with national governments to (i) update the regulatory framework that governs access to water, irrigation equipment and high-quality agricultural inputs; (ii) improve the security of access to and tenure of land, and improve record-keeping of land titles; (iii) legislate the prevention of over-abstraction and monitor the environmental impact of irrigation solutions; and (iv) evaluate optimal systems for SSI and provide approved options that are eligible for grant support;
- **Improving scheme governance with capacity-building in technical and institutional aspects, and transparency regarding the various O&M costs.** SSI operating models vary greatly, but successful, sustainable models share several features. There are three main operating model categories: (i) a shared system (farmers have control of their own in-field irrigation system but receive water from a source owned by someone else), (ii) a collective system (a group of irrigators own and share the hydraulic infrastructure) and (iii) an individual-farmer system (farmers have control of their irrigation system and have their own water source). Although models may differ in their day-to-day management, governance, payment mechanisms and land ownership arrangements, most successful models have adopted effective approaches such as participatory management, accountability of irrigation unit leadership, youth involvement and strengthening the capacity of farmers (IFAD and IFC, 2022). The capacity-building for WUGs and farmers groups in SSI projects is to enable them to (i) provide a reliable, suitable and equitable water supply to field edge – the right amount, right place and right time; (ii) evaluate the seasonality and adequacy of water sources to ensure a sufficient bulk water supply; and (iii) ensure that the aggregated demand will be met more efficiently than it would be through a collection of individual systems. Women and youth must be involved in the design process and provided with targeted access to training;
- **Improving financial management systems to ensure that routine O&M is funded from WUG, local and central administrations.** In the case of SSI, the national legislation may define categories and may set specific thresholds for ownership of the irrigation infrastructure for local/regional/national government or the WUGs depending on, for example, the channel/hydraulic structure hierarchy (such as headworks; primary, secondary and tertiary channels; and watercourses). This may ultimately result in each stakeholder being responsible for securing O&M funding for the assets under their direct responsibility, in which case the application of an asset management planning approach is highly recommended as best practice. An important application of this approach is the transfer of the management, operation and maintenance of the irrigation and drainage system to the WUGs, thereby

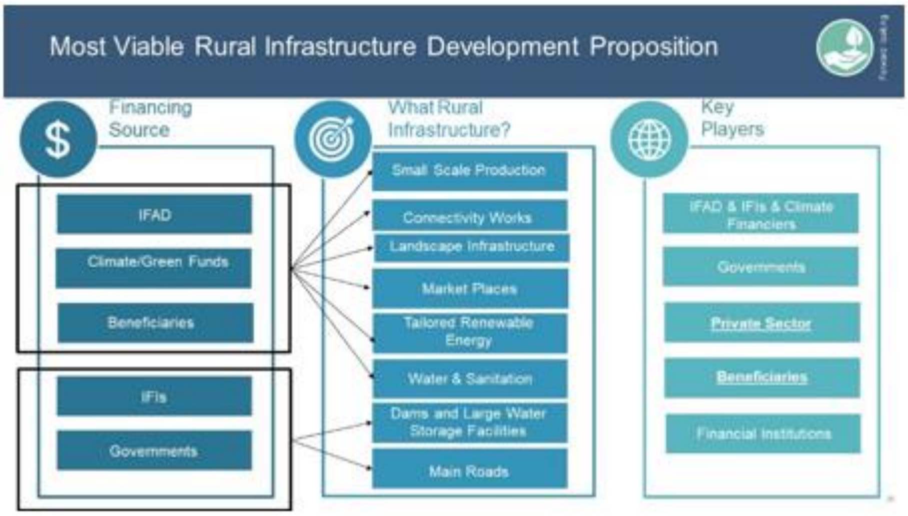
identifying water users' desired level of service, and their capacity and willingness to pay for it. In particular, WUGs and farmers' groups involved in the management of the SSI schemes need to (i) use asset management planning to calculate the level of shared costs; (ii) share information on asset management plan timelines, priorities and costs; (iii) collect members' payments and provide services on time; and (iv) ensure routine maintenance is performed on the system, including preventive maintenance and repair work;

- **Facilitating access to funding for emergency repairs, replacement of major items, etc.** This issue falls under the broader theme of smallholders/WUG members' challenges in accessing funding. Depending on the context, these challenges may be contingent on the lack or short-term nature of land tenure, farmers' traditional risk aversion and/or preference for informal lending, for example. Relevant recommended actions to support smallholder producers (as WUG members) directly in SSI development projects are (i) training to increase financial literacy and farming business skills, and (ii) fostering the establishment of accounts with financial institutions and leveraging mobile banking for ease of repayment. These soft interventions may be combined with the development of dedicated loan products tailor-made to support irrigated farming at both individual and group/WUG/cooperative levels.

