Landscape Analysis Report to scale up the installation of solar irrigation businesses in Senegal

November2020

Table of Contents

Executive Summary (will be completed after final review and comments) 4
1. Introduction 1
2. Country context 2
2.1. Geography, Topography and Climate 2
2.2. Demography 5
2.3. Political and Economic Situation 5
3. Agricultural Sector of Senegal 7
3.1. Crop Pattern 7
3.2. Import 8
3.3. Market segmentation and Farmer's Profile 9
3.4. Land Ownership: 10
3.5. Existing Irrigation Schemes: 10
3.6. Institutional setup of Agricultural Sector 14
Ministry of Agriculture and Rural Equipment (Senegal) (MAER) 14
3.7. Access to water 14
3.8. Cropping seasons 15
3.9. Challenges in Agriculture Sector 15
4. Electricity Sector 15
4.1. Legal and regulatory framework 16
4.2. Electricity Generation 18
4.3. Electricity Tariffs 20
4.4. Solar Energy Potential 21
5. Solar Irrigation Landscape Policy 21
5.1. Renewable Energy Act 2010 22
5.2. Action Plans[i] 23
5.3. Taxation and fiscal benefits 25
5.4. Policy relation- Agriculture and Solar Irrigation 25
6. Solar Irrigation- Business Models 29
7. Solar Irrigation- Technology and market chain 31
8. Solar Irrigation- Access to finance 32
9. Solar Irrigation- Capacity development 34
10. Recommendation 35

Access to finance 37
Business Models 37
Water Management 37

List of Tables

Table 1: Demographic indicators of Senegal 5
Table 2: Senegal — macro-economic indicators 6
Table 3: Senegal — agricultural sector facts and figures (GET.INVEST, 2019) 9
Table 4: Irrigation potential in Senegal 11
Table 5: Estimated market size for different irrigation segments 13
Table 6: Generation capacity 15
Table 7: RE target in National Action Plan 23
Table 8: Import revenues in Senegal 25
Table 9: Planned amount of investment for the different agricultural sub-sectors 26
Table 10: sector wise water demand and demand projection 28
Table 11: Cost of SIPS in Senegal 33

List of Figures

Figure 1: Map of Senegal 3
Figure 2: Climate of Senegal 4
Figure 3: Senegal — agro-ecological zones 7
Figure 4: Gross production value of main agricultural products in Senegal (A) 8
Figure 5: Crop calendar for Senegal 8
Figure 6: Value of food imports in Senegal 9
Figure 7: Overview of main irrigation zones in Senegal 11
Figure 8: Irrigation schemes in the Senegal River Valley and Delta 13
Figure 9: Senegal Off-grid institutional framework 16
Figure 10: Map of electricity generation and transmission in Senegal 20
Figure 11: Average electricity price by country 21
Figure 12: Solar irradiation in Senegal 21
Figure 13:12 Solar irradiation in Senegal 21
Figure 14: Electricity sector policies, laws and regulations 24
Figure 15: Aquifer systems of Senegal 28
Figure 16: Investment structure to support SME's in Senegal 33
Figure 1715: Investment structure to support SME's in Senegal 33

Executive Summary (will be completed after final review and comments)

This chapter will summarize the whole report presenting the list of opportunities/gaps to be addressed by the country.

1. Introduction

The Global Green Growth Institute (GGGI) is a treaty-based international, inter-governmental organization dedicated to supporting and promoting strong, inclusive, and sustainable economic growth in developing countries and emerging economies. GGGI interventions emphasize change in four priority areas considered to be essential to transforming countries' economies. While not limited to these themes, GGGI is maximizing the impact of its products and services in the following areas: Sustainable Energy, Water and Sanitation, Sustainable Landscapes, and Green Cities.

GGGI has recently launched the Global Program on solar irrigation with an aim to create an enabling environment (policy, business model, technology, knowledge sharing) for solar based irrigation systems in the target region. Global Program at its inception includes four (4) member countries including Senegal.

