PROMOTING AGRICULTURE COMPETITIVENESS THROUGH SOLAR ENERGY

BACKGROUND NOTE

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ECOWAS CENTRE FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY
CENTRO PARA AS ENERGIAS RENOVÁVEIS E EFICIÊNCIA ENERGÉTICA DA CEDEAO
CENTRE POUR LES ENERGIES RENOUVELABLES ET L'EFFICACITÉ ENERGÉTIQUE DE LA CEDEAO

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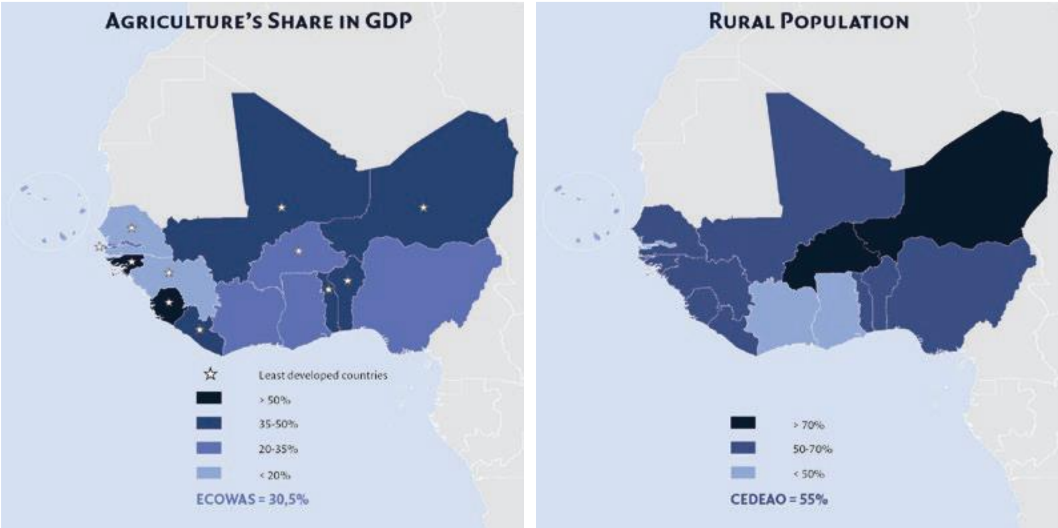
1 INTRODUCTION

Agriculture is the main economic activity in the ECOWAS region, contributing about 30% of the regional GDP and employing 55% of the population (ECOWAS, 2015). It is often the sole source of household income for millions of people in rural areas, where most of Sub-Saharan Africa's poor live. The potential for agricultural growth is huge in the sub-region, with vast tracks of land suitable for agriculture and favourable ecological conditions for the production of high-yielding rice varieties and vegetables. Agricultural growth is therefore key to poverty reduction, and can also help drive national economic growth and employment (World Bank, 2017).

Figure 1- Agriculture's share in GDP in ECOWAS countries



Source: ECOWAS, 2015

Despite its importance, agriculture remains largely a subsistence activity (Mensah et al., 2016). Per hectare yields are among the lowest in the world, as increases in production have been obtained by putting more land under cultivation (extensification), not by increasing productivity of existing agricultural land through appropriate technologies and crop varieties (intensification). An additional problem is the high rate of post-harvest losses, reaching 20% in Sub-Saharan Africa due to, among others, poor transport links and lack of refrigerated storage.

In addition to the previous limitations, agriculture suffers major environmental impacts, particularly as a result of climate change. The sub-region has experienced a 25% decline in rainfall over the last fifty years, damaging predominantly dryland areas. But agriculture does not only suffer climate change impacts, it is also a key contributor to them. As a result of extensive farming, as well as uncontrolled logging and firewood collection, forests and woodlands in West Africa are receding at an alarming rate.

Improvements in infrastructure, access to technology and markets are all key to increasing competitiveness of agriculture in West Africa. Sustainable energy solutions can contribute to these needs throughout the life of the crop: from irrigation to processing for final consumption. Electricity demand from agriculture in Sub-Saharan Africa is expected to double between 2015 and 2030 (World Bank, 2017). Irrigation systems will be the largest source of electricity demand from agriculture, representing 75% of demand, with the rest from agro-processing. Geographically, West Africa will dominate this demand, driven from small-scale developments in the Gulf of Guinea and the rehabilitation of existing schemes in the Sudano-Sahelian region (ibid). Considering the importance of irrigation's electricity demand in the ECOWAS region, this concept note provides some background on about agriculture in the region, its gender dimensions and the role that ECREEE can play in promoting gender equitable solar irrigation systems.

West Africa has an enormous potential for solar irrigation. Although the region has relatively abundant water resources, irrigated lands represent a very small percentage of agricultural lands. For example, in the Sahel less than 5 percent of agricultural lands are irrigated, compared to about 20 percent worldwide. Among irrigated lands, there is an abundance of diesel generators, even in lands with access to the grid, due to the poor reliability of electricity supply in rural areas. Costs of fuel and transportation are very high as a consequence. Solar irrigation systems can reduce production costs and support diversification into high-value crops. Their deployment can dramatically improve agricultural productivity and raise the incomes of the poor if adequately linked to regional, national, and international markets.

Like in all other economic sectors, gender matters in agriculture. Women provide much of the agricultural labour but they face distinct constraints that keep their productivity lower than that of male farmers. Women have typically lower access to agricultural inputs like labour, land or fertilizer. They exhibit lower rates of adoption of high-yielding varieties and improved management systems. When they adopt new technologies, often these have differential impacts on their well-being as compared to men. Hence, gender neutral interventions to improve agricultural productivity are unlikely to deliver equal results for men and women farmers.

The remaining of this concept note reviews the regional policy background; the evidence about constraints to agriculture productivity in West Africa; highlights gender differences in the agricultural sector; then provides recommendations on how to implement gender inclusive solar irrigation projects; and closes reflecting on the role ECREEE can play to improve agriculture competitiveness with sustainable energy. Some key regional stakeholders and previous experiences of irrigation in West Africa are detail in the annexes.

2 REGIONAL AGRICULTURAL POLICY BACKGROUND

West African Agricultural Productivity Program (WAAPP)[1]

The West African Agricultural Productivity Program (WAAPP) was designed to respond to the challenges of increasing agricultural productivity. It started in 2008 under the auspices of the ECOWAS, with a financial facilitation from the World Bank (WB) and coordinated at sub-regional level by CORAF/WECARD. WAAPP aims to generate and accelerate the adoption of improved technologies in key priority areas of agricultural sectors involved in WAAPP, technologies that align with the priorities of the main agricultural priorities of the sub-region. It also aims to provide producers with technologies to enhance and improve the competitiveness of the main speculations in each beneficiary country. Across West Africa, WAAPP has delivered around 160 climate-smart crop varieties, technologies and techniques to approximately 5.7 million farmers covering 3.6 million hectares. These technologies have boosted productivity by up to 150%[2].

West African Alliance for Climate-smart Agriculture (CSA)[3]

CSA was born in 2015, in the context of the COP21. Through this Alliance the regional actors plan to develop and implement "instruments to support climate-smart agriculture to increase, sustainably

[1] WAAP official website: http://www.waapp-ppaao.org/en/content/who-we-are
[2] West Africa Agricultural Productivity Program (WAAP). Available at: http://www.worldbank.org/en/topic/agriculture/brief/the-west-africa-agricultural-productivity-program
[3] West African Alliance for Climate Smart Agriculture. https://ccafs.cgiar.org/publications/climate-smart-agriculture-alliance-and-framework-west-africa#.XJDXLigRc2w

and equitably, farm productivity and incomes, enhance adaptation and resilience to climate variability and change, and sequestrate and/or reduce greenhouse gas emissions wherever possible and appropriate".

ECOWAS regional agricultural policy (ECOWAP)[4]

The ECOWAS Regional Agricultural Policy for West Africa (ECOWAP) was produced for the Paris conference on the Regional Agricultural Policy for West Africa, held on the 9th of December 2008. The regional Agricultural Policy adopted by ECOWAS sets out a vision of "a modern and sustainable agriculture based on effective and efficient family farms and the promotion of agricultural enterprises through the involvement of the private sector. Once productivity and competitiveness on the intra-community and international markets are achieved, the policy should be able to guarantee food security and secure decent incomes for agricultural workers." Its general objective is to "contribute in a sustainable way to meeting the food needs of the population, to economic and social development, to the reduction of poverty in the Member States, and thus to reduce existing inequalities among territories, zones and nations." In order to achieve a coherent implementation of ECOWAP and NEPAD's agricultural programme, a joint implementation plan was defined, with six priority areas, the first of which is improved water management through promoting irrigation and integrated water resource management.

Irrigation Initiative in the Sahel (2is)[5]

the High Level Forum on Irrigation in Sahel held in Dakar in October 2013 resulted in the launch of the Sahel Irrigation Initiative (2iS) by the six Sahelian countries and the Comité Permanent Inter-États de Lutte contre la Sécheresse au Sahel (Permanent Interstate Committee for Drought Control in the Sahel, CILSS). The Dakar Declaration, adopted by all participating countries and CILSS, recommends ensuring "that all hydro-agricultural developments be based on appropriate sectoral policies and strategies, which are integrated in a value chain approach and based on a rational and sustainable use of available resources." The initiative was supported by the regional economic communities (ECOWAS and UEMOA) and the World Bank.

Regional Agency for Agriculture and Food (RAAF or ARAA)[6]

RAAF is specialized technical body to manage ECOWAP projects and programmes and build the capacities of bodies comprising the ECOWAS Commission, particularly the Department of Agriculture, Environment and Water Resources. The Agency was officially launched in Lome, Togo on the 27th September 2013.