IFAD strategy and business model for irrigation development

Although large-scale infrastructure investment is outside IFAD's mandate, community-level infrastructure such as irrigation systems, access roads and local storage and market structures will be pursued to facilitate connectivity and the inclusion of rural people in high-value agricultural markets (IFAD, 2020). (IFAD 12- Strategic Directions) The most viable infrastructure development proposition (figure 2, below) is that IFAD, cofinanced by climate funds and beneficiaries, supports the development of infrastructure for small-scale production, connectivity, markets, water/sanitation and renewable energy. Along these lines, technology packages for smallholder farmers would be developed and promoted. More specifically, regarding SSI, the public sector continues to have an essential role in building and operating bulk water supply infrastructure, such as dams and reservoirs, that provide strategic reserves of water, may contribute to energy production and affect downstream water flow. This infrastructure has strategic importance and is seldom developed only by the private sector solely for the benefit of smallholders. However, the role of the private sector should grow as demand for SSI systems reaches a level that justifies the private sector's investment in the human resources and infrastructure required for a sustained market presence. To this effect, the private sector and smallholder beneficiaries will play greater roles in infrastructure identification and implementation. Specifically, the private sector will play a critical role in tailoring technology to smallholder farmers and packaging it for easy access. Smallholder beneficiaries will play a larger role in financing and implementing O&M activities of irrigation systems at tertiary and farm levels. Planning, design and implementation teams need to ensure that successful and sustainable grassroots-level institutions are established, and that good, sustainable management is in place prior to handover. This is to be achieved through (i) institutional building/strengthening, building on current/traditional practices to ensure that all user groups are represented in the proposed organizational structures and a conflict of interests is avoided as far as possible; and (ii) capacity-building and training focusing on different elements – governance, accounting, management and maintenance of the infrastructure. Financial institutions, including banks and local lenders, will finance small-scale irrigation infrastructure by making funding accessible to small farmers through tailored financial products.

FIGURE 2: Business model for the development and financing of irrigation infrastructure



How large upstream irrigation needs are addressed

The main IFAD cofinancers, such as the World Bank, Islamic Development Bank, Asian Development Bank and African Development Bank, finance the development of large irrigation infrastructure such as large dams, headworks and main canals, whereas IFAD finances the development of small irrigation schemes that benefit from the increased availability of the water made by large infrastructure (e.g. by supporting smallholders on-farm irrigation downstream major dam and hydropower projects). In this context of cofinancing or parallel financing, the project design must ensure the synchronization of the construction and/or rehabilitation of upstream structures (dams, main canals, etc.) with downstream structures (tertiary canals, water-lifting facilities, etc.). In these cases, the development of SSI should not happen before access to water is secured and headworks are constructed, and hence water availability increased. A lack of appropriate phasing may result in disappointing farmers and will probably disengage them from the project, as was the case of a recent project in Azerbaijan. Most importantly, large infrastructure projects are to be introduced gradually into both the detailed design or feasibility study phase (preferably funded by governments) and the implementation phase to ensure there is sufficient time and focus for each phase. The launch of the next phase will be conditional on the completion of the current phase. Appropriate coordination mechanisms, such as the establishment of a project steering committee, with representation at the executive level of all stakeholders concerned in the overall development of the schemes (from the source to field edge), are also an effective and recommended means of securing coordination and appropriate phasing of planned investments in irrigation development.

Process of supporting irrigation development projects

Country request

IFAD receives requests from borrowers to finance projects with irrigation infrastructure development components in different ways depending on the requesting country and the amount of financing. A detailed request will include the geographic area; target beneficiaries; project components, including irrigation infrastructure and irrigation techniques; irrigation infrastructure development approach; who the infrastructure constructors are; preliminary cost tables; economic and financial analysis; environmental safeguards, etc. Some advanced requests have a feasibility and/or pre-feasibility study attached, but this has happened in relatively few cases so far. However, IFAD's current approach is to encourage borrowers to carry out a feasibility study or, in the worst case scenario, a pre-feasibility study for projects requiring the development of irrigation infrastructure. IFAD is also ready to support the technical dimension of the preparation of these studies through early engagement with the lead agency of the project.