The Republic of Senegal is a country in West Africa. Predominantly rural, and with limited natural resources, the economy of Senegal is dominated by agriculture. The agricultural sector of Senegal is highly vulnerable to environmental conditions, such as variations in rainfall, temperature risen, the occurrence of extreme phenomena such as flooding, and changes in world commodity prices. Therefore, Senegal like many other developing countries in Africa faces challenges in meeting the growing demands of food, water, and energy. Meeting these demands forms the basis of sustainable, economic, and environmental development of a country or a region. Nevertheless, the discussed sectors i.e. food, water, and energy form a nexus of high correlation. A change in one sector will certainly have direct or indirect impact on the other. According to United Nation Food and Agriculture Organization (FAO), the global demand for food will rise by 60% by 2050[1]. The rising food demand is putting a great strain on existing water and energy systems (need for irrigation, fertilizers, etc.).

Agriculture, being one of the world's largest economic sectors, accounts for about 70% of global freshwater and 5% of global energy consumption[2]. The supply of sufficient water is key for successful irrigation which eventually results in better yield of agriculture. At the same time, supply of water from the source to the irrigation field requires energy. Surface water bodies are the most common source of water due to ease of transportation. However, underground water is also commonly tapped for irrigation where surface water is not available. Around 57% of current irrigation water demand is covered by surface water, the remaining 43% by the underground sources (The World Bank 2010)[3]. Irrespective of the type of water sources for irrigation requires a significant amount of energy. While electric pumps are common and reliable in grid areas, a large part of the demand in off-grid areas is met through fossil fuel-based generators[4]. The disadvantages of this fossil energy supply are known and are attributed as high operating costs and frequent maintenance, environmental damage through groundwater soiling with fuels and lubricants, or CO_2 emissions. Total greenhouse gas (GHG) emissions from the agri-food chain (excluding land-use) are over 20% of global GHG emissions per year[5]. Replacing the same with Renewable Energy (RE) sources is an attractive alternative as they feature several economic, managerial, and ecological advantages.

Solar Irrigation Pumping System (SIPS) is a green alternative to address the problem associated with fossil fuel-based irrigation systems. It is characterized as a low operating cost, minimum maintenance, ease of use, and most importantly environment friendly. An off-grid solar pumping system that replaces a typical

1 http://www.fao.org/fileadmin/user_upload/esag/docs/AT2050_revision_summary.pdf
2 Water for Sustainable Food and Agriculture: A report produced for the G20 Presidency of Germany, Rome 2017.
3 https://energypedia.info/wiki/Powering_Agriculture:_Irrigation
4 https://energypedia.info/wiki/Powering_Agriculture:_Irrigationhttps://energypedia.info/wiki/Powering_Agriculture:_Irrigationhttps://energypedia.info/wiki/Powering_Agriculture:_Irrigation
5 ENERGY, AGRICULTURE AND CLIMATE CHANGE: Towards energy-smart agriculture, FAO/USAID, 2015.

diesel generator unit will save about 1 kg of CO_2 per kilowatt-hour of output[6]. However, since there is no requirement of fuel, the unregulated operation of SIPS may also lead to the exploitation of groundwater usage. Incentive mechanism backed by policy and regulatory support can address the issue effectively. Solar irrigation has a direct impact on women empowerment since women are the backbone of rural agriculture in Asia and Africa, although invisible because their work is often uncounted. Therefore, the said intervention has significant potential impact on food yield, environment, ground water resource management, gender and of course access to energy.

There are multiple efforts for implementing SIPS is Senegal driven by public and private interventions. Scaling up the number of installation of SIPS is still a challenge that might be caused by different market indicators including policy framework, business model, institutional setup, technology market chain, quality control, access to finance, and capacity of different stakeholders. GGGI Global Program intends to identify the challenges and then help the Government of Senegal (GoS) in developing different instruments based on country buy-in.

This Landscape Analysis report is a GGGI internal document to communicate the overall solar irrigation landscape of Senegal. The analysis is meant to provide a consolidated resource of key information for understanding the key measures to be undertaken by the country to scale up the installation of solar irrigation business.

