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THE WORLD BANK, FAO, IFAD, PRACTICA, ARID, AND IWMI

LESSONS LEARNED IN THE DEVELOPMENT OF SMALLHOLDER PRIVATE IRRIGATION FOR HIGH-VALUE CROPS IN WEST AFRICA

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ACRONYMS AND ABBREVIATIONS

ADP	Agricultural Development Project
AfDB	African Development Bank
AFVP	*Association Française des Volontaires du Progrès* (French Association of Volunteers for Progress)
AMG	African Market Garden
ANPIP	*Association Nigérienne pour la Promotion de l'Irrigation Privée* (Nigerien Association for the Promotion of Private Irrigation).
APIPAC	*Association des Professionnels de l'Irrigation Privée et des Activités Connexes* (Association of Professionals for Private Irrigation and Related Activities)
APROFA	*Agence pour la Promotion des Filières Agricoles* (Agricultural supply chain promotion agency)
ARID	*Association Régionale d'Irrigation et Drainage* (Irrigation and Drainage Regional Association)
ASAPI	*Appui à la Sécurité Alimentaire par la Petite Irrigation* (Support to Food Security through Small-Scale Irrigation, Niger)
BADEA	*Banque Arabe pour le Développement Economique en Afrique* (Arab Bank for Economic Development in Africa)
BOAD	West African Development Bank
CAADP	Comprehensive Africa Agriculture Development Program
CFAF	Franc CFA
CILSS	*Comité Permanent Inter-Etats de Lutte contre la Sécheresse au Sahel* (Permanent Interstate Committee for Drought Control in the Sahel)
DDEA	*Direction du Développement de l'Entrepreneuriat Agricole* (Agricultural Entrepreneurship Development Direction)
DFID	Department for International Development (UK)
DIPAC	*Développement de l'Irrigation Privée et des Activités Connexes* (Pilot Private Irrigation Development Project)
ECOWAS	Economic Commission of West African States
EIER	*Ecole Inter Etats d'Ingénieurs de l'Equipement Rural* (Inter –States School of Rural Equipment Engineers)
ETC	Educational Training Consultancy
ETSHER	*Ecole des Techniciens Supérieurs de l'Hydraulique et de l'Equipement Rural* (School for Hydraulics and Rural Equipment Senior Technicians)
EWW	Enterprise Works Worldwide
FAO	Food and Agriculture Organization
FMWR	Federal Ministry of Water Resources
GDP	Gross Domestic Product
GEF	Global Environment Fund
GIE	*Groupement d'Intérêt Economique* (Economic Interest Group)
GSC	*Groupement de Services-Conseils* (Advisory Service Group)
HIPC	Heavily Indebted Poor Countries
ICR	Implementation Completion Report
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDE	International Development Enterprise
IFAD	International Agriculture Development Fund
IFPRI	International Food Policy Research Institute
IsDB	Islamic Development Bank
IWMI	International Water Management Institute
LWR	Lutheran World Relief
MAHRH	*Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques* (Ministry of Agriculture, Water and Fisheries, Burkina Faso)

MDA	*Ministère du Développement Rural* (Ministry of Agricultural Development, Niger)
NFCO	National Fadama Coordination Office
NFDO	National Fadama Development Office
NGO	Non-Governmental Organization
OFID	OPEC Fund for International Development
PAD	Project Appraisal Document
PADL/CLK	*Projet d'Appui au Développement Local Comoé – Leraba –Kénédougou* (Local Development Supporting Project Comoé – Leraba –Kénédougou)
PAFASP	*Projet d'Appui aux Filières Agro-Sylvo-Pastorales* (Agricultural Diversification and Market Development Project, Burkina Faso)
PASAOP	*Projet d'Appui aux Services Agricoles et aux Organisations de Producteurs* (Agricultural Services and Producer Organizations Project, Mali)
PCDA	*Programme de Compétitivité et Diversification Agricoles* (Agricultural Competiveness and Diversification Project, Mali)
PCU	Project Coordinating Unit
PDR	*Projet de Développement Rural* (Rural Development Project, Burkina Faso)
PIGEPE	*Projet d'Irrigation et de Gestion de l'Eau à Petite Echelle* (Small-Scale Irrigation and Water Management Project, Burkina Faso)
PIP2	*Projet de Promotion de l'Irrigation Privée* (Private Irrigation Promotion Project, Niger)
PNUD	United Nations Development Program
PPIP	*Projet Pilote pour l'Irrigation Privée* (Pilot Private Irrigation Project, Niger, Mali)
PPIV	*Programme de Développement de la Petite Irrigation Villageoise* (Small-scale Irrigation Development Program in the Village)
PPP	Public –Private Partnership
PRODEX	*Projet de Développement des Exportations et des Marchés Agro-Sylvo-Pastoraux* (Agro-Pastoral Export and Market Development Project Niger)
PSSA	*Programme Spécial de Sécurité Alimentaire* (Special Program for Food Security, Mali, Niger, Burkina Faso)
PVC	Polyvinyl chloride
ROSELT	*Réseau d'Observatoires et de Surveillance Ecologique à Long Terme* (Long Term Ecological Surveillance and Observatory Network, Niger)
SFD	*Système Financier Décentralisé* (Decentralized Financial System)
SPFS	Special Program for Food Security
SSA	Sub-Saharan Africa
TDH	Total Dynamic Height
UNICEF	United Nations Children Fund
USAID	United States International Development Agency
VISA	*Valorisation de l'Irrigué pour la Souveraineté Alimentaire* (Irrigation Promotion for Food Sovereignty)
WAEMU	West African Economic and Monetary Union
WBI	World Bank Institute

EXECUTIVE SUMMARY

Better water management for smallholder farming in Sub-Saharan Africa will produce larger and more reliable yields and increase the income of farmers. Despite the huge potential of irrigation, and some expansion in the past decade, overall water withdrawals for agriculture are still limited in Sub-Saharan Africa: irrigation uses less than 3 percent of total renewable resources compared to 36 percent in South Asia and 51 percent in the Middle East and North Africa. Five business lines have been identified by the World Bank and its partners to effectively increase investments in agricultural water management (WB 2007a): (1) market oriented irrigation on a public-private partnership basis; (2) smallholder private irrigation for high-value markets; (3) small-scale community-managed irrigation for local markets; (4) large-scale irrigation; and (5) improved water control and watershed management in a rainfed environment. Experience in smallholder private irrigation shows that there is potential for further growth in most countries of Sub-Saharan Africa. The introduction and dissemination of individually managed, low-cost irrigation technologies has given incentives to many smallholder farmers (often with farms of less than 1 hectare) to use privately managed irrigation to increase the productivity of their farms. Several past and ongoing projects that aimed to improve agriculture competiveness in Sub-Saharan Africa have included a component on the development of smallholder private irrigation.

The objective of this report is to identify, characterize, and evaluate best practices in smallholder private irrigation in West Africa. The report presents a comparative assessment of the smallholder private irrigation initiatives in Burkina Faso, Mali, Niger, and Nigeria. Issues discussed include: the potential and impacts of new technologies; the successes and challenges of different approaches to develop smallholder private irrigation (promotion of technologies, institutional arrangements, advisory and financial services, and environmental impact mitigation); and the lessons learned.

SMALLHOLDER PRIVATE IRRIGATION IN WEST AFRICA

In West Africa, irrigation has been practiced on a very small scale for hundreds of years to cope with low or erratic rainfall but has recently received more attention. In the colonial period and just after independence, investments were normally made in medium to large-scale irrigation. In the 1970s and 1980s community-managed small-scale irrigation programs were initiated to contribute to food security. Informal smallholder private irrigation expanded gradually during this time. Since the 1990s, governments have encouraged the development of small-scale irrigation which yields better results than large-scale irrigation. For the past fifteen years, smallholder private irrigation has been heavily promoted. More sophisticated drilling, pumping, and water distribution techniques have been introduced and are now practiced in 55 percent of the irrigated area in Niger (excluding the community-managed, often partially irrigated areas) and 75 percent of the currently irrigated area in Nigeria. The most common crops are vegetables, fruits, and to a lesser extent cereals. Yields are higher under smallholder private irrigation than average national yields, which include rainfed agriculture and other types of irrigation.

LOW COST TECHNOLOGIES FOR SMALLHOLDER PRIVATE IRRIGATION

Low-cost small-scale irrigation technologies made a significant breakthrough in the past two decades. Trials and demonstrations as well as training programs have been established and have made it easier for small farmers to adopt and maintain new technologies.

Manual drilling of tube wells experienced a huge boom in the 1990s. Manual auger and washbore drilling techniques are commonly used in areas where the soil is soft, whereas percussion and sludging techniques are more suitable for harder soil. Manual drilling was quickly adopted by farmers in Niger and Nigeria because of its low cost (ten times less expensive than machine-drilled concrete wells) and because it is relatively easy and quick to execute. Today, there are more than 18,000 manually drilled tube wells and 42 teams specialized in manual drilling in Niger and more than 100,000 manually drilled tube wells in Nigeria. In the 2000s, manual drilling was also promoted through projects in Senegal, Mali, Burkina Faso, Ghana, and Benin.

Treadle pumps were introduced in West Africa in the 1990s and were progressively adapted to the pumping conditions in a variety of regions. A treadle pump can irrigate more than twice the area (up to 0.4 hectares) than watering with a bucket or calabash, doubling average net income per hectare. The cost of treadle pumps varies by country and model, but by and large prices fall between CFAF 30,000 and CFAF 90,000 (US$60 and US$180). Since 1990, NGOs EWW and Kickstart have developed a program to distribute treadle pumps in East and West Africa. Dissemination relies on the existence of a multi-step, sustainable, and efficient chain of distribution, including market identification, research and development, centralized or decentralized manufacturing, the development of a network of retailers, and marketing operations. Some of the links in this chain have often been supported by projects.

In West Africa, the use of low-power motorized pumps (2.5 hp to 5 hp) to irrigate plots of between 0.5 and 3 hectares has increased substantially over the past 15 years. Motorized irrigation is less physically demanding than human-powered pumps. At an average cost of CFAF 250,000 (US$500), motorized pumping can irrigate larger areas of land, which can raise producers' incomes. The profitability of motorized pumps depends on the area irrigated, the yield obtained, the market for the produce, and the subsidies available for energy—which can account for 40 percent of the annual costs—or for the initial investment. Motorized pumps have been widely used since the 1980s in Nigeria, where highly subsidized fuel and the support of several agricultural development projects have encouraged the installation of more than 100,000 motorized pumps. Cultural proximity and informal trade has spread the distribution of motorized pumps across the border from Nigeria to Niger. Motorized pumps have also been promoted by projects in Mali and Burkina Faso.

Water distribution systems are not widely used in West Africa because of their high cost. With a Californian system (buried PVC pipes), a farmer can increase the irrigated area, save labor, and reduce pumping charges with an initial cost of CFAF 300,000 per hectare (around US$600). The technique was quickly adopted in the Senegal River valley area with limited project support. Drip irrigation performs better than Californian networks in terms of yield and in terms of water and labor savings, but for a higher cost (CFAF 2 to 4 million per hectare, US$4,000). The drip-irrigation-kit supply chain is not well developed as the market for the kits is still limited. This technology needs more support for its introduction and maturation phase especially in areas where water resources are limited and where aquifers are deep.

PROMOTING SMALLHOLDER PRIVATE IRRIGATION DEVELOPMENT: CASE STUDIES IN WEST AFRICA

Agricultural Development Projects of the 1980s and the Fadama projects of the 1990s and 2000s contributed to the wide dissemination of motorized pumps and manual drilling techniques in the fadama area of Nigeria, increasing agricultural productivity and the incomes of farmers. In addition to subsidies to buy pumps, farmers acquired knowledge about available drilling techniques and lifting devices. In all projects, investment in agricultural water management was part of a policy of broader support to agricultural development, including subsidies for input supply (fertilizer and seeds), extension services, rural infrastructure, and access to markets. Fadama projects also supported the formation of fadama user groups, which created an efficient conflict resolution mechanism between water users (pastoralists and irrigators). Participation in the Fadama II project increased the value of individual productive assets by 49 percent while the value of productive assets owned by groups of beneficiaries increased by 590 percent.

In spite of these successes, challenges persist. Farmers in many states complain of decreasing groundwater levels that lead to increases in the cost of energy for pumping. Also, the problems of processing, storage, and transportation of agricultural production have not been properly addressed. Without storage facilities or transportation, the producers are forced to put their products on the local market soon after harvest, when the price is at its lowest. Most critically, there is a huge dependence on subsidies. To increase the sustainability of support, the Fadama III project established the Fadama Users' Equity Fund so that farmers can save some of the benefits of the project-supported common assets. This fund can be used for replication of assets, asset operation and maintenance, or for any other activity that the group decides is viable.

In Niger, scaling-up a pilot approach aimed at strengthening the private sector led to huge growth in smallholder private irrigation, with significant socio-economic impacts. In 1995, the implementation of the Pilot Private Irrigation Project (PPIP) was delegated to a privately-managed agency (Association Nigérienne pour la Promotion de l'Irrigation Privée, ANPIP) under a public-private partnership. This project and the following scale-up project (Projet de Promotion de l'Irrigation Privée, PIP2, 2002) supported the promotion of low-cost irrigation technologies, built capacity of private operators and advisory-service providers, and supported the private irrigation agency (ANPIP) in charge of project implementation, although this responsibility was eventually shifted back to the Ministry of Agricultural Development.

About 20,000 pumps, 5,000 tube wells, and 17,000 low-pressure distribution systems were disseminated through both the PPIP and PIP2 projects, covering an irrigated area of 16,000 hectares, and benefiting about 30,000 people. Farmers who participated in the project earned revenues 1.5 to 3 times larger than the average revenue in Niger. By the end of the PIP2 project, a supply chain for irrigation technologies was in place, and advisory-service groups had become reliable partners in smallholder private irrigation. However, these supply chain and advisory services were heavily dependent on project support and subsidies, which ceased with the end of the PIP2. In addition, poor marketing conditions in the country and across borders remained a problem. The most recent project (PRODEX, 2009) aims to address these issues, but the targeted beneficiaries are larger commercial farms (between 1 and 5 hectares) and not the smallholders who were targeted in the PPIP and PIP2.

In Mali and Burkina Faso, a lack of continuity between projects constrained the dissemination of low-cost irrigation technologies. Following the positive experience in Niger, small-scale irrigation pilot projects were funded by the World Bank in Mali (PPIP, 1997) and in Burkina Faso (Développement de l'Irrigation Privée et des Activités Connexes, DIPAC, 1999). These projects supported the promotion of new low-cost technologies by the private sector through tests, demonstrations, along with the strengthening of local private input supplier capacity. The projects also included support to advisory services. Unlike in Niger and Nigeria, later projects (Programme de Compétitivité et Diversification Agricoles, PCDA, 2005 in Mali and Projet d'Appui aux Filières Agro-Sylvo-Pastorales, PAFASP, 2006 in Burkina Faso) were not scale-up projects of the pilot phase. Although these projects also supported private-sector development to improve agriculture productivity and competitiveness, they started several years after the end of the pilot phase and provided greater support to non-irrigation components.

In Burkina Faso, the DIPAC pilot project successfully began the dissemination of new technologies and strengthening of the private sector. Farmers involved in the project doubled or tripled the area of their irrigated plots and increased their incomes by 50 percent. The guarantee fund established by DIPAC (without subsidies) was considered a positive experience. The succeeding PAFASP project partially built on these successes, but eligibility criteria (more than 3 hectares for individuals and more than 5 hectares for groups of farmers) excluded some former beneficiaries, and some low-cost technologies, such as treadle pumps, are not applicable to plots of more than 0.5 hectares. Project implementation shifted from a private irrigation agency to the Ministry of Agriculture, Hydraulic and Halieutic Resources.

In Mali, the lack of capacity and delays in implementation of the pilot project (PPIP) led to unsatisfactory results. PPIP did not succeed in testing and disseminating new technologies, and the following project, PCDA, had to undertake the testing and demonstration of low-cost irrigation technologies in order to establish technical and economic guidelines.

LESSONS LEARNED AND RECOMMENDATIONS

Stimulating supply-chain development of low-cost irrigation technologies

The introduction phase of new technologies should be supported through promotional campaigns, quality assessments, and private-sector organization. Low-cost irrigation technologies in West Africa could benefit from more public support to the private sector. For example, manual drilling is not commonly used in Mali and Burkina Faso, and low-cost water distribution systems, such as the Californian system, are not widely disseminated in any West African countries.

Matching grants can give farmers access to technology, but should not jeopardize post-project sustainability. High levels of support for equipment create artificial demand, which can put private stakeholders involved in the supply chain at risk once the support ends. Matching grants targeting only a subgroup of potential clients (for example the poorest) may be one option. An exit strategy needs to be included in the design of any matching-grant funding mechanism.

Regional knowledge exchange involving private stakeholders should be facilitated. A large range of technical expertise was developed by mechanics, drilling teams, advisory services, and project technicians in these projects, but this expertise was underused by recent smallholder private irrigation programs. Actions to be taken include: (i) supporting regional initiatives that aim to share knowledge, focusing on private stakeholders; (ii) involving international specialized NGOs as well as the existing national organizations (NGOs, private agencies, technical experts) in project preparation; (iii) sharing technical guides and manuals prepared for specific projects with other projects or countries.

A programmatic approach should be promoted with specific attention to harmonization of support between projects. The continuity of successive projects is critical to obtaining sustainable outcomes. Introducing new technologies through the private sector requires time. The promotion of multiple initiatives with different levels of subsidy at the same time leads to confusion for the farmers and difficulties for long-term private-sector involvement.

Beneficiaries and private-sector operators should be involved in project implementation, but public-private partnerships are risky. Even when tasks such as the promotion and dissemination of technology or advisory services can be delegated to a private agency, the delegation of responsibility for the implementation of a smallholder private irrigation development project to a private entity can result in political problems, as seen in Niger and Burkina Faso. The responsibilities of beneficiaries and their organizations (e.g., professional associations and producers' organizations) should be clearly spelled out in the project framework.

Promoting the progressive increase of production capacity

Support for improvements to irrigation technology should be adapted to farmers' evolving needs. Smallholder private irrigation development initiatives should include several components adapted to each type of farm to allow farmers to gradually increase the area that they cultivate. Different categories of farmers require different support, and individual farmers are likely to gradually upgrade from one category to the next.

Advisory-service providers should have specialized skills, including the competence to build farmer entrepreneurial capacity. Three types of advisory-service providers have been supported in the countries under review: networks of private advisory-service providers specialized in smallholder private irrigation, private consulting companies or other existing organizations, and public extension services. They all present pros and cons, and funding remains the major issue to advisory-service development and sustainability.

Financial products should be developed not only to allow access to irrigation technology but also for maintenance and replacement. The use of matching grants may be improved by requiring farmers to save money, as proposed in the Fadama III project with the Fadama Users Equity Fund. Improving land tenure can be an effective way to increase farmers' access to credit, but promotion of land tenure should be clearly separated from support to irrigation since it involves a broader range of issues. Other financial instruments that have been tried in smallholder private irrigation projects (warrantage, revolving funds, guarantee funds) show promising results, but their implementation will need to be improved if they are to be applied successfully.

Designing smallholder private irrigation investment as part of a comprehensive investment package including environmental impact mitigation

Input suppliers should be strengthened with specific attention to quality. Experience in Niger and Burkina Faso shows that private companies can be used to provide inputs to farmers, but they need support to reach profitability. The government should also ensure that supplies comply with health and environmental regulations.

Storage, processing, marketing, and transportation of often perishable products remain challenges to the development of irrigation in the four countries under review. These issues require major efforts to link supply and demand in the most effective way. The development projects under implementation in 2010 address some of these issues.

Environmentally-friendly agricultural practices should be promoted and sound impact-monitoring systems should be included in smallholder private irrigation projects. Experiences worldwide show that smallholder private irrigation may have a significant negative environmental impact on land and water resources. Because of the private nature of smallholder private irrigation, national environment protection policies are often difficult for public institutions to enforce. Several actions could help monitor and reduce environmental impacts on land and water resources: (i) evaluating and monitoring groundwater resources with a participative approach; (ii) promoting environmentally friendly agricultural practices through training and guidelines; and (iii) investing in measures to increase groundwater recharge.

Smallholder private irrigation holds enormous potential for reducing poverty and increasing agricultural productivity in West Africa over the next decade. The potential, however, cannot be achieved without the participation of the private sector, which in turn depends on the existence of an enabling environment for the development of private entrepreneurship and a strong supply chain. Going forward, a programmatic approach that supports a comprehensive investment package including marketing, input supply, and environmental impact mitigation will enhance the progress that has already been made in the sector. It will also be critical to harmonize the efforts of different development projects and to share the large range of technical expertise that has been developed over the past two decades across regions and national borders.

Chapter 1: INTRODUCTION

Improving agricultural water management is critical for better agricultural productivity in most of West Africa, where agriculture remains essential for growth, food security, and poverty reduction. Increasing agricultural performance can lead to dramatic improvements in the incomes of the poor. In some areas, irrigation helped double, even quadruple yields and lifted the beneficiary population above the poverty threshold. The Comprehensive Africa Agriculture Development Program (CAADP), which is based on four mutually reinforcing pillars, has focused its first pillar on expanding the area under sustainable land and water management.

Irrigation is also key to guaranteeing product quality and supply, which improves the competiveness of high-value-added produce. Although staple crops currently dominate production in West Africa, high-value crops have the potential for rapid expansion if adequately linked to regional, national, and international markets. Improved irrigation can create consistently high-quality produce and will be critical to integrating West African farmers into the growing global agricultural markets and supply chains.

Despite the expansion of irrigation-based agriculture in the past decade, overall water withdrawals for agriculture are still limited in Sub-Saharan Africa (SSA): less than 3 percent of total renewable resources compared to 36 percent in South Asia and 51 percent in the Middle East and North Africa (FAO 2009a). Although a number of basins are currently experiencing or are approaching water scarcity, this is mainly because of a lack of storage rather than absolute water scarcity. Of the 183 million hectares of cultivated land in Sub-Saharan Africa, 95 percent is rainfed and only 5 percent (or 9 million hectares) benefits from some kind of irrigation—by far the lowest rate of irrigation agriculture of any region in the world. There is a huge, untapped development potential for various types of irrigation.

Based on a collaborative review of experience in agricultural water management (AfDB et al. 2007), the World Bank Africa irrigation business plan identified five business lines that have potential to effectively increase investments in agricultural water management (World Bank 2007a): (1) market oriented irrigation on a public–private partnership basis; (2) smallholder private irrigation for high-value markets; (3) small-scale community-managed irrigation for local markets; (4) reform and modernization of existing large-scale irrigation; and (5) improved water control and watershed management in a rainfed environment. Each of these business lines represents a comprehensive approach to agricultural water development, including technology, marketing, agricultural service provision, environmental sustainability, private-sector involvement, institutional reforms, and capacity strengthening.

The present report is related to the second business line: smallholder private irrigation for high-value markets. This type of irrigation includes small farms (less than 2 hectares, typically around 0.1 hectare), privately owned, and under the complete control of the farmer. Farmers usually have direct access to surface water or groundwater (often groundwater) and make their own decisions about irrigation. Its simple design, low cost, easy application, and socio-economic benefits make smallholder private irrigation an efficient alternative to large, public irrigated perimeters and an attractive option for poor farmers. Private ownership of irrigation technologies also avoids problems with collective action related to larger public or communal schemes. This type of irrigation management has recently increased: although statistics are not available for all countries, smallholder private irrigation represents 15 percent of irrigated area in Kenya, 55 percent in Niger (excluding partially irrigated areas), and up to 75 percent in Nigeria. There is potential to increase smallholder private irrigation in most countries in Sub-Saharan Africa.

Many projects aimed at improving agriculture competiveness in West Africa have included a component on smallholder private irrigation. In the 1980s, agricultural development projects in Nigeria included support to small-scale irrigation to develop the fadama area. Since this approach proved successful, it was further pursued in three successive Fadama development projects (Fadama I in 1992, Fadama II in 2003, and Fadama III in 2008). In the 1990s and 2000s, smallholder private irrigation pilot projects were also implemented in Niger (Projet Pilote pour l'Irrigation Privée, PPIP), Burkina Faso (Développement de l'Irrigation Privée et des Activités Connexes, DIPAC) and Mali (PPIP). Pilot projects were followed by PIP2 (Projet de Promotion de l'Irrigation Privée) and PRODEX (Projet de développement des Exportations et des Marchés Agro-Sylvo-Pastoraux) in Niger, PAFASP (Projet d'Appui aux Filières Agro-Sylvo-Pastorales) in Burkina Faso and the PCDA (Programme de Compétitivité et Diversification Agricoles) in Mali. There is now a need to take stock in the progress made in the development and dissemination of smallholder irrigation technologies and management, and to identify the successes and challenges of efforts to expand smallholder private irrigation systems.

The objective of this report is to identify and evaluate best practices in smallholder private irrigation in West Africa. The report is based on a comparative assessment of the smallholder private irrigation subsector in Burkina Faso, Mali, Niger, and Nigeria, which included a literature review, field visits, and workshops at both national and regional levels. The task list for the assessment is provided in Annex 1. This report first presents the main features of smallholder irrigation and the development projects that have promoted its use in West Africa in Chapter 2. We then describe the low-cost technologies available for this type of irrigation, including drilling, pumping, and water distribution in Chapter 3. Chapter 4 reviews the successes and remaining challenges of the development projects involving smallholder private irrigation in West Africa. Chapter 5 draws the lessons learned from these experiences and proposes recommendations for future investments, including more support to the development of a supply-chain for low-cost irrigation technologies, the adoption of a programmatic approach, and the necessity for a comprehensive investment package—including environmental impact mitigation—to sustainably support smallholder irrigators.

Chapter 2: SMALLHOLDER PRIVATE IRRIGATION IN WEST AFRICA

This chapter reviews the history and extent of smallholder irrigation in West Africa and presents a summary of the development projects that have sought to promote it over the past few decades, focusing on the World Bank projects in Nigeria, Niger, Mali, and Burkina Faso.

2.1 A LONG HISTORY OF SMALLHOLDER IRRIGATION IN WEST AFRICA

Smallholder irrigation has a long history in West Africa. In many countries, dry season supplemental irrigation has been practiced on a very small scale for a long time to cope with low rainfall. In Mali, Niger, and Nigeria, *shaduf* and *delou* systems—water lifting devices with simple rope and bucket arrangements—were used to lift water for human and animal consumption and for small-scale irrigation. In northern Nigeria *shaduf* and calabash irrigation probably introduced from North Africa were recorded by Arab travelers in the eighth century (FAO 2004). The *delou* was introduced in Mali and in the Aïr in Niger in the seventeenth and eighteenth centuries by Berber marabouts, and groups from Egypt developed irrigation in the southern part of the region in the eighteenth century (Lazarev 1988). In Northern Mali (Tombouctou and Diré), wheat was irrigated with techniques developed under Moroccan influence during the colonial conquest of the sixteenth century (Lazarev 1988). Since water-lifting systems were hard to use, labor resources limited, and smallholder farms predominated, irrigation was limited to only a very small fraction of land farmed.