Request verification by IFAD and concept note preparation

The IFAD country director, the project technical lead and the regional director, supported by the IFAD team of experts, assess the country's request by conducting a field mission to review the project request, including site visits and stakeholders' consultations. If the country's request is found to be feasible, the team will prepare a project concept note using the information included in the feasibility or pre-feasibility study, and the information gathered during field visits and stakeholders' consultations. The concept note template can be found on the IFAD website (https://xdesk.ifad.org/sites/opsmanual/index). The preliminary Social, Environmental and Climate Assessment Procedures are also developed at this stage. As for all IFAD supported projects, a meeting of the Operational Strategy Committee follows to review and approve the concept note and the use of the country performance-based allocation system.

Key considerations for irrigation system design

In addition to the key considerations below, improving the design of irrigation investments should consider sufficient inclusion of gender, youth (Jordans, 1998), nutrition and hygiene aspects, thus transforming irrigation interventions into interventions with the potential to provide multiple water use services as an integral part of poverty, hunger and malnutrition reduction strategies. Irrigation can improve health and development outcomes by reducing excessive labour for women; increasing yields of nutrition-sensitive, high-value crops; increasing personal security; and increasing income by allowing year-round growing. Moreover, women's role in implementing irrigation systems is critical because their involvement produces significantly better outcomes at all levels of agricultural production, more efficient water use and a greater level of sustainability for the systems. Decision-making processes during a project's feasibility assessment, design and implementation stages should include women and youth, and support their access to ownership through farmers' organizations or WUGs. National agencies should ensure the consistency of policy, legal and regulatory frameworks, and adopt and promote intergenerational learning programmes on irrigated farming for youth.

IFAD supports multiple-use water services

IFAD promotes projects with an irrigation component that provide an opportunity for multiple-use water services,[2] and thereby meet a wider range of community water needs, including, but not limited to, crops, livestock, fishing, small businesses, home gardening and domestic use. When the water quality is appropriate, multiple-use water services can improve households' access to potable water and water for other domestic uses owing to the proximity to homesteads, the generally high availability of the resource and the lack of water supply, sanitation and hygiene (WASH) services in rural areas of low-income countries. Therefore, these projects reduce the overall drudgery of and time spent collecting water, freeing up time for productive and social activities, and time for women and girls to perform household activities and study (IFAD, 2016). Thus, irrigation investors should consider technology choices that allow multiple-use water services from the initial design of the project, if required by the communities, and enable water re-use to increase system efficiency (IFAD and IFC, 2022).

Irrigation system linkage to the value chain

The type of crop (commodity) has a direct influence on the type of irrigation technique, the entire irrigation system and the water requirements, and therefore on the storage facilities, and energy source and amount. Developing market links and engaging in profitable commodity value chains is also essential for the viability and sustainability of projects, and should not be left until the construction of the irrigation system is complete. The investment in infrastructure may be pointless if the market linkages do not function as intended. Opportunities to support weak links in the value chain may be missed if not acted on in a timely manner at the very beginning of system development. Prospects for sustainability are enhanced by identifying the main actors, arranging contracts and initiating value-chain-specific training before irrigated farming operations begin. Importantly, WUGs and other farmers' organizations should be supported to engage with the different value chain actors.

Irrigation water quality

IFAD requires that agricultural drainage, other types of return flow and municipal wastewater are used in a planned manner from the project design phase as a means to increase water use efficiency, and are treated at the level most appropriate for its intended "safe" use (fit for purpose) following World Health Organization guidelines (WHO, 2006). Adequate protection must be provided to all exposed groups (i.e. agricultural workers and those living in nearby areas, and handlers and consumers). By considering the above, various health protection measures (barriers) are economically combined depending on the water quality and the purpose of reuse, such as treatment options, post-treatment and non-treatment.