The mandate assigned to the RAAF is to "ensure the technical implementation of the regional investment programmes and plans contributing to making the ECOWAS agricultural policy operational by calling on the regional institutions, bodies and actors with recognised competencies". More specifically, RAAF has the mandate to:

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[4] ECOWAS Regional Agricultural Policy (ECOWAP): https://www.diplomatie.gouv.fr/IMG/pdf/01_ANG-ComCEDEAO.pdf

[5] Cadre Stratégique pour l'Eau Agricole au Sahel, http://www.reca-niger.org/IMG/pdf/2iS_CadreStrategique_FINAL.pdf

[6] http://www.araa-raaf.org/en

3 CONSTRAINS TO AGRICULTURE PRODUCTIVITY IN WEST AFRICA

The agriculture sector in West Africa faces several constraints to increase productivity. This section reviews the evidence about some of these constraints, highlighting debates about their importance and the ways to address them.

3.1 Land ownership

In West Africa, smallholder farmers typically claim rights over land through customary procedures and do not hold formal land titles (Camilla and Guèye, 2003). Traditional practices can lead to land litigation between families and community members, as well as to land seizure by elites. Besides, lack of land ownership titles can become an obstacle to agricultural development if they remove the incentive to invest in developing the land, or prevent the use of land as a collateral for agricultural credit. Policymakers have typically tried to address this situation by replacing customary systems with modern systems of land tenure involving land titling and registration (for example USAID, 2013).

There is evidence, however, showing that registration may not have the intended effects. It can in fact exacerbate disputes and enable land grabbing by elite groups. Farmers without access to education, information and contacts are particularly at risk of losing their rights over land. Women, and herders are among the most vulnerable, as holders of secondary land rights that do not tend to appear in land registers. Moreover, when transaction costs of registering land are high, land transfers stop being recorded and the register becomes quickly out of date (Cotula et al., 2014).

Flexible approaches are proposed as the best way to deal with land ownership problems. Communities could devise the tenure options most appropriate to their specific needs and retain the elements of customary systems they find useful, taking into account vulnerable groups. Land users should be well informed and effective dispute settlement procedures should be established (Cotula et al., 2014).

3.2 Smallholdings

Sub-Saharan Africa, like the developing world as a whole, produces most of its food in small (Mensah et al., 2016; FAO, 2011). The debate on whether small or large farms are more productive is still not settled. A large body of empirical research argues that there are efficiency benefits to small farms, while other research points at the advantages of large commercial farms in terms of finance, technology and learning effects. There is in fact a dynamic argument for farm efficiency according to size, that indicates that small farms have an advantage over large farms in terms of labour supervision and local knowledge, but larger farms gain the advantage as an economy shifts toward technologically advanced, capital-intensive, and market-oriented agriculture. These advantages emerge from economies of scale in lumpy investments such as machinery or oxen and working capital needs (Poulton, Dorward, and Kydd 2010).

There are both supporters and detractors for small farms in Sub-Saharan Africa. On one hand, smallholders and the institutions supporting them are considered as weak agents for labour productivity growth in Africa (Collier and Dercon, 2009). The Chinese or Vietnamese models, with an increasing size of landholdings, strong economic growth in non-farm sectors and massive migration from rural to urban areas could potentially accelerate structural transformation. On the other hand, this model is considered ill-suited for Sub-Saharan Africa due to a lack of non-farm employment opportunities commensurate with the growth of unemployed rural youth. Other reasons to avoid large scale agriculture are the potential emergence of a large class of discontented landless rural workers and the numerous reported failures of large scale agriculture in Africa. For example, support to irrigation in the Sahel saw heavy investments in large scale public irrigation schemes in the 1960s and 1970s, fuelled by heavy subsidies. The entire agricultural production cycle, from input provision to marketing, was vertically integrated and controlled by public irrigation companies. However, this model collapsed in the 1980s and irrigation companies refocused on water management, sometimes transferring management to irrigation users' associations. At the same time, a larger share of investments was directed to small-scale irrigation and to food security, so that it now represents the largest part of irrigated and irrigable land (World Bank, 2017).

Context-specific policies on farm size can help balance the needs of small farmers with the economies of scale achievable through large scale land acquisitions by foreign and domestic entities (IFPRI, 2013). Smallholders' productivity can improve through stronger links to input and output markets; better access to rural infrastructure (including irrigation) and agricultural services; access to capital and capacity building, especially among young people in agriculture; and land policies that enable efficient smallholders to expand their operations by acquiring or renting land from less efficient neighbours.

3.3 Underdeveloped value chains

In many West African countries, value chains are severely underdeveloped, leading to high rates of post-harvest losses (Feed the Future, 2015). Many smallholders are unable to participate in domestic or international value chains because they cannot meet increasingly specific and strict quality standards, high volume requirements, and logistics specifications. Distribution and retail companies tend to contract with larger farmers first and prefer farmers with certain non-land assets, such as irrigation or access to paved roads. These preferences act as barriers to smallholder participation in domestic (especially urban) and international markets. Innovations for vertical and horizontal coordination among smallholders could facilitate their inclusion in value chains. Some of these coordination mechanisms are group lending, rural marketing cooperatives, and producer associations (IFPRI, 2013).

3.4 Lack of policy support to food crops

Past policies of liberalisation in the context of structural adjustment favoured agricultural policy tools to promote cash crops for export, rather than food crops. This left the region open to unfair competition from cheap food imports and damaged food security, rural employment and integration in the regional market.

Many regional and national policies are trying to reverse this situation, by supporting food security, access to inputs, information, markets and technologies. For example, the Regional Agency for Agriculture and Food (RAAF), through its Support Program for Food and Nutrition Security[7] (2013-2017) aimed to provide institutional support to ECOWAS and its Member States in two key areas of food security: the regulation of agricultural markets and social safety nets. The programme awarded funding to projects for the fortification of foods, security of pastoral activities, and financial services for agriculture such as credit and insurance.

3.5 Poor water management

Water availability is the main concern for ECOWAS agricultural sector. West Africa faces a number of water management challenges as a result of rapid urbanization; weather variability; the potential impacts of climate change; unclear or limited access to water for farmers; and limited capacity among farmers to cope with changes in water availability (IWMI, 2019[8]).

Most rural populations in the region heavily depend on groundwater, and the promotion of irrigation is frequently cited as a strategy for reducing poverty and improving food and nutrition security (Keller & Roberts, 2004; Magistro et al., 2007; Polak & Yoder, 2006; World Bank, 2007). As Asia's Green Revolution demonstrates, irrigation, when combined with the availability of inputs (fertilizer) and

[7] http://www.araa.ecowas-agriculture.org/programme/support-program-food-and-nutrition-security
[8] http://westafrica.iwmi.cgiar.org/

improved crop varieties, can enable year-round cultivation and promote increased yields (Burney and Naylor, 2012).

While groundwater is significantly underexploited in much of Sub-Saharan Africa, significant progress has been made, mainly to increase provision of drinking water under the auspices of the Millenium Development Goal targets (USAID, 2014). Numerous boreholes have been drilled and hand pumps installed, but extraction remains low enough not to threaten long-term sustainability of the underlying aquifers. In any case, groundwater resources are not fully renewable and can be threatened by the increasing promotion of diesel and solar pumping.

Poor governance of water resources remains a key limitation for the implementation of successful irrigation projects. Water management initiatives are mostly confined to national-level dialogue and do not reach down to the local level, where water is actually managed. There is increasing recognition that Integrated Water Resources Management (IWRM) is the best option for sustainable exploitation of water, not only at national level but also at the local level, where day-to-day decisions are made about water use (USAID, 2014). IWRM is defined as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership, 2019[9]) . IWRM emphasises the interdependency of different water uses. For example, high irrigation demands and polluted drainage flows from agriculture reduce availability of drinking water; while polluted municipal or industrial wastewater threatens ecosystems and food safety.

In the implementation of IWRM systems, two key approaches need to be adopted:

- Integrated management of both ground and surface water, as well as management of both demand-side (cropping practices, pricing, regulation) and supply-side issues (natural resources management, soil conservation, augmenting groundwater recharge)
- Participatory processes including not only government actors, but also water users for the definition of management targets and techniques, policies, and regulations.

Stable water production systems should have the capacity to respond to external threats such as climate change, while ensuring continuity of traditional uses for domestic and livestock consumption, and even irrigation. A compilation of key sources on how to design and implement IWRM can be found in the Integrated Water Resources Management Reader, by the UN-Water Decade Programme on Advocacy and Communication (UNW-DPAC)[10].

4 MEN AND WOMEN DIFFERENTIAL CONSTRAINTS

Women comprise 50% of the agricultural labour force in Sub-Saharan Africa, but manage plots that are reportedly on average 20–30% less productive (Ali et al, 2016). In West Africa, women's role in agriculture is even higher, with more than 64% of women engaged in the sector, producing 80% of the food resources (ILO, 2009). What are then the causes for their reported lower productivity? Some sources point at discrimination in the labour market, limited access to land, and exclusion from agricultural development projects that tend to target male-dominated activities (FAO, 2001; ILO, 2009). This section reviews the evidence supporting the differential constraints that men and women face.