In the colonial period and just after independence, attention was given to medium- and large-scale irrigation. In the late colonial period, large-scale irrigation schemes were developed in two main areas in West Africa: Richard Toll in the valley of the Senegal River and in the Inner Niger Delta in Mali. The objective was to produce rice by pumping water in Richard Toll, and rice and cotton with gravity irrigation in the Inner Niger Delta. In the first decade after independence, the new states did not invest heavily in irrigation. When they did, investments were normally made in medium- to large-scale irrigation. In Burkina Faso for example, the government developed the SOCOBAM project around Bam Lake, Nagbangré, PK25, and Ouedbila projects in the Bazéga area, and the Kou valley schemes in the area of Bobo-Dioulasso. These projects were designed, owned, and managed either by the state or a para-public institution, and—with the exception of the Inner Niger Delta in Mali—they generally performed below expectations (WB 2005b). In addition agro-industry irrigation schemes were developed to supply either sugar refineries (Burkina Faso, Côte d'Ivoire and Cameroon), or fruit and vegetable processing units (Côte d'Ivoire, Nigeria, Senegal).

During the following decades, community-managed small-scale irrigation programs were initiated to contribute to food security. In the 1970s and 1980s, West Africa experienced a series of droughts that forced governments to change their agricultural development strategies, which had been based mainly on rainfed agriculture. Small-scale irrigation schemes, as well as medium-scale schemes with small plots of equal size for each farmer, were developed. In the same period, irrigation experts recognized that farmers should be more involved in irrigation management and should receive support to develop irrigation systems for their farms (FAO 1987).

In addition to these government initiatives to formally develop irrigation, the importance of informal smallholder private irrigation was gradually growing especially in urban and peri-urban areas. In 1992, a review of irrigation use showed that there were successful, privately operated, small-scale irrigated areas in Niger, northern Nigeria, Mali, and Mauritania, as well as in Chad, Senegal, and Burkina Faso. In some cases, the development of these systems had been spontaneous, and in others was supported by NGOs or minimal government assistance (World Bank 1992, Payen and Gillet 2007). Urbanization and the lack of refrigerated transportation and storage created new markets for urban and peri-urban irrigated agriculture, which could supplement rural agriculture by supplying cities with fresh vegetables (Drechsel et al. 2006). As most surface water bodies around African cities are polluted, marginal-quality water or some kind of diluted, partially treated, or untreated urban wastewater (including storm water) is often used for irrigation, which poses high health risks to farmers and consumers.

For the past 15 years, smallholder private irrigation has been more heavily promoted, mostly in rural areas (Kay 2001). Building on the success of this type of irrigation, governments started to include smallholder private irrigation in their strategies and to support its development through the promotion of innovative low-cost technologies for farmers. Urban and peri-urban irrigated agriculture was generally not directly targeted by this support (Payen and Gillet 2007).

2.2 THE SMALLHOLDER PRIVATE IRRIGATION SECTOR IN THE FOUR COUNTRIES UNDER REVIEW

Smallholder private irrigation consists of small farms (less than 2 hectares, typically around 0.1 hectare), privately owned or leased and under the complete control of the farmer. Farmers usually have direct access to surface water or groundwater (often groundwater) and make their own decisions about how and when they will irrigate and how much water to apply. With non-mechanized systems using ropes, buckets, and watering cans, irrigation of even such small areas can be extremely labor intensive, and labor constraints often limit increased production simply because the farm family lacks the time and energy to provide sufficient water for the crops (WB 2006a). This constraint can be addressed by providing access to labor-saving technologies for lifting and distributing water.

Smallholder private irrigation is promising because of its simple design, low cost, easy application, and socio-economic benefits, all of which make it an attractive option for poor farmers. Private ownership of irrigation technologies also avoids collective-action problems related to larger public or communal schemes and prevents long-term reliance on government assistance. This increases the likelihood that irrigation assets will be maintained. The four countries examined in this study explicitly mention smallholder private irrigation in their national strategies and policies as a model of irrigation to promote. These governments are withdrawing from medium- and large-scale public irrigation schemes and encouraging the development of community-managed or privately-managed small-scale irrigation.

2.2.1 Significance

Smallholder private irrigation has played a major role in the expansion of irrigation and resulting increases in food security. The area managed by smallholder irrigators has recently increased, although statistics are not available for all countries. In Burkina Faso, small-scale irrigation (both smallholder and community-managed) increased from 10,000 hectares in 2004 to 30,000 in 2007 (MAHRH 2004). In Niger, small-scale irrigation was widely practiced using traditional irrigation techniques (60,000 hectares in 1990, including community-managed, often partially irrigated areas) (World Bank 1992). More sophisticated techniques, including treadle or motorized pumping and water distribution systems, have been introduced more recently: the total area of farmland using these technologies grew from 520 hectares in 2001 to 16,350 hectares in 2008. These techniques are now practiced in 55 percent of the irrigated area, excluding the community-managed, often partially irrigated areas. In Nigeria, irrigation in the fadama area (in the northern part of the country) covers about 55,000 hectares; in addition, smallholder private irrigation is practiced on 128,000 hectares distributed all over the country, mostly close to cities. In total, smallholder private irrigation accounts for 75 percent of the currently irrigated area (Table 2.1). In Kenya, smallholder private irrigation covers only 15,000 hectares—15 percent of the irrigated area—because, although low-cost technologies

TABLE 2.1: Irrigated areas in the four countries under review (hectares)

	LARGE-SCALE IRRIGATION (>100 HA)	MEDIUM-SCALE IRRIGATION (20–100 HA)	SMALL-SCALE IRRIGATION (<20 HA)	TOTAL	URBAN AGRICULTURE IRRIGATED AROUND THE CAPITAL CITY
Niger (2005)	12,735		16,150[a]	28,885	400–600
Nigeria (2004)	35,800		183,000[b]	218,800	40–100
Burkina Faso (2007)	13,000	3,000	30,000[c]	43,000	25–43
Mali (2007)	113,490	34,153[c,d]		147,643	300–650

Sources: Drechsel et al. 2006; MDA 2005; FMWR 2004 (as quoted in FAO 2004); MAHRH 2007; Ministère de l'Agriculture, Mali 2008.
Note: Partially irrigated areas and flood recession irrigation are not included.
a. includes smallholder private irrigation only; 60,000 hectares of small-scale community-managed often partially irrigated area are not included
b. includes smallholder private irrigation only; about 55,000 hectares in the fadama area, 128,000 hectares of other vegetable, horticulture and flower producing small-scale schemes.
c. includes smallholder private irrigation and community-managed irrigation.
d. includes 5,000 hectares for vegetable production.

are widely disseminated, other types of irrigation are also used extensively (Grimm and Richter 2006).

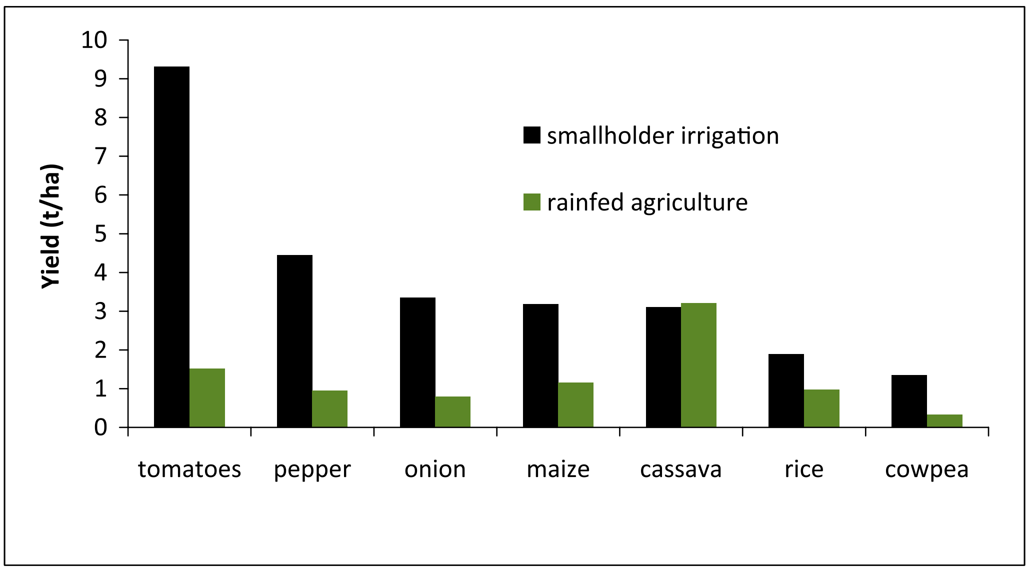
Smallholder irrigators practice mostly horticulture and to a lesser extent grow cereals. The main crops are:

- Niger: onion, pepper, tomatoes, rice
- Nigeria: vegetables (onion, cabbage, telferia, okra, pepper, tomatoes), maize, rice, wheat, sugarcane, amaranth
- Mali: vegetables (beans, nuts, potatoes, pepper, cabbage, tomatoes) fruits (mango, banana, papaya)
- Burkina Faso: vegetables (onion, cabbage, tomatoes, potatoes, beans, hot pepper) and fruits (mango, banana, papaya)

In urban and peri-urban informal irrigation schemes, most common crops are highly perishable, often leafy, vegetables, such as lettuce, spring onion, spinach greens, and cabbage. Other common vegetables are carrot, onion, amaranth, eggplant, tomato, okra, hot pepper, green bean, and cucumber. Although urban and peri-urban agriculture covers a small percentage of the total irrigated area (Table 2.1), it accounts for between 60 and 100 percent of the consumed leafy vegetables in cities like Dakar, Bamako, Accra, Kumasi, and Tamale, depending on crop and season (Drechsel et al. 2006).

Yields are much higher under irrigation than with rainfed agriculture (Figure 2.1). In fact, except in Nigeria, most of these crops are produced only under irrigation. Smallholder private irrigation almost always produces higher yields than the average national yield, including crops grown with other types of irrigation (Table 2.2). Only onion in the Fadama area in Nigeria has lower yields than the national average.

FIGURE 2.1: Crop yield with and without irrigation in the fadama area, Nigeria



Source: IFPRI 2008.

TABLE 2.2: Crop yield obtained under smallholder private irrigation (metric ton)

		TOMATOES	ONIONS
Niger	National average	24.53	35.58
	Observed in smallholder private irrigation	32.00	41.00
Nigeria	National average	6.42	14.79
	Observed in smallholder private irrigation	9.31	3.35
Burkina Faso	National average	10.00	17.14
	Observed in smallholder private irrigation		30.00
Mali	National average	19.23	21.11
	Observed in smallholder private irrigation	91.00	

Sources: FAO 2008; World Bank 2009a; IFPRI 2008; World Bank 2005a; World Bank 2004.
Note: In Mali, the observed value corresponds to demonstration plots (PPIP project).

2.3 RECENT INITIATIVES FOR SMALLHOLDER PRIVATE IRRIGATION DEVELOPMENT

Smallholder private irrigation with low cost technologies was principally promoted through development projects in West Africa. The range of low-cost technologies promoted by the projects varies from one country to another, depending on the environmental context (geology, aquifer characteristics) and on the socio-economic context (energy cost, farming system, network of suppliers). The technologies and their dissemination in the different countries are presented in Chapter 3.

The 18 projects reviewed in the report are listed in Table 2.3; their duration varies from two to eight years. Two thirds of the projects were co-financed by the World Bank. They are briefly described here, and the results of each project are evaluated in Chapter 4. Some projects are linked to each other, such as the series of Fadama projects in Nigeria, or the Pilot Private Irrigation Project in Niger (PPIP) followed by the Private Irrigation Promotion Project (PIP2). Those countries will be treated separately.

2.3.1 Projects in Nigeria

In the northern part of Nigeria, small-scale irrigation was practiced before the colonial era; agricultural development projects have helped disseminate improved irrigation technologies.

In the mid-1970s, a series of statewide agricultural development projects (ADPs) were launched to raise the productivity and real incomes of farm families through a coordinated approach to rural development. The main elements were improved technology (backed by expanded extension services), increased supplies of inputs, and infrastructure

TABLE 2.3: Projects of smallholder private irrigation included in the review

COUNTRY	PROJECT	DATE	SOURCE OF FINANCING
Nigeria	Agriculture Development Project (ADP) Kano	1981–1989	Nigeria, World Bank
	Agriculture Development Project (ADP) Sokoto	1982–1990	Nigeria, World Bank
	Fadama[a]	1993–1999	Nigeria, World Bank
	Special Program for Food Security (SPFS) (pilot phase and phase I)	1999–2001 2001–2007	Nigeria, AfDB, IsDB, BADEA, FAO
	Fadama II[a]	2004–2009	Nigeria, World Bank, GEF
	Fadama Development Project	2005-2009	Nigeria, AfDB
	Fadama III[a]	2008–2014	Nigeria, World Bank, GEF
Niger	Pilot Private Irrigation Project (PPIP)[a]	1995–2001	Niger, World Bank
	Support to Food Security through Small-Scale Irrigation (ASAPI)	2001–2006	European Union
	Private Irrigation Promotion Project (PIP2)[a]	2002–2008	Niger, World Bank, France
	Special Program for Food Security (PSSA)	2003–2005	IsDB, Libya, FAO
	Agro-Pastoral Export and Market Development Project (PRODEX)	2009–2014	Niger, World Bank
Burkina Faso	Pilot Private Irrigation Project (DIPAC)[a]	1999–2004	Burkina Faso, World Bank
	Small-scale village irrigation development program (PPIV)	2001–2004	Burkina Faso (HIPC funds)
	Boulgou Rural Development Project (PDR/B)	2000–2005	Danish International Development Agency
	Local Development Supporting Project Comoé – Leraba –Kénédougou (PADL/CLK)	2002–2011	AfDB
	Special Program for Food Security (PSSA)	2002–2005	Belgium, Libya, FAO
	Agricultural Diversification and Market Development Project (PAFASP)[a]	2006–2012	Burkina Faso, World Bank
	Small-Scale Irrigation and Water Management Project (PIGEPE)	2008–2014	Burkina Faso, IFAD, OFID
	AgWater Solutions Project	2009–2011	Bill and Melinda Gates foundation
Mali	Pilot Private Irrigation Project (PPIP)[a]	1997–2003	Mali, World Bank
	Agricultural Competitiveness and Diversification Project (PCDA)[a]	2005–2011	Mali, World Bank
	Special Program for Food Security (PSSA) pilot phase and phase 1	1998–2001 2004–2006	The Netherlands, FAO, Libya

Note: a. These projects will be discussed in detail in Chapter 4. Only certain aspects of other listed projects will be discussed.

improvements. Some programs, such as input subsidies and free extension services are still in place in many states. Two ADPs in the Kano and Sokoto states in northern Nigeria included pilot efforts to increase irrigated crop production in small flood plains (fadamas) where the potential area favorable to small-scale irrigation is estimated at 1.9 million hectares (World Bank 1995). By 1992, more than 80,000 small, motorized pumps were distributed, each of which could irrigate between one half to one hectare of land. These projects contributed to the cross-border spread of motorized pumps, mainly into Niger. This was intensified by the expansion of onion cultivation, which, with three harvests a year, increases the economic viability of irrigation with motorized pumps.

Building on this success, the first national Fadama development program was launched in 1992 by the Nigerian government and the World Bank to consolidate the dissemination of low-cost technologies (manual drilling and motorized pumps) in five northern states. The project included support for farmer training, especially in manual drilling techniques, in order to build ownership for further development. By 1999, more than 55,000 motorized pumps were acquired to pump water from shallow tube wells. The resulting expansion in agricultural production led to a significant increase in rural incomes and a reduction in poverty. Other donors also became involved in the sector: in 1999, the FAO Special Program for Food Security (SPFS) started a pilot project including 280 hectares in Kano State, where farmers were provided with motorized pumps and tube wells to enable them to engage in irrigated agriculture in the fadama lands. The project adopted a participatory community development approach, in which farmers' groups have ownership of the project and are primarily responsible for planning. The project was extended in 2002 to 109 sites in all 36 states.

Given the success of Fadama I and the SPFS, Fadama II arose from a demand by government to replicate this successful experience on a larger scale. The Fadama II strategy represented a shift from the public sector to a community-driven development approach; the project refined approaches for increased ownership and improved use of these lands through local development plans and by building on the success of the community-driven development mechanisms of the SPFS project. Locally planned development activities were funded through a matching grant scheme and included income-generating assets, such as fishing nets, water-pumps and activities like business training, agro-processing, demand-driven advisory services, and rural infrastructure (roads, irrigation systems). The African Development Bank also implemented a project similar to Fadama II (Fadama Development Project) in six states bringing the total number of states benefiting from the Fadama II project to 18.

The Fadama III Project, launched in 2008, builds on the success achieved and expands the scope of the project to cover all 36 states of the Federation and the Federal Capital Territory. The third phase also offers a more diversified set of livelihood activities than was possible under the Fadama II Project.

2.3.2 Projects in Niger

In the mid-1990s, the Government of Niger and the World Bank jointly decided to emphasize the role of the private sector and to favor smallholder private irrigation rather than large-scale schemes.

The Pilot Private Irrigation Project (PPIP, 1995–2001) supported the creation of a private irrigation agency (Association Nigérienne pour la Promotion de l'Irrigation Privée, ANPIP) to implement the project. ANPIP was made up of private farmers and irrigation equipment manufacturers and retailers, through a Public Private Partnership (PPP) arrangement. The main components of the project were: (i) promotion of new low-cost technologies by the private sector through tests, demonstration sites, and strengthening the capacity of local, private, input suppliers; (ii) support to advisory services for savings and credit schemes; and (iii) monitoring of environmental impact.

The lessons drawn from the implementation of the PPIP pilot phase contributed in a significant manner to the design of the Private Irrigation Project 2 (PIP2, 2002–2008). The promising approaches used to promote technologies and to advise farmers—such as the "make do" approach in which project activities are implemented by operators who are not part of the public sector—and the use of the irrigation technologies developed during the pilot phase were integrated in the PIP2 and scaled up to be disseminated throughout the country. Other components were added to strengthen weaknesses observed in the pilot phase. These two projects benefited from NGO contributions especially for technology dissemination and private-sector development.

Building on these projects, other donors promoted low-cost irrigation technologies in their projects. The EU-funded ASAPI in 2001 and the Libyan and IsDB-funded food security project SPFS in 2000 aimed to support food security through small-scale irrigation. The research institute ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in Niamey promotes the African Market Garden (AMG), which is based on a low-pressure drip irrigation system combined with a comprehensive crop husbandry package.

The follow-up World Bank project, Niger Agro-Pastoral Export and Market Development Project (PRODEX, 2009-2014), switched from an irrigation development approach toward a project aiming to increase the value of selected products marketed by project-supported producers. Irrigation is part of one component, but the targeted beneficiaries are commercial farmers rather than the smallholders who were targeted in the PPIP and PIP2. For this reason, the project will not be presented in detail in Chapter 4, but will be part of the discussion of recommendations in Chapter 5.

2.3.3 Projects in Burkina Faso and Mali

Following Niger's experience, small-scale irrigation pilot projects were funded by the World Bank in Mali (PPIP, 1997) and in Burkina Faso (DIPAC, 1999) with a budget of about US$4 to 6 million. Similarly to the Niger approach, These projects supported the promotion of new low-cost technologies by the private sector through tests, demonstrations, along with the strengthening of local private input supplier capacity. The projects also included support to advisory services.

In 2001 in Burkina Faso, three other initiatives aimed to promote low-cost irrigation technologies and develop small-scale irrigation parallel to the DIPAC project. The Rural Development Program (PDR) contracted the Nigerian small-scale irrigation agency ANPIP (see section 2.3.2) and a specialized NGO to introduce treadle pumps in the Boulgou area. The special program for food security (Programme Spécial de Sécurité Alimentaire, PSSA) supported small-scale irrigation development in peri-urban and rural areas with treadle pumps and motorized pumps (US$0.6 million targeting around 174 hectares). The Small-Scale Village Irrigation Development Program (Programme de Développement de la Petite Irrigation Villageoise, PPIV) started its pilot phase in 2001, to test the feasibility of crop production during the dry season with appropriate irrigation technologies (around US$1.9 million mostly financed by the Heavily Indebted Poor Country initiative). More recently, in 2007, a Small-Scale Irrigation and Water Management Project (Projet d'Irrigation et de Gestion de l'Eau à Petite Echelle, PIGEPE, US$19.1 million partly financed by IFAD) was launched to improve agricultural practices and access to water and low-cost technologies for the poorest families in several provinces of Southern Burkina Faso. The AgWater Solutions Project funded by the Bill and Melinda Gates foundation since 2009, will also help develop smallholder irrigation by identifying the factors that influence successful adoption and scaling-up of small-scale agricultural water management interventions and by providing a set of evidence-based tools and recommendations.

In Mali, the Libya-supported food security project (PSSA phase I), which started in 2004 in this country, also had a component on water management like in Niger and Burkina Faso and included the promotion of treadle pumps and motorized pumps (US$0.7 million targeting about 300 hectares to be developed or rehabilitated).

Unlike in Niger and Nigeria, the second generation of World Bank-supported projects in Mali and Burkina Faso (PAFASP and PCDA) were not scale-up projects of the pilot phase. These projects started several years after the end of the pilot phase and provided greater support to non-irrigation components. However they both supported private-sector development to improve agriculture productivity and competitiveness.

The Agricultural Competitiveness and Diversification Project in Mali (PCDA, 2005–2011) aims to reinforce the competitiveness of both traditional (cotton, rice) and nontraditional (fruit, horticulture products) agricultural crops. The major component supports the demonstration and dissemination by private-sector providers of innovative technologies, including smallholder private irrigation technologies and low-cost irrigation equipment, as well as technologies for cropping system intensification, storage, and post-harvest agroprocessing.

The Agricultural Diversification and Market Development Project in Burkina Faso (PAFASP, 2006-2012) aims to increase the competitiveness of select agricultural subsectors that target national and regional markets. Large-scale and small-scale irrigation will be developed by private-sector investors, with promotion and dissemination of low-cost technologies for small-scale irrigation. In this project, small-scale irrigation development targets individual farmers holding more than 3 hectares and groups of farmers holding more than 5 hectares; large-scale irrigation plots range between 20 and 50 hectares. Support for the development of supply chains is a major component of the PAFASP. The promotion of marketing infrastructure, capacity building of agricultural trade organizations, and provision of private advisory services are also included in the project.

Chapter 3: LOW COST TECHNOLOGIES FOR SMALLHOLDER PRIVATE IRRIGATION

The success of smallholder irrigation in West Africa in the past 15 years was based on the development and dissemination of low cost irrigation technologies. This chapter describes these technologies, analyzes their applicability to different regional contexts, examines their current pattern of dissemination, and evaluates their utility in terms of cost and return on investment.[1]

To be effective for smallholder irrigation systems must be:

- inexpensive
- simple to use and maintain
- efficient in terms of labor, energy, and water
- well adapted to local conditions and farming practices
- readily reproducible in a variety of regions

These technologies, developed in part by international NGOs, help to improve the productivity of irrigated crops and raise household incomes. The equipment can be manufactured and/or disseminated through the local private sector, which can offer sustainable service to farmers. These small-scale irrigation systems have proved to be as effective as more expensive conventional techniques.

3.1 LOW COST DRILLING

Low cost drilling techniques have had a huge impact on the availability of water both for drinking and irrigation in West Africa over the past few decades. There are several potentially suitable low-cost and sustainable drilling solutions for smallholder private irrigation; the choice of the technique depends on the intended application and on environmental and hydro-geological conditions.

3.1.1 Manual drilling

In West Africa, manual drilling has been practiced for many decades. In the 1960s, Richard Koegel of the FAO introduced the concept in Niger. In the 1970s and 1980s, low-cost manual drilling methods started to be disseminated in Niger and Nigeria. In Nigeria during the 1980s, manual drilling was used to drill 80,000 irrigation tube wells by Agricultural Development Projects (ADPs) in the northern states (see Chapters 2 and 4).

Manual drilling of tube wells experienced a huge boom in the 1990s. The technique was promoted in Niger with the Lutheran World Relief (LWR) and the Low Valley Project of Tarka (funded by the European Union Fund), and in Nigeria with the Fadama I project (funded by the World Bank, see Chapters 2 and 4). During that decade more than 50,000 tube wells were manually drilled in northern Nigeria (World Bank 2000) and more than 4,000 in Niger.

In the 2000s, manual drilling was also promoted through projects in Senegal, Mali, Burkina Faso, Ghana, and Benin. In Niger, Nigeria, and Benin the dissemination of manual drilling techniques continued even after the projects had been completed.

Today, there are more than 18,000 manually drilled tube wells and 42 teams specialized in manual drilling in Niger (UNICEF 2009), and more than 100,000 drilled wells in Nigeria. In addition, for the last three years, UNICEF and international NGOs have been using manual drilling methods to access potable water to meet the growing demand for drinking water in rural areas.

Types of manual drilling

Different manual drilling methods are used according to the density of the soil layers to be dug. The drilling method must penetrate the formation, remove the material from the borehole, and maintain the sides of the borehole to avoid collapse. The methods can be divided into four categories:

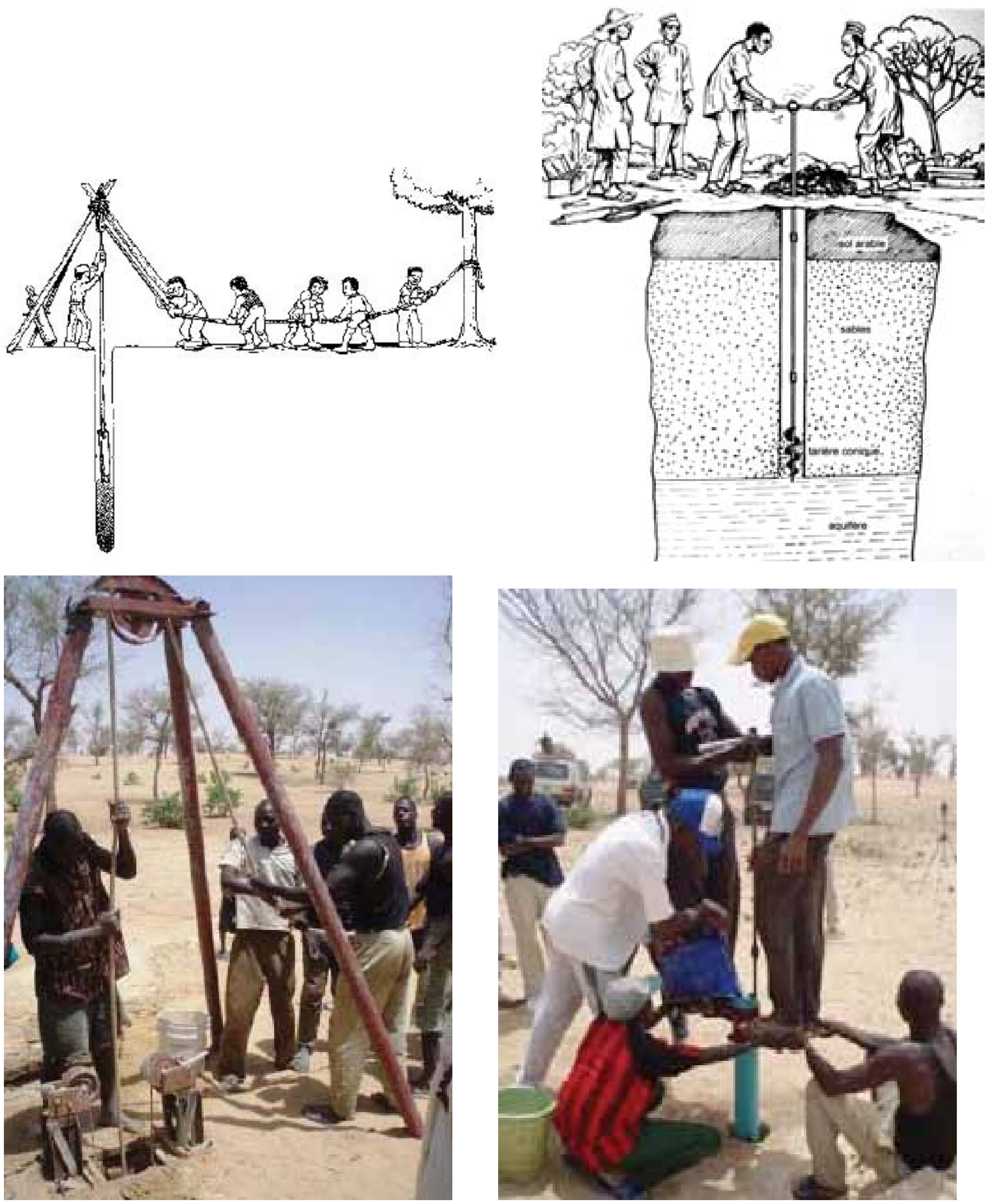
- Manual auger: The helicoid auger is rotated into the ground until it is full and then lifted out of the borehole to be emptied. Below the water table a cylindrical auger equipped with a bailer is used to empty water

1 Technical references for each of the technologies presented are listed in Annex 2.

and soil. The sides of the borehole are maintained with a temporary casing.