The report is organized in ten sections. Following this introduction, the next section depicts an overview of the country. Section 3 and 4 discuss about two important sectors in regard to solar irrigation such as the agricultural sector and electricity sector respectively. From section 5 to section 9 this report presents Senegal's policy aspects, business aspects, technical aspects, access to finance, and capacity development scenario in relation to solar irrigation business environment. Finally, Section 10 details the list of measures to be undertaken by the country for scaling up of solar irrigation business.

2. Country context

Senegal is the westernmost point on the African mainland, and its capital, Dakar, has historically served as the gateway to West Africa. Much of Senegal is covered in rolling, sandy plains courtesy of the western Sahel - a transition zone between the Saharadesert and Sudanian Savannas. Senegal remains one of the most stable nations on the continent having gained independence from France in 1960.

2.1. Geography, Topography and Climate[7]

Senegal has a land area of approximately 196,190 km^2 with a total boundary length of about 3,171 kilometers (km), of which over 530 km is Atlantic Ocean coastline (Figure 1). Senegal is bounded to the north and northeast by the Senegal River, which separates it from Mauritania; to the east by Mali; to the south by Guinea and Guinea-Bissau; and to the west by the Atlantic Ocean. Cape Verde (Cap Vert) Peninsula is the westernmost point of the African continent. The Gambia consists of a narrow strip of

6 Toolbox on Solar Powered Irrigation Systems, FAO and GIZ 2018.
7 GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

territory that extends from the coast eastward into Senegal along the Gambia River and isolates the southern Senegalese area of Casamance.

Senegal is a flat country that lies in the depression known as the Senegal-Mauritanian Basin. Elevations of more than about 330 feet (100 meters) are found only on the Cape Verde Peninsula and in the southeast of the country. The country as a whole falls into three structural divisions: the Cape Verde headland, which forms the western extremity and consists of a grouping of small plateaus made of hard rock of volcanic origin; the southeastern and the eastern parts of the country, which consist of the fringes of ancient massifs (mountain masses) contiguous with those buttressing the massif of Fouta Djallon on the Guinea frontier and which include the highest point in the country, reaching an elevation of 1,906 feet (581 meters) near Népen Diakha; and a large but shallow landmass lying between Cape Verde to the west and the edges of the massif to the east[8].

Figure 1: Map of Senegal[9]

Senegal has three types of climate[10]: hot semi-arid (e.g. Dakar, Diourbel), hot desert (e.g. Louga, Dagana), and tropical savanna climate (e.g. Kolda). Temperatures vary according to the season and are lowest along the coast and highest inland with the peak temperatures in the northeast. Whereas there is virtually no rainfall in the desert climate, there is little rainfall in the semi-arid and more in the tropical savanna climates. As shown through the example of Dakar (Figure 2), it mostly rains between June and October. The wet season is shorter in the north and longer in the south, especially near the southwest coast. The

[8] https://www.britannica.com/place/Senegalhttps://www.britannica.com/place/Senegalhttps://www.britannica.com/place/Senegal

[9] Link: http://www.un.org/Depts/Cartographic/map/profile/senegal.pdf — accessed May 2020

[10] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

average annual rainfall ranges from 34 cm at Podor in the extreme north to 155 cm at Ziguinchor, in the southwest.