[9] https://www.gwp.org/en/GWP-CEE/about/why/what-is-iwrm/
[10] http://www.un.org/waterforlifedecade/pdf/05_2010_reader_iwrm_eng.pdf

4.1 Land ownership

Before being able to assess differences in land ownership, a definition of what is understood as male or female farmer is required. A farmer can be: the head of a farming household; an individual who holds the plot of land (whether though holding a formal title for the land or the right to farm it); the individual who keeps the revenue from the plot of land; or the "manager" of the plot of land. Although reliable data are scarce, and there are very different ways to measure ownership, across countries, the pattern that women own less land than men, regardless of how ownership is conceptualized, is remarkably consistent. Further, in many cases, the gender gaps are quite large.

Gendered statistics are typically more equitable for management indicators, or for land with use or access rights only. On the contrary, indicators on reported or documented ownership are the least equitable. An eight-country analysis from the FAO's Gender and Land Rights Database shows that women account for an average of 24 percent of agricultural landholders in West Africa (ranging from 3.1 percent in Mali to 50.5 percent in Cape Verde) (Doss et al., 2013).

Women's lower access to land is often due to patrilineal systems, such as that of Burkina Faso, in which land rights are transmitted via male family members (Theriault, Smale and Haider, 2017). Because of the principle of exogamy (marriage outside the family), women are generally awarded no more than usufruct rights at marriage. The possibility of divorce, and thus alienation of lineage lands outside the family, poses an inherent threat. Thus, despite that all Burkinabe are equal in the rights according to the Constitution, and that the Agrarian Reform of 1996 declares no discrimination, customary norms, which are inherently unequal, prevail in practice.

Gender discrimination in access to land has several manifestations. For instance, in some regions of Burkina Faso, women have no access to plots except for the off-season, and irrigated plots are allocated to male farmers only (Theriault et al., 2017). In Kenya, significant differences in plot sizes have been documented, with women managing smaller plots (Ndiritu et al., 2014). Other literatures show that women's landholdings are less fertile and more distant from the homestead than tose of men (Doss, 2001).

The security of land tenure affects the adoption of technology. In making investment decisions, farmers are concerned with their future benefits, which shrink if there is a high probability that a farmer will lose the land where the investment has been made. Therefore, poorer farmers and those with the least secure tenure are less likely to adopt new technologies.

4.2 Crop choices and division of labour

In many places in Africa, there has been a division of labour by gender in agriculture, based on crop, task or both. These divisions are not static and may change in response to new economic opportunities (Doss, 2001). Throughout Sub-Saharan Africa, lucrative cash crops are often perceived to be "male crops" while crops for home consumption are perceived to be female crops. A standard explanation for this would be that women are responsible for feeding the family and thus prefer to grow subsistence crops, while men are responsible for providing cash income and to this end grow cash and export crops. One frequent critique of agricultural development programs has therefore been that they have focused on men's crops rather than women's crops.

The previous assumptions, however, do not always hold. For example, household survey data from Ghana could not find evidence of crops defined as male or female (Doss, 2002). What is more, the distinction between cash crop and subsistence crops was not always clear. For example, maize is both a cash and a subsistence crop. A context specific analysis is therefore required in each area of intervention to understand if targeting specific crops benefits disproportionally one sex over the other.

With regards to the division of labour, men are typically responsible for the most physically intensive tasks, such us clearing the land, while women are responsible for weeding and post-harvest processing (Peterman et al., 2010). Women may be crowded into the worst jobs in the sector – those that are most poorly paid and with the worst working conditions (Cramer, Oya and Sender 2008). A promising alternative for women is their involvement in high-value, export-geared agriculture, such as floriculture, spices, non-traditional vegetables and fruits. Some studies show that women make up a proportionally higher share of specialised producers of flowers in Kenya, Uganda, Colombia and Zimbabwe, vanilla in Uganda, or grapes in Chile, Brazil and South Africa (Peterman et al., 2010)

4.3 Non-land agricultural inputs, technology, and services

A significant body of work exists on the importance of women's ownership of and control over assets for a range of development outcomes, both for women themselves and for their families (Johnson et al, 2016).

The gender norms that govern asset ownership make men more likely to own more assets and of higher value than women. Furthermore, because tasks vary by gender and the value of women's time is lower, farmers may be more inclined to adopt technologies that save men's time (Doss, 2001). There is some evidence that men move into women's activities when these become profitable, often as a result of new technologies. For example, evidence from Senegal showed that after the adoption of the stabling technique, which made milk production more profitable, marketing milk shifted from women to men (Peterman et al., 2010). Hence, programs need to ensure ways for women to maintain control over their activities once they become profitable.

Several studies also show that female managers are less likely than their counterparts to adopt yield enhancing and soil restoring practices (Theriault et al. 2017). Yield enhancing inputs include fertilizers and improved seeds, which are lumpy and costly per unit, and typically extended via formal channels to the household head. Soil restorative practices are particularly labour intensive and require access to transport equipment for manure. The authors explain that in patrilineal societies like that in Burkina Faso, women have less bargaining power than men, which limits their access to and control over household resources, and their incentives to make investments in their plots. Female plot managers in households that have secure rights over their plots are more likely to adopt yield enhancing and soil restoring practices. Besides, cereal associations positively influence technology adoption, especially for female plot managers.

A study of gender differences in the adoption agricultural intensification practices in Kenya also showed female managers as less likely to adopt minimum tillage and animal manure in crop production. However, no gender differences were found in the adoption of soil and water conservation measures, improved seed varieties, chemical fertilizers, maize-legume intercropping, and maize-legume rotations (Ndiritu et all, 2014). Differences in results points at the importance of context specificity when designing gender inclusive agricultural policies.

Finally, studies on irrigation technology adoption patterns in Ghana (Namara et al., 2014) and Zambia (van Koppen et al, 2012) show that women are underrepresented in the group of water lifting technology adopters. In Ghana, women are more likely to adopt canal irrigation technologies, probably as a result of deliberate targeting of women farmers in irrigated land allocation in the public schemes.

4.4 Women's disempowerment in agriculture

In terms of control over income, the International Food Policy Research Institute's (IFPRI's) Women's Empowerment in Agriculture Index (WEAI) provides a well-established and widely-used set of indicators for measuring women's roles and engagement in the agriculture sector in five domains: (1)

decisions about agricultural production, (2) access to and decision making power over productive resources, (3) control over use of income, (4) leadership in the community, and (5) time use. It also measures women's empowerment relative to men within their households.

The last WEAI report including data for 13 countries in 5 regions, shows that the greatest constraints on empowerment among women in agriculture are a lack of access to credit and the power to make credit-related decisions; excessive workloads; and a low prevalence of group membership. The two West African countries included in the study: Ghana and Liberia, had lower WEAI scores than countries in East and Southern Africa[11]. Disempowerment was higher in Liberia than in Ghana, but gender differences were higher in Ghana. The main reason for disempowerment in Ghana is a lack of access to productive resources, but differences are also stark between men and women in their production decision making, and in their control over their own income. In Liberia, gender differences are less stark, but both sexes are highly disempowered. The main reasons for women's disempowerment are lack of decision making in production and lack of access to productive resources.

Differences in time use are also an important reason for women's disempowerment. Women's care responsibilities limit their possibilities for economic advancement through agriculture commercialisation. Women's time and energy, timetables, seasonality and locations, and the need to travel or spend significant periods away from immobile infants, elderly or sick family members shape whether and how much they are able to participate in income-earning work. Who wins and who loses from agricultural commercialisation depends in part on how unpaid care work is reorganised as household resources of cash, labour, and time are reallocated. For these reasons, public policies in relation to public health infrastructure, healthcare and food systems, are acknowledged to play a significant potential role in enabling women's empowerment, and are more likely to matter directly for women's empowerment than for men (Razavi 2011).

When planning for mechanisation in agriculture, it is important to take into account the time allocation impact this will have for women. Labour-saving technologies can impact women both positively and negatively. Women from better-off households can gain more leisure time with these new technologies, while poorer, landless women could lose an important source of income when the tasks for which they were being hired were mechanized (GAAP, 2013).

5 HOW TO IMPLEMENT SUSTAINABLE, GENDER SENSITIVE IRRIGATION PROJECTS

The previous sections have shown that access to water and irrigation technologies are only one of several constraints facing West Africa to improved agricultural productivity. It is one of the clearest areas where renewable energy access can contribute. Other areas include energy's contribution to develop the agricultural value chain through improved product preservation (refrigeration and drying) and improved agro-processing. This section focuses on irrigation technologies, providing an overview of the technologies, institutional context, gender and monitoring and evaluation considerations. Annex 2 includes a compilation of

5.1 Technologies

Irrigation systems follow two major modalities: large irrigation schemes and small-scale irrigation. Due to previous failures, high costs and a drop in river output in which they depend, there is a decreased interest in large scale schemes among development partners, which tend to favour small scale

[11] http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128190

irrigation. The literature about small scale irrigation is also more abundant than about large scale irrigation in the ECOWAS region.

Smallholder irrigation systems are in fact the fastest growing type of irrigation in Africa, based on boreholes or reservoirs (Frenken, 2005; ECOWAS, 2015). On one hand, smallholders dominate agriculture production, and on the other hand, small holder irrigation has many benefits. It does not require large infrastructure investments or accompanying institutions such as water management boards.