The fit-for-purpose reuse of wastewater for irrigation can reduce a number of barriers by following the principles of a circular economy (European Parliament, 2015), and recycling nutrients from the collected water and applying them to crops via different methods of fertigation. Globally, 7.1 billion m^3 of treated wastewater (5 per cent of treated wastewater) is reused for irrigation per year (IFAD and IFC, 2022). At the same time, at least 20 million hectares in 50 countries are irrigated with untreated, partially treated or partially diluted wastewater. Although the benefits of

[2] For more information, see the Multiple-Use Water Services Group website (https://www.musgroup.net/).

reusing wastewater in agriculture are manifold, there are also critical considerations for this practice, including the public health challenges associated with farmers, workers and consumers coming into contact with pathogens in wastewater, and the build-up of heavy metals, salts, antibiotics, growth hormones and other hazardous substances in soil and water.

Climate and environment-resilient irrigation infrastructure

Irrigation can mitigate the impact of climate change by increasing the reliability of the water supply for crop growth. But irrigation schemes themselves are threatened by climate change scenarios such as damage caused by increased incidence rates of extreme flooding, increased risks of erosion and sedimentation, decreased precipitation, increased evapotranspiration and increased water demand. Integrating climate change adaptation interventions into the planning and design of irrigation investments (Global Centre on Adaptation, 2021) has become crucial in order to (i) reduce risks to irrigation infrastructure, (ii) reduce the vulnerability of rural communities and mitigate the impacts of climatic stressors and (iii) reduce the negative impact on agricultural yields, thus ensuring food security. These adaptation interventions must integrate actions that target policies, institutions, cropping pattern selection, investments, infrastructure development and O&M.

IFAD's Social, Environmental and Climate Assessment Procedures (SECAP) require that all new investment projects be screened for climate risk, and they provide a methodology for doing so. The project design report needs to be explicit about how climate change is considered in the irrigation designs. The challenge is how to adapt the engineering design criteria[3] to climate change in the absence of country-level standard codes of practice for climate-resilient engineering design. Generic scheme-level measures could include increased flood protection and drainage, increased system capacity and water storage.

Another potential environmental impact of irrigation is the overexploitation of surface water and groundwater. An estimated 20 per cent of the world's aquifers are being overexploited (Gleeson et al., 2012) and the environmental flows[4] of rivers are not always guaranteed, as the knowledge of local river regimes remain limited. Furthermore, excessive loading of nutrients such as nitrogen and phosphorus in drainage return flows or leaching volumes affects the quality of the receiving bodies of water. Irrigation system designers must consider all of these influencing factors, and design appropriate interventions that mitigate or help adapt to them.

Quality control of works

Project teams must ensure rigorous quality control of technical designs and construction of irrigation infrastructure. This requires the preparation of a field supervision schedule that includes on-site inspections, and testing of materials used and infrastructure constructed. Unless the irrigation infrastructure is functioning as intended, all other irrigation activities are likely to be ineffective, thereby jeopardizing the overall viability and sustainability of the investment. Quality control is even more important for community-built infrastructure as implementation standards can

[3] The Food and Agriculture Organization of the United Nations (FAO) *Climate-smart Agriculture Sourcebook* (FAO: 2013) focuses on the impacts of climate change on land, water and crops, and does not cover engineering issues.
[4] Environmental flows describe the quantity, quality and timing of water flows required to sustain freshwater ecosystems. Over 200 approaches for determining environmental flows exist. The International Water Management Institute Environmental Flow Calculators (available on the International Water Management Institute website: http://www.iwmi.cgiar.org/resources/models-and-software/environmental-flow-calculators/) are a family of software for the rapid desktop assessment of environmental flows.

often fall short (ILO, 2010). Quality control will normally answer the following questions: (i) are construction materials supplied, stored and tested to standards? (ii) are the workforce and machinery sufficient at all construction stages and are they within the agreed work programme? (iii) is the construction work meeting sustainability and climate adaptation needs? and (iv) are O&M procedures being taken into account during construction?

IFAD's supervisory role should be strengthened in the quality assurance, design review and field inspection through implementation support or supervision missions and, if necessary, through dedicated irrigation infrastructure missions if the project includes extensive irrigation works. Quality control should be carried out against national or international quality standards, depending on the availability of national standards; in many cases, national standards are insufficient or do not meet particular requirements, especially those related to climate change resilience.

Water user groups and O&M arrangements

The project implementation team should facilitate the formation and legal registration of WUGs for the proposed irrigation scheme, if the WUG and/or registration are not already in place. A constitution and by-laws, including arrangements for payment of user fees and the election of officers, should also be facilitated. If there is no existing legal framework providing WUGs with legal status, a form of legal registration should be identified to effectively empower them. The responsibilities of the implementing agency and the WUG should be clearly spelled out, including the agreement on the type of infrastructure interventions and cost-sharing mechanism, required labour inputs for construction if the community is to be involved in construction, and subsequent O&M arrangements. Two different documents may be required, one for construction and one for O&M during the lifetime of the infrastructure.