- Percussion: A heavy cutting or hammering bit attached to a cable is lowered into the open hole. By moving the cable up and down, the cutting or hammering bit loosens the soil or consolidated rock in the borehole, which is later extracted by using a bailer.
- Sludging: A drill bit penetrates the hard layers of soil with a vertical, rotating movement. Thickeners (clay or cow dung) are added to the water in order to prevent the borehole from collapsing and to reduce water loss. Water pressure keeps the borehole open. The excavated material is brought to the surface with the ascending movement of the fluid.
- Washbore: The injection with a motorized pump of pressurized water into a tube penetrates the soil and lifts the soil to the surface of the borehole.

FIGURE 3.1: (a) Percussion drilling (b) Manual auger drilling



(a) **(b)**

Sources: Practica 2008b; Naugle 1996.

FIGURE 3.2: Sludging

Source: Practica 2008b.

FIGURE 3.3: Washbore drilling

Source: Practica 2008b.

Manual drilling development experience

Drilling methods can be used independently or combined to meet the requirements of the region's geology. The density of the soil can limit the applicability of manual techniques in some areas and small-scale motorized techniques must be used instead.

Manual auger and washbore drilling are commonly used in areas where the soil is soft (sand) and the aquifers shallow (2 to 6 meters). They are well adapted to conditions in northern Nigeria (fadamas) and to the large fossils valleys of Niger (*dallols*). In these areas, a tube well can be drilled in less than one day with simple techniques, light equipment, and skills that are easily learned by drilling teams or farmers. The resulting wells are very productive, and water can be pumped from them with motorized or treadle pumps.

The consolidated soils and metamorphic geology in Burkina Faso and Mali are less favorable to manual drilling, and in these countries the dissemination of manual drilling techniques has been slower. The manual auger technique needs to be combined with hammering and sludging techniques in order to dig through the harder layers of soil. In the DIPAC project in Burkina Faso, the utility of the chosen manual auger technique was limited to the lowland areas, and it was therefore impossible to extend manual drilling to areas with consolidated soils which require percussion and sludging.

In Mali, manual drilling is not widespread, and no survey has been done to determine which areas would be most suitable for its use. In 2009, the PCDA project introduced manual auger drilling in Sikasso (an alterite area with weathered rocks) but did not thoroughly appreciate the development potential of manual drilling techniques in the other areas covered by the project. By combining drilling methods (manual auger and percussion) as was done in alterite zones in Niger, it is possible to dig a well in under a week.

Costs and impact of manual drilling

The costs of key drilling techniques in the four countries covered by the study are shown in Table 3.1.

TABLE 3.1: Average cost of shallow well drilling (6-12 m) (CFAF, US$1.00=CFAF 484)

	BURKINA FASO	NIGER	NIGERIA[b]	MALI
Washbore	—	25,000–50,000	8,700–30,000	—
Manual auger	60,000–80,000	50,000–75,000	—	80,000–100,000
Motorized auger[a]	600,000–800,000	—	—	—
Concrete well (Diameter: 0.8 m)	330,000–600,000	500,000–700,000	—	—
Concrete well (Diameter: 1.5 m)	—	1,200,000–2,400,000	—	—

Source: Authors.
Notes: a. The recorded price for Burkina Faso is for a 20 to 30 meter deep well. Other costs listed are for a 6 to 12 meter deep well
b. CFAF is also used for Nigeria for consistency
— = not available.

The washbore technique was quickly adopted by farmers in Nigeria because it was easy to use and was inexpensive: from CFAF 8,700 when used by farmers to CFAF 30,000 when produced by a drilling team. In Niger, the increase in the number of drilling teams made it possible to increase competition among service providers and to reduce the manual auger drilling cost by 50 percent: CFAF 30,000 to CFAF 100,000 depending on the depth of the well.

A manually drilled tube well can be more profitable than a concrete well because it is both less expensive to build and more productive. Because a tube well (with slots) has a larger surface hydraulically in contact with the aquifer than a concrete well, in regions where concrete wells can go dry in a few minutes with a motorized pump, farmers can continue pumping in tube wells with outflows ranging from 3 to 5 liters per second for the same aquifer, as observed by the authors in Niger and Nigeria. However, the financial profitability of low cost drilling depends on the pumping mechanism used as a motorized pump can irrigate a larger area than a treadle pump.

3.1.2 Motorized drilling

Motorized techniques, including motorized augers and percussion drills, can be used to drill tube wells in regions with hard soil layers, but the outcomes of projects using these methods have been inconclusive:

- Enterprise Works Worldwide (EWW) introduced a motorized auger in Burkina Faso, but since 2004, when the company was handed over to a private operator, only 20 wells were drilled because the cost of digging with a motorized auger is 10 times higher than the cost of a manual drill (both methods being used in different geological contexts). A similar pilot study was conducted by the AFVP (Association Française des Volontaires du Progrès) for the PPIP in Niger in 1999, leading to the same conclusions.
- In 2007, the NGO Winrock conducted trials in Mali with a locally manufactured, motorized auger and percussion drill, but the project ended before conclusions could be drawn.

The motorized auger is most suitable for drilling in geological strata that cannot be penetrated by manual drills or where aquifers are more than 25 meters deep. Pumping to this depth is in any case not feasible for most smallholder private irrigators because it requires investment in expensive immersion pumping systems.

3.1.3 Drilling techniques: synthesis

Manual drilling techniques are a potentially suitable low-cost and sustainable solution for smallholder private irrigation; the choice of the technique depends on the environmental and hydro-geological situation (Table 3.2). Maps of areas appropriate for manual drilling in 12 West African countries have recently been made available to help identify the areas where irrigation development is possible (UNICEF et al. 2011). Financial profitability depends on the pumping system used.

TABLE 3.2: Drilling methods and techniques: conditions of application

METHODS	TECHNIQUES	AVERAGE DEPTH (METERS)	GEOLOGY	ADVANTAGES	DRAWBACKS	EXECUTION TIME (DAYS)
Manual auger	Manual auger	10–15	Sand, silt, clay (soft soils), gravel < 4 mm	Easy to use	Temporary casing difficult to remove when there is a thick layer of clay	1
Sludging	Madrill, rotary, emas, rota-sludge	20–35	Sand, silt, clay (soft soils), soft consolidated formation (alterites)	Easy to use	Significant water consumption in permeable soils	2–4
Washbore	Jetting, washbore	6–15	Sand and silt	Fast	Needs a significant volume of water over a short period of time	<1
Percussion	Percussion, stone hammer	15–25	Consolidated formation (laterite, rock)	Adapted to hard formation	High cost of equipment and not always available in time	7–10
Motorized auger	Motorized rotary, PAT-Drill 201	35–45	Any type of rock free consolidated formation	Fast in hard soil	Significant consumption of water; equipment, and implementation cost very high	1–5

Source: Practica 2008b.

3.2 LOW COST PUMPING TECHNOLOGIES

Low-cost pumping technologies have changed the nature of small-scale irrigation for hundreds of thousands of farmers in West Africa over the past two decades. They require much less time and effort than irrigating with a bucket or calabash, and they can more than double the area that can be irrigated by a single farmer. Treadle pumps and low-cost motorized pumps are the most attractive solutions for smallholder private irrigation.

3.2.1 Treadle pumps

The treadle suction pump was developed by Gunnar Barnes in Bangladesh in the 1970s. In the early 1990s some technical improvements were made to the pump to adapt it to conditions in Africa. In the mid 1990s, two NGOs contributed to designing different models of treadle pumps for African conditions: the NGO Enterprise Works Worldwide (EWW) (known then as Appropriate Technology International) in West Africa and some years later, the NGO Kickstart (formerly ApproTEC) in East Africa.

In the last 20 years, EWW contributed significantly to the dissemination of treadle pumps in West Africa (Senegal , Mali, Niger, Burkina Faso, Côte d'Ivoire, Benin, and Ghana),[2] where thousands of pumps were used by market garden farmers: during this period more than 15,000 pumps were in use in Niger and 13,000 in Burkina Faso.

In the 2000s, Kickstart was the catalyst for the dissemination of 100,000 treadle pumps, mainly in Eastern Africa (Kenya, Tanzania, Malawi, Uganda, Zambia, and Zimbabwe) (Kickstart 2011a) and, beginning in 2005, in West Africa (Mali, Burkina Faso, and Ghana) with more than 5,000 pumps sold (Kickstart, personal communication).

Since the early 1990s, USAID, the World Bank, IFAD and FAO have contributed to financing projects to put in place a sustainable chain of manufacturing and distribution for treadle pumps.

Types of treadle pumps

There are many models of pumps (Table 3.3), but they can be divided into two main categories:

- Suction pumps bring water to the surface from aquifers of less than about 7–8 meters deep. They are operated with hand- or foot-powered treadles. Water flows directly to irrigation canals or plot furrows.
- Pressure pumps deliver pressurized water to a pipe or hose to fill a tank or to irrigate a plot located above the pumping point. They are also used in aquifers of less than 8 meters deep.

2 EWW has recently changed its name to Relief International, but in order to avoid confusion, the name EWW will be used throughout this report.

TABLE 3.3: Models of human powered pump

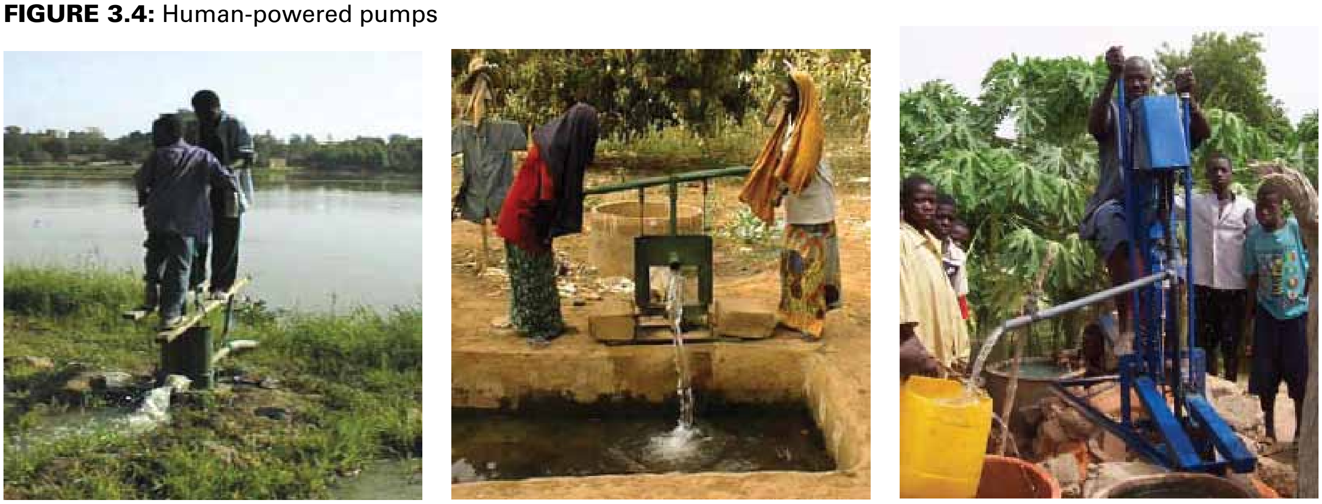
MODEL	COMMERCIAL NAME	OUTFLOW IN m^3/HOUR	MAX TOTAL DYNAMIC HEIGHT TDH (METERS)
EWW			
Pressure		1.3–6	6
Suction	Ciwara in Mali	0.8–5.2	7
Pressure—high outflow	Nafa in Burkina Faso	2.8–7.5	2
Suction—hand powered	Niyya Da Kokari in Niger	1.2–8.2	8
Pressure—compact		0.8–5.2	6.5
Suction—deep wells (2 steps of pumping)		1.5–3.5	15–18
Kickstart			
Pressure	Nafasoro in Mali and Burkina Faso	4	14
Winrock			
Pressure	Lafia in Mali	2–5	—
Suction	Sauki Da Riba in Niger	2–5	—
W3W			
Suction		2.5–7.5	7–8

Sources: Enterprise Works 2004b; Winrock 2008; MDA Niger 2008a; W3W 2008; and authors.
Note: The Total Dynamic Height is the sum of the total vertical distance the pump must lift water (equal to the suction height + discharge height) and the friction losses. To convert maximum pump outflow into irrigated area, one has to take into account the water distribution system (improved systems require less water), the type of soil (sandy soil may require more water than clay soil) the local evapotranspiration, and the aquifer depth (pumping is more difficult in deep aquifers, and the irrigated area is likely to be smaller). The average irrigated area of a treadle pump is 0.2 to 0.4 ha.
— not available.

Some trials were conducted by various international NGOs (EWW, IDE, and Winrock) to develop pumps adapted to private irrigation that are able to lift water from an aquifer more than 10 meters deep. Other improvements are still under way to reduce the cost of the pump or to make it smaller and lighter.

The pressure treadle pump distributed by Kickstart, a leading product sold by the thousands in Eastern Africa, distinguishes itself from other models by a Total Dynamic Height of 14 meters versus 8 meters for the models promoted by EWW in Niger, Mali, and Burkina Faso. The mechanical advantage of Kickstart pressure pumps is higher than most other pumps because of the optimization of the lever effect (Kay and Brabben 2000). This decreases the difficulty of pumping and can be used on plots where the aquifer is too deep, or the conditions too harsh, for other forms of pumps.

FIGURE 3.4: Human-powered pumps



a. Large diameter pressure pump

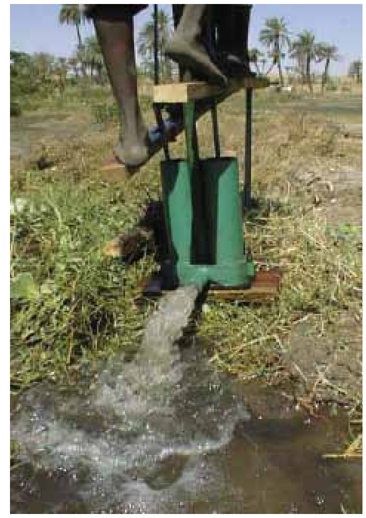
b. Manual suction pump

c. Lafia deep pump

(continued)

d. Nafasoro pump (Kickstart)

e. Bangladesh suction pump



f. NDK pressure pump

g. Gagéra suction pump

h. Bangladesh large diameter suction pump

i. Lafia suction pump

Sources: Enterprise Works 2004b; Winrock 2008; MDA Niger 2008; Kickstart 2007.

Treadle pump development experience

The sales volume of pumps is strongly dependent on the support provided by projects. In Niger, more than 10 years after the introduction of treadle pumps, only 27 percent of manual pumps were purchased using the users' own funds (MDA 2008b). This trend was also reported by a manufacturers association in Burkina Faso: in 2009, only 20 percent of pumps were purchased directly by the users; the remaining 80 percent were purchased with government subsidies or were donations provided by NGOs.

Estimating the number of pumps in operation is difficult. Little information is available on the number of pumps being actively used for irrigation, but it is probably quite different from the volume of sales. In Burkina Faso, between 2001 and 2004, the PPIV project (see Chapters 2 and 4) acquired 10,000 pumps, but only 5,600 were distributed in 2004 as all micro-projects were not implemented (MAHRH 2005). In Niger, it is difficult to distinguish sales of pumps used for irrigation and those used for drinking water.

The intensity of actual pump use also depends on how the pump was acquired. A study conducted by EWW (Enterprise Works 2004a) in Burkina Faso showed that (i) 50 percent of the pumps acquired through a project or a NGO were not regularly used compared to 5 percent for pumps purchased by the farmers, and (ii) there is an increase in the area irrigated of 140 percent with treadle pumps purchased with the farmers' own funds against an area increase of only 40 percent with a pump distributed by a project.

Success of pump types (suction or pressure pumps) depends on the region. In Niger, pressure pumps make up only 10 to 30 percent of the market whereas the sale of suction pumps has grown, reaching 45 percent of the market in some areas.[3] High sales of suction pumps may be due to a higher demand for pumps for drinking water rather than irrigation. In Mali pressure pumps promoted by Kickstart have experienced a large jump in sales. In Sikasso (Mali) a mechanic manufacturing treadle pumps sells four times more Kickstart pumps than pumps manufactured in his workshop. He states that ease of use, the relatively low cost, and the pump's ability to connect to a hose are the reasons why people choose the Kickstart pumps (personal communication).

In West Africa, both centralized and decentralized manufacturing were promoted for treadle pumps (Box 3.1). There is no locally manufactured treadle pressure pump with features close to the Kickstart model. It is more difficult to manufacture pressure pumps than suction pumps because pressure pumps must be made with high quality specifications: if the quality of a pressure pump is poor, it quickly breaks down with use. Poor sales of pressure pumps in West Africa are probably due to a lack of locally available high quality pumps.

In Nigeria, in regions bordering Niger, and in Benin the relatively low cost of motorized pumps (CFAF 40,000 to 75,000) and fuel (CFAF 185 per liter) has led to a lack of interest in treadle pumps.

BOX 3.1: Centralized or decentralized manufacturing for treadle pumps?

EWW and Kickstart use two different strategies in manufacturing treadle pumps.

EWW used decentralized manufacturing by small workshops of independent mechanics. The workshops received an initial, two- week training and were then supported by EWW over several months with training in marketing, quality control, and choice of materials. By the end of the project (four years in Niger with the PPIP and three to five years in Burkina Faso with the DIPAC) EWW no longer provided technical support to the mechanics trained, although an association of mechanics was created to ensure monitoring of the quality of manufacturing and distribution. Quality control has been difficult with this decentralized production system. In Niger, the 20 mechanics trained in treadle pump manufacturing and marketing are still active although the volume of their pump sales has decreased considerably. Diversification through the manufacture and sale of other products or services has absorbed the decline in pump sales.

Kickstart has adopted a centralized production model using high-performing machines and efficient methods of production in factories in Africa and China. The production technicians are trained by Kickstart in manufacturing and quality control. Today, 80 percent of the Kickstart treadle pumps, like those distributed in Mali, are manufactured in China.

Source: Authors.

Cost and impact of treadle pumps

The cost of treadle pumps (Table 3.4) varies by country and model, but by and large prices fall between CFAF 30,000 and CFAF 90,000. Hand-operated pumps are generally more expensive than foot-operated pumps although Kickstart recently developed a cheap hand-operated pump.

In Burkina Faso, the maximum area irrigated by one treadle pump varies between 0.24 hectares and 0.38 hectares with an average of 0.26 hectares (Enterprise Works 2004b). These figures are similar to those reported in other West African countries (Senegal, Benin) and to those observed in East Africa.

Enterprise Works (2004a) found that, with the acquisition of a treadle pump, the irrigated area of a plot formerly watered with a bucket or calabash could be more than doubled. The average net income can also be doubled: this amounts to about CFAF 350,000 over the cropping season in Burkina Faso, CFAF 182,000 in Niger, CFAF 196,000 in Mali, and CFAF 410,000 in Benin and Senegal. Operating costs are limited to maintenance (lubricant, cord, leather) and repair costs which amount to about CFAF 4,800 per year. The use-life of a pump is estimated at 3 to 5 years.

In addition to increasing incomes, the treadle pump is the most cost-efficient way to significantly reduce the onerous labor of irrigating crops with a bucket and calabash.

3 Adamou Fall president of the association of craftsmen A2F (Niamey) and Sani Rabo (Maradi), personal communication 2009

TABLE 3.4: Average cost of human-powered pumps in 2009

COUNTRY	PUMP MODEL	COST (CFAF, US$1.00=CFAF 484)
Niger	Pressure Gagéra	35,000–40,000
	Suction Gagéra	35,000–40,000
	NDK pressure	60,000
	NDK pressure (large diameter)	90,000
	Suction Bangladesh	60,000
	Suction Bangladesh (large diameter)	90,000
	NDK manual pump	80,000–90,000
	Sauki Da Riba suction	30,000
Burkina Faso	Nafa suction	55,000–70,000
	Nafa suction	45,000
	Nafa depth pump	135,000–175,000
	Nafa pressure pump (large diameter)	90,000
	Nafa manual pump	90,000
Mali and Burkina Faso	Pressure Nafasoro pump	49,500
Mali	Pressure Ciwara pump	77,500
	Depth Ciwara pump	175,000
	Lafia pressure pump	75,000
	Lafia depth	125,000

Sources: Enterprise Works 2004b; MAD Niger 2008a; Winrock 2008; authors.
Note: EWW prices quoted are from 2004 but prices remained steady through 2009.

BOX 3.2: Dissemination of treadle pump technologies

The successful dissemination of treadle pumps in West Africa depended on the establishment of a sustainable and efficient distribution chain. During the past 20 years EWW and Kickstart have tested dissemination models in the framework of development projects supported by the World Bank, USAID, DFID, IFAD and other financial partners. Several steps in the marketing process have proven critical.

Market identification: The introduction of small-scale irrigation technologies should target areas where there is a strong concentration of market gardening production; the presence of surface water and/or shallow aquifers suitable for human-powered pumping; the availability of local private operators including metalworkers, hardware shops, plumbers, drilling teams, and inputs retailers; existing market outlets for agricultural products; and the availability of materials.

Research and development: The development or consolidation of new technologies can be engaged in to overcome a particular technical constraint. For example, EWW developed a pump to reach aquifers below 7 meters.

Retailers:

- EWW: Technicians trained by EWW directly lead the selling of the treadle pumps, ensuring the installation of the pump at the plot level. In Niger and Burkina Faso the technicians association, in conjunction with EWW, defines the selling price of the pump, which is uniform throughout the country. In Mali, with the support of the PCDA project, technician-salespeople ensure the relay of information to farmers on the whole range of products manufactured. In theory, when the development project is completed, the technician-salespeople will become salaried employees of the workshop.

(continued)

(continued)

- Kickstart: Kickstart pumps are sold through a network of wholesalers and small retailers scattered throughout the country. In Mali more than 50 small retailers including traders, metalworking workshops, inputs shops, and hardware stores sell Kickstart pumps. Kickstart offers a one-year guarantee and supplies spare parts to its retailers, who are trained in use of the pump and in basic marketing. The cost of the pump is set at the national level and is designed to allow the wholesalers and retailers to receive a decent profit margin while maintaining a competitive price for the product.[4]

Promotion and advertising: The principle has been to show that treadle pumps are not pumps for the poor, but that they are a high-quality product that will help farmers to increase their incomes. Branding has been important with names like 'Niyya Da Kokari' (willingness and courage) for treadle pumps in Niger and 'Money Maker' for Kickstart treadle pumps in Kenya. Different means of promotion are used including radio, television, newspapers, plays, demonstrations at local fairs, flyers, stickers, tee-shirts, and songs. Publicity campaigns have been very effective at stimulating sales of new technologies during their introduction phase, but they are expensive and dependent on funds made available by short-term development projects. EWW reports that the technicians who manufacture and distribute their treadle pumps do not invest, or invest little, in the promotion of their products some years after the closing of the project (Schmid 2002).

Establishment of a distribution chain: The distribution chain of treadle pumps has been supported by development projects during the introduction and maturation phase of the technology but is expected to become sustainable and profitable in the long term. Kickstart estimates that products can be marketed independently when they have reached 15-20 percent of the potential market on a deadline ranging from 12 to14 years after the product introduction, depending on the intensity of product marketing.

4 The cost of the pumps is defined through an agreement with the association of craftsmen. It takes into consideration the cost of the material, the manpower, energy, workshop equipment depreciation and the profit margin.

3.2.2 Motorized pumps

Over the past 15 years, the use of low-power motorized pumps (2.5 hp to 5 hp) to irrigate plots of between 0.5 and 2 hectares has increased substantially in West Africa. The marketing of low cost motorized pumps from China and subsidies for motorized irrigation explain this boom in spite of increases in fuel prices. Several generations of mechanics have been trained and equipped by rural development projects to provide service to motorized pumps. The growing increase in the number of motorized pumps has also helped to increase the availability of spare parts, although the quality remains unreliable.

Motorized irrigation is less physically demanding than human-powered pumps, which are particularly arduous to use in sandy soil conditions or where aquifers are more than 5 meters deep. Motorized pumping can also irrigate larger areas of land, which can raise producers' incomes. Finally small motorized pumps can be easily transported (even by bike) and shared. However, water control may be more difficult with a motorized pump compared with a human-powered pump, which may result in lower water efficiency and relatively high cost of energy per hectare.

Types and dissemination of motorized pumps

Motorized pumps widely available on the market range between 3 to 5 hp in power (Table 3.5) and can irrigate an area of 0.5 to 2 hectares (EIER/ETSHER 2004). However, some types of agriculture, such as small, intensively cultivated gardens of 0.25 to 0.75 hectares, do not need motorized pumps with this much power.

Motorized pumps of 1 to 2 hp appeared on the market, following demonstrations carried out in Burkina Faso (Sainte Famille Center), Niger (PPIP), Mali (PCDA) and Chad (PNUD). Their low fuel consumption (0.5 liters per hour) and their low cost (CFAF 90,000 to 130,000) attracted many customers. Small motorized pumps are widely used in Madagascar (Box 3.3). By optimizing the choice of pump to the needs of farmers engaged in small-scale irrigation, costs can be reduced by up to 40 percent (Abric et al. 2000).