A smallholder irrigation system is an aggregate of three components (Burney and Naylor, 2012):

- **Water access technology**, or a method of moving water from its source. From most basic and cheaper to most sophisticated and expensive, these technologies include: hand-carrying of water from a well or surface source; human powered treadle pumps, extracting water from up to 7 m depth; motor pumps using fossil fuels from 5-10 m depth; and solar pumps using phovoltaic arrays to power either surface or submersible pumps across a large range of depths. Although their initial investment is much higher than for fossil fuel systems, PV systems are more economically viable over their lifetime with a payback time of 4-6 years (Wazed et al, 2018). Besides, they are well developed, easily accessible and require almost no maintenance.
- **Water distribution technology**, or a method of spreading water across the field. From less to more efficient these include: direct flooding (large plots) and hand pouring (small plots); furrows (for large plots) and watering cans (small plots); sprinklers; and drip irrigation kits using a series of tubes and emitters to distribute water (and soluble fertilizer) directly to individual plants. The latter achieve water savings of up to 50%. Modern drip irrigation features pressure-regulated emitters enabling uniform water distribution over very large areas. Conventional, lower cost, drip irrigations used in the developing world feed water to drip lines via small reservoirs or oil drums from a height of 1-3 meters and do not have pressure-regulated emitters. Therefore, they cover smaller areas.
- **Water use, or productive water application**, refers to the types of crops watered. It is what provides the ability to generate greater returns to land, via higher value crops and improved yields. This component is therefore what makes water access and distribution technologies affordable for farmers. There has been a lack of emphasis on this component in Sub-Saharan Africa, but it was a key to the success of smallholder irrigators in Asia. Besides, as SSA has the fastest declining per capita land holdings in the world, increased attention to the use component for improved returns to land is critical.

Technology design needs to take into account synergies and dependencies between these three components. When introduced together, there is a higher likelihood that the farmer will survive the learning period with sufficient gains.

A strong knowledge of the farming system to be served is essential in the selection of the appropriate water access technology. Key data inputs for selecting water access technologies are presented in the table below. The size of the PV generator is mainly determined by the water and pressure requirements of the irrigation scheme. Water-saving irrigation technologies such as drip irrigation – working at comparably low operating pressures – are the preferred option in connection with PV pumping systems. Details of different irrigation systems are provided in the Powering Agriculture Massive Online Open Course[12].

[12] https://poweringag.org/mooc

Table 1- Indicators to select appropriate water access technologies

Indicator	Definition and source
Daily crop water requirement (m^3/day)	This should be known to the farmer, but can be analysed and optimised using comprehensive procedures like Cropwat from FAO[13]
Total pumping head (m)	height difference between the water level in the well/basin along with the highest point of the system (e.g. storage tank or sprinkler outlet), plus pressure losses due to friction in the pipes. A pumping head calculator can be used to measure this.[14]
Mean daily solar radiation (KWh/m^2/day)	This can be measured on site or obtained from the NASA website or local alternatives like ECOWREX

Failures in the implementation of smallholder distribution technologies are mainly caused by unreliable water access, inadequate institutions for water allocation at the community level, equipment failure and inadequate supply chains. An telling example is a programme in Zimbabwe, which distributed 70,000 low cost drip irrigation kits between 2002 and 2006, along with seed packs, training and in some cases fertilizer. After 3 years, only 16% of the kits were still in use. Many disadoptions were due to technical problems (mainly clogging) and unreliable access to water. The further the water source was from a household's plot, the more likely that the drip kit would be abandoned. Perceived water efficiency was low as households did not understand how to check soil moisture conditions and often added supplemental water by hand. A study of standalone low cost drip irrigation systems in Kenya offered similar disadoption rates and reasons (Kulecho & Weatherhead, 2005).

Inadequate supply chains are considered a key problem by many available studies (Namara et al, 2014; Colenbrander and van Koppen, 2013). Some of the imperfections found for the proper functioning of water pumps supply chain include: their highly centralized structure in urban centers; lack of information among small dealers on fiscal measures to support them; the high travel cost for rural smallholders wanting to purchase pumps or spare parts in urban centers; lack of information about prices, use and maintenance needs of pumps'and lack of financing facilities to purchase pumps. Many of this problems could be addressed by involving farmer's organisations in the provision of information to smallholders about import procedures, technologies, prices, and credit facilities. Farmers' organisations could also make use of economies of scale to negotiate better terms to purchase and obtain credit and after sales services.

The literature about large scale irrigation systems is limited as compared to small scale. A recent exception is a study sponsored by the African Development Bank, with ECREEE's support, carrying an economic assessment of large power photovoltaic irrigation systems in the ECOWAS region (Lorenzo et al., 2018). The study explored the feasibility of PV irrigation systems with enough power to supply water to professional agricultural exploitations (big farmers, irrigator communities and agro-industries) in the range of tens or hundreds of kW. Based on simulations of irrigation systems in 7 countries, the study concluded that the installation of sand-alone large power PV generators in the ECOWAS region would be very profitable in already existing grid-powered and diesel-powered irrigation systems. Therefore, solar PV should be implemented even in regions with good grid access. Payback periods were in the 2-10 years range, well below the lifetime of the systems (25 years) and

[13] CROPWAT: http://www.fao.org/land-water/databases-and-software/cropwat/en/
[14] Pumping head calculator: http://www.pumpworld.com/total-dynamic-head-calculator.htm

LCOE were the lowest for PV irrigation systems, in the 4.5-17.4 $cents/kWh, representing savings in the range of 30-84% as compared to diesel-powered and grid-powered systems.

5.2 Institutional context

The institutional context of irrigation projects is crucial for their success. They must take into account farmer organisations, credit programs, land tenure arrangements, insurance and risk-spreading, technical support, market access, access to information, education, local or regional supply chains. However, there is no single institutional structure that works across the developing world to facilitate the management of irrigation water.

A common dilemma among development institutions is whether to support small or large scale irrigation. Evidence is building up against large scale irrigation schemes for the Sahel region. For example, an early World Bank technical paper on irrigation found that, across the countries of the Sahel, projects that involved private farmers or leveraged autonomous farmer groups (formal and informal) were more likely to be successful than those undertaken with larger water user associations and cooperatives (Brown & Nooter, 1992). More recent reports show the poor track record of large scale irrigation in Niger and other countries (Merrey and Sally, 2017; Lankford et al., 2016).

Some of the benefits of smallholder private irrigation for poor farmers are their simple design, low cost, easy application and socio-economic benefits. Some of the challenges include deficiencies in the supply network leading to a lack of access to efficient and relatively inexpensive equipment; and farmer's lack of access to financing. Besides, the geographic distribution of boreholes is becoming an important challenge to preserve water resources in the long term. New forms of governance are required that facilitate a dialogue between water and agriculture sectors in the framework of integrated water resource management (ECOWAS, 2015).

On the other hand, some of the problems of large scale irrigation are a drop in river output, deficits in management and organisational skills among farmer beneficiaries, deferred maintenance, lack of resources to deal with major repairs and renewal, large initial investment and low returns on investment (Inocencio et al., 2007[15]). The key challenge is reconciling the short term (affordable user fees for farmers) with the long term (regular maintenance and resource protection) (ECOWAS, 2015). A detailed review from IWMI shows that large projects investing in multiple small-scale irrigation systems have reasonable costs and often achieve high returns on investment. This type of irrigation management has increased in recent times, representing 15 percent of irrigated area in Kenya, 55 percent in Niger, and up to 75 percent in Nigeria.

In spite of the poor performance of previous large scale irrigation schemes, many Governments and development partners have retained a taste for large scale water infrastructure. This is partly founded on the belief that large scale investment in irrigation (mainly rice) are required for agricultural development and food security (Inter-réseaux Développement rural, 2016). This is in spite of evidence pointing at the benefits of small-scale farmer driven irrigation systems and at the reluctance of many farmers to focus primarily on large scale irrigated rice production (Adolph, 2016; Katic, 2013). There might also be political reasons for the support of mega-projects, as these provide Governments with more political capital and higher control over the funds, as compared to decentralised funding into smaller packages to local NGOs and implementers.

An important donor's concern when promoting smallholder irrigation systems is reaching the poorest. Often, this is not the case as they are unable to afford even low cost systems. Even if an irrigation system is adopted by a poor farmer, inputs may not be allocated optimally to irrigated land, particularly if gender relations are unbalanced (Udry, 1996) or if farmers fail to balance investments

[15] This is a study from the International Water Management Institute (IWMI)

in divisible (fertilizer and seed) and lumpy (irrigation and capital equipment) technologies (Feder, 1982; Feder, Just, & Zilberman, 1985). Besides, as a consequence of lower education the poorest farmers would face more inefficiencies during their learning period (van de Walle, 2003; Foster & Rosenzweig, 1995).

5.3 Gender inclusion

Section 4 has shown that gender matters in the agriculture sector. However, dealing with gender differences is not straightforward due to the complexity of women's roles and responsibilities within households and communities and their dynamic nature, changing with new economic circumstances. Specifically targeting women and encouraging their participation in governance structures has been found to enhance productivity and poverty reduction impacts (World Bank, 2007). However, there is little ability to prescribe specific universal remedies or technological-fixes that will resolve Africa's gender gap in agricultural productivity (Doss, 2001).

Ideally, improved technologies should: Increase the agricultural productivity of men and women farmers; increase the availability and affordability of food for consumers, especially poor women; and promote economic growth, thereby expanding non-agricultural opportunities for women. But new technologies often have both positive and negative effects on these. For example, increasing land productivity may encourage men to return to agriculture and decrease women's access to land.

Some recommendations to design irrigation projects that take into account women needs include:

- Select technologies that reduce women's labour burdens overall and complementary interventions to provide them with greater control over their labour and its outputs
- Ensure that the social and legal factors are in place to ensure that women retain control over the land where irrigation systems will be installed, and the proceeds from it.
- Involve women and men farmers in the full process of technology development and adoption: from identifying the needs for new technologies, to participatory breeding of new varieties.
- Use participatory approaches to gather information from men and women on how the technology adoption may affect relationships among household and community members.
- Consider innovations that increase the productivity of women's labour in the processing and preparation of food, as women tend to be responsible for these tasks.
- Understand the reasons why women do not adopt new technologies. There are two potential explanations. First, they may have different preferences than men, for example preferring to grow varieties of maize that have particular processing and storage characteristics. In this case, it is important to develop varieties that meet women's specific needs and preferences. Second, women may face different constraints than men, such as different access to credit or markets, in which case the policy solution is to address the constraints.