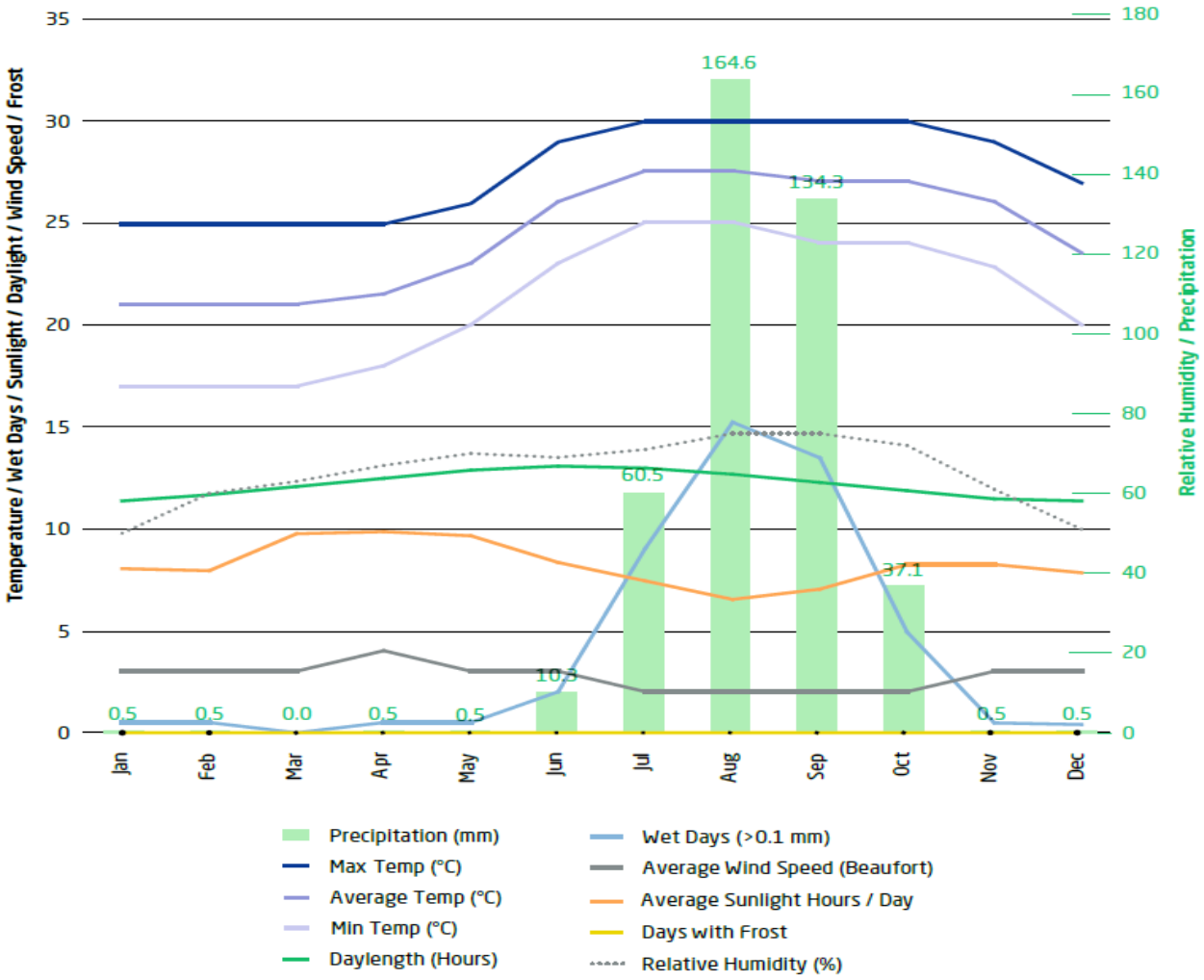


Figure 2: Climate of Senegal[11]

The country is drained by the Senegal, Saloum, Gambia (Gambia), and Casamance rivers, all of which are subjected to a monsoonal climatic regime—i.e., a dry season and a rainy season. Of these rivers, the Senegal—which was long the main route to the interior—is the most important. The river rises in the Fouta Djallon highlands of Guinea and, after traversing the old massifs, rapidly drops downward before reaching Senegalese territory. At Dagana it forms the so-called False Delta (or Ouolof), which supplies Lake Guiers on the south (left) bank.

[11] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

2.2. Demography[12]

Senegal's population was recently estimated at 15.4 million (Table 1), with high fertility rates translating into almost 43% being younger than 15 years old (OECD, 2017). The urbanization rate is relatively high with 44% living in urban areas (Table 1). About 42.7% of the population lives below the national poverty line, though there are geographic disparities with rural areas registering significantly above that figure at over 57%.