In northern Nigeria, the dissemination of motorized pumps was initiated by the ADP projects in the 1980s (see Chapters 2 and 4). Nigeria's cultural proximity and informal trade with Niger caused the spontaneous dissemination of motorized pumps across the border to Niger without the support of projects or financial institutions. Indeed, in the mid 1990s, the motorized pump stock in the Aïr valley grew from a few dozen to more than 500 in less than four years (Abric and Al Moctar 2000).

The PPIP (Niger) and DIPAC (Burkina Faso) created a standardized technical reference guide for motorized pumps available on the local market that can be used to optimize the choice of pumping systems (Abric et al. 2000; Sedogo, 2004; see also Annex 2).

FIGURE 3.5: Motorized pumps

Source: Authors 2009.

BOX 3.3: Low-power motorized pumps for irrigation: example in Madagascar

In 2007, new low-power motorized pumps of 1.5 hp were introduced in Madagascar with the support of the FAO in order to help small producers access motorized pumps. The project helps local suppliers to import the pumps from China, to test the quality, and to develop a marketing strategy. In return, the local supplier commits himself to sell the motorized pumps at an affordable price. The cost of this pump was four times lower than the cost of the motorized pumps of 3 to 3.5 hp available on the market. In addition, operational costs are halved because of the low fuel consumption (0.5 liters per hour). Because these pumps are distinct in their application, they do not present a serious competitive threat to other brands. Four years after the introduction of these small motorized pumps the relationship between local suppliers and manufacturers in China is solid and import of the pumps is reliable.

Source: Practica 2007.

Costs and impact of motorized pumps

The average cost for a motorized pump for smallholder irrigation is about CFAF 250,000 (Burkina, Mali, and Niger in 2009). The price varies from CFAF 40,000 to more than CFAF 1,000,000, depending on the technical characteristics (TDH, outflow, hp), the quality (use-life), and the fuel consumption. The local demand can also influence the price: in Burkina Faso, prices fell by 40 percent in the past five years due to growing demand, increased competition in the market, tax-free measures and diversification of the supply networks. The use-life of a motorized pump is reported to be about 2,500 hours for a four-cylinder gasoline engine. In practice, motorized pumps last between two to five years depending on the intensity of use and the degree of maintenance.

The costs for fuel, lubricants and maintenance make up the bulk of the expenses in running a motorized pump. The high rates of motorized irrigation in Nigeria can be partly attributed to the low cost of fuel which is two to three times cheaper than in neighboring countries. Economic analysis conducted in Niger and Mauritania shows that operation and maintenance (mainly fuel consumption and lubricating oil) accounted for about 25 to 35 percent of the annual production cost for a farmer (including seeds, fertilizers, labor, and depreciation of equipment) (Ibrahim et al. 2008, Practica 2008a). Adding the depreciation charge of the pump to the cost of operation and maintenance leads to a total cost of motorized pumping of irrigation water between 40 percent and 60 percent of the annual production cost (compared to about 15 percent for a manual pump, World Bank 2005a). Some trials on the use of agro-fuel (jatropha oil) in modified motorized pumps were conducted by EWW (DIPAC project in Burkina Faso), but they were inconclusive. It would appear that the cost of agro-fuel was not substantially different than the cost of diesel.

The profitability of a motorized pump depends on the subsidies available (for energy or for the initial investment), the area irrigated, the yield obtained, and the commercialization of production. Farmers can irrigate a larger area with a motorized pump than with a treadle pump. The average area

TABLE 3.5: Range of motorized pumps in Burkina Faso, Mali, and Mauritania

COMMERCIAL NAME	MODEL	MAXIMUM OUTFLOW (m^3/HOUR)	TDH (METERS)	POWER (HP)
Chinese pump	SPP50	24	14	2
DTE	ZB50	24	14	2
DTE	ZB80	50	55	5
DTE	50ZB45	18	45	6
Eletop	WP20	22	23	2.9
Greenmax	WP20X	30	28	3.3
Honda	WP30X	60	30	3.8
Honda	SEH50X	36	30	3.5
Honda	SEH80X	58	30	5
Jinling	JL30PG	55	31	4.5
Kama	KDP20	22	23	3.8
Kama	KDP30	30	21	5.4
Koshin	SEH50X	36	30	2.9
Koshin	SE50X	36	30	2.7
Koshin	SE80X	55.8	26	3.5
Koshin	SEH80X	55.8	26	3.8
Robin	SE80X	36	32	3.5
Robin	Jard1.35E	36	30	3.5
Robin	PTK305	50	23	4.3
Robin	RD55	55	28	4.2
Robin	Jard3.62	36	32	3.5
Yamaha	SGP80X	56	30	5.5
Yamaha	YP20GN	33	23	3.6
Yamaha	YP30GN	54	26	5.2
Yamaha	MTT	32	33	3

Sources: Practica 2008a; Abric et al. 2000; Sedogo 2004.
Note: To convert maximum pump outflow into irrigated area, one has to take into account the water distribution system (improved systems require less water), the type of soil (sandy soil may require more water than clay soil) and the local evapotranspiration. On average, 2–3.5 hp motorized pumps can irrigate 0.5–1 ha and 3.5–5.5 hp pumps 1–2 ha.

irrigated varies from 1.5 to 3 hectares in Burkina Faso, and from 0.5 to 2.5 hectares in Niger and Nigeria. The financial internal rate of return of irrigation activities using motorized pumps ranges from 52 percent to 70 percent in the Fadama II project in Nigeria, depending on the crop produced (World Bank 2010). In Niger after the PPIP project (with low subsidies), the economic rate of return (ERR) of manual pumping and motorized irrigation were 68 and 66 percent, respectively (World Bank 2002). After the follow up project (with larger subsidies) motorized pumps had a slight advantage over manual pumps, and larger small-scale farm plots, typically needing a more powerful 5 hp pump, tended to be more profitable (for a manual pump, 3.5 hp pump, and a 5 hp pump the financial rate of return was 78 percent, 79 percent and 124 percent and ERR was 80 percent, 113 percent and 142 percent respectively) (World Bank 2009a).

Although it was found profitable, the high initial investment is often a limiting factor to the development of motorized irrigation. Treadle pumps remain a good alternative for poor farmers seeking to make an initial investment in irrigation (see Chapter 5).

3.2.3 Electric immersion pumps with generators or solar energy

Immersion pumps can be used for aquifers that are deeper than 7 meters, which a motorized pump on the soil surface cannot reach. The combination of an electric immersion pump and a generator is under trial by the PCDA project in Mali. The profitability of this technique depends on the area irrigated. For example, the cost of an immersion pump and a generator to irrigate 300 square meters with a network of micro-jets costs about CFAF 300,000.

Solar-powered immersion pumps are another alternative for deep wells, but this option is rarely used because of its prohibitive initial cost of about CFAF 2 million per hectare (Burney et al. 2011). In the long term, however, the long use-life of solar powered equipment (8 to 10 years), and low operating costs, lead to an annual cost four times lower than the cost of a gas-powered pump (annual cost of CFAF 250,000 per hectare for solar powered pumping and CFAF 1,000,000 for a traditional motorized pump).[5]

5 Annual depreciation + man power + operating cost + maintenance

There are several constraints to the use of solar powered pumps:

- Solar-powered pumping can only operate directly from 10:00 a.m. to 5:00 p.m., when people do not generally irrigate. A basin for intermediate storage is often necessary, and this adds to the cost of the system.
- The management of a solar-powered system requires the availability of skilled technicians.
- To be profitable, solar-powered systems must irrigate an optimal area with a limited volume of water per day and work best with water-saving distribution systems like the drip system. In a trial by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger (near Balleyara) and in Benin (Burney et al. 2009), a solar pumping station feeds reservoirs supplying each of the drip lines (0.5 hectares in Benin).
- The theft of solar panels presents a significant risk to the farmer.

Although solar-powered systems are an attractive solution in principle, their adoption depends strongly on highly subsidized systems. It may be more cost effective to design systems that serve several purposes, such as water supply and irrigation. The cost of this technology is expected to drop to more affordable levels in the future as efforts to reduce greenhouse gas emissions result in better and cheaper solar-power products.

3.2.4 Low cost pumps: synthesis

Treadle pumps and low-cost motorized pumps are the most attractive solutions for smallholder private irrigation. These options should be adapted to (i) the plot size, (ii) the water distribution system (the need for pressurized water), and (iii) the cost of labor and of energy (Table 3.6). Profitability depends on the area irrigated and on the type of production (Table 3.7).

TABLE 3.6: Low cost pumps: conditions of application

	TREADLE PUMPS SUCTION	TREADLE PUMPS PRESSURE	MOTORIZED PUMPS
Size of the plot (ha)	0.2–0.4	0.2–0.4	0.5–2
Water delivery	Water flows directly to irrigation canals or plot furrows	Pressurized water delivered to a pipe or hose to fill a tank or to irrigate a plot	
Advantages	Low investment and operational cost compared to motorized pumps Reduced labor compared to watering cans Easier to use than pressure pumps	Low investment and operational cost compared to motorized pumps Reduced labor compared to watering cans Possible to irrigate land above the pump	Reduced labor compared to treadle pumps Irrigated area larger than with a treadle pump Possible to irrigate land above the pump
Drawbacks	More difficult to operate than a motorized pump Surface irrigation only	More difficult to operate than a motorized pump Difficult to manufacture compared to suction pumps	High investment and operational cost compared to treadle pumps Higher likelihood of wasting water due to relatively high flow and ease of use
Use Life	3–5 years	3–5 years	2–5 years

Source: Authors.

TABLE 3.7: Cost-benefit analysis for four types of farm production using treadle pumps and motorized pumps in Burkina Faso

	FARM SYSTEM			
	0.25 HA OF ONION PRODUCTION WITH A TREADLE PUMP	1 HA OF MAIZE PRODUCTION WITH FOUR TREADLE PUMPS	4 HA OF MAIZE WITH A MOTORIZED PUMP (60 m³/HOUR)	6 HA (4.5 HA MAIZE, 1 HA POTATOES AND 0.5 HA TOMATOES) WITH A MOTORIZED PUMP (80 m³/HOUR)
Production cost (CFAF)	302,261	163,250	982,435	2,381,209
Including: Inputs (seeds, fertilizers) (%) Labor (%) Equipment (%) Marketing fees (%)	 41 40 7 12	 26 31 43	 18 20 44 18	 58 13 19 10
Production value (CFAF)	900,000	360,000	1,440,000	5,620,000
Benefit per ha (CFAF)	2,390,956	196,750	114,391	539,799
Benefit / cost ratio (%)	198	121	47	136

Sources: World Bank 2005a; MAHRH 2005.

3.3 WATER DISTRIBUTION SYSTEMS

Gravity-powered irrigation with earthen canals is the most widespread method of distributing irrigation water in the sudano-sahelian zone. However, in the western part of Mali and Burkina Faso water is primarily transported by calabash or watering can, and the consequent productivity rate is low. The same low productivity rate prevails in most gardens managed by women where water is manually carried from the water source to the garden. Late in the 1990s, some international NGOs started to test and develop technologies that could improve water transportation for irrigation (Gadelle 1998 and 2001).[6]

3.3.1 Californian system

The Californian system consists of buried PVC pipes. These systems can reduce losses from infiltration, supply fields that are far from the pumping source or that have an irregular topography, and adapt to different water levels without adding or moving pipes. Through the use of this technique, irrigated areas can be increased from 1,000 square meters to 2 hectares or more depending on the outflow of the pump.

The Californian system is not yet widely used in West Africa because of the high cost of the pressure PVC pipe. However in 1997, the PPIP (Niger) successfully tested the use of low-pressure PVC piping (inferior to 2 bars) which is normally used for sewerage, with a cost two to three times less than the average pressure PVC (about 4 bars). With the lower-cost pipes, the Californian system could prove a valuable resource for small-scale irrigation.

Dissemination of the Californian system

The dissemination of the Californian system is made through a network of bricklayers and plumbers who have been trained by development projects. The PIP2 in Niger subsidized the installation of 738 kilometers of Californian network and the PAFASP in Burkina Faso engaged in a similar project. It is difficult to assess the overall impact of this system of distribution because of the lack of data about how many people have adopted the technology outside the PIP2 or PAFASP. Low-pressure PVC pipes have been widely adopted in West Africa as suction or pressure pipes, but not as buried networks like the Californian system.

The potential of the Californian system is still not well known or promoted in Burkina Faso, Mali and Nigeria.[7] In Mauritania, the Californian system was introduced in 2007 (with the VISA project) to ease the constraints related to the withdrawal of water from the Senegal River in different seasons. The technique was quickly adopted in the Senegal River valley.

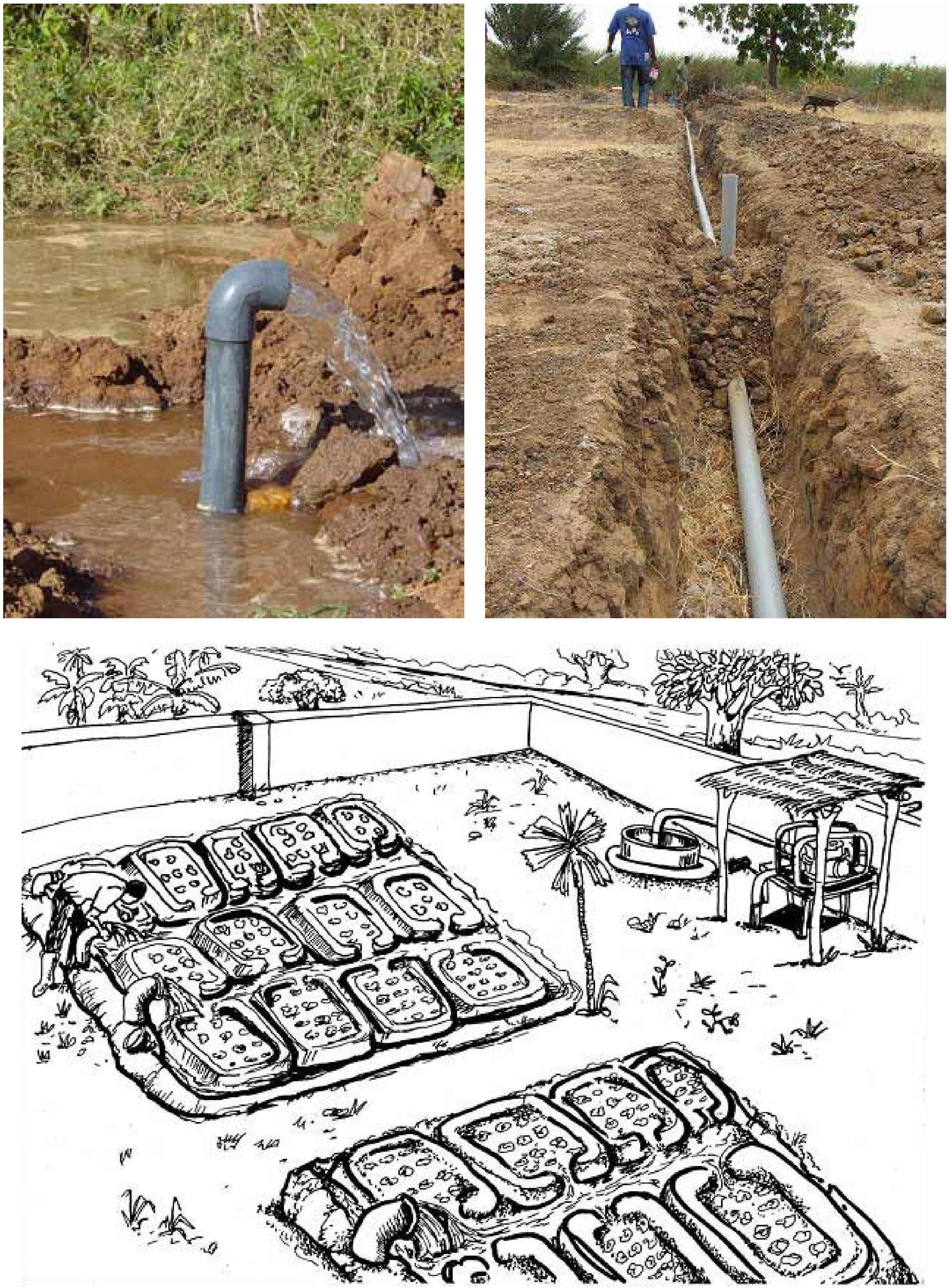
Cost and impact of the Californian system

The initial cost of installation for a Californian system is about CFAF 300,000 to 350,000 per hectare (about CFAF 1,500 / meter) with a return on investment over two to three seasons

6 These reports provide an inventory of the techniques and the reasons for which they were adopted or abandoned. The present report does not describe those technologies which were tested and failed.

7 Many demonstrations are underway in Burkina Faso, Mali and Niger in the frame of a project funded by FAO and Japan.

FIGURE 3.6: The Californian system



Sources: EIER/ETSHER 2004; Practica Foundation 2007 and 2008.

(one to two years). In the State of Kaduna in Nigeria, the Fadama project funded the installation of many low-pressure Californian systems from 2006 to 2008 for community use, with low-pressure pipes costing CFAF 500,000 per hectare. The installation can be carried out incrementally depending on the farmer's financial capability, since supplementary lengths of buried pipes can be successively added without requiring technical expertise.

The Californian system improves irrigation efficiency, reduces pumping charges, and increases irrigated area: a 25 percent reduction in pumping charges, 50 percent decrease in water use per hectare, and 154 percent increase in irrigated area were recorded in Burkina Faso (World Bank 2005a; Zerbo 2006).

3.3.2 Drip irrigation

Localized irrigation systems, such as drip irrigation supply water directly to the plants and thereby minimize water loss to evaporation and seepage compared to surface irrigation. In areas where water is scarce, these techniques can greatly increase the efficiency of water delivery. In West Africa, there have been limited trials of drip and micro-sprinkler systems for localized irrigation.

Drip irrigation kit

Drip irrigation kits were developed in the mid-1990s by the NGO IDE in India in order to provide the poorest Indian and Nepalese farmers with access to efficient low cost irrigation technologies. In the early 2000s, about 2,000 drip irrigation kits were introduced by the research institute ICRISAT in 12 West African countries including Niger. Since then a variety of drip techniques have been tested and/or are being distributed in Mali, Niger, and Burkina-Faso by international NGOs, research centers, and development projects.

The drip technique improves water distribution and application at the plot level by controlling the amount of water delivered to the crop. The water-use efficiency of drip irrigation is between 90 to 95 percent versus 40 to 50 percent for gravity-fed irrigation and 70 to 80 percent for spray systems.[8] To maximize efficiency, different kits were designed for areas of 20 square meters, 100 square meters, 200 square meters and 500 square meters.

All the drip irrigation kits tested or distributed in West Africa use a low-pressure system. Water pressure is obtained from a raised reservoir with capacity varying from 100 liters to 4 cubic meters, which is supplied once or twice a day by a manual or motorized pump. This reduces the cost incurred by continuous pumping. Since one reservoir can supply many irrigation kits, farmers can gradually extend their irrigated plots by purchasing supplemental kits, although this potential expansion has not been observed yet in practice.

Cost and impact of drip irrigation

The initial cost of a drip irrigation kit is relatively high: CFAF 21,000 to 40,000 for 100 square meters and CFAF 150,000 for 500 square meters, or CFAF 2,100,000 to 4,000,000 per hectare (Table 3.8). Although these irrigation drip kits were specifically designed to reduce the price point, the high purchasing cost remains a barrier to the dissemination of this technology.

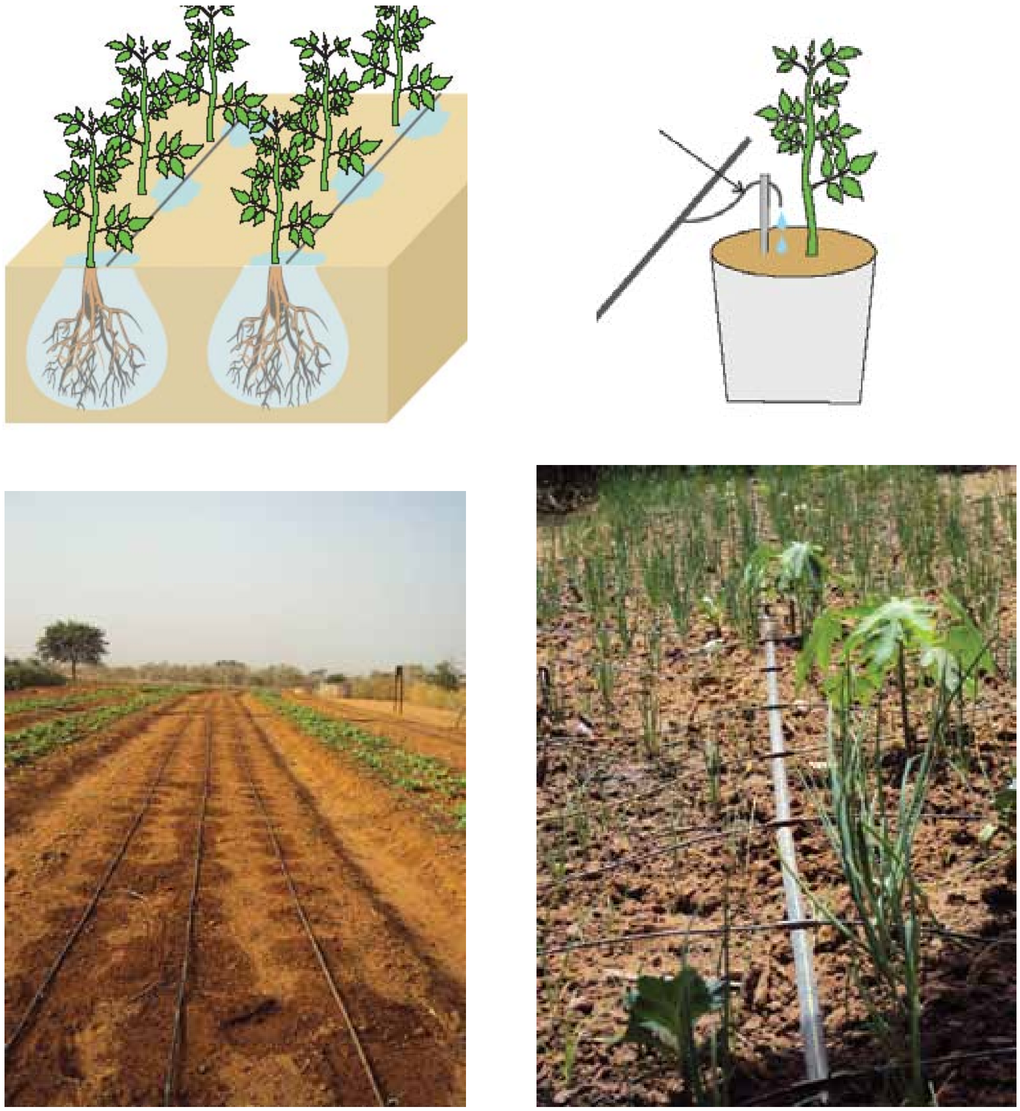
8 Efficiency is the ratio between the water quantity that reaches the crop and the quantity supplied by the irrigation system.

TABLE 3.8: Cost of drip irrigation kits (market gardening)

COUNTRY	SUPPLIER	ORIGIN	AREA (M^2)	COST (CFAF, US$1.00=CFAF 484)
Niger	Nétafim	Israel	80	39,410
			500	141,500
	NaanDan Jain	Israel	500	150,000
Mali	IDE	India	20	12,000
			100	21,000
			200	35,000
			500	72,000
Burkina Faso	Chapin	United States	500	150,000
	Nétafim	Israel	500	131,000

Sources: Winrock 2009; authors.

FIGURE 3.7: Drip irrigation systems: (a) on-line system (b) capillary system



Sources: Chapeaux and Enomoto 2009; authors 2009.

This cost does not include the water source (drilling a well if necessary), the pump, or the water storage reservoir which in Niger would add an additional CFAF 350,000 to the initial cost.[9] The profitability of the full system (water source, pump, storage reservoir, and drip irrigation kit), increases with the number of kits that can be supplied from a single water source, pump, and reservoir.

The major impact of the use of drip irrigation systems is a decrease in the cost of labor. In Mali, decreases of 40 to 50 percent in labor costs were reported (Winrock 2007), which corresponds to a saving of CFAF 200,000 to 300,000 per hectare. Fertilizers can be applied through drip irrigation (fertigation), which also saves labor.

Since 2001, trials of low pressure drip kits were conducted by ICRISAT in Niger in the framework of the development of a horticultural production system called African Market Garden. Results show this technology can be profitable (Box 3.4).

9 treadle pump + concrete reservoir of 2 m^3 + drip kit of 500 m^2

BOX 3.4: The African Market Garden experience in Niger

Since 2001, ICRISAT introduced and adapted low-pressure drip irrigation systems in Niger to become the basis of an integrated production system, called the African Market Garden (AMG) (in French Jardin Potager Africain). Four AMG systems were used in these pilot studies. They can be classified in two categories:

- Individual systems: includes 'thrifty' (80 square meters) and 'commercial' systems (500 square meters)
- Collective systems (collective use of water, energy and land): includes kits in series (multiple kits of 500 square meters) and community systems (5,000 square meters).

AMG systems were compared to the traditional irrigation system (watering can with a motorized pump). Results indicate:

- The set-up cost per hectare of individual systems is 70 percent higher than the set-up cost of traditional systems, but the economy of scale of collective systems is significant and reduces this cost by half, making it 30 percent cheaper than traditional systems.
- Operational costs for the AMG are about half of that of the gardens irrigated with watering cans. This is due to large savings in labor and fuel and water savings of up to 50 percent.
- A similar gross revenue per hectare between the different AMG systems, which is 38 percent higher than with traditional systems.
- A return on investment of six months for the collective systems and one year for the individual and traditional systems.

Sources: Bustan and Pasternak 2003; Woltering et al. 2011.

Drip irrigation development experience

The establishment of a distribution chain for drip irrigation kits has proved difficult. The network of drip-kit suppliers is not well developed, and the technology depends on project funds that provide partial or full subsidy to acquire the kits. The main drip-kit brands represented in the study area are IDE, NaanDan Jain and Nétafim. These kits are distributed by retailers with a limited stock. Winrock in Mali tried to facilitate the establishment of a network of drip-irrigation-kit suppliers, but the relatively short project duration (two years) and the small amount allocated to the promotion activities did not make it possible to consolidate the fragile chain of distribution. The demand remains very low and comes mainly from farmers or companies involved in commercial agriculture.

Several attempts have been made to reduce the cost of this technology. Since 1995, IDE has been developing alternative techniques to reduce the cost of drip irrigation kits, while maintaining production quality and offering a range of kits to meet the needs of producers. In Mali, some limited trials were conducted with manufacturing drip irrigation systems using local materials (electric casing, polythene) or with the substitution of primary and lateral pipes with pipes available on the local market (Sahel Consult 2002). In Burkina Faso, the group EIER/ETSHER (Ecole Inter Etats d'Ingénieurs de l'Equipement Rural and Ecole des Techniciens Supérieurs de l'Hydraulique et de l'Equipement Rural) conducted several trials on the use of local materials to manufacture localized irrigation networks (EIER/ETSHER 2004).