5.4 Monitoring and Evaluation

Gender disaggregated baseline, midline, and endline surveys are required to be able to explain the changes irrigation systems may cause for men and women. Regular monitoring is also essential to identify problems during project implementation. Several toolkits exist for M&E of agricultural management projects. For example, the World Bank has published a toolkit (WB, 2008) detailing the process and indicators required for M&E of the projects. These guidelines should be complemented with gender M&E guidelines as provided in the Gender in monitoring and evaluation in rural development a tool kit (WB, 2008) which includes specific M&E indicators for gender in agricultural water management. Many other resources, from other authors are also available, and a multi-methods approach, combining quantitative, qualitative and participatory approaches is recommended[16].

5.5 Financing

Financing partners of energy in agriculture projects include all donors active in the region, from the EU, to bilateral cooperation, the AfDB, FIDA, the World Bank, etc. Among these, the World Bank stands out in terms of the amount of funding provided and the experience accumulated.

Based on their experience, the World Bank has produced an Africa Irrigation Business Plan (WB, 2007)[17], identifying five building blocks that will be used to construct effective irrigation development:

(1) **market oriented irrigation on a public private partnership basis.** Medium and large scale irrigation development presents enormous challenges to African governments but partnership approaches between the public and private sector can develop successful commercial irrigation. One example is the Green Scheme in Namibia where the Government has developed basic water delivery infrastructure and allocated 50% of the irrigated infrastructure to large scale farmers than then provide water services to smallholder commercial farmers

(2) **individual smallholder irrigation for high value markets.** In areas close to urban or export markets, there has been considerable success with individual smallholder irrigation, usually based on pump technology, either manual or motorized. The Niger Pilot Private Irrigation Project has spread a variety of manual and small-scale mechanized irrigation technologies, creating both a demand and a supply chain and a network of irrigator organizations. Manual pumping technology affordable to poor farmers allowed a doubling of the cultivated area and earned a 68% economic rate of return. This is a highly attractive business line that could be replicated and scaled up.

(3) **small scale community-managed irrigation for local markets.** Much development of small scale irrigation has been done through integrated rural development, where agricultural water is only one amongst several investments on offer. It is likely that this business line will continue to be promoted through decentralized and demand-driven projects.

(4) **reform and modernization of existing large scale irrigation.** Although many countries in SSA have invested heavily in large scale irrigation, it is hard to find examples of successful, or even adequate, results from these investments over the past decades, and there have been a number of spectacular failures. However, recent results, particularly from the Office du Niger in Mali, have shown that institutional reforms can make management accountable and obtain high rates of cost recovery. Given the large number of these schemes and their potential for contributing to poverty reduction and inclusive economic growth, this could be an important business line.

(5) **improved water control and watershed management in a rainfed environment.** The potential for growth and poverty reduction through improved rainfed agriculture is theoretically vast: more than 80% of the region’s households are rainfed farmers. Projects in several countries have developed profitable technologies, although there is little evidence that these technologies are readily adopted spontaneously. Scaled up at the catchment level, these technologies also form an important part of soil and water conservation programs. Given the potentially high gearing of success and the important environmental benefits, it is expected that this will be a business line at both pilot and full scales.

[16] http://siteresources.worldbank.org/INTCDD/Resources/sleepingg.pdf
https://betterevaluation.org/en/toolkits/equal_access_participatory_monitoring
[17] http://documents.worldbank.org/curated/en/617191468212388493/Africa-region-irrigation-business-plan

The WB planned to implement each of these building blocks within a comprehensive approach to agricultural water development, covering marketing, agricultural service provision, environmental sustainability, private sector involvement, as well as institutional reforms and capacity strengthening.

The Specific Investment Loan (SIL) would be the primary financing instrument delivering the business plan. Priority countries would be defined according to three criteria: irrigation development potential, country readiness and World Bank involvement and readiness. In the ECOWAS region, Burkina Faso, Ghana, Mali, Niger, Nigeria and Senegal are considered in the first priority group. Ivory Coast and Guinea fall under the second priority group due to low WB involvement. Benin, Guinea Bissau, Liberia, Sierra Leone and Togo in the third priority group, due to low country readiness and low WB involvement. Finally, the irrigation development potential is considered as low in Cape Verde and Gambia. With regards to area developed, the business plan puts more emphasis on small and micro irrigation as compared to large scale irrigation.

Table 1: Categorization of countries in four main groups and recommended interventions

Group	*Irrigation development. Potential*	*Country readiness and interest*	*World Bank involvement and readiness*	*Countries*	*Recommended interventions*
1	High	High / Medium	High / Medium	Burkina Faso, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Senegal, Tanzania, Zambia	Investment, analytical and advisory work
2	High	High / Medium	Low / No projects	Angola, Cameroon, Chad, Cote d'Ivoire, Democratic Republic of Congo, Guinea, Namibia, Rwanda, Sudan, Swaziland, Uganda	Analytical and advisory work, business development, then investment
3	High	Low	Low / No projects	Benin, Burundi, Central African Republic, Rep. of Congo, Eritrea, Gabon, Guinea Bissau, Liberia, Sierra Leone, Somalia, Togo, Zimbabwe	Analytical and advisory work
4	Low			Botswana, Cape Verde, Comoros, Equatorial Guinea, Gambia, Lesotho, Mauritius, Sao Tome & Príncipe, Seychelles	No action

6 WHICH ROLE FOR ECREEE?

Previous experiences, as compiled in Annex 2, demonstrate that irrigation systems cannot succeed in isolation. They need to be part of a wider package, combining: access to land, agricultural machinery, seeds, credit and markets and crop diversification. Among these elements, crop diversification with an increasing share of high value crops holds the biggest promise to dismantle the poverty trap. Comprehensive investment packages need to be designed accordingly, addressing the entire production chain. At the same time, rural electrification projects cannot succeed without rural demand creation from the agricultural sector. Strategies in the power sector, should therefore be coordinated with strategies on agriculture and rural development.

ECREEE's activities to promote agricultural competitiveness should build from strong partnerships with experienced actors in the agriculture sector. Annex 1 includes a compilation of key actors in the sector. In these partnerships, ECREEE should focus on those areas where it has a competitive advantage gained through its ongoing programmes. Some of these key areas of ECREEE's expertise include:

- Creating **awareness** among agricultural actors about the financial and environmental benefits of renewable energy for the sector. ECREEE could contribute to campaigns by local and national governments to promote electricity as a substitute for diesel engines among farmers in areas just gaining access to electricity, or solar electricity for farmers not yet reached by the national grid.

- Supporting the **development of a supply chain for solar irrigation technologies.** Previous experiences have shown the importance of creating awareness among farmers and financing organisations; supplying good quality systems and customer support for the viability of irrigation. It is essential to develop a local supply chain in which systems can be serviced, and potentially manufactured locally, and where regional technological exchange is promoted. ECREEE's extensive experience in energy capacity building can contribute to this goal.
- Promote **policies** that contribute to the viability of power generation for agriculture. For example, agroindustries could benefit from economies of scale in the development of power generation projects producing more than the local demand, and selling surplus power to the grid. This is possible if the tariffs offered by the national utility are above generation costs, and if rural power producers are guaranteed purchase of their excess power.
- Promote **harmonisation of customs duties** at the regional level for solar irrigation equipment. Some countries have established policies to exempt pumps from certain taxes as part of import provisions for agricultural equipment, however the processes of obtaining tax exemptions are complicated and heterogeneous in the ECOWAS region, and clearing processes at the port cause significant delays (Namara et al., 2014)
- Offering **co-funding of solar irrigation, refrigeration, or agro-processing**, to complement traditional funding from agriculture funders.
- Promote synergies between solar irrigation and the agricultural activities of ECREEE's **bioenergy programme**, centred in rural agricultural settings.
- Promote **gender mainstreaming** in all activities to promote agriculture competiveness, building from ECREEE's Gender Programme.

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8 ANNEX 1: KEY STAKEHOLDERS

Stakeholder	Type of Stakeholder	Projects implemented or under implementation	Countries of operation
FAO	International policy and knowledge partner	The Food and Agriculture Organization is a specialized agency of the United Nations that leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate arguments and debate policy. FAO is also a source of knowledge and information, and helps developing countries in transition modernize and improve agriculture, forestry and fisheries practices, ensuring good nutrition and food security for all.	Global reach, a list of projects can be found in this link http://www.fao.org/in-action/fao-projects/en/
IFAD	Financing partner	The International Fund for Agricultural Development (IFAD) is an international financial institution and a specialized agency of the United Nations dedicated to eradicating poverty and hunger in rural areas of developing countries. By the end of 2016, they were running 41 ongoing programmes in partnership with 23 governments in the West and Central Africa region, and had invested a total of US$1.2 million. Current priorities are to strengthen the value chains that link producers and their organizations to markets and consumers, and to create a virtuous upward spiral by helping farmers to sell more and earn more.	Global reach. IFAD support projects in all ECOWAS countries
AfDB	Financing partner	Funds irrigation projects in the regin	All ECOWAS
World Bank	Financing partner	Funded numerous irrigation projects in the region, most lately the SIIPS-PARIIS initiative	All ECOWAS
ARAA/RAAF Regional Agency for Agriculture and Food	Regional Government	Support Program for Food and Nutrition Security	ECOWAS
Comité Permanent Inter-États de Lutte Contre la	Regional Agency	Coordinating Agency of the World Bank funded Sahel Irrigation Initiative Support Project (SIIPS or PARIIS)	Burkina Faso, Chad, Mali, Niger, Mauritania and Senegal.