Table 1: Demographic indicators of Senegal

Parameter	Value
Population (2016)	15.4 m
Population growth (2017 est.)	2.39%
Median age (2017 est.)	18.8 years
Urbanization rate (2015–2020 est.)	3.73% p.a.
Urban population (2017)	44% of total
Rural population (2017)	56% of total
Population density (2017)	82 per km2
HDI (2015)	162 of 188

2.3. Political and Economic Situation[13]

Senegal is one of the most stable countries in Africa and has considerably strengthened its democratic institutions over the last decades. Politically, since independence from France in 1960, Senegal has had peaceful transitions. From the mid-1990s until 2005, Senegal had one of the best performing economies in Sub-Saharan Africa. The share of the population below the national poverty line declined from 68% in 1994–1995, to 57% in 2000–2001, and to 51% in 2005–2006, marking the first sustained increase in average per capita growth since independence in 1960.

Starting in 2006, several external and domestic shocks took a toll on the economy. Agricultural output experienced a sharp decline due to unfavorable rainfall in 2006–07. In addition, the rising oil prices, the surge in food prices in 2007 and the global financial crisis, which started in 2008, weighed heavily on Senegal's open economy. Domestic shocks, including floods in the Dakar region and continued electricity shortages, further contributed to the general slowdown of the country's economic activity.

In recent years, the economy has started to recover again, making Senegal the second fastest growing economy in West Africa in 2016. Growth remained strong in 2017 being recorded at 6.8%, with the African Development Bank (AfDB) predicting further improvement in 2018 projecting a 7% growth rate.

The COVID-19 pandemic is already having a significant impact on Senegal's economy both in terms of the rapid deterioration of global economic conditions as well as the spread of the coronavirus in the country[14]. Therefore, real GDP growth is projected at 1.1 percent of GDP in 2020, compared to 5.3 percent in 2019. Faced with the need to

[12] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

[13] https://www.get-invest.eu/market-information/senegal/ - accessed in May 2020https://www.get-invest.eu/market-information/senegal/https://www.get-invest.eu/market-information/senegal/ - accessed in May 2020

[14] https://www.imf.org/external/np/loi/2020/sen/062620.pdf

take urgent action to mitigate the effects of the COVID-19 crisis, the government has implemented an economic and social resilience program (PRES), endowed with a fund of CFAF one thousand (1,000) billion, in order to strengthen the health system and support households, the Senegalese diaspora, as well as firms and their employees. This program includes four pillars: (i) support for the health sector; (ii) strengthened social resilience for the general public; (iii) macroeconomic and financial stability to support the private sector and maintain employment; (iv) ensuring that the country has regular supplies of oil and gas, medical and pharmaceutical products, and essential foodstuffs.

The current crisis is changing consumption and production patterns within countries. Senegal should also modify its production structure and expedite the structural transformation process already begun in phase I of the Emerging Senegal Plan (PSE). Therefore, the second Priority Action Plan (PAP2A) for the second phase of the PSE has been adjusted and accelerated to boost local production, enhance the economy's resilience, address its fragilities and vulnerabilities, and safeguard the general public from such crises.

The primary sector has been identified as the most dynamic, growing at over 7%[15] with agriculture playing a critical role.

The aim is to ease bottlenecks to growth and facilitate private initiatives through basic structural reforms. The goal is turning Senegal into an emerging economy by 2035 with an average growth of 7% at that time. The table 2 present the macro-economic indicator.