In some cases the additional initial costs involved in localized irrigation may be compensated by long-term water savings (Box 3.5). In these cases, policies to sustain the local production of drip irrigation or to strengthen the chain of distribution of imported materials should be encouraged. Water resources should still be carefully monitored: although drip irrigation considerably reduces the water applied to farmlands, it may sometimes produce higher evapotranspiration than surface irrigation by producing higher crop yields or by leading to an increased production area. As return flow

BOX 3.5: Where will localized irrigation (drip) be a critical component of small-scale irrigation?

In areas where water resources are limited and where aquifers are deep, the use of drip irrigation may be key to reducing the cost of pumping and the impact of irrigation on water resources in the long term by reducing evaporative losses.

Because of their fragile water resources, oasis systems are primary candidates for the application of localized irrigation. In these environments, irrigated agriculture can be very productive, providing up to three cycles of market gardens a year, but can also be very damaging to water resources; groundwater levels in the Ingal oasis (Niger) decreased by several meters in a few years, endangering traditional date palm agriculture. Localized irrigation optimizes the use of water, but monitoring of groundwater is still necessary to avoid depletion by excessive levels of crop production.

In Mali and in Burkina Faso, some aquifers are deep (more than seven meters below the surface) and wells are characterized by low outflows (1 to 5 cubic meters per hour). The use of localized irrigation can contribute to significantly reducing the volume of pumped water needed to irrigate and can irrigate a much larger area than traditional systems.

Source: Authors.

to the aquifer is lower and crop consumption is higher, the problem of aquifer depletion may not be solved (Ward and Pulido-Velazquez 2008).

3.3.3 Spraying

Spraying with sprinklers is practiced less in West Africa because of its high cost (CFAF 2 to 3 million per hectare). It is practiced primarily on large commercial plots by agro-industry for high-value crops. For these large-scale systems, this technology can reduce labor costs substantially as one person can oversee the irrigation of a plot of 5 hectares or more. Spraying uses less water than surface irrigation as evaporation and seepage are reduced,[10] but energy costs can be very high because high powered pumps are required to maintain pressure throughout the system.

The PPIP and DIPAC projects conducted some small-scale trials that revealed several difficulties with adapting high-pressure spraying systems to small-scale irrigation.

- The initial investment is prohibitive (up to CFAF 1,000,000 per hectare for mobile ramps manufactured with low pressure pipes)
- Water pressure must be higher than 25 meters (2.5 bar) to ensure watering uniformity. The majority of available motorized pumps do not meet this requirement.
- The cost of fuel for a spraying system is four times higher than for a Californian system.
- The pipes are not available, or it is difficult to find them on the market.

Low pressure spraying: a possible alternative but insufficiently studied

Low-pressure spraying consists of a motorized pump connected to a pipe with a rose pipe at its end. This technique is used by many smallholder farmers in West Africa. Many instances of its use are reported in Mali and Niger (Van't Hoff 2001), and it is commonly practiced on the coast of the Guinea Gulf (Nigeria, Ghana, Benin, and Togo). In Niger, the use of a low-pressure pipe with a diameter of 50 millimeters limits the applicability of this technique to very small plots because the pipe gets too heavy to move easily by hand if it is too long. Trials monitored by the FAO in Madagascar indicated that a simple low-pressure spray irrigation kit made up of average pressure PVC pipes of 40 millimeters in diameter and a hosepipe of 20 millimeters in diameter can irrigate an area of 1,500 to 5,000 square meters at an installation cost less than CFAF 175,000 (Practica 2007).

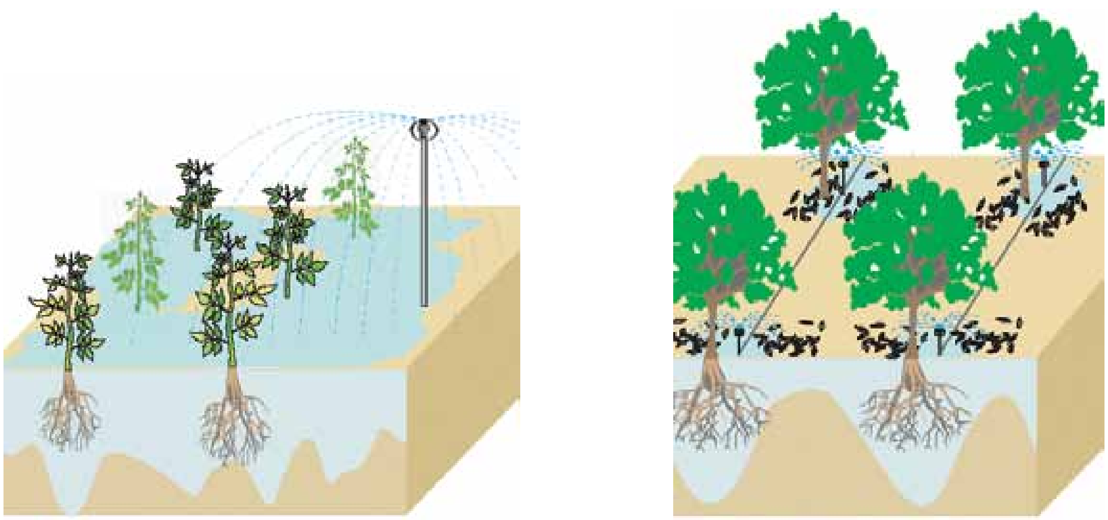
Some trials of micro-spraying kits (320 square meter coverage), of mini-spraying kits (150 square meter coverage), and of micro-jets were conducted in Mali by Winrock and the PCDA project. These technologies require a constant pressure of 5 to 10 meters (0.5 to 1 bar) provided by a pumping system (treadle pump, motorized pump, or electrical pump). There is little information on the performance of these systems or on their use by farmers in West Africa.

10 The water efficiency of sprinkler irrigation is lower in the sahel where evaporation of the droplets is more pronounced.

FIGURE 3.8: Spraying with a pipe and a rose pipe

Sources: Practica 2007; Nétafim 2009.

FIGURE 3.9: (a) Spraying and (b) Micro-spraying



(a) **(b)**

(continued)

(a)

(b)

Sources: Chapeaux and Enomoto 2009; authors.

3.3.4 Water distribution systems: synthesis

Improved water distribution systems can reduce the operational cost of irrigation because they require less labor and have lower pumping costs: less water can irrigate a larger area and a farmer can use the time saved on labor to pursue other income-generating activities. The choice of the technology depends on the pumping system available, the size of the plot, the topography, and the need to reduce water losses, labor, and pumping costs (Table 3.9).

TABLE 3.9: Water distribution systems: conditions of application

	CALIFORNIAN SYSTEM	DRIP IRRIGATION	SPRAYING WITH A HOSE PIPE
Investment cost	Medium	High	Low
Common system used	Motorized pump	One or several tanks supplied by a motorized pump or a treadle pump	Treadle pumps or low-power motorized pumps
Area irrigated	Up to 2 ha	1000 to 2000 m2 for one reservoir (a motorized pumps can supply 4 reservoirs)	Up to 5,000m2
Advantages	Reduce pumping charges and/or increase irrigated area Reduce water losses caused by infiltration Easy to adapt to plot topography and type of production Reduce irrigation time Water can be transported in long distance Easy to implement, material often available locally Irrigated area easy to expand	Reduce pumping charges and/or increase irrigated area Reduce water losses caused by infiltration, and non-beneficial evaporation Reduce labor Allow fertigation (save labor)	Reduce pumping charges and/or increase irrigated area Reduce water losses caused by infiltration Material often available locally
Drawbacks		Maintenance requires specific skills Equipment not available locally Difficult to adapt to plot topography (needs flat topography) and to the type of production (distance between crops not flexible)	Not suitable for large areas For pipe with a large diameter, space is needed Needs an additional person to operate (to hold the pipe)

Chapter 4: PROMOTING SMALLHOLDER PRIVATE IRRIGATION DEVELOPMENT: CASE STUDIES IN WEST AFRICA

This chapter presents the main features of the small-scale irrigation development projects in Nigeria, Niger, Mali, and Burkina Faso outlined in Chapter 2. We review the structure, goals, achievements, and challenges of each project and examine what worked and what did not work in terms of approach, implementation, and sustainability. The focus here is on the series of World Bank funded projects, although we also discuss the impacts of projects funded by other entities when they enlighten or clarify important issues. The lessons learned from these projects and some recommendations for going forward are then presented in Chapter 5.

4.1 NIGERIA: FROM A TOP-DOWN APPROACH TOWARD A COMMUNITY DEMAND DRIVEN APPROACH

In Nigeria, smallholder irrigation was promoted through two Agricultural Development Projects (ADPs) in the 1980s and a series of projects in the fadama region from 1990 through the present. Together these projects represent a comprehensive package for agriculture development that emphasized the empowerment of communities. In all these projects, investment in agricultural water management was part of a policy of broader support to agriculture development, including input supply (particularly fertilizers and seeds), extension services, rural infrastructure and access to output markets. The Fadama projects supported the development of institutions aiming to organize farmers into fadama users groups. The support to rural infrastructure development increased between Fadama I and Fadama II, as did the support to advisory services on production and commercialization.

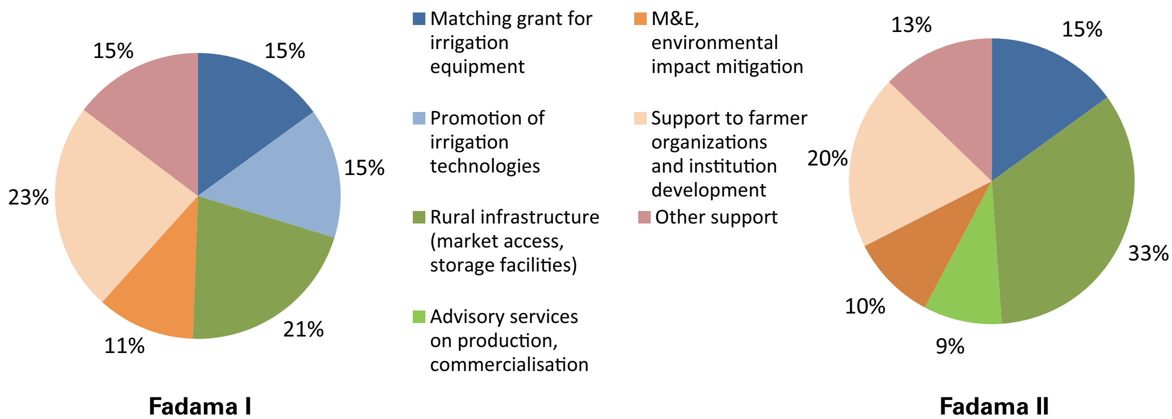
This report focuses on the Fadama series of projects, the main features of which are summarized in Table 4.1.

TABLE 4.1: Smallholder private irrigation projects funded by the World Bank in Nigeria

	ADP KANO	ADP SOKOTO	FADAMA 1	FADAMA 2	FADAMA 3
Project cost at appraisal (million $US)	482	498.7	105.9	100	457
Actual project cost (million $US)	187	257	104.2	102.8	—
Year of approval	1981	1982	1993	2004	2008
Closing date	1989	1990	1999	2009	2014
Project management institution	State and federal authorities	State and federal authorities	PCU/NFDO	PCU/NFDO	NFCO
General approach	Not part of the review		Supply driven approach benefiting only farmers	Community demand driven approach including all the fadama users	Community demand driven approach including all the fadama users
Support to irrigation technologies			Loan package provided by the government	Matching grants	Matching grants
Access to finance					Fadama equity funds
Advisory-service providers			Free public extension services	Matching grant for private service providers (demand responsive approach)	Matching grant for private service providers and support to public services
Supply of inputs			Subsidies	Subsidies	Subsidies
Environmental impact assessment			Federal authorities	State authorities and communities	State authorities and communities

Sources: World Bank 1995 ; World Bank 2000 ; World Bank 2010.
Note: PCU=Project Coordinating Unit; NFCO=National Fadama Coordination Office; NFDO=National Fadama Development Office.

FIGURE 4.1: Budget allocation of the Fadama I and Fadama II smallholder private irrigation projects in Nigeria



Sources: World Bank 2000 ; World Bank 2010.

4.1.1 Main features of the projects

Support to agricultural inputs, rural infrastructure, and access to finance

In the agricultural development projects and other national programs, the government of Nigeria provided support for access to finance for farmers through:

- A guarantee fund: The current interest rate of all banks on agricultural loans is 19–25 percent. However, small farmers can benefit from a refund of 40 percent of the interest, under the Agricultural Credit Guarantee Scheme Fund.
- Subsidies ranging from 50 percent to 65 percent granted to fertilizers and other inputs. For fertilizers, the federal government provides a contribution of 25 percent and the government of each state contributes up to 40 percent.

In addition, the Fadama projects provided matching grants for advisory services, rural infrastructure, and productive assets with different levels of contribution. Under the Fadama II project, the matching grants covered:

- 90 percent of the cost for the advisory services
- 90 percent of the cost for rural infrastructure, including rural roads, culverts, markets stalls, cold storage, boreholes, and irrigation infrastructure
- 70 percent of the cost of productive assets (initially 60 percent but this was increased to allow participation of more beneficiaries)

Under the Fadama III project, beneficiaries are also expected to benefit from similar matching grants, but the sustainability of these investments will be strengthened with the establishment of the Fadama Users Equity Fund. This fund will allow fadama user groups who receive matching grants for productive assets to withhold and save some percentage of the monthly benefits of the project-supported common assets. This fund can be used for replication of assets, asset operation and maintenance, or for any other activity that the group decides is viable to undertake. Because it decreases the dependence on future matching grants to maintain and replace equipment, this fund is expected to increase the sustainability of the investments after completion of the matching grant scheme.

Advisory services: from a supply-driven to a demand-driven approach

The Fadama I project adopted a supply-driven approach by providing free advisory services to beneficiaries through the existing state-led ADPs. The project provided advisory services to artisans and farmers, mainly about crop production techniques and the development of washbore drilling techniques.

The Fadama II and III projects adopted a demand-responsive service provision. The services are provided on request by users, who can choose their service providers (including NGOs and consultants). They pay 10 percent of the cost, the balance being paid by a matching grant. The scope of the service provision covers irrigation technologies, as well as agro-processing and marketing, and the service providers receive training in order to improve the quality of the services. In many states, in parallel to this Fadama project component, state extension workers still provide free extension services to farmers. Fadama III also includes support for these public services through training activities.

Monitoring environmental impacts

Fadama I financed aquifer studies and a monitoring system to assess the environmental impact of fadama development, which included the preparation of environmental and social impact assessments for the whole project; construction and monitoring of observation wells, and hydrological and meteorological stations; and soil sample measurements. The federal government was in charge of this component. No funding was allocated for mitigation measures (for example, pastoralist-farmer conflict resolution and good environmental management practices).

Fadama II environmental management plans were managed at the state level and included monitoring of individual project impact as well as cumulative impacts. Mitigation measures were included in each subproject. The project was completed by a grant from the Global Environmental Facility (GEF) Trust Fund (the second National Development Critical Ecosystem management project approved in 2006), with the objective to enhance the productivity of fadama areas and the livelihood systems they support through sustainable land use and water management. Additional monitoring of environmental mitigation measures was carried out, and sensitivity awareness and training was provided for fadama user groups. Resource use conflicts were addressed through integrated planning at the community level.

Based on the experience of Fadama II, the environmental and social impact assessment developed and used in the local development plan process was maintained and updated under Fadama III. A new GEF grant was also available to alert stakeholders to more sustainable options, depending on the local context and available sustainable land management options.

4.1.2 Achievements and remaining challenges

The World Bank post-project assessments (summarized in the Implementation Completion Report World Bank 1995, World Bank 2000, and World Bank 2010) rated most of the projects satisfactory or highly satisfactory (Table 4.2). The ADP Sokoto was rated unsatisfactory, but the irrigation component was by far the most successful element of the project.

TABLE 4.2: ICR ratings for projects in Nigeria

	ADP KANO	ADP SOKOTO	FADAMA I	FADAMA II	FADAMA III
ICR rating	Satisfactory	Unsatisfactory but component on irrigation rated satisfactory	Satisfactory	Highly satisfactory	(ongoing project)
Financial rate of return (%)			114 and 152[a]	48	
Economic rate of Return (%)			24	43	

Sources: World Bank 1995; World Bank 2000; World Bank 2010.
Note: a. Calculated for a farm using washbore and tube well technology, respectively.

Successful low-cost irrigation technology dissemination

Motorized pumps and manual drilling techniques have been widely disseminated in the fadama areas. In the Kano and Sokoto states ADPs, the components on pumps were by far the most successful elements of the projects and were greatly expanded beyond original plans. By 1992, more than 80,000 pumps, each irrigating between 0.5 and 1.0 hectares, had been distributed (World Bank 1995). The success of this program was due to i) its simplicity and low cost, ii) the ease with which farmers could take ownership of this technology, iii) subsidized inputs and iv) inexpensive fuel. The distribution was further expanded through loan packages under the Fadama I project with 55,000 pumps acquired through the project (although not all of them were used, see World Bank 2000). Demand-driven matching grants were available for rural infrastructure in Fadama II and many farmers were able to replace their pumps using these grants. The network of pump providers is now largely in place in Nigeria. Informal irrigation was developed from self-financing in states in Nigeria bordering the states where the Fadama I and II projects were implemented. These states benefitted from the informal trade of subsidized motorized pumps.

Through the Fadama I capacity-building program, farmers acquired knowledge about the necessary drilling techniques and lifting devices. All the farmers interviewed for the present study attributed improvements to drilling and pumping water easily to the introduction of the Fadama I project. No further support was needed for drilling techniques in subsequent projects.

Water is distributed through surface water distribution systems predominantly using the furrow, basin, and border methods. No new distribution technologies (drip irrigation, or other water saving systems) have been introduced on a broad scale.

Positive socio-economic impacts

All the project assessments show positive socio-economic impacts of the development of irrigation-based agriculture in the fadama areas.

In Gombe State, nearly 90 percent of beneficiaries of the Fadama I project reported that their incomes increased by some 5, 10, 13, and 20 percent (World Bank 2000). More remarkably, participation in the Fadama II project increased the value of individual productive assets by 49 percent, while the value of productive assets owned by groups of beneficiaries increased by 590 percent. Water and irrigation equipment was the most common group-owned productive assets acquired and the second most common individually-owned asset after transportation equipment (Nkonya et al. 2008). The direct and indirect beneficiaries of the project were estimated at about 3 million households of fadama resource users and non-resource users who live in fadama communities (World Bank 2010).

By the end of Fadama II, the benefit-cost ratio for enterprises was the highest for pineapple orchards (4.3) followed by sweet potatoes (3.2), tomatoes (2.7), onions (2.2), peppers and vegetables (1.8), okra (1.5), maize (1.4), and rice (1.3). The corresponding financial internal rate of return was again the highest for pineapple orchards (105 percent), followed by onion and tomatoes (70 percent), sweet potatoes and peppers (68 percent), and vegetables (55 percent). The economic rate of return and financial rate of return of the whole project were 43 percent and 48 percent respectively (World Bank 2010).

The development of irrigation in the fadamas created agricultural job opportunities during both the dry and rainy seasons. The assessment of the impact of the Kano and Sokoto ADPs reported that 80 to 90 percent of producers who were interviewed stated that they regularly used additional workers in their activities (World Bank 1995). The Fadama I project trained technicians about shallow drilling; these technicians are still working today. The construction of related infrastructure (rural roads, facilities for storage, processing and marketing) also created temporary jobs.

Surveys conducted after the ADPs and Fadama I program confirmed the traditional tension between farmers and pastoralists and noted that this has been heightened by increased cropping. To address this issue, a conflict resolution mechanism was promoted in Fadama II that led to an 85 percent reduction in conflicts among resource users (World Bank 2010). This notable achievement is attributable to the successful adoption of local development plans which bring to the table all the participating economic interest/resource-user groups (sedentary farmers, pastoralists, gatherers, etc.). They participate in a socially inclusive process of identifying the development priorities of their respective communities and translating those priorities into investment activities.

Advisory services: low involvement of NGOs and private sector

Advisory support services are mostly provided by the technical agents of the state. The results of these services during the Fadama I project were recognized as very positive by farmers. Yet, the ratio of extension workers to farmers is low, and the quality is not always satisfactory. Moreover, the scope of advice is limited to what the agents have to offer. For example, in almost all the sites visited, field observations revealed the absence of advice on proper irrigation scheduling.

Although Fadama II and Fadama III allow farmer groups to choose their service providers, involvement of private advisory-service providers (NGOs or private consultants) is generally low. The concept of demand-driven extension advisory delivery services has not been widely adopted. Farmers were used to the traditional supply-driven, free extension advisory services of the past, and most farmers are reluctant to pay for advisory services even with a 90 percent subsidy. There is a need for advocacy programs to be carried out to inform farmers about the effectiveness of demand-driven advisory services and a need to build capacity of extension workers to broaden the scope of their intervention.

The challenge of managing shared water resources

Groundwater monitoring systems were put in place by the successive projects, but data collection and analysis was not always constant, which made interpretation of the results difficult; the causes of variations in water level or the actions necessary to mitigate decreases in the water table were not identified. The Federal Ministry of Water Resources (FMWR) was in charge of the piezometric monitoring put in place by the Fadama I and II projects with minor involvement by the producers associations (10 percent of piezometric reports).

Farmers in many states complain extensively of decreasing groundwater levels that lead to increases in the cost of energy for pumping. The consequence of such aquifer overuse has also been felt in Niger as some aquifers extend into both countries. In order to limit over-abstraction, a minimum distance between wells (about 25 meters) was established in order not to affect the pumping conditions of neighboring gardens, but the limit is not always respected. However, the participatory approach developed by Fadama II and III is an efficient conflict resolution mechanism between water users. It brings to the table the resource-user groups, who collectively identify the development priorities of their respective communities.

Conflicts between water users, especially in the context of resource depletion are partly solved through this mechanism.

Progress can be made in saving water. In 2002, a study showed that most of the fadama farmers have little or no knowledge of good water management practices and conservation techniques (PSE 2002). Crop water demands and suitable application techniques are not widely disseminated. In addition, the observed groundwater depletion may not be due only to increased irrigation. On a market gardening plot near Kano, the producers have noted a decrease in the water level in direct correlation with the setting up of a sand extraction company on a river located upstream of the production area. The balance in water resources needs to be established at the level of the catchment, not limited to the irrigated area.

The challenge of processing and commercialization

While Fadama I expanded production and incomes, thanks to the adoption of simple, low cost irrigation techniques, crop losses were very high due to a lack of attention to marketing infrastructure and other value-addition interventions, such as processing; this lesson was incorporated in the design of Fadama II, which increased its support to rural infrastructure and advisory services on commercialization.

However, the problems of processing, storage, and transportation have not been properly addressed. Farmers have benefited from some processing equipment, such as cassava processing machines, groundnut oil extractors, maize shredders, and milling machines under the Fadama I and II projects, but there is still a lack of storage facilities. Packaging and transportation of produce to distant markets within the country is unsatisfactory, and goods deteriorate before reaching their respective destinations. Without storage facilities or transportation, the producers are forced to put their products on the local market soon after harvest, regardless of the demand and market price.

4.2 NIGER: SUCCESSFUL SCALING-UP OF A PILOT APPROACH

In Niger, low-cost irrigation technologies were promoted in the 1990s and 2000s through private-sector development and matching grant facilities of the Pilot Private Irrigation Project (PPIP) and the Private Irrigation Promotion Project (PIP2). These projects supported predominantly (i) the promotion of irrigation technologies, and (ii) capacity building and institutional development (for the irrigation agency in charge of the project implementation and for the private sector). Both projects also included a small component on environmental impact mitigation (Table 4.3).

TABLE 4.3: Smallholder private irrigation projects funded by the World Bank in Niger

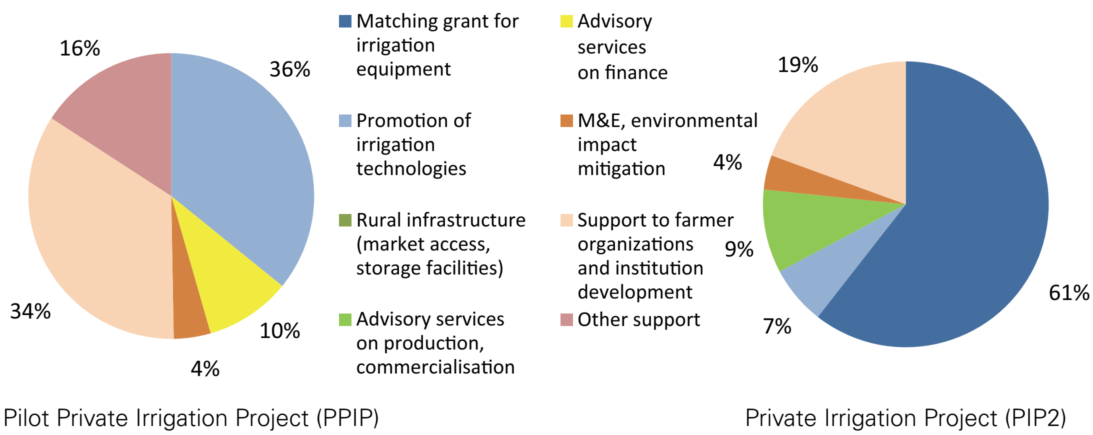
	PILOT PRIVATE IRRIGATION PROJECT PPIP	PRIVATE IRRIGATION PROMOTION PROJECT PIP2	AGRO-PASTORAL EXPORT AND MARKET DEVELOPMENT PROJECT PRODEX
Project cost at appraisal (million $US)	6.8	38.7	43.25
Actual project cost (million $US)	5.9	45.4	40
Year of approval	1995	2002	2009
Closing date	2001	2008	2014
Project management	ANPIP	ANPIP then Project Management Unit	Project Coordination Unit
General approach	Irrigation development through support to private sector (pilot)	Irrigation development through support to private sector	(not part of the review)
Institutional arrangement	Implemented by a private irrigation agency ANPIP (association) through PPP	Implemented by a private irrigation agency ANPIP through PPP, then by a project coordination unit	
Support to irrigation technologies	Promotion of technologies Use of private sector through ANPIP	Promotion (through ANPIP) and matching grant	
Access to finance	Advisory services to improve access to credit	Support to microfinance institution	
Advisory-service providers	Private operators (Economic interest groups GSC) established and trained by ANPIP Part of micro-project support	GSC trained by ANPIP Part of micro-project support	
Supply of inputs	Support to private retailers (training)	Support to private retailers (matching grant and training)	
Environmental impact assessment	Impact assessment and mitigation measures are part of a project component implemented by a research institute (transferred to NGO and local public services)	Impact assessment and mitigation measures are part of a project component implemented by another public agency (ROSELT), groundwater recharge infrastructure built	

Sources: World Bank 2002; World Bank 2009a; World Bank 2009b.