Stakeholder	Type of Stakeholder	Projects implemented or under implementation	Countries of operation
Sécheresse dans le Sahel (CILSS)			
GIZ- Powering Agriculture	Development partner	Powering Agriculture, in collaboration with USAID and Green innovation centres for the agriculture and food sector	Senegal, Ghana, Nigeria and Benin. Green innovation centers operate in Benin, Burkina Faso, Ghana, Mali, Nigeria and Togo
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Research Centre	African Market Garden, a low pressure drip irrigation system with installations in several countries in West Africa: Niger, Burkina Faso, Northern Ghana. Each using systems appropriate to their context. Through their previous experiences, ICRISAT has developed a package appropriate for poorer producers (often women)	Based in Niamey, Niger. Started in Niger, but the system has been implemented in several West African countries
IWMI (International Water Management Institute)	Research Centre	non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries.	Regional oureach, but based in Accra
University for Development Studies (UDS)	Research Centre	UDS hosts one of the World Bank's African centres of excellence, the West Africa Center for Water, Irrigation and Sustainable Agriculture (WACWISA.org). The establishment of WACWISA at UDS recognises the university's longstanding expertise in irrigation and water management solutions. UDS has a practical orientation, operating in rural communities across the northern Ghana and working at the local level with government units, traditional authorities, FBOs and all actors involved in development.	Northern Ghana, Tamale
Groupe de Recherche sur les Initiatives Locales (GRIL), University of Ouagadougou	Research Centre	The GRIL, at the UOI is a leading social sciences organisation with expertise in participatory methods and social science research on gender and livelihoods dynamics (specially on natural resource management).	Burkina Faso
Association Régionale d'Irrigation et Drainage	Network of professionals	Coordination of irrigation professionals and preparation of knowledge-sharing events in French and English	Regional, but based in Burkina Faso

Stakeholder	Type of Stakeholder	Projects implemented or under implementation	Countries of operation
de l'Afrique de l'Ouest (ARID)			
Solar Electric Light Fund (SELF)	NGO that designs and implements solar energy-based solutions	SELF's work in Benin began in 2006 when it put together a plan to use solar power in the district of Kalalé. A needs assessment revealed that the primary concern among the local communities was food security. o solve that problem, SELF developed an innovative way to use solar energy to power a well pump to draw water from an underground acquirer and gravity feed it through a drip irrigation system into gardens. The system became known as a Solar Market Garden™ (SMG). In 2007, SELF installed three SMGs for women farming collectives in the villages of Dunkassa and Bessassi located in Kalalé. The local community also collaborated with SELF to develop and build a solar powered micro-enterprise center.	Benin
Sunny irrigation	Supplier of solar pumps	They provide Portable solar water pump for irrigating small farms. They use pay as you go technologies	East Africa: Kenya and Rwanda
Future pumps	Supplier of solar pumps	The SF2 solar irrigation pump is both robust and portable. It offers smallholder farmers a cheaper, cleaner and more sustainable alternative to costly and polluting petrol or diesel pumps.	Based in Kisumu, Kenya
International Development Enterprises (IDE)	Development partner and supplier of solar pumps	Promotion of very low-cost water access and distribution technologies, the "Sunflower pump". The Sunflower pump radically changes the way smallholder farmers irrigate their fields: It requires no fuel and has no recurring costs; and when paired with a low-pressure drip system, labor requirements are significantly reduced	In West Africa: Mali, Niger and Ghana
New Energy	Local NGO implementing irrigation schemes in Ghana	Implementation of a solar powered irrigation project in the Northern Region of Ghana, supported by UNDP and the Energy Commission. Solar powered irrigation schemes were established for four farmer associations at Tamalgu in the Karaga District, Nakpanduri in the Bunkpurugu Yunyoo District, and Datoyili and Fooshegu in the Tamale Metropolis. The installations have a total capacity of 22.5 Kilowatts and are capable of delivering up to 1 million liters of water per day.	Tamale, Ghana

9 ANNEX 2: SOLAR IRRIGATION INITIATIVES IN THE ECOWAS REGION

This section reviews a small selection of regional initiatives applying solar irrigation in ECOWAS Member States. These experiences are useful to identify good practices, reasons for failures, and gaps that can inform ECREEE's contribution to improve agricultural productivity.

9.1 Regional Villageoise Improved Hydraulics Programme (PRHVA - ECOWAS)[18]

- **Implementers:** Department of Agriculture Environment and Water Resources (DAERE) through the Regional Agency for Agriculture and Food (ARAA) in close collaboration with the Coordination Center of Water Resources (CCRE) and the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE).
- **Countries:** Priority given to post-conflict countries. ECOWAS wishes to support vulnerable populations affected by conflict, degradation of access to water and displacement.
- **Objectives:**
  - Improve access to drinking water, health and nutrition of vulnerable populations.
  - Improve agro-pastoral production and enhance food security through drip irrigation demonstration plots.
- **Scale of funding:** 100 million USD for 5000 multipurpose boreholes with pumps running with solar power
- **Technology**
  - Water access: multi drilling and solar pumps
  - Water distribution: drip system
  - Water use: market gardening.
- **Selection of target areas:**
  - Each country organises an exchange workshop to select sites for drilling and other associated infrastructure. This workshop would provide an opportunity to discuss the establishment of management mechanisms.
  - Each country will discuss the merits and the possibility of setting up a committee of municipal and community management to ensure ownership by communities, local communities and all beneficiaries;
  - Durability: propose a realistic contribution fee from beneficiaries to ensure access and optimal use of water
  - Preference will be given to border areas for the selection of sites for the works to strengthen the exchange of experiences between the riparian areas of neighboring countries and promote regional integration.
- **Gender issues**: It is assumed that solar pumps benefit women by reducing drudgery, as compared to hand pumps.
- **Evaluation**: Not publicly available. The project started in 2014

9.2 Africa Market Garden project

- **Implementers:** ICRISAT, an NGO partner, the Solar Electric Light Fund and a local CBO
- **Countries**: 11 countries in West Africa
- **Objective:** help farmers surmount the energy barrier to year-round horticulture production in the Sudano-Sahelian climate. By providing reliable renewable energy access for irrigation, the SMG project enables enhanced production, sales and consumption of these high value micronutrient crops, and helps combat high malnutrition and poverty levels throughout the year, and especially during the dry season when malnutrition is accentuated.

[18] http://www.old.araa-raaf.org/blog/hydraulique.html

- **Target:** the ultra-poor within a weak institutional background. Geographically, the target are rural areas with no electricity access, where fuel supply is unreliable and fuel prices volatile or too expensive for smallholders
- **Technology:** conventional drip irrigation kits fed by concrete reservoirs or oil drums paired with a variety of water access technologies, from shallow dams to artesian wells to solar-powered pumps. In solar market gardens, a solar photovoltaic array powers a pump (either surface or submersible, depending on the water source) that feeds water to a reservoir; the reservoir then gravity-distributes the water to a low-pressure drip irrigation system. Local water availability and evapotranspiration needs inform the sizing of pumps, reservoirs, and fields. It is not an off-the-shelf product, but an integrated technology and management package with a significant associated learning curve. Solar-powered pumps and conventional drip irrigation systems were combined with the high-value horticultural production training developed by ICRISAT in the previous AMG projects. Access to extension services and technical support is critical for its sustainability and long-term functionality.
- **Socio-institutional configurations**: diverse, including individual systems, “cluster” models (a group of individual systems connected to a common water source), and “communal” gardens (shared systems divided into individual plots). In all of these cases, drip irrigation is applied to a diversified mix of market garden crops and installed as part of a larger management and training package that includes ongoing horticultural training and initial access to improved seeds.
- **Gender component**: Solar Market Garden systems were installed in Benin in conjunction with pre-existing local women’s agricultural groups. Almost all of the villages have such groups, which engage in activities from vegetable production to collective harvesting of members’ fields to value-added activities, depending on the group and village. A rigorous impact evaluation was undertaken to estimate changes on women’s empowerment as a result of the project (Burney et al., 2017). To create an empowerment metric, a 32 empowerment related questions were included in a household survey, based on IFPRI’s WEAI and the World Bank gender database. Latent variable analysis (factor analysis) was used to understand the underlying structure of empowerment locally, reducing the information gathered by the 32 questions to 6 underlying factors or domains. The levels and likelihood of empowerment over time was monitored. Results show that the Solar Market Garden significantly positively impacted women’s empowerment, particularly through the domain of economic independence (being able to provide for some of their own needs), male help with domestic tasks, self-confidence and participation in other groups. Although the impact decreased over time, it was still significant in the longer term. The authors cannot explain why women’s perceived empowerment decreased over time.
- **Results:** ICRISAT implemented these systems successfully in Burkina Faso and Northern Ghana. In both Burkina Faso and Ghana, farmers realized large yield gains, on average doubled their revenues, and elected to continue with the technology. The experience with cluster systems in northern Ghana and of self-organized reservoir sharing in Burkina Faso highlighted the role farmer groups might play in driving down start-up costs, economizing on input purchases, spreading risk, facilitating training and knowledge transfer, and creating bargaining power in the marketplace. The experiences from the series of AMG projects anecdotally support the idea that the combination of water access, efficient water delivery, and production of high-value crops results in synergistic gains; economic analysis of AMG systems in comparison with traditional watering can systems have shown increased returns to land, labor, and water. However, evidence from many studies shows that that uptake of low-cost irrigation systems by smallholders does not necessarily lead to production of high-value crops.