Whether ownership of the infrastructure should be granted to the WUG or retained as a public good is usually a matter of government policy. However, the agreement should clearly state the responsibilities of the WUG in maintaining the infrastructure in working order, including provisions for minor repairs and replacements. It should also state the physical boundary of the WUG's responsibility (e.g. just upstream of the diversion and headworks, or immediately downstream). This responsibility should be determined on the principle of "subsidiarity"; that is, the WUG (or the apex body of the WUG) should take responsibility for the uppermost point in the system of which it can realistically take care. The agreement should also confirm that the agency will retain responsibility for rectifying design faults and (depending on ownership of the infrastructure) emergency repairs after extreme weather events. If farmers are expected to bear the risk, project implementation teams should consider options for derisking these investments, such as insurance. In addition, project teams should ensure that the clearest possible workable O&M solutions are included in the project design report, based on realistic estimates of their costs.

Prior to signature of the implementation agreement, the WUG should indicate its understanding of and agreement on:

- the actual amounts, in cash or in kind, that it is expected to contribute towards capital costs;
- accurate estimates of the expected O&M costs and workload (ILO, 2021),[5] including water charges and pumping costs (Jensen (ed.), 1980);[6]

[5] For example, ILO, *Guidance for operation and maintenance (O&M) of irrigation systems: Maximizing local resources and community participation, Nepal and the Philippines* (Geneva: ILO, 2021).

- best estimates of potential net farm income, based on conservative assumptions for markets, prices, crop yields and cropping intensity, considering potential yield limitations imposed by constraints to crop rotation on smallholders' plots;
- potential temporary loss of income during the construction period;
- expectations related to sharing land and water resources in the irrigated area;
- knowledge of the reference contact at the responsible agency.

None of this can be expected to happen without training the WUG members and agency officers. This training should be upgraded and delivered every year for the entire project duration, depending on the implementation stage and system's maturity. Following the investment project life cycle, the relevant agency or local authority should provide continuing support.

Exit strategy

To ensure the long-term sustainability of the irrigation infrastructure and the whole irrigated agricultural project, it remains essential for irrigation to be introduced and managed in a sustainable manner, which involves:

- clear and legally stipulated ownership arrangements;
- functioning WUGs and/or farmers' organizations with clear by-laws;
- clear mandates for all relevant actors at multiple levels, from institutions and the state's specialized entities to WUGs, policies, financing arrangements and governance arrangements;
- efficient asset management planning and sustainable O&M arrangements, with costs and responsibilities sustainably allocated (including water fees and pumping costs, and ordinary and extraordinary maintenance costs);
- formal handover of the irrigation scheme to a legal entity representing the users, such as a WUG, municipality or district council;
- any existing insurance policies;
- functioning access to markets and finance;
- continued adequate technical training on O&M, or the cautious and balanced use of water resources.[7]

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[6] Marvin E. Jensen (ed.), *Design and Operation of Farm Irrigation Systems* (St Joseph, MI: American Society of Agricultural Engineers, 1980), provides a detailed methodology for estimating O&M and replacement costs.

[7] See the following irrigation water management training manuals: FAO, *Training Manual No. 1: Introduction to irrigation* (FAO, 1985); FAO, *Training Manual No. 3: Irrigation water needs* (FAO, 1986); FAO, *Training Manual No. 4: Irrigation scheduling* (FAO: 1989); and FAO, *Training Manual No. 7: Canals* (FAO: 1993).

Every IFAD project must develop a full exit strategy document, which is to be developed either by project management units or through a dedicated consultancy and must be reflected in the project's budget (COSTABS). The government's formal endorsement of the exit strategy is a good practice to secure commitment to post-project follow-up. The project's exit strategy must be clearly established from the first IFAD supervision mission, without waiting for the midterm review, as currently indicated in the project supervision guidelines.

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International Fund for Agricultural Development
Via Paolo di Dono, 44 - 00142 Rome, Italy
Tel: +39 06 54591 - Fax: +39 06 5043463
Email: ifad@ifad.org
www.ifad.org
facebook.com/ifad
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