A third ongoing project, the Agro-Pastoral Export and Market Development Project (PRODEX) was implemented in 2009, but the targeted beneficiaries of PRODEX are commercial farmers rather than the smallholders who were targeted in the PPIP and PIP2. For this reason, the project will not be presented in detail in this section, but will be part of the discussion in Chapter 5.

The budget allocations for the two projects are presented in Figure 4.2. The support to advisory services on access to credit in PPIP was replaced by a matching grant to allow farmers to buy the technologies in PIP2, and this component became a major feature of the project. PIP2 also supported a specific component on production and marketing advisory services.

FIGURE 4.2: Budget allocation of two World Bank-financed smallholder private irrigation projects in Niger



Sources: World Bank 2002; World Bank 2009a; World Bank 2009b.

4.2.1 Main features of the projects

Institutional arrangement based on a public-private partnership

The Ministry of Agricultural Development delegated responsibility to a private irrigation management agency (ANPIP) to: (i) carry out promotional campaigns in support of the government's irrigation development strategy; (ii) facilitate small farmers' access to the legal and administrative procedures for obtaining tenure security; (iii) provide assistance, upon demand, in preparation of bankable irrigation projects and in establishing economic interest groups (Groupement d'Intérêt Economique, GIEs) then called Advisory Service Groups (Groupement de Services Conseils, GSCs); and (iv) ensure overall project implementation. As the overall results achieved under the PPIP were satisfactory, the Ministry of Agricultural Development also delegated the implementation of the PIP2 project to ANPIP through a similar project management contract, modified to take into account the new activities and the geographical expansion of the project.

ANPIP is an association that comprises private irrigators and operators involved in smallholder irrigation such as manufacturers, retailers, or advisory-service providers. A committee of monitoring and evaluation with stakeholders from ANPIP and from the government was established under the authority of the Ministry of Agricultural Development to report on the activities of ANPIP and provide suggestions.

Support to agricultural inputs, rural infrastructure and access to finance: matching grants preferred to access to credit facilitation

In Niger, access to finance is very limited for farmers. Microfinance institutions—called Decentralized Financial Systems (SFD) in West Africa—which are located in rural areas, require an annual interest rate of up to 24 percent (1.5 to 2 percent a month), which is higher than the interest rates of commercial banks. Attempts to develop access to credit for small farmers have not always been applicable to smallholder private irrigation.[11] The one exception to this is securing credit through storage, which can be a viable option

11 The West African Development Bank (BOAD) and the Swiss government supported a credit line for smallholder private irrigation through a microfinance institution in the Gaya region, but the experience was not successful as debts were still outstanding five years after the due date.

for farmers involved in onion production, one of the major crops in Niger,[12] as onions can be stored.[13]

The PPIP did not provide direct support to farmers to buy irrigation technologies or other inputs. The advisory services provided to facilitate access to credit and the low cost of available technologies were intended to supply farmers' demand. Suppliers also provided credit directly to farmers.

PIP2 provided a matching grant for irrigation investments in order to reach a broader range of farmers. The grant covered 70 percent of the investment cost for individual plots, 80 percent for producer organizations, and up to 90 percent for vulnerable groups (women and young farmers). In addition, a capacity-building fund for micro-finance institutions was put in place to benefit local savings-and-loans for irrigation operations.

Both PPIP and PIP2 supported the development and strengthened the capacity of a large number of pre-existing local, private input retailers (*boutiques d'intrants*). Matching grants were made available for working capital, and technical training was provided to the retailers.

Advisory services: the Economic Interest Group (GIE) or Advisory Service Groups (GSC) experience

The use of private specialized organizations to provide advisory services was tested in the pilot project and more largely promoted in the PIP2. The three main phases of the promotion of such specialized service providers are described in Box 4.1.

BOX 4.1: Three phases for promotion of specialized service providers

Learning process: At the beginning of the PPIP, young engineers (agronomists, agro-economists and rural engineers) were recruited and trained to support the emergence of small, private operators and to provide advisory services for the smallholder private irrigation stakeholders (producers, ONG, projects, donors). The two to three month training included issues related to innovative irrigation technologies, micro-project design and supervision, financing requests, accounting and management, and crop processing and storage.

Maturation: The PPIP project covered the cost of advisory services in areas close to sites with high irrigation development potential during the first two years. Engineers with complementary profiles were grouped into two newly created Economic Interest Groups (GIE), later called Advisory Service Group (GSC), which provided a large range of expertise. Then, the support gradually declined to help the activity become sustainable after the completion of the project.

Expansion: In 2002, the PIP2 project renewed its support to the GSCs by extending coverage to the whole country. The cost for the advisory services was fully included in the overall cost of the financing requests (about 8 percent of the overall request amount). Up to 43 GSCs were created but, after an assessment conducted in 2005, only 29 were considered to be performing satisfactorily and benefiting from project support. The PIP2 subcontracted many activities with the GSCs such as preparing technical and economic studies for producers, helping prepare subproject funding requests, conducting technology tests and dissemination, and building producers' capacity for crop production on irrigated plots.

Source: Authors.

Environmental impact assessment

In the pilot phase, groundwater monitoring activities as well as the analysis of the physico-chemical parameters of water and soil were managed by a public research institute, but the expected results were never achieved; the management was transferred to a NGO and local public services at midterm. To better address this issue, these activities were subcontracted by the PIP2 (Niger) to the Long Term Ecological Surveillance and Observation Network (Réseau d'Observatoires et de Surveillance Ecologique à Long Terme, ROSELT) to guarantee the sustainability of the mechanism. Small infrastructures (weirs) were also financed to allow groundwater recharge.

4.2.2 Achievements and remaining challenges

The World Bank post-project assessments (summarized in the Implementation Completion Report, World Bank 2002 and World Bank 2009a) rated the PPIP as satisfactory and the PIP2 as highly satisfactory (Table 4.4).

12 Niger is the number one producer of onions in West Africa (340,000 metric tons /yr).

13 In the FAO-supported input project in 1999, credit was secured by agricultural production (nonperishable crops) stored in a secured area. This credit was used to facilitate access to inputs for producer organizations. However, most irrigated crops (except onions) are perishable. This credit is not available for all farmers involved in smallholder private irrigation.

TABLE 4.4: ICR ratings for projects in Niger

	PPIP	PIP2	PRODEX
ICR rating	Satisfactory	Highly Satisfactory	(Ongoing project)
Financial Rate of Return (%)		24	
Economic Rate of Return (%)	66 and 68 a	27	

Sources: World Bank 2002 ; World Bank 2009a.
Note: a. calculated for the components on manual and mechanized irrigation, respectively.

Successful low-cost irrigation technology dissemination but dependence on subsidies

Around 20,000 pumps, 5,000 tube wells, and 17,000 low-pressure distribution systems were disseminated through the PPIP and PIP2 projects, covering an irrigated area of 16,000 hectares, and benefitting about 30,000 people (World Bank 2002, World Bank 2009a). A supply chain of irrigation technologies was in place at the end of the PIP2 project.

Part of the success is attributable to the commitment of farmers, who were well informed on all the aspects of crop production and were able to make decisions as private entrepreneurs. Part of the renewal of equipment for the extension of irrigated plots was self-financed by farmers. According to the survey conducted during PIP2 in Niger, 32 percent of manual pumps were acquired with personal funds. As an example, in Balleyara, Niger, M. Ahmed Abdou was operating a site equipped with a well and a motorized pump acquired through the food security project. The success was striking; he was able, with his own funds, to extend his plot to a second site equipped with four tube wells and a new pump.

However, because of the high level of subsidies for technologies during PIP2, the demand was artificially high and dropped when the project was completed. The private sector involved in the maintenance or manufacture of these technologies needed to diversify their activities. The support to the micro-finance institutions, which had very low capacity, was dropped at midterm; the project did not manage to improve their services and channel them to meet the demands of the farmers. The Implementation Completion report of the project (World Bank, 2009a) mentioned other issues related to the use of matching grants, including equity concerns (relatively better-off farmers tried to benefit disproportionately from the grant and in a few cases prepared fake applications), inefficiencies in incentives (incentives for farmers to buy motorized pumps rather than manual pumps even if their farming conditions did not require mechanized pumping), and crowding-out effects for other rural programs, with potential for distortions to the rural financial sector.

Positive socio-economic impacts

The PIP2 has demonstrated that small-scale irrigation is a valuable way to fight poverty and food insecurity. The financial analysis of subprojects showed that the income per hectare is at least ten times higher than for millet grown in rainfed systems. Farmers who participated in the PIP2 benefitted from revenue one and a half to three times the average revenue in Niger. At the household level, improvement in self-consumption averaged about 10 percent. The project had a total annual output of about 375,000 tons of all products at closure, representing 48,000 tons of cereal equivalent. This improvement is even more significant in the context of a chronic food deficit in Niger of an estimated 300,000 tons of cereal equivalent per year (World Bank 2009a).

In addition, the project created other types of employment: workers were trained in drilling tube wells, in manufacturing and servicing treadle pumps, as input retailers, and as advisory-service providers. The economic rates of return calculated for the manual and mechanized irrigation components of the PPIP were high (66 and 68 percent respectively), but the assessment was partial (World Bank 2002). The economic rate of return of the PIP2, at 27 percent, was also considered as excellent as it almost doubled the estimate calculated at appraisal. The financial rate of return of the same project was also high (24 percent) (World Bank 2009a).

The initial criteria for the selection of farmers by ANPIP (possession of a plot of land and monetary capital to invest in irrigation, among others) contributed to the exclusion of most of the poorest segments of the population including women. However, thanks to a specific effort after the PIP2 midterm review and an increase in the subsidy rates, women and young adults represented an average of 47 percent of the total beneficiaries by the end the project (World Bank 2009a).

Institutional arrangement: successes and limitations of public–private partnerships for project implementation

The performance of ANPIP during the pilot phase of the PPIP in Niger was praised as highly satisfactory (World Bank 2002).

The project succeeded in establishing an association covering private irrigation agents and professionals in related activities, from the grassroots to the national level. The association represents, provides services for, and defends the interests of small-scale irrigators. As the project implementing agency, ANPIP was also able to maintain good relationships with the government, the Bank, and the producers associations.

The Niger PIP2 project was initially managed through a similar institutional arrangement with ANPIP, but the responsibility for project management was shifted from ANPIP to a project management unit under the Ministry of Agricultural Development before the end of the project in May 2007. Officially, ANPIP failed to demonstrate sufficient integrity in the management of important funds (about US$40 million), but the decision also reflected a political choice; with the increase of project size from PPIP to PIP2 and the higher visibility of the project, the dialogue with the line ministry became difficult and resulted in a leadership crisis. The capacity of ANPIP was considered adequate at the PIP2 appraisal because of its achievements under PPIP, but it should have been reassessed against the increased size of the new project. When managing public funds the private sector needs to be proactive and stand as a best-practice example of transparency, with zero tolerance for any slippage. Today, ANPIP is responsible for implementing small projects and remains quite strong at the local level, but the long-term viability of the organization is in question.

Advisory services: the success of the GIE/GSCs and the need for further public support

The creation of a specific advisory support service, through the PPIP then by the PIP2, over a period of more than 10 years and extending to the entire territory of Niger, is a unique and rich lesson. Advisory service groups (GSCs) participated and supported the different steps in the development of small-scale private irrigation, and they acquired an incomparable expertise in the domain.

GSCs are located throughout the territory and have become reliable partners in the local agricultural development arena. They have also gained legitimacy as experts in smallholder private irrigation. The GSCs mostly give technical advice to producers, with few financial or economic management services provided. The GSCs are seen as ideal structures: they have the necessary skills to meet the demands of smallholder private irrigation farmers; they have a range of expertise; and they are close to the beneficiaries. At the height of the PIP2, some GSCs employed 7 permanent executives with supplementary profiles and 23 temporary agents in addition to technical senior executives who were subcontractors from the state.

However, access to GSC services and funds depends entirely on outside funds. The customers targeted by the GSC are mainly project beneficiaries because the farmers do not have the means to afford these types of services on their own—although the cost was lower than consultant companies. Contract activities with the PIP2 represented about 80 percent of the GSC activities volume; the remaining 20 percent came from other development projects that operated in the GSC action zone. In December 2009, more than one year after the closing of the PIP2 project, the overall staff of the GSCs had been cut in half, but the number of GSCs remained stable because of activity generated by other projects or partners (NGOs and other donors). The government has not stepped in to maintain the level of activity and expand the coverage to non-project farmers. The cost of the advisory services provided by the GSCs is a major constraint to poor farmers, and it seems unrealistic to expect the producers to fully finance these costs.

Environmental impact: lack of monitoring but efforts to raise farmer awareness

Through the PPIP and PIP2, efforts were made to inform farmers about environmental sustainable agricultural practices. The PIP2 supported the preparation of nine practical and applied guidelines covering various topics such as use of pesticides, use of fertilizers, water use and management, pest diagnostics and integrated pest management, environmental assessment of subprojects, control of disease vectors on irrigated plots, integrated natural resources management on irrigated plots, best practices in drainage and irrigation, and water management diagnostics. These guidelines contributed to the environmental education of the different stakeholders involved in the development of smallholder private irrigation and can be disseminated in other areas.

However, both the PPIP and PIP2 projects failed to adequately monitor groundwater quantity and quality. At the end of the PPIP, the results of the piezometric measurements were difficult to interpret because of the small number of piezometers and lack of leveling. Water and soil analyses as well as the water-level measurements available did not show any negative impact of agricultural practices used by farmers on their irrigated plots (World Bank 2002). At the end of the PIP2, water- and soil-management activities were considered one of the important components that would need to be strengthened in the future. Analysis allowed the identification of a number of fragile sites with regard to the availability of water. An action plan was elaborated to attenuate this risk, but could not be financed (World Bank 2009a). These activities have been incorporated in the follow-up PRODEX project.

The data available on groundwater levels are not sufficient to detect regional trends, although a decrease in water level has been observed locally in some areas. There is also not much information on soil salinity. A study carried out in 2009 by the Practica Foundation on the quality of drinking water from drillings and boreholes in the areas with shallow aquifers did not show significant correlations between the agricultural activity areas and water pollution by nitrates and nitrites (Practica et al. 2009).

The challenge of commercialization

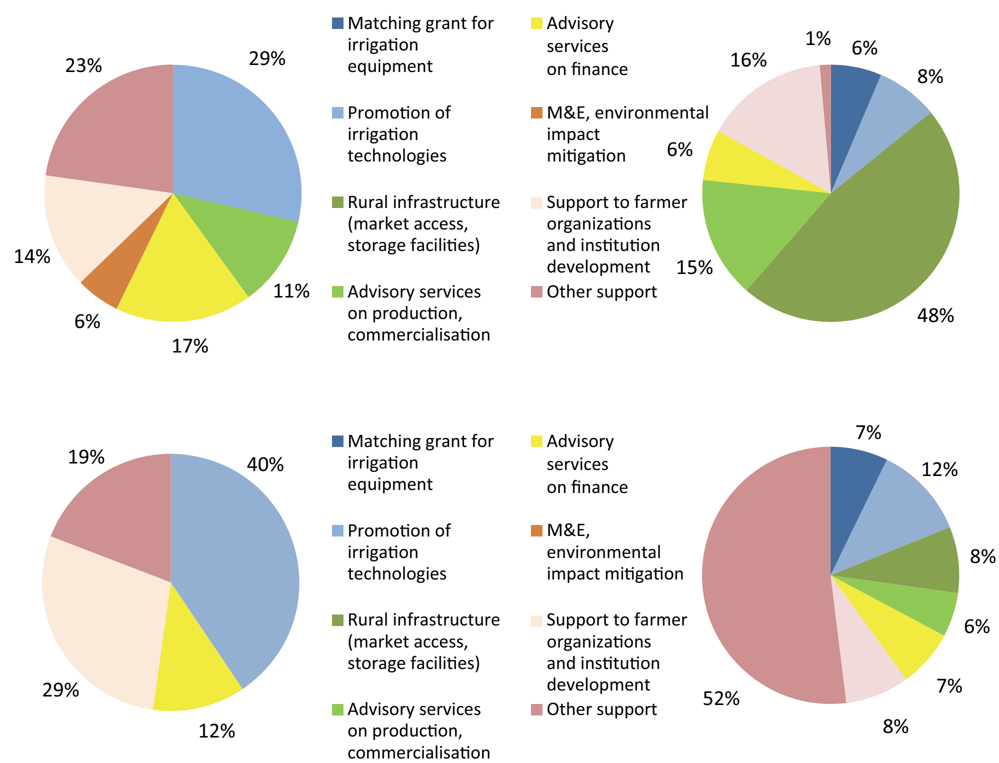
One of the constraints identified at the end of the PIP2 was the poor marketing conditions within the country and across borders, including but not limited to poor transportation services, lack of adequate storage and market infrastructure, excessive police and customs checkpoints, and an absence of regulation enforcement for regional markets.

For example, onion producers sell about 60 percent of their production after harvesting, when the price is low. After four to six months of storage, prices can often quadruple. However, traditional storage facilities can accommodate only two months of storage with a risk of losing 50–100 percent of production. More effective modern facilities were tested during the PIP2 but are not widely disseminated. Some farmers have started to adapt the production cycle to the period of high demand and high price, or to sign contracts with retailers guaranteeing a price, but they are still exceptions.

4.3 MALI AND BURKINA FASO: FROM PILOT SMALLHOLDER PRIVATE IRRIGATION PROJECTS TO A VALUE CHAIN DEVELOPMENT APPROACH

In Burkina Faso and Mali, the irrigation technologies were first promoted through irrigation private-sector development and then included in a broad range of support to agriculture. Pilot projects—PPIP in Mali and DIPAC in Burkina Faso—focused on the promotion of small-scale irrigation technologies, but they also supported related activities, such as institutional development (for irrigation agencies) and advisory services on access to finance. The PPIP also financed advisory services on crop production, environmental impact mitigation measures, and support to improved land titling (Figure 4.3).

FIGURE 4.3: Budget allocation of World Bank-financed smallholder private irrigation projects in Mali and Burkina Faso



Burkina Faso DIPAC

Burkina Faso PAFASP

Sources: World Bank 2004; World Bank 2005a; World Bank 2006b; World Bank 2007b.

In the second generation of projects, PCDA and PAFASP, the share of the budget allocated to irrigation equipment and promotion of technologies was lower, but the total cost of the project is much higher (see Figure 4.3 and Table 4.5), so the budget remains higher than the one available in the pilot phases. The projects focus more on rural infrastructure (PCDA) and supply chain development (PAFASP), with about half the budget allocated to these activities.

In addition to the World Bank projects, other initiatives aimed to promote smallholder irrigation technologies such as the PPIV, the PSSA, the PDR/B (Project de Développement Rural, Burkina Faso) and the PADL/CLK (Projet d'Appui au Développement Local Comoé–Leraba–Kénédougou) in Burkina Faso and the PSSA in Mali (see Chapter 2, Table 2.3)

TABLE 4.5: Smallholder private irrigation projects funded by the World Bank in Mali and Burkina Faso

	BURKINA FASO		MALI	
	Pilot Private Irrigation Development Project **DIPAC**	Agricultural Diversification and Market Development Project **PAFASP**	Pilot Private Irrigation Promotion Project **PPIP**	Agricultural Competitiveness and Diversification Project **PCDA**
Project cost at appraisal (million $US)	5.2	84.5	4.7	47.4
Actual project cost (million $US)	5.7	-	2.4	-
Year of approval	1999	2006	1997	2005
Closing date	2004	2012	2003	2011
Project management	APIPAC (private agency)	Project Coordination Unit	APROFA (public agency	Project Coordination Unit
General approach	Irrigation development through support to private sector (pilot)	Increase in agriculture competitiveness, through support to private sector	Irrigation development through support to private sector (pilot)	Increase in agriculture competitiveness, through support to private sector
Institutional arrangement	Implemented by a private irrigation agency APIPAC through PPP	Implemented by a project coordination unit	Implemented by a public agency (APROFA)	Implemented by a project coordination unit
Support to irrigation technologies	Promotion only, use of private sector through APIPAC	Promotion and matching grant	Promotion only	Promotion and matching grant
Access to finance	Guarantee fund	Guarantee fund and innovative financial instruments		Guarantee fund and development of financial instruments
Advisory-service providers	APIPAC, part of micro-project support	Three private operators supported directly by the project	Public agency (APROFA) supported directly by the project	Matching grant to pay for private operators Capacity building for private operators
Supply of inputs	Support to private retailers, guaranty facility available	Capacity building for private input suppliers		Capacity building for private input suppliers
Environmental impact assessment		Implemented through World Bank safeguard policy application	Included in a project component	Implemented through World Bank safeguard policy application

Sources: World Bank 2004; World Bank 2005a; World Bank 2006b; World Bank 2007b.

4.3.1 Main features of the projects

Institutional arrangement: pilot projects implemented by agencies (privately managed in Burkina Faso), but no follow up in the second generation of projects

In Burkina Faso, following Niger's PPIP success, the implementation of DIPAC was delegated to a private institution (Association des Professionnels de l'Irrigation Privée et des Activités Connexes, APIPAC). Each year, APIPAC signed an agreement of project management delegation with the government. A specific oversight arrangement allowed the government to control all expenditures higher than a certain threshold (about US$1,800).

In Mali, project implementation was delegated to an existing project implementation agency (a para-public structure). Although project preparation studies had proposed that project implementation be entrusted to an association of irrigation professionals, the government preferred to entrust implementation management to APROFA (Agence pour la Promotion des Filières Agricoles), an agency created to manage an existing agriculture commercialization project.

APROFA was in charge of the implementation of the two projects, but this agency had no experience or skills to manage private-sector development projects. The PPIP midterm review recommended the creation of an APROFA-Association with members being sector professionals to implement the project and foster a greater sense of ownership on the part of beneficiaries. But this transfer of responsibility was not implemented before the close of the project.

The governments did not renew the experience with implementation agencies in the second generation of projects. The PAFASP and the PCDA were implemented by a project coordinating unit (PCU), both under the leadership of the relevant ministries. These units improved their efficiency by delegating the implementation of some of their tasks to the public and private sector in the form of contracted services following competitive selection.

Access to finance: guarantee funds completed by a matching grant facility and by the development of innovative financing instruments

Access to financial services was addressed as part of activities related to guarantee funds in the DIPAC project. Secured funds provided by the Government of Burkina Faso to the banks involved in the operation offered a guarantee to mitigate irrigation loan risks. In parallel, the PSSA provided matching grants covering a maximum of (i) 50 percent of the cost for the rehabilitation or extension of irrigation perimeters, small infrastructure for water management in lowland areas, and rehabilitation of floodplain water management, (ii) 75 percent of the cost for the construction of weirs, crossing works and development of irrigated horticulture schemes, and (iii) 83 percent of the cost of well drilling (FAO 2001).

The PAFASP also plans to mobilize the guarantee facility, but it supports the test of innovative financing instruments (e.g., leasing, inventory credit) and most importantly, it includes the establishment of a supply chain promotion fund that will provide matching grants to finance micro-projects (75 percent of irrigation infrastructure). Other local development projects provide direct support to irrigation equipment (PDR, PSSA, PPIV). For example, the PADL in Comoé, Leraba, and Kénédougou (PADL-CLK, 2002-2011) aims to strengthen food security by increasing agricultural production by approximately 40 percent and supports 90 percent of the cost of irrigation equipment.

In Mali, the PCDA also provides technical assistance for the operation of a partial guarantee fund. In addition, it supports the creation and development of a range of financing instruments adapted to farmers, service providers, and agro-businesses. In addition to the World Bank projects, the PSSA phase 1, which started in 2004, provided additional financing instrument for small-scale irrigation development: a matching grant for infrastructures and a revolving fund to facilitate access to credit (Box 4.2).

BOX 4.2: Financing instruments available under the food security project (PSSA) in Mali

In Mali, the PSSA established a revolving fund. Groups of producers were able to open two bank accounts:

- The first account receives an initial fund from the project, which is used to start the first crop production season. Farmers reimburse this initial fund with a certain interest rate, and can use the initial fund again for the next production season.
- The second account is a blocked interest-bearing account, which receives the interest rate of the initial credit. This account can be used later depending on the producer needs, or can be used as a guarantee to request another credit.

Source: FAO 2009c.

Advisory-service providers changed from one project to the next

In the pilot projects, advisory services were provided directly by the implementing agencies, APIPAC and APROFA. In Burkina Faso, APIPAC provided significant support for marketing of agricultural products, mainly fruit and vegetables, through subregional and international market surveys, building the capacity of stakeholders to master the techniques and tools related to the business environment and supporting the establishment of partnerships between small producers and commercial companies.

In the second generation of projects, two types of advisory-service providers were used: research institutes and universities and independent consultants (although in Burkina Faso, the irrigation agency APIPAC is also eligible to provide advice). In Mali, the PCDA supports the promotion of advisory services by building the capacity of local operators (consulting companies), and matching grants from another Bank-supported project (Projet d'Appui aux Services Agricoles et aux Organisations de Producteurs, PASAOP) can be used by the farmer to pay for advisory services. In Burkina Faso, the project has a capacity-building component for advisory-service providers and a matching grant facility, which includes technical advisory services. Advisory-service providers are contracted and paid directly by the project; the service is free for the farmer. The implementation arrangements are different from Niger, where the payment for advisory services was part of the cost of the irrigation subprojects (therefore the farmer was aware of the cost of the service).

In Burkina Faso in early 2009, the creation of the agricultural entrepreneurship development office (Direction du Développement de l'Entrepreneuriat Agricole, DDEA) completed the effort to support advisory services. The mission of the DDEA is to promote agricultural entrepreneurship through developing enterprise incubators, supporting the creation of pilot production and processing units, identifying training needs, proposing management and normalization procedures and contributing to drafting legal and legislative texts related to agricultural enterprises.

Agricultural inputs and post production infrastructure

In Burkina Faso, the officially recognized distribution circuit for agricultural inputs consists of wholesalers and retailers, including input retailers as in Niger. There is also an informal distribution circuit of illegally imported inputs, mostly from Ghana and Nigeria, which are often not of satisfactory quality. In the Burkina Faso pilot project DIPAC, APIPAC provided a guarantee facility for new input supply centers to develop a private input supplier network and controlled some fertilizers and pesticides available for certain crops. The PAFASP also promotes capacity building for input quality for private input suppliers.

In Mali, the pilot project did not support input distribution or suppliers, but the PCDA includes a component for the development of private supply chains for the provision of inputs, including by building capacity.

Post-production infrastructure, including marketing, storage, post-harvest, and processing facilities are mainly supported by the second generation of projects. The PAFASP provides a matching grant facility that includes this type of infrastructure, whereas the PCDA finances the demonstration and dissemination of related technologies.

Environmental impacts

In Burkina Faso and in Mali, the creation of an aquifer monitoring system is part of the government strategy to mitigate the environmental impact caused by irrigation, but this mechanism has never been put in place.