- **Robust impact evaluations.** Experimental examination of the Benin case by Burmey and Naylor (2012) and Burmey et al. (2010) shows an increase in the standard of living in project households after one year of using the systems. Project households also improved their food and water security as compared to non-using households. They also looked for evidence beyond the short run, finding some encouraging institutional changes, like formalisation of land tenure by women's groups, and official constitution as NGOs of this women's group, which would grant them the opportunity to hold low cost bank accounts, for example. Another key lesson of this impact evaluation is that due to the higher up-front costs of a PV system and the lack of rural finance institutions providing low cost credits for small amounts, the technology is best suited for investment by farmer groups as opposed to individuals in very poor communities. Promoting these farmer groups could be a good way to improve the viability of irrigation kits. However, it is very important to take care of the group dynamics that may emerge when these groups receive external grants (for example younger members might be attracted to the groups and expel the older, less productive ones that made their higher contributions to the group in their younger age…). The mere presence of resources, might therefore change the organisation of these groups.
- **Lessons for scalability**:
    - Lower-cost technologies are not appropriate for the ultrapoor against a weak institutional backdrop. They may fail to kickstart a cycle of increasing returns and investment.
    - Access and distribution systems do not automatically precipitate a successful transition into production of high-value crops, but crop diversification is the component of a smallholder irrigation system with the most promise to dismantle the poverty trap.
    - Interactions between technology design and institutional context are essential.
    - A single policy strategy that relies on investment in small-scale irrigation alone will almost surely fail over time. Governments should invest in meso-scale credit for farmers associations and regional traders of horticulture crops (not just in micro-credit for poor, individual farmers), in developing the local supply chain and regional manufacture, including the vocational skills to support higher performance irrigation technologies, in transport infrastructure and information technologies, in linkages to larger markets.

9.3 Powering agriculture: An Energy Grand Challenge for Development (PAEGC)[19]

This is a joint initiative of the German Federal Ministry for Economic Cooperation and Development (BMZ) with GIZ implementation, the United States Agency for International Development (USAID), the Swedish development agency Sida, the US Government's development finance institution Overseas Private Investment Corporation (OPIC) and the US energy company Duke Energy.

It is a global project, whose objective is to promote the development and dissemination of innovative, marketable approaches to the use of climate-friendly energy technologies in agriculture in developing countries and emerging economies. International competitions are run to select companies, universities and non-governmental organisations to receive direct grants. PAEGC is currently funding 24 projects. In a further 16 pilots, the project is testing sustainable energy solutions in agricultural value chains. Supported projects are predominantly in East Africa, with a few ones in West Africa (Senegal, Ghana, Nigeria and Benin). Innovators are dominantly from the United States. Value Chain studies have so far included: Tanzania's milk, Kenya's milk, Kenya's vegetables like tomatoes and green

[19] https://poweringag.org/resources

beans, the Philippines rice. They have produced many studies about agri-food opportunities to become energy smart through the value chains.

All clean energy innovations selected for funding under the PAEGC initiative must "contribute to reducing gender disparities in access to, control over and benefit from clean energy resources, wealth, opportunities and services: economic, social, political, and cultural". Moreover, Powering Agriculture will not fund an innovation or implementation approach that can "reinforce harmful gender norms" within the target implementation area. The project has produced 6 topical guides for Gender integration in the different aspects of the agriculture value chain, for example, "a powering agriculture guide on integrating gender in the deployment of clean energy solutions for agriculture"[20]. Relevant gender guides are also available for product development, financial products, marketing, monitoring and evaluation and human resources.

As part of this project, GIZ has produced a toolbox on Solar Powered Irrigation Systems (SPSIS)[21] with extensive information about the system, investment analysis, market analysis, finance access, implementation and maintenance procedures.

9.4 World Bank Sahel Irrigation Initiative Support Project (SIIPS or PARIIS in French)[22]

- Supported by the World Bank. It covers six West African countries: Burkina Faso, Chad, Mali, Niger, Mauritania and Senegal. The responsible agency is CILSS: Interstate Committee for Drought Control in the Sahel.
- The project was officially launched on November 8, 2018, Ouagadougou officially launched the Regional Support Project for the Sahel Irrigation Initiative (PARIIS).
- A regional approach to irrigation development will: (a) facilitate coordinated investment planning in shared natural resource areas; (b) build the knowledge base and facilitate cross-learning at the regional level; (c) attract/facilitate participation of the private sector to innovate and provide high quality services at regional level at lower cost; and (d) facilitate adoption of regional policies through institutional benchmarking
- The project funding amounts to nearly 200 $ million in grants and credits to these countries. The majority of this amount is directed to financing irrigation investment solutions.
- The Project Development Objective is "to improve stakeholders' capacity to develop and manage irrigation and to increase irrigated areas using a regional "solutions" approach in participating countries across the Sahel."
- Reflecting on lessons learnt from the past, the World Bank is changing its approach to irrigation development in the region, by: (a) balancing public interventions across the different types of irrigation systems in the region to allow for a more efficient use of land and water resources; (b) adopting a market-oriented, production system approach to irrigation development; and (c) engaging stakeholders directly in the planning and implementation in a holistic way early in the project cycle.
- Project beneficiaries will include farmers (both women and men, youth included) who will benefit directly from selected investments financed under the project and indirectly from the increased capacity of public and private stakeholders to deliver enhanced irrigation services.

[20] https://poweringag.org/sites/default/files/PA_Gender_Guide_Deployment_2017.pdf
[21] https://energypedia.info/wiki/Toolbox_on_SPIS
[22] International Development Association Project Appraisal Document on Proposed Grants, (November 10, 2017): http://documents.worldbank.org/curated/en/515131512702151121/pdf/WESTERN-AFRICA-PADnew-11142017.pdf

The planned irrigation schemes will directly benefit over 58,000 farmers, mostly from poor households, with a focus on small to medium scale irrigation systems.

- The project will generate **benefits along the value chains**. Therefore, other beneficiaries include suppliers, non-family farm workers, and various service providers (processing, marketing, maintenance). In total, the project would reach 72,000 households, corresponding to about 430,000 people.
- Project interventions broadly based on **five types of systems** commonly found in the Sahel, 3 systems for small-scale farmers and 2 for large scale, combining public and private ownership and management.

Table 1. The Five Main Types of Irrigation Systems in the Sahel

Type		Description
SMALL-SCALE	1	Improved rainwater harvesting with partial water control: inland valley bottom development (*bas-fonds*), flood recession plains or partial control (sometimes thousands of ha), sand dams for groundwater recharge (*seuils d'épandage*). Crops are rice, sorghum and vegetables.
	2	Small-scale private irrigation systems (less than 1 ha up to a few ha) for individuals or small groups of producers, involving pumping equipment, devoted to high value crops such as vegetables.
	3	Small-scale community-based irrigation schemes of less than 50 ha, usually promoted by nongovernmental organizations (NGO) or Governments, for villages or large groups of producers who collectively manage pumping equipment and canals to produce rice or vegetables.
LARGE-SCALE	4	Large-scale irrigation schemes (from 500 ha to more than 5,000 ha with a vast majority below 1000 ha) publicly financed, managed or supervised by public authorities, located usually along large rivers regulated by dams, comprising a combination of pump stations and a network of canal and drainage systems, service roads. They require a complex management structure.
	5	Medium- to large-scale irrigation schemes involving a partnership between the Government, a private party, and the communities surrounding the scheme, for the development and management of the irrigation system (with same technical features as for Type 4).

- Elaborating solutions for **solar pumping** is a priority for all countries, as well as developing financial mechanisms to support Type 2 private irrigation schemes.

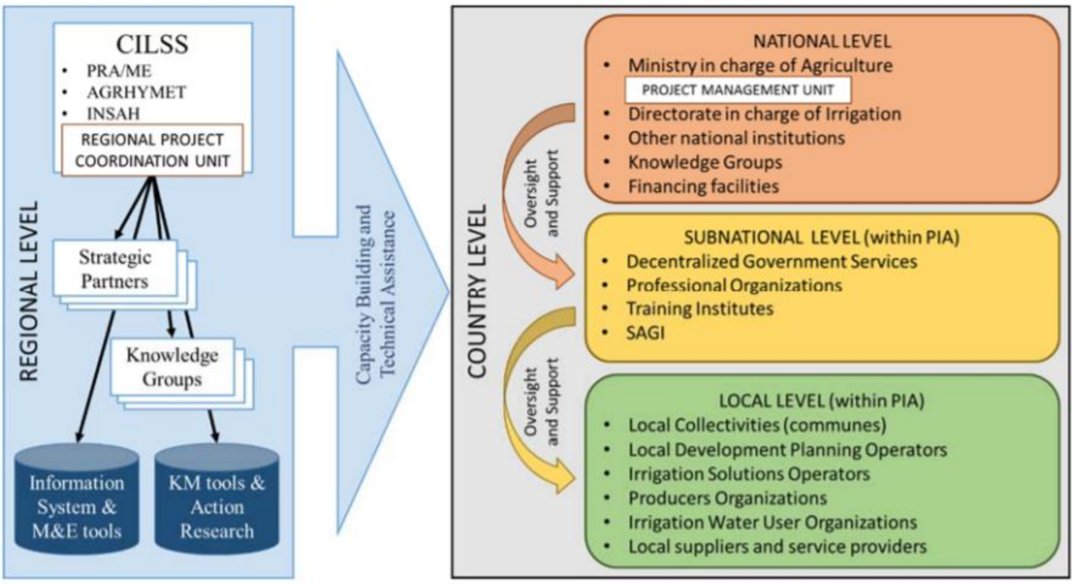
Table 2.12. Priorities for Pilot Projects and Applied Research by Country