In the PCDA (Mali) and PAFASP (Burkina Faso), subproject procedure manuals incorporate environmental impact assessments, but there is no detailed guide for operators (consultants and research departments) for preparing subproject impact assessments.

4.3.2 Achievements and remaining challenges

The World Bank post-project assessments (summarized in the Implementation Completion Report, World Bank 2004, World Bank 2005a) rated the DIPAC project as satisfactory and the PPIP as unsatisfactory. Although some positive results were obtained with the demonstration of production techniques in the PPIP, these results came too late to be disseminated under the project, and they have not yet been validated over the course of several cropping seasons. The project did not help to remove any of the baseline constraints identified at appraisal. The management by a para-public structure (APROFA) with no experience in private-sector development was unsuccessful.

Financial and economic rates of return are not available for the DIPAC and the PPIP projects.

Limited low-cost irrigation technology dissemination and lack of knowledge sharing:

The DIPAC project in Burkina Faso, in conjunction with other initiatives (PDR, PSSA, and PPIV), constituted a successful start to disseminate technology and strengthen the private sector:

- APIPAC achieved some of its targets and exceeded some of them. For instance, 1,547 treadle pumps, APIPAC's major irrigation equipment for smallholders, were sold against an initial target of 900 units. Beyond technology dissemination, APIPAC succeeded in two essential fields: (i) the development of agricultural advisory services for producers: 329 producers received technical and feasibility advice for the acquisition of irrigation equipment; (ii) the establishment of an extensive network of private providers of equipment and services: more than 50 artisans were trained in equipment manufacturing and maintenance and were organized in economic groups (World Bank 2005a).
- Between 2000 and 2005, the PDR sold 600 treadle pumps (covering 50 percent of the cost), 325 large wells and 52 manually drilled tube wells and built capacity of the technology suppliers (Darga 2005).

- Under the water management component of the PSSA between 2002 and 2005, 110 tube wells were drilled and equipped with treadle or motorized pumps (83 percent of the cost was covered), 36 hectares of irrigated horticulture schemes were developed, and water management was improved in 110 hectares of lowlands for rice production (FAO 2009b).
- Between 2001 and 2004, the PPIV helped develop 34,000 hectares of irrigated area, including 12,000 hectares for fruit and vegetable production (these small-scale irrigation schemes are mostly collectively managed) (MAHRH 2005).

Although these projects achieved their objectives, the lack of harmonization between projects (i.e., different level of subsidies, different technologies promoted, and different approaches) was seen as a constraint by many stakeholders. Private operators could not build a long-term strategy for their businesses, since they depended so heavily on project support (data from the association of Nafa irrigation technology suppliers show that only 20 percent of pumps are self-financed). Farmers were confused as they received different offers, and they were not always fully committed to irrigated crop production (many pumps were not used). Most of the project designs did not take into account other project strategies. As a result, projects were put in a position of competing against one another and some of them were slowed down as a result.

The PAFASP built partially on these experiences, but eligibility criteria (more than 3 hectares for individuals and more than 5 hectares for groups of farmers) excluded a large group of former project beneficiaries, and some low-cost technologies such as treadle pumps are less relevant for plots of more than 1 hectare. Local chains of distribution for low-cost technologies, such as treadle pumps installed during the pilot phase, are no longer supported. This change in the scale and the category of beneficiaries partly explains the difficulties encountered by the PAFASP, which did not have any technical, economic, or methodological reference for work at this scale. For eligible farmers, the additional irrigated area supported by the project is often significant, and the issue of product commercialization becomes more important.

In Mali, the pilot project did not succeed in testing and disseminating new technologies. Under the equipment testing protocols, the firm chosen to perform the tests (after a lengthy selection procedure lasting over two years) proved not to have the requisite skills. The second service provider hired (October 2002) to replace the first was even weaker. American NGOs, which are generally the most competent provider of testing services, were ineligible due to the type of funding (World Bank 2004). The following project (PCDA) could not use the results of the pilot phase and had to undertake the demonstration and dissemination of low-cost irrigation technologies in order to establish technical and economic guidelines. Unfortunately, they didn't use the knowledge and skills developed in Niger or Burkina Faso. For example, manual auger drilling was tried for the first time by the PCDA project in Mali early in 2009, whereas some trials had been conducted by the Niger PPIP 10 years before.

The PSSA in Mali failed to sustainably disseminate treadle pumps and motorized pumps. The major constraint was the lack of technical assistance to adapt the choice of technology to the local context: in some areas, the groundwater was too deep to use the treadle pump selected; in others, motorized pumps were used on small plots and the benefits were not sufficient to pay for operation and maintenance (FAO 2009c).

The PCDA project in Mali has already had some positive impacts from its support of irrigation and commercialization. For example, Dramane Kone, a producer of potatoes in Sikasso, used a manual auger to drill an irrigation borehole with his own funds. He then bought a motorized pump of 5.5 hp at CFAF 400,000 in Koutiala. Through the matching grant offered by the PCDA project, he built a storage area for his potatoes which allowed him to reduce his postharvest losses from 50 to 15 percent and increase storage time to 6 months. Now, he can sell his stored potatoes for CFAF 250–300/kg instead of the much lower harvest-time price of CFAF 150/kg. He negotiates credit for the cropping season with a micro-finance institution.

Socio-economic impacts: some positive results in Burkina Faso but no significant improvement in Mali

In Burkina Faso, smallholder private irrigation contributed 5 percent to GDP during the past five years through fruit and vegetable production and created nearly 400,000 jobs, including from irrigation in and around cities and jobs in micro-industries specialized in processing, marketing, and exports (Ouedraogo 2008).

Under DIPAC in Burkina Faso, producers doubled or tripled the area of their irrigated plots and increased their incomes by 50 percent; the training program increased the range of activities of some 500 input suppliers. The network of manufacturers and technicians that was created was able to offer more job opportunities; more than 30,000 operators (49 percent of them women) benefited from DIPAC services over 80 percent of the national territory (World Bank 2005a). From 2001 to 2005, the Village Private Irrigation Development Program (PPIV), employed a total of 175,886 people, including 61,560 women, to perform the activities included in the program (MAHRH 2005).

No significant socio-economic impacts were recorded after the PPIP in Mali. The PPIP put in place a system to facilitate land-title acquisition for farmers with an irrigation project. To a certain extent, the project helped increase familiarity with the legal aspects of land tenure and raised awareness of the importance of land ownership. But the component was not successfully implemented, as most land title applications were for purposes other than those targeted by the project, and only a few land title applications were actually accepted.

PPP arrangements not well accepted

In the completion report of DIPAC, the performance of the implementing agency (APIPAC) was judged highly satisfactory. This evaluation was based on (i) the dynamism of APIPAC both at the level of its technical team and its members; (ii) the range and volume of activities carried out during the implementation of the project; (iii) the results achieved in the field with producers and throughout the fruit and vegetable industry with private operators; (iv) the technical and commercial partnership developed by APIPAC (World Bank 2005a).

However, in 2007, the government of Burkina Faso handed over the implementation of PAFASP to the Ministry of Agriculture, Hydraulic and Halieutic Resources (MAHRH), citing its policy of "not putting money in the hands of the private sector." APIPAC continued to provide services to PAFASP through the formulation of subprojects after a competitive selection.

Access to finance: encouraging experience of guarantee funds and revolving funds

The guarantee funds established by DIPAC in Burkina Faso were used by 184 loan recipients; individual investors account for 70 percent and professional organizations for 30 percent representing a total of 5,800 people. Loans were used for production (65 percent), marketing (25 percent) and post-harvest operations (10 percent). The fund has had a low rate of disbursement (18 percent after two years, 40 percent at the end of the project) due to the lack of creditworthiness of the requesters (e.g. difficulty for small producers to mobilize additional guarantees) and the long processing time by commercial banks. Some investors may also have decided to drop their project because they realized that APIPAC credits were real bank loans, as opposed to project partial credit or matching grants (World Bank 2005a).

In Mali, the PSSA revolving fund was used by different types of producers and contributed to intensify rice and maize farming through the acquisition of high-quality, reliable fertilizers and seeds. This experience shows that revolving funds could be an efficient tool to build capacity on credit and to manage savings. However, they require strong producer organizations to collectively decide how to invest the savings and a clear definition of rules for each type of activity. In livestock management, for example, it may take several decades until all members benefit from the funds, and the risk that the organization will dissolve before that time is high (FAO 2009c).

Advisory services: a lack of strategic long-term vision

In Burkina Faso, advisory services provided by the private irrigation agency APIPAC showed satisfactory results. Producers received technical advice for the acquisition of irrigation equipment as well as advice on crop production. Because the agency did not directly depend on project support, it remained in place after the project closed and still provides advisory services with recognized expertise in small-scale irrigation. However, the demand for advisory services depends on the financial support of other projects, since farmers are not generally in a position to pay for advisory services without subsidies.

The second generation of projects, PCDA and PAFASP, support demand-responsive advisory services through universities and consultants. This mechanism does not establish a sustainable specialized advisory service, but it extends services to a broader range of possible topics. Some problems occurred in the implementation of this approach to managing advisory services:

- In the PAFASP project, the recruitment of service providers was delayed because of lengthy procurement procedures. In addition, the contracts were too short to include the design and the supervision of subprojects. As a result, investors were left without support after construction. New consultants were hired to fill the gap, but there was no continuity in the advisory services to producers.
- In the case of the PCDA, technical studies are often prepared by the technicians of the management unit in charge of coordination at the local level and not by consultants or research institutes. Even though the unit has some staff with technical expertise (agronomist–engineers and rural engineers), the technologies

being applied to smallholder private irrigation are innovative and require specific knowledge; technical capacity building is needed.

Environmental impacts: irrigation in urban and peri-urban areas presents health risks

In Burkina Faso, the expansion of small-scale irrigation contributes to the fragility of river and reservoir banks, and reduces the capacity of storage reservoirs through silting. In Mali, small-scale irrigation has not been widely developed, but positive impacts have been observed: fruit trees form hedges that protect irrigated plots from erosion and create more shade.

The main environmental issue raised in both countries concerns informal irrigated horticulture sites in urban areas, which are often exposed to polluted irrigation water. Sewerage often connects directly or indirectly to water points used for irrigation, and this has huge consequences on human health. Severe problems with polluted irrigation water in urban areas occur in Bamako, Ouagadougou, Niamey, Kano, and other cities (Drechsel et al. 2006). A study conducted on perceptions and risk management in irrigated urban and peri-urban agriculture in Burkina Faso revealed that only a small proportion of producers (14 percent) is fully aware of sanitation risks caused by wastewater use for irrigation (Ouedraogo et al. 2008). Yet, the majority of market gardening producers clearly understand other risks (expulsion, market, and climate).

4.4 COMPARISON BETWEEN COUNTRY EXPERIENCES

The review of projects presented in this chapter demonstrates that several approaches are possible to develop smallholder private irrigation. Each country has followed its own way to develop the sector, building on lessons learned from the successive support projects. Comparing these experiences is challenging because of the specificity of each case (socio-economic and environmental context, project design, success in implementation). Table 4.6 presents a synthesis of these experiences. Three main avenues for successful development of smallholder private irrigation can be identified: (i) stimulating supply-chain development of low-cost irrigation technologies, (ii) building the technical and financial capacity of farmers, and (iii) designing irrigation investment as part of a comprehensive investment package. Recommendations about how to pursue these approaches are detailed in Chapter 5.

TABLE 4.6: Successful measures and remaining challenges for the four case studies

	NIGER	NIGERIA	BURKINA FASO	MALI
STIMULATING SUPPLY-CHAIN DEVELOPMENT OF LOW-COST IRRIGATION TECHNOLOGIES				
Successful measures	Series of projects resulting in continued support and stable environment for private stakeholders and beneficiaries Development of an organized network of private suppliers Projects implemented by a private party representing the irrigation sector stakeholders [resulting in enhanced representation of stakeholders' interest in decision making]	Series of projects resulting in continued support and stable environment for private stakeholders and beneficiaries Continued financial support for technologies (manual drilling and pumps) Demand-driven approach resulting in a better ownership	Introduction of network of private suppliers (pilot project) Pilot project implemented by a private party representing the irrigation sector stakeholders	Continued test and promotion of low cost technologies
Remaining challenges	High subsidy rates resulting in dependence on subsidies and lack of sustainability Governance issues with the private implementation agency and implementation reverted back to a Project Implementation Unit thus reducing the long-term sustainability of the approach	High subsidy rates resulting in dependence on subsidies Improved water distribution systems not disseminated Low private-sector development and organization	Lack of harmonization between projects / financiers resulting in competing approaches and lack of visibility for private sector and farmers High subsidy rates in some projects; (subsidized equipment not properly used or maintained) Lag between pilot and following project and changes in design resulting in reduced consolidation of the promising results of the pilot project	Unsatisfactory performance of the public implementing agency Lack of knowledge sharing with other countries

(continued)

TABLE 4.6: Successful measures and remaining challenges for the four case studies *(continued)*

	NIGER	NIGERIA	BURKINA FASO	MALI
BUILDING FARMERS' TECHNICAL AND FINANCIAL CAPACITY				
Successful measures	Establishment of specialized private advisory-service providers (GSC) resulting in beneficiaries well targeted and committed in crop production GSC successful in getting funds from different projects	Farmer training in manual drilling resulting in local capacity building and low unit cost Continued involvement of public extension services Establishment of a Fadama Equity fund to increase savings for enhanced sustainability	Introduction of specialized private advisory-service providers Establishment of a guarantee fund resulting in increased involvement of commercial banks in the irrigation sector although the mobilization rate remained low	Establishment of a revolving fund to increase savings for enhanced sustainability, development of new financial instruments
Remaining challenges	GSCs rely on project support Lack of access to credit thus the need for high level of subsidy (addressed in the last generation of projects) Change in target beneficiaries in the last generation of projects (criteria not adapted to very small farmers)	Low involvement of NGO and private sector in advisory services resulting in high reliance on public extension services Lack of technical advisory services on water use	Change in target beneficiaries in the last generation of projects (criteria not adapted to very small farmers) Lack of long-term vision in the support to advisory-service providers	Change in target beneficiaries in the last generation of projects (criteria not adapted to very small farmers) Lack of long-term vision in the support to advisory-service providers
DESIGNING IRRIGATION INVESTMENT AS PART OF A COMPREHENSIVE INVESTMENT PACKAGE				
Successful measures	Continuous support to private input suppliers resulting in a large network of retailers Environmental impact assessment included as a component in some projects resulting in a better visibility and evaluation of this activity On-going support of value chain development through stakeholders organization	Continuous support to rural and marketing infrastructure Involvement of local communities in the water monitoring and management system resulting in enhanced conflict resolution Associated GEF grant to promote sustainable land management measures	Continuous support to private input suppliers resulting in a large network of retailers On-going support of value chain development through stakeholders organization	On-going support of value chain development through stakeholders organization
Remaining challenges	Focus on production compared to marketing which became the bottleneck (addressed in the last generation of projects) Issue of irrigation water quality in urban area not addressed No large-scale (watershed) approach to manage water	Focus on production compared to marketing which became the bottleneck Dependence on subsidies for inputs Lack of information on evolution of groundwater resources Issue of irrigation water quality in urban area not addressed	Issue of irrigation water quality in urban area not addressed Lack of groundwater monitoring systems No large-scale (watershed) approach to manage water	Issue of irrigation water quality in urban area not addressed Lack of groundwater monitoring systems

Chapter 5: LESSONS LEARNED AND RECOMMENDATIONS

The comparative study of a series of projects in four countries in West Africa demonstrates that there is significant potential for low-cost irrigation technologies to reduce poverty and generate agricultural growth for smallholder farmers. But the sector faces many constraints, and a comprehensive approach based on sustained policies is key to achieving the expected outcomes. There is still considerable room for improvement with regard to:

- building a strong, durable supply chain of irrigation technologies and promoting technological knowledge exchange by using a programmatic approach that harmonizes the work of different projects in the region;
- promoting the progressive increase in smallholder farmers' production capacity through support to well-adapted irrigation technologies, the development of specialized advisory services, and the design of financing for irrigation technologies that supports the farmer from initial investment to replacement without jeopardizing the development of a viable supply chain;
- designing comprehensive investment packages that address the entire production chain from the supply of inputs to the marketing of produce, while also ensuring that results do not harm the broader environment.

5.1 STIMULATING SUPPLY-CHAIN DEVELOPMENT OF LOW-COST IRRIGATION TECHNOLOGIES

One of the most persistent challenges to all the projects reviewed was how to build a strong, durable supply chain for irrigation technologies that can be maintained even after the project's close. We propose several recommendations drawn from the successes and challenges of the projects analyzed.

5.1.1 Support the introduction phase of new technologies through promotion campaigns, quality assessments, and private-sector organization

Engaging the private sector in the dissemination of irrigation technologies works, as demonstrated in Niger and Burkina Faso. However, the market is not always sufficient to promote new technologies; the public sector needs to play a central role in initiating the development and establishing an enabling environment. This support needs to be established with clear policies and government-established targets for the development of supply chains. Most critically, an exit strategy must be put in place for ending support when the activity becomes viable on a commercial footing.

The introduction of a completely new product may take a lot of time and money. It first requires research to develop or adapt the product to the context of the country. Low-cost irrigation technologies in West Africa could benefit from more public support to the private sector to undertake research and development of new products and technology and increased transboundary knowledge exchange (see below). For example, manual drilling is not commonly used in Mali and Burkina Faso, and low-cost water distribution systems, such as the Californian system, are not widely disseminated in West Africa although they have been adopted successfully in Mauritania; the areas where these techniques can be used need to be identified, and the potential for new product development and marketing needs to be assessed, before support is given for the introduction of new technologies.

Once a product has been developed and adapted to the regional context, the introduction of the product to the market is typically characterized by very slow sales, which may grow only slightly over a period of time. While profits will gradually improve during this stage, it may take a long time before the product becomes profitable. External funds are needed to subsidize this stage.[14] Kickstart estimates that the tipping point for self-sustaining profitability for treadle pumps will be met when sales reach 15 to 20 percent of the total market potential, and that it can take up to 12 to 14 years from

14 In most of the private companies, the products that are already at maturation stage "subsidize" the development of others. When it comes to products targeting high-risk clients (for example with very low purchasing power), the initial investment is not likely to be done by the private sector unless there is public subsidies to support it.

market entry to tipping point (Kickstart 2011b). Experience in Nigeria and Niger shows that the dissemination is much faster when operational costs (fuel for motorized pumps) or investment costs are subsidized, but the sustainability of the supply chain is then put at risk if subsidies are removed.

Several actions can help the private sector launch a newly developed technology:

i. A first action, at the early stage of the introduction phase, is the preparation of a market identification study supported by government. Broad marketing studies can be undertaken by consultants hired by the government, while studies related to a specific product would be best implemented by the investors themselves using a grant or credit provided for this purpose.
ii. A second action that efficiently accelerates the dissemination of proven irrigation technologies is to finance marketing operations in order to reach the tipping point of profitability more quickly. Experience suggests that these marketing operations are best implemented by a specialized operator involved in the supply chain.
iii. A third action is to inform the potential users about the quality of the products. This can be achieved through demonstration plots, guides, or the establishment and dissemination of quality standards. A sound policy of quality standards has not yet been established in the region. This could have a tremendous impact on market development, but it requires long-term substantial government support to suppliers' associations, and the mobilization of the necessary laboratory equipment.
iv. Finally, the private sector needs to be organized to deliver services to the operators involved in the value chain, including dialogue on policy issues with government, promotion of value chains, and advisory services for members. Projects in Burkina Faso and Niger show that a private irrigation agency can successfully represent, provide services to, and defend the interests of smallholder private irrigators as long as it receives some financial support from the government.

5.1.2 Support technology uptake without jeopardizing the viability of the supply chain

In addition to support to suppliers that directly targets the supply chain, technology uptake can be promoted at the client level through financial support, advice and training for farmers. However, high levels of financial support for equipment costs create an artificial demand, and this can jeopardize the private stakeholders involved in the supply chain once the support ends. Strategies for subsidizing irrigation equipment should be appropriately designed to limit their effect on post-project sustainability. An exit strategy needs to be included in the design of a matching-grant funding mechanism; this can be done through, for example, the progressive decrease of the subsidy rates or the establishment of saving funds that allow farmers to replace their equipment. The financing issue is discussed further below.

In the pilot projects in Niger, Mali, and Burkina Faso, subsidies were avoided during the introduction phase in order to build a strong foundation for the supply chain: the low cost and high investment return of these technologies should be attractive enough to allow a significant number of farmers to buy them, although the poorest farmers may still be excluded. The dissemination of motorized pumps from Nigeria to Niger is an example of the spontaneous diffusion that can occur when the product and its advantages are well known. Matching grants targeting only one group of potential clients (for example the poorest) can then accelerate the expansion phase of the technology without compromising the supply chain.

Finally, more than the level of subsidy, the key issue for sustainable supply chain development seems to be the appropriate selection of beneficiaries in the early stages of technology dissemination in order to create a critical mass of successful examples for others to follow.

5.1.3 Facilitate regional knowledge exchange involving private stakeholders

After 20 years of smallholder private irrigation development in West Africa, there is a lack of knowledge sharing and capitalization of experience. A large range of technical expertise was developed by mechanics, drilling teams, advisory services, and project technicians, but this expertise was underused by the recent smallholder private irrigation programs. Similarly, many lessons have been drawn from trials and demonstrations of low cost technologies appropriate to smallholder private irrigation, but because of the lack of knowledge sharing, experiments on already proven or rejected technologies are frequently duplicated. Language can also be a barrier to knowledge dissemination, particularly in francophone Africa. For example, treadle pumps are widely used in Eastern Africa and well disseminated through the internet with documentation available in English, whereas few francophone Web pages are dedicated to this technology.

Several actions can be taken to promote knowledge sharing:

i. **Support regional initiatives that aim to share knowledge, focusing on private stakeholders.** South-south knowledge exchange is critical. It can be done through Web platforms (such as the Communities of Practices in Horticulture cop-horti),[15] regional training modules, studies on the capitalization of experience between countries, or regional events that involve the private sector. The regional irrigation and drainage association, ARID, which represent 23 countries, has already demonstrated its efficiency in the coordination of irrigation professionals and in the preparation of knowledge-sharing events in French and English.

ii. **Involve NGOs with international experience in developing countries, as well as existing national organizations (NGOs, private agencies, technical experts), in project preparation by building on their knowledge of the sector.** The involvement of experts, technicians, and farmers from neighboring countries should also be promoted (for example, the involvement of the agency ANPIP from Niger in Burkina Faso). The creation of a professional directory to identify available multi-disciplinary experts capable of preparing and implementing smallholder private irrigation projects would be useful. ARID (Association Régionale d'Irrigation et Drainage) could carry out this task.

iii. **Share technical guides and manuals prepared for specific projects with other projects or countries.** Many documents on smallholder private irrigation have been collected as part of the present study (see the list in Annex 2). Many of them are already available on line. The Cop-horti Web site also includes many documents.

iv. **Define common quality standards, coordinate market development, and provide joint support to promotion and marketing activities.** Common standards and regional cooperation would help improve smallholder private irrigation equipment distribution chains across the region. The Economic Commission of West African States (ECOWAS) may be the most appropriate organization to coordinate these actions at the regional level.

15 Communities of Practice in Horticulture (Cop Horti) is a knowledge sharing platform where West African actors can combine and improve what they know and what they do about horticultural value chains in the region. http://www.cop-horti.net

5.1.4 Promote a programmatic approach and harmonize support policies between projects

A programmatic approach can be defined as a long-term and strategic arrangement of interlinked projects that aims to achieve large-scale impacts; in the long term, this approach will be more effective than piecemeal projects.

The continuity of successive projects is critical to obtaining sustainable outcomes. Introducing new technologies through the private sector requires time; the successive Fadama projects in Nigeria demonstrate how long-term support that builds on lessons learned from previous projects can bring successful results. Starting with a pilot project and then scaling up has also delivered results in Niger. On the other hand, the lack of follow up between the pilot phase and the second generation of projects created constraints to the successful implementation of projects in Burkina Faso and Mali.

The harmonization of initiatives from different donors should also be ensured to avoid competition between technologies. High levels of subsidies for a certain type of pump in a given area have an impact on demand and therefore on private stakeholders who try to develop the distribution of technologies based on farmers' needs. In Burkina Faso multiple initiatives with different levels of subsidy were promoted at the same time, leading to confusion for the farmers and for the private sector and slowing project implementation.

Lastly, the harmonization of customs duties at the regional level of the West African Economic and Monetary Union (WAEMU), which led to the adoption of the external common tariff, should be expanded to the other ECOWAS countries. Irrigation equipment as well as agricultural inputs are mainly imported and would benefit from a harmonization of import/export duties.

5.1.5 Set up an institutional arrangement for project implementation that involves beneficiaries and private-sector operators

The evaluation of the projects presented above revealed the importance of involving beneficiaries and their organizations (e.g., professional associations, producers' organizations) from the initial planning stages onward, and of giving them responsibility for implementation. The institutional framework should clearly spell out these responsibilities. Substantial support is required to enable them to assume this role.

Establishing private–public–partnerships (PPPs) that include management of public funds is risky, as PPPs require strong political willingness and sound supervision. The definition of tasks and responsibilities needs to be carefully defined and agreed upon. Even when tasks such as the promotion and dissemination of technology or advisory services can be delegated to a privately managed agency, the delegation of responsibility for the implementation of a smallholder private irrigation development project to a private partner may result in political problems, as seen in Niger and Burkina Faso.

5.2 PROMOTING THE PROGRESSIVE INCREASE OF PRODUCTION CAPACITY

One of the lessons that emerged from this project review was that different categories of farmers require different types of support to enable them to increase productivity sustainably through irrigation. And as farmers increase production capacity, their needs change. Successful projects should promote the progressive increase in smallholder farmers' production capacity through support to irrigation technologies adapted to local conditions and to the size of the farm, the development of advisory services tailored to the farmers' needs, and the design of financing for irrigation technologies that supports the farmer from initial investment to replacement without jeopardizing the development of a viable supply chain.

5.2.1 Support improvements to irrigation technology adapted to farmers' evolving needs

Recent projects tend to classify farmers using smallholder private irrigation into two categories:

i. Farmers with small plots (less than one hectare), who use low-cost irrigation technologies and sell most of their produce on the local market. This category, which can potentially represent a large number of farmers, was promoted in the Fadama projects as well as in the first generation of small-scale irrigation pilot projects funded by the World Bank in Niger, Burkina Faso, and Mali.

ii. Farmers with large plots (generally ranging between one and five hectares) who could benefit from high-performing (less labor intensive and more expensive) irrigation technologies but who, in most cases, are equipped only with simple irrigation equipment that may be inadequate for the area cultivated. This category of producers encompasses fewer farmers than the first but includes farmers with enough capacity and land guarantees to partially invest in market development and export. This category of producers is targeted by the second generation of smallholder private irrigation projects funded by the World Bank in Niger (PRODEX), Mali (PCDA) and Burkina Faso (PAFASP).

In Mali, Burkina Faso, and Niger most of the small farmers in the first category, who benefitted from the first generation of pilot projects, are not eligible for support under the second generation projects. And yet, in Niger and Burkina Faso, a promising dynamic of professionalization had started to respond to the demand of small farmers and further support would have encouraged this development.

Different categories of farmers require different support. Smallholder private irrigation development initiatives should not support one category or another but rather should include several components adapted to each to allow farms to gradually increase the area that they cultivate. Farmers' needs and constraints change after the adoption of new irrigation techniques. As described in Chapter 3, the cost of irrigation systems varies depending on the context of application including the size of the production area and the availability of labor and water. A smallholder farmer using traditional bucket irrigation is likely to buy the cheapest technology, such as a treadle pump, as a first investment. Once they achieve a return on this investment the farmer may use project support to invest in a motorized pump, and then in a water distribution system. Commercialization may be the next hurdle, and the farmer may build storage infrastructure and join a producer organization. Farmers in oasis areas may find water resources are a major concern and may therefore invest in drip irrigation.

The strong readiness of rural women to undertake income-generating activities, their reliability in terms of credit payment, as well as their inclination to lead the fight against poverty and food insecurity at the household level should be accommodated in the definition of the criteria for target groups for formal smallholder private irrigation projects.

Two types of social risks were raised in the projects reviewed and should be looked at during project preparation: (i) inequity in the access to land and to technologies as in Burkina Faso and Niger; (ii) potential conflict between water users as in Nigeria. The other negative social impact of smallholder private irrigation is limited compared to large- and medium-scale irrigation. The development is mostly demand-driven and doesn't require involuntary resettlement.

5.2.2 Promote specialized advisory services and build farmer entrepreneurial capacity

All the projects discussed in this report with the exception of Fadama I have encouraged producers to choose their own service providers and have promoted private service providers, but there are still constraints to this approach.

Traditionally, advisory services were provided by state-run extension services. For the past 15 years, West African countries, with the exception of Nigeria, have been gradually withdrawing from this costly activity. Funding remains the major issue to advisory-service development and sustainability (CAM-CIRAD 2006). Projects that promote producer participation have had difficulty in get the producers to pay even a small contribution. Financial support by the government and other partners remains indispensable. Three types of advisory-service providers have been supported in these projects; they each have advantages and disadvantages:

- A network of private advisory-service providers specialized in smallholder private irrigation can deliver results but requires long-term support. In Niger, private advisory services providers (GSCs) acquired exceptional expertise in the techniques available for smallholder private irrigation, and their proximity to beneficiaries meant that they could deliver services quickly and efficiently. But it took a long time (almost 10 years) for these services to mature and to be sustainable, and they still provide services mainly for development project-related activities since farmers cannot afford to pay for these services on their own.
- Private consulting companies or other existing organizations (such as producer organizations, and research institutes) can also be targeted as potential advisory-service providers, but they often don't have experience in promoting low-cost innovative technologies. Capacity strengthening is likely to be needed to ensure sound technical and financial design of the subprojects and appropriate use of low-cost irrigation technologies. This mechanism can be implemented faster than the first option, but it does not establish a sustainable specialized advisory service and is therefore not recommended.
- Public extension services are still key stakeholders in some countries. In Nigeria, although private-sector service providers and NGOs are eligible for matching grants, the existing free public extension services, together with the project technical team, are often preferred by farmers who are familiar with and trust this system; for example, public extension services played a key role in the dissemination of manual drilling techniques in the Fadama I project. Involving the private sector or NGOs in this context requires understanding the complementarity of different types of service providers; the Fadama III project, for example, will need to target its support based on the potential value-added of each approach. If the utility of the different kinds of services is made clear, farmers will have an incentive to use the new advisory-service providers and be willing to pay at least a small share of their cost.

Advisory services should not focus on advice for the use of the irrigation technology itself, which is usually provided by the retailer directly, but should instead cover key topics needed to optimize the use of the technology (e.g., technology choice, crop choice, calendar of production, nursery, treatment, fertilization, harvesting, conservation, and commercialization). Farmer entrepreneurship, in relation to production, processing, and marketing should be included. Irrigation subprojects funded by smallholder private irrigation development projects should be seen as small private enterprises that require sound financial management. The majority of small rural producers do not have the basic skills needed to manage their agricultural enterprises. For example, they often consider their farm profitable when the upfront costs are lower than the sales of the production, without considering equipment replacement costs especially when the initial investment was subsidized. Past projects did not support this type of advisory service, but in the PAFASP (Burkina Faso), the creation of the agricultural entrepreneurship development office (DDEA) in early 2009 was a positive step in this direction.

5.2.3 Support finance products that allow initial investment, maintenance, and replacement of irrigation technology

One of the central challenges to sustainable agriculture development in West Africa is to expand opportunities for resource-poor farmers to become actors and stakeholders in innovative systems. This category of farmer is severally constrained by a lack of access to affordable financing.

A matching-grant funding mechanism may be considered in smallholder private irrigation projects to allow the poorest farmers access to the technology. Successful results were obtained in Nigeria and in Niger under such a poverty reduction strategy. Matching grants and other direct grants should not become the main instrument for financing smallholder private irrigation and agriculture inputs, although they can be used to help the poorest farmers secure funding for their irrigation projects. Such grants could mistakenly encourage farmers to buy equipment that they cannot afford to maintain and replace—and could potentially create a black market in subsidized equipment below market prices. The use of matching grants may be improved by enhancing the selection process and by requiring farmers to save money to replace the equipment, as proposed in the Fadama III project with the Fadama Users Equity Fund.

The monitoring and evaluation of projects with matching grants should be strengthened and should include asset verification. As shown in Burkina Faso, many pumps subsidized by projects or NGOs are not in operation. Including physical asset verification, together with follow-up training one or two years after the implementation of each microproject, would help assess the effectiveness of the support through matching grants and adapt the subsidy policy accordingly.

Improving land tenure can be an effective way to increase farmers' access to credit, but it should be clearly separated from support to irrigation development. Otherwise, as shown in Burkina Faso, farmers may apply for project support to get land title without any interest in irrigation.

Other financial instruments that have been tried in smallholder private irrigation projects show promising results, but their implementation will need to be improved if they are to be applied successfully. Revolving funds (as in the Mali PSSA project) are intended to build capacity for credit, encourage better management of savings, and allow farmers to raise additional resources, but they require strong farmer organizations. A lack of transparency in the collective management of these funds increases the risk that the transfer of benefits from one member to the next will be interrupted. Guarantee funds (like in Burkina Faso) can be put in place with profitable capitalization mechanisms, but commercial bank requirements need to be adapted to farmers' needs. Lastly, credit secured by stored production (warrantage, like for onions in Niger) can help producers increase revenue from their produce by selling it at a higher price than is available right after the harvest, but they are only viable for products that can be stored easily.

5.3 DESIGNING SMALLHOLDER PRIVATE IRRIGATION INVESTMENT AS PART OF A COMPREHENSIVE INVESTMENT PACKAGE INCLUDING ENVIRONMENTAL IMPACT MITIGATION

One of the main lessons of the project review undertaken here is that successful growth in smallholder irrigation depends on the broader context of support. In the long term, it will be necessary to design comprehensive investment packages that address the entire production chain from the supply of inputs to the marketing of produce, while also ensuring that results do not harm the broader environment.

5.3.1 Improve the supply of inputs

The success of any agricultural production intervention depends on access to fertilizers and good quality seed, adapted to local conditions and at a price that the majority of farmers can afford. These factors are only partially covered in this report, based on lessons learned from the reviewed experience.

Experience shows that private companies can be used to provide inputs to farmers, but they need support to reach profitability. In Burkina Faso and Niger, past projects helped develop a network of private input retailers. The Niger PRODEX project continues this support through technical assistance to private operators to structure their businesses, organizing contract farming, building producer-trader partnerships based on commercial relationships, and training small producers in seed production and best packaging practices and granting them licenses.

Subsidizing inputs, the option chosen in Nigeria, is well received by farmers, although the quality of services is not always satisfactory. The lack of sustainability of this option and the need to identify an exit strategy are issues that go beyond the scope of smallholder private irrigation development. The government should ensure that supplies comply with health and environmental regulations. Problems of quality can appear when informal markets start to develop, as happened in Nigeria.

5.3.2 Address marketing issues

Storage, processing, marketing, and transportation of products remain a challenge in the development of irrigation in the four countries under review. The state of the roads and the administrative and customs constraints associated with transportation to markets increase the price of products and limit intra- and inter-regional trade. Accessing international markets requires appropriate packaging and compliance with standards, which also increases the cost.

From a value chain perspective, the key challenge is to link supply and demand in the most effective way; information sharing is very important for enabling these producer-consumer linkages. Organizations that help link producers, transporters, and distributors to consumer markets are vital if value chains are to function effectively. One key parameter to be considered at project design or in marketing studies is the need for geographical concentration of production, which will establish the critical mass required to attract wholesalers to production areas.

The development projects under implementation in 2010 address some of these issues. Their approaches consider irrigation as an input to production. They aim to help organize producers and other agro-business stakeholders and to develop value chains for different produce: mangoes and onions in Burkina Faso (PAFASP), cowpea and onion in Niger (PRODEX), and mangoes and other horticulture production in Mali (PCDA). In Nigeria (Fadama III), more support is given to rural infrastructure including roads and storage and processing facilities. At the regional level, improved coordination could ensure that internal competiveness is based on a common strategy to promote complementary and comparative advantages in the region.

5.3.3 Promote mainstreaming of environmentally friendly agricultural practices and sound impact monitoring systems

Because of the private nature of smallholder private irrigation, national environment protection policies often are difficult for public institutions to enforce. The control of small-scale irrigators, who are free to choose types of investments, crops, and agricultural practices, requires clear rules, a sound monitoring system, and a penalty mechanism. Experiences from smallholder private irrigation projects show that institutions in charge of the environment failed to properly address this issue in West Africa. Similar problems have been observed in other regions of the world, including India, the Middle East, and North Africa. Although groundwater depletion in West Africa is not yet as critical as it is in these areas, the risk of overuse of resources linked to the increase in the number of irrigators should not be overlooked.

Groundwater resources are poorly monitored and hydrology is not always properly analyzed. Piezometric monitoring should be conducted over several years to evaluate the groundwater balance (e.g., actual water consumption by the crop, evaporation, irrigation return and exchange with the river) taking into account inter-annual climate variability to establish trends. The cost of such a program can be reduced by increasing the participation of advisory-service providers, farmers, and drilling teams in data collection, and by giving priority to areas with a high concentration of irrigation. Data analysis can be carried out by national institutions or basin agencies, but results need to be discussed with communities and farmer associations.

Groundwater quality needs specific attention in urban and peri-urban areas. Again, participation by farmers in monitoring and data collection, and effective communication of the results, are critical to raise awareness about the health and environmental risks of wastewater use in irrigation.

Participative approaches toward environmental management should be associated with a mechanism for conflict resolution. Water shortages can lead to conflicts between users (pastoralist and farmers or between farmers), as happened in Nigeria. Under Fadama II, a conflict resolution mechanism was put in place and produced positive results.

To better protect the environment, farmers should be made aware of the environmental impact of their activities and be encouraged to adopt good water and agro-chemical management practices. Securing access to water for irrigation creates agricultural intensification and the increased use of fertilizers and pesticides. Guidelines on best practices in irrigated agriculture, including appropriate drainage, irrigation water application, fertilizer, and pesticide use were prepared under the PIP2 in Niger and could be adapted to other projects. Such practices should be promoted by advisory-service providers; specific training may be required for suppliers and users of agro chemical products.

This approach should be part of a holistic vision linking the development of irrigation and environmental protection. For example, in Nigeria, farmers have limited access to advice on how much and when to irrigate. Controlling the amount of water used and the timing of irrigation can limit evaporative losses and increase productivity. In water-scarce areas like oases in northern Niger, irrigation technologies, like drip systems, that bring the necessary quantity of water to the crop can help reduce water losses and soil salinity, increasing soil fertility.

Groundwater recharge can be increased by facilitating infiltration into the aquifer through local water retention. This type of measure was promoted under the PIP2 and PRODEX projects in Niger. The measures include small catchments dams and weirs or half-moon structures (that also allow restoration of degraded land). Beneficiaries are in charge of implementation and will bear operating and maintenance costs.

5.4 CONCLUSION

The success of smallholder irrigation in West Africa in the past 20 years was based on the development and dissemination of low cost irrigation technologies that respond to farmers' needs, allow individual ownership, improve the productivity of irrigated crops, and raise household incomes.

The potential, however, cannot be achieved without the participation of the private sector, which in turn depends on the existence of an enabling environment for the development of private entrepreneurship in the sub sector. Stimulating supply-chain development will be important and can be greatly facilitated by the use of a programmatic approach. Matching grants targeting one subgroup of potential clients (for example the poorest) may be considered, but other financial instruments (warrantage, revolving funds, guarantee funds) show promising and more sustainable results. Smallholder private irrigation investment should be part of a comprehensive investment package including marketing, input supply, and environmental impact mitigation.

The large range of technical expertise developed in the countries under review, especially in Niger and Nigeria should be shared at the regional scale. Training modules targeting project managers, advisory-service providers, engineers and technicians could be prepared with the experts of different countries and made available in the regional institution such as the International Water and Environment Institute based in Ouagadougou. This would also benefit other countries in the region.

Enhanced monitoring systems and detailed impact evaluation studies would help to further improve our understanding of how to best support the development of smallholder private irrigation. Harmonization between projects and countries in terms of monitoring systems with a shared set of indicators would greatly facilitate the comparisons between different approaches. This is something that could be supported at regional level by institutions like ARID, CILSS (Comité Permanent Inter-Etats de Lutte contre la Sécheresse au Sahel) and ECOWAS.

ANNEX 1: "KNOWLEDGE SHARING IN THE DEVELOPMENT OF SMALLHOLDER PRIVATE IRRIGATION FOR HIGH-VALUE CROPS IN AFRICA: A REVIEW OF RECENT AND ONGOING EXPERIENCES": TASK LIST

This report is based on a number of background reports, field visits, and workshops that were carried out as part of the knowledge-sharing activity "Knowledge sharing in the development of smallholder private irrigation for high-value crops in Africa: a review of recent and ongoing experiences."

The objective of this knowledge-sharing activity was to generate best practices approaches to address shortcomings in the sustainable development of smallholder private irrigation schemes. Past and ongoing experiences in privately managed small-scale irrigation activities in Niger, Nigeria, Mali, and Burkina Faso were reviewed. Issues to be addressed included: (i) adequacy of the institutional and regulatory framework, the respective roles of the government and professional organizations; (ii) strategy for promoting private suppliers of irrigation equipment and maintenance services; (iii) technical design of irrigation technologies; (iv) availability of market outlets for high-value crops; and (v) the availability of funding resources such as rural credit.

The activity included the following tasks:

Task 1: Desk study

The literature review was carried out to gather documentation on smallholder private irrigation projects in West Africa (project design and evaluation) and on the technical, financial, and institutional aspects of the subsector. Technical references collected are listed in Annex2.

Task 2: Work program and definition of methodology

A workshop was held in Ouagadougou in Sept 23-26, 2009 to present the objective of the activity, formulate the work program, and develop the methodology for field visits focusing on identification of good practices and definition of comparable indicators. Forty people involved in smallholder irrigation projects in the four countries attended this workshop. A methodology note was prepared.

Task 3: Fieldwork

Fieldwork was conducted in each of the four countries to (i) gather information from professionals on small-scale irrigation, progress on irrigation development, and issues and challenges; (ii) visit sites of ongoing and completed projects; and (iii) discuss the results with the professionals during a national workshop. Around 40 people attended each of the four national workshops. Field visits lasted between 10 and 15 days in each country and were structured as follows: Sept 27–Oct 5, 2009 in Burkina Faso; October 5–15, 2009 in Mali; November 16–24, 2009 in Niger, and November 25–December 3, 2009 in Nigeria. Four national reports were prepared

Task 4: Result dissemination

A regional synthesis was prepared and presented during a three-day regional workshop held in Ouagadougou (Burkina Faso) on June 15–17, 2010. This report is based on the regional synthesis and includes the main points raised during the workshop. Eighty-five stakeholders involved in smallholder private irrigation development attended the workshop including irrigation experts, irrigation project coordinators, private-sector groups working on irrigation technologies, local financing institutions (micro finance), NGOs, farmers' organizations, research centers, relevant services of the ministries at the national level, regional institutions, and donors. The four targeted countries were represented as well as four other West African countries (Senegal, Ghana, Togo, and Côte d'Ivoire).

Dissemination of the results started shortly after the final workshop. A short movie was prepared in August 2010 by the World Bank Institute (WBI). A session presenting best practice in small-scale private irrigation was included in a regional learning event on agricultural water management and climate change organized by WBI in Ouagadougou in November 2010. The relevant lessons of the learning event were presented at the World Bank Water Days in February 2011.

ANNEX 2: TECHNICAL REFERENCES FOR LOW-COST IRRIGATION TECHNOLOGIES

References for low-cost drilling techniques

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Hand Drilling Directory: summary of hand drilling techniques; overview of dissemination in select countries; list of organizations involved and other references	RWSN, UNICEF, WSP, 2009. Hand Drilling Directory. Kerstin Danert Ed. Rural Water Supply Network, St Gallen, Switzerland.	http://www.rwsn.ch/documentation/skatdocumentation.2009-11-17.8949250582/file (English)
Report on the financing options for low-cost wells for rural water supply	Practica, EWV, UNICEF, 2010. Financing Options for Low-Cost Well Drillers & Communities for Rural Water Supply. UNICEF, New York, USA.	http://www.unicef.org/wash/files/02.pdf (English) and http://www.unicef.org/wash/files/02_F.pdf (French)
Technical manuals on augering, jetting, percussion		http://www.unicef.org/wash/index_49090.html (French and English)
Technical manual on rota sludge and stone hammer drilling techniques	Van Herwijnen, A., 2005. Rota Sludge & Stone Hammer drilling 1: Drilling Manual. ETC-Foundation, Leusden and Practica Foundation, Papendrecht, the Netherlands.	http://www.pseau.org/outils/biblio/resume.php?docu_document_id=1798 (English)
Maps of areas appropriate for manual drilling in Africa (Benin, Central African Republic, Chad, Cote d'Ivoire, Liberia, Madagascar, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo)		http://www.unicef.org/wash/index_54332.html (English)
Technical manual for smallholder irrigators in Niger, which includes augering and washbore techniques	MDA Niger, 2008. Manuel technique de l'irrigant privé, prepared for the PIP2 project. Niamey, Niger.	http://www.cop-horti.net/IMG/pdf/150_Manuel_Technique_de_l_irrigant_prive.pdf (French)
Technical characteristics of manual drilling in Burkina Faso	Enterprise Works, 2004. Rapport technique final. Volet technologies de captage de l'eau. Prepared for the DIPAC project. APIPAC, Ouagadougou, Burkina Faso.	
Technical manual for smallholder irrigators in West Africa, which includes augering and washbore techniques	EIER/ETSHER, 2004. Les petits systèmes d'irrigation à faible coût en Afrique Sub-saharienne - Manuel technique de réalisation. Prepared for FAO and Japan GCP/RAF/340/JPN. Ouagadougou, Burkina Faso.	

References for treadle and manual pumps

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Technical manual for smallholder irrigators in Niger, which includes the description of seven treadle and manual pumps	MDA Niger, 2008. Manuel technique de l'irrigant privé, prepared for the PIP2 project. Niamey, Niger	http://www.cop-horti.net/IMG/pdf/150_Manuel_Technique_de_l_irrigant_prive.pdf (French)
Technical characteristics of six low-cost pumps in Burkina Faso	Enterprise Works, 2004. Rapport technique final. Volet technologies d'exhaure de l'eau. Prepared for the DIPAC project. APIPAC, Ouagadougou, Burkina Faso.	
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Brochure W3W pump	W3W, 2008. La petite irrigation avec la PEP. Brochure. Oberburg, Swizerland.	http://www.w-3-w.ch/pep_e.html (English) http://www.w-3-w.ch/pep_f.html (French)
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Note on IDE pumps		http://www.ideorg.org/OurTechnologies/TreadlePump.aspx (English)
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References for motorized pumps

CONTENT	REFERENCE	LINKS
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Performance of motorized pumps in Mauritania	Practica, 2008. Banc d'essais motopompes et analyse technicoéconomique de la campagne 2007/2008. Report prepared for the project VISA. Ministère de l'Agriculture et de l'Elevage, Nouakchott, Mauritania.	http://www.cop-horti.net/IMG/pdf/235_Volet_PIP_-_Banc_d_essais_motopompes_et_analyse_technico_economique_de_la_campagne_2007_et_2008.pdf (French)
Performance of 13 motorized pumps in Burkina Faso	Sedogo, 2004. Programme de Test de la gamme de motopompes vendues au Burkina Faso. Report prepared for the project DIPAC. APIPAC, Ouagadougou, Burkina Faso.	
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Performance of 13 motorized pumps in Niger	Abric, S. Bom, G.J. Lacas, J.G. Oumarou H. 2000. Banc d'Essai Motopompes. Prepared for the PPIP project, ANPIP, Niamey, Niger.	
Manual for motorized pump maintenance in Mauritania	Practica, 2008. Manuel maintenance motopompe. Prepared for the VISA project, Ministère de l'Agriculture et de l'Elevage, Nouakchott, Mauritania.	http://www.cop-horti.net/IMG/pdf/249_Manuel_maintenance_motopompe.pdf
Technical manual for smallholder irrigators in West Africa, which includes instruction for installation and maintenance of motorized pumps	EIER/ETSHER 2004. Les petits systèmes d'irrigation à faible coût en Afrique Sub-saharienne - Manuel technique de réalisation. Prepared for FAO and Japan GCP/RAF/340/JPN. Ouagadougou, Burkina Faso.	

References for low cost water distribution techniques: the Californian system

CONTENT	REFERENCE	LINKS
Technical manual for smallholder irrigators in West Africa, which includes instructions on Californian system design and maintenance	EIER/ETSHER, 2004. Les petits systèmes d'irrigation à faible coût en Afrique Sub-saharienne - Manuel technique de réalisation. Prepared for FAO and Japan GCP/RAF/340/JPN. Ouagadougou, Burkina Faso.	
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Technical manual for smallholder irrigators in Niger, which includes the description of the Californian system	MDA Niger, 2008. Manuel technique de l'irrigant privé, prepared for the PIP2 project, Niamey, Niger	http://www.cop-horti.net/IMG/pdf/150_Manuel_Technique_de_l_irrigant_prive.pdf (French)

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Technical manual on drip irrigation design and maintenance in Mali	Chapeaux, J.P. and R. Enomoto, 2009. Guide d'irrigation 3. Installation des systèmes d'irrigation. Prepared for the PCDA project, Ministère de l'Agriculture, Bamako, Mali.	http://www.pcda-mali.org/docs/Guides%20irrigation/guide_irrigation_3.pdf (French)
Technical manual for smallholder irrigators in Senegal, which includes instruction on drip irrigation design and maintenance	Chapeaux, J.P. Chapeaux, J.P. and R. Enomoto. GUIDE 2 ÆEquipements des Parcelles ÆPrepared for the PDMAS project. Unité de gestion et coordination, Dakar, Sénégal	
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CONTENT	REFERENCE	LINKS
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Technical manual on micro-sprinkler and sprinkler irrigation	Chapeaux, J.P. and R. Enomoto, 2009. Guide d'irrigation 3. Installation des systèmes d'irrigation. Prepared for the PCDA project, Ministère de l'Agriculture, Bamako, Mali.	http://www.pcda-mali.org/docs/Guides%20 irrigation/Guide_irrigation_1.pdf French)
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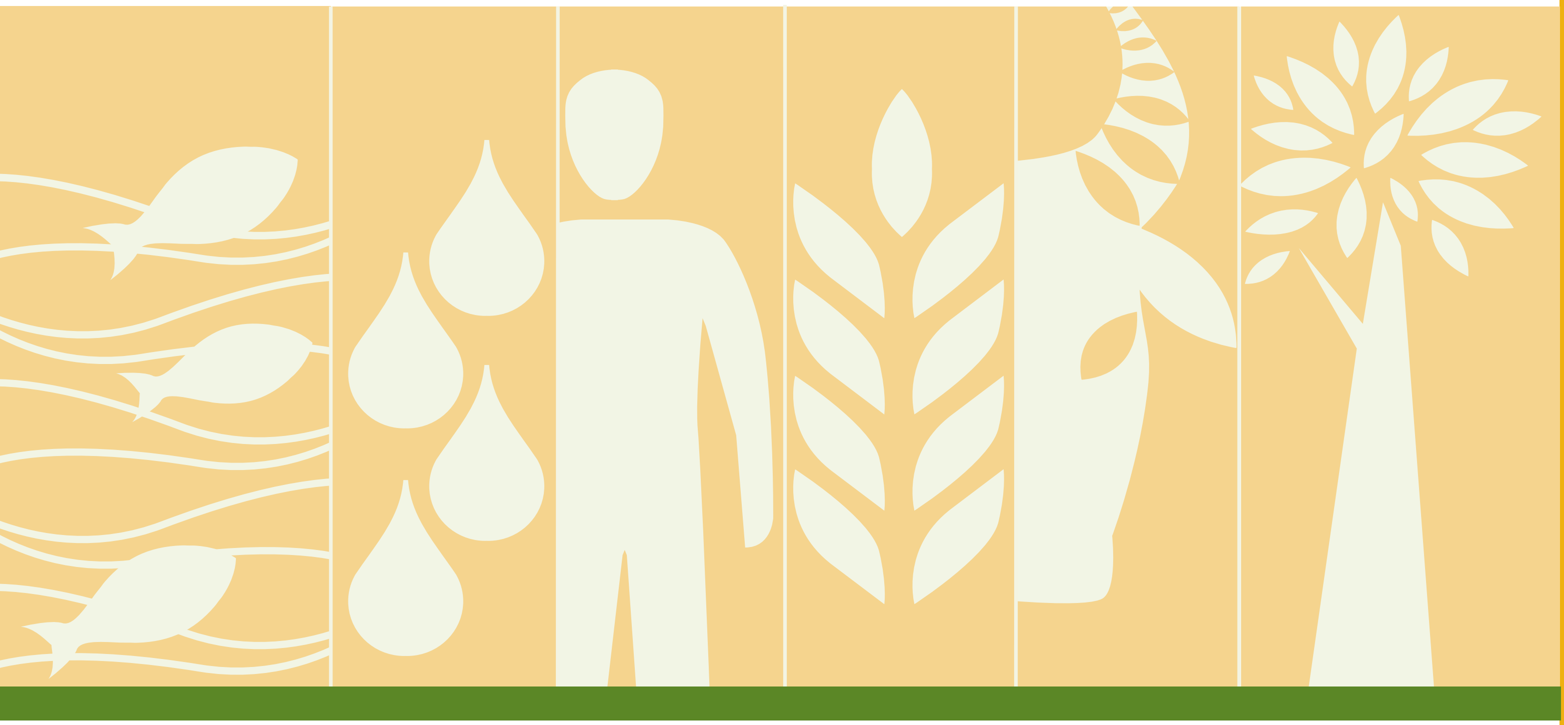

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