Country	Pilot Projects and Applied Research Required to Elaborate Solutions
Burkina Faso	• Solar pumping and drip irrigation • Developing a medium scheme based on a comprehensive package of solutions
Chad	• Rehabilitation of Type 3 village irrigation schemes • Solar pumping
Mali	• PPP (Type 5) • Solar pumping and automated irrigation • Financial mechanisms to support Type 2 (private irrigation) development
Mauritania	• Improved VISA schemes (Type 2), organizing the value chain • Solar pumping • Financial mechanisms to support Type 2 (private irrigation) development
Niger	• Solar pumping • Articulation of Niger Small-Scale Irrigation Strategy (*Stratégie de la Petite Irrigation au Niger*)-FISAN • Complementary irrigation from small reservoirs • Financial mechanisms to support Type 2 (private irrigation) development
Senegal	• Irrigation from ground water including with solar pumping • Applied research on drainage and soil salinity • Financial mechanisms to support Type 2 (private irrigation) development

- **Financing of $140 Million** is available for irrigation investment solutions. There are 3 sub-components to this work: 1. Preparation or update of bankable investment proposals, including carrying out feasibility studies and environmental and social assessments for medium or large irrigation schemes and assistance in mobilizing extra financing; and 2: Design and implementation of irrigation solutions for the revitalization, modernization of existing schemes and construction of new small scale irrigation schemes and appurtenant infrastructure.

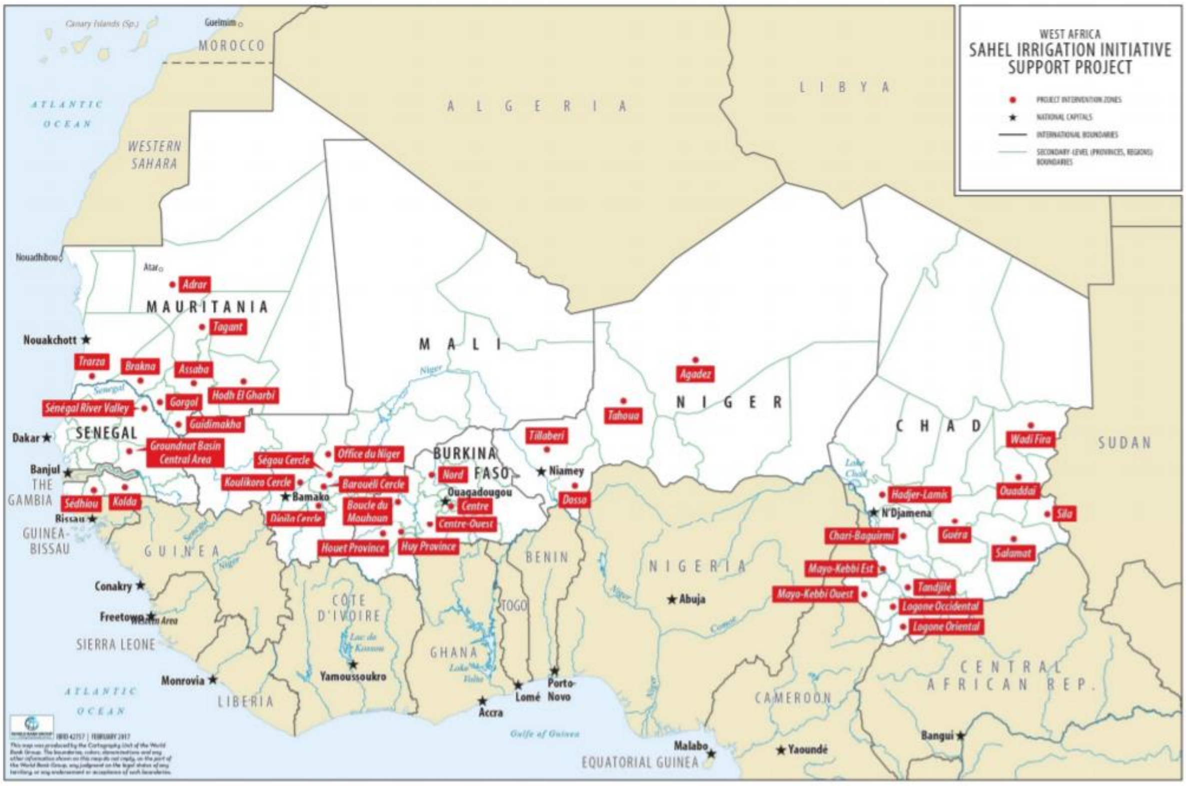
- The **management structure** of the project is as follows: CILSS acts as the regional project coordinating unit. The CILSS has a track record of implementing regional projects funded by various partners including the World Bank. At the country level, the Project Management Unit is in the Ministry in charge of Agriculture. There are then other management units at the subnational and local level.

Figure 1. Schematic Implementation Arrangements



- **Gender component**. About 35 percent of the direct beneficiaries in irrigation schemes will be women. Women's situation in the irrigation sector is known to be difficult, particularly when it comes to access to land, information, and finance. Irrigated agriculture represents a very important opportunity for women, whereby access to irrigated land can help them develop income generating activities and improve the nutritional quality of the family meals. The project is expected to promote gender inclusive approaches to agricultural development, capacity building activities, local development planning processes. The project will ensure that women are fully consulted in discussions on arrangements for water management and land distribution, through social mobilization practices that ensure high levels of their participation, as well as their involvement in water user organizations
- **Youth component.** There is a unique niche for the youth to get engaged in various aspects of farming management, notably through the use of ICTs, for instance, to obtain the best market prices, keep records, find crops in high demand, get information on pest and disease control, get access to new farming practices and agricultural/irrigation technologies, get access to financing products, communicate with other farmers, and raise awareness.

Geographical coverage



9.5 Initiatives for smallholder private irrigation development

There is a long history of support to smallholder private irrigation in West Africa. A World Bank's publication[23] reviews 18 of these projects in Nigeria, Niger, Burkina Faso and Mali.

Some remarkable projects include:

- the Fadama projects in Nigeria, launched by the Nigerian government and the World Bank, with other donors getting involved later on, such as FAO or the African Development Bank.
- The Pilot Private Irrigation Project in Niger, which supported the creation of a private irrigation agency.
- The research institute ICRISAT in Niamey promotes the African Market Garden, which is based on a low-pressure drip irrigation system combined with a comprehensive crop husbandry package.
- Niger Agro-Pastoral Export and Market Development Project (PRODEX 2009-2014) targeted commercial farmers rather than the smallholders targeted in the previous PPIP and PIP2.
- AgWater Solutions Project funded by the Bill and Melinda Gates foundation since 2009 will develop smallholder irrigation by identifying the factors that influence successful adoption and scaling up of small-scale agricultural water management interventions and providing a set of evidence-based tools and recommendations.

[23] Lessons Learned in the Development of Smallholder Private Irrigation for High Value Crops in West Africa," World Bank, (June 2011): http://siteresources.worldbank.org/INTARD/Resources/West_Africa_web_fc.pdf

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

Key lessons learnt from an in-depth review of a series of projects in four countries I West Africa shows that there is considerable room for improvement in:

- Building a **strong, durable supply chain of irrigation technologies** and promoting technological knowledge exchange by using a programmatic approach that harmonises 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 specialised advisory services, and the design of financing for irrigation technologies that supports the farmer from initial investment to replacement.
- Designing **comprehensive investment packages that address the entire production chain.**

9.6 GIZ-EnDev- Solar Pumps for Irrigation

Energising Development (EnDev) is an energy access partnership programme financed by six donor countries – the Netherlands, Germany, Norway, the United Kingdom, Switzerland and Sweden. GIZ acts as lead agency for the implementation of the programme and cooperates closely with the Netherlands Enterprise Agency (RVO) on the global level as well as other implementation partners on the country level. EnDev promotes sustainable access to modern energy services that meet the needs of the poor – long lasting, affordable, and appreciated by users.

In Ghana, a key component of the project is supporting small scale farmers to access and use solar PV pumps for irrigation purposes through market incentives and capacity development for solar companies and farmers. The market development approach was used to link suppliers of PV pumps to the farmers.

The main objective of this intervention is to provide energy for irrigation for all year round farming. The target group was private small scale farmers practicing informal irrigation and willing to invest in PV pumps, mainly to substitute manual practices but potentially to substitute petrol or electrical pumps too.

The Project had no regional focus in Ghana but responded to the demand for PV pumps by farmers. The project built upon a private sector development approach. It provided incentives to facilitate the market introduction of PV-pumps for small-scale irrigation through private initiative of Renewable Energy system integrators, pump-suppliers and suppliers of agricultural equipment who identified customers for their systems.

Potential beneficiaries were mobilised through the equipment providers. Private farmers involved in informal irrigation and willing to invest 60 - 70% of the total investment were considered. The project subsidised between 30 -40% of the cost of the Solar pumping system including installation and maintenance.

- 69,000 W generated capacity installed nationwide
- 110 farmers have new access to energy
- Training of solar pump installers and suppliers, agricultural extension officers and MFI's on the use of SPIS manual & tools
- Increase in land under acreage which has provided employment for 680 individuals
- Ability to use all types of irrigation system such as sprinklers, drip and irrigation tubes

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