Table 2: Senegal — macro-economic indicators[16]

Overview	Last	Reference	Previous
GDP Growth Rate (%)	-0.5	Dec/19	4
GDP Annual Growth Rate (%)	-1.3	Jun/20	1.4
Unemployment Rate (%)	17	Dec/19	14
Inflation Rate (%)	2.6	Oct/20	2.8
Interest Rate (%)	4	Sep/20	4
Balance of Trade (CFA Franc Billion)	-144	Aug/20	-159
Current Account (XOF Billion)	-1181	Dec/19	-1230
Current Account to GDP (%)	-8.8	Dec/19	-6.9
Government Debt to GDP (%)	47.7	Dec/19	47.9
Government Budget (% of GDP)	-3.6	Dec/19	-3.6
Corporate Tax Rate (%)	30	Dec/20	30
Personal Income Tax Rate (%)	40	Dec/20	40

[15] Link: http://www.worldbank.org/en/country/senegal/overview — accessed May 2020
[16] https://tradingeconomics.com/senegal/indicators

3. Agricultural Sector of Senegal[17]

The agriculture and livestock sector are Senegal's main economic activity, representing approximately 17% of gross domestic product (GDP) and employing 70% of the population. Production has been growing steadily in past years reaching an aggregate value of close to USD 1.5 billion in 2014 with crops making up over 90% of the value.

3.1. Crop Pattern

Senegal is divided into six agro-ecological zones (AEZs) based on biophysical and socio-economic characteristics (Figure 3). Although most crops are grown across the country, certain crops are more dominant in specific zones being — River Valley (irrigated rice, vegetables); Niayes (80% of the horticulture produced in the country); the Groundnut Basin (groundnuts, millet); Silvo-Pastoral zone (livestock); Eastern Senegal and upper and lower Casamance (rainfed rice, vegetables, and fruits).The three most important agricultural products in terms of gross production value are groundnuts, rice and milk (Figure 4) with the horticulture sub-sector identified as key with great growth potential.

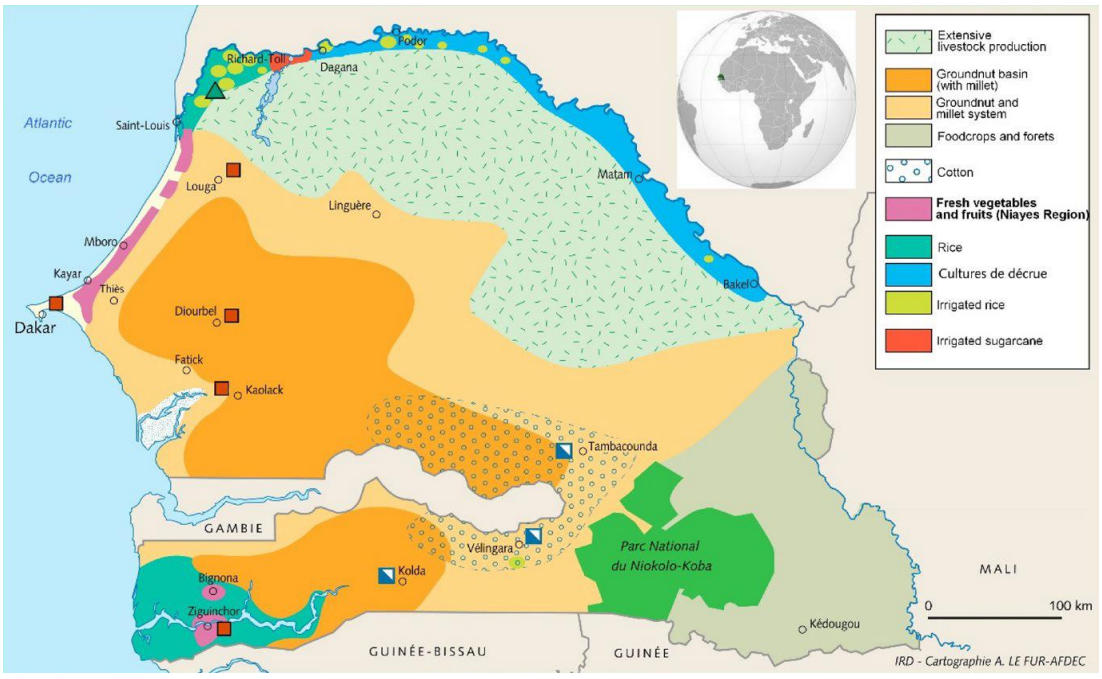


Figure 3: Senegal — agro-ecological zones

[17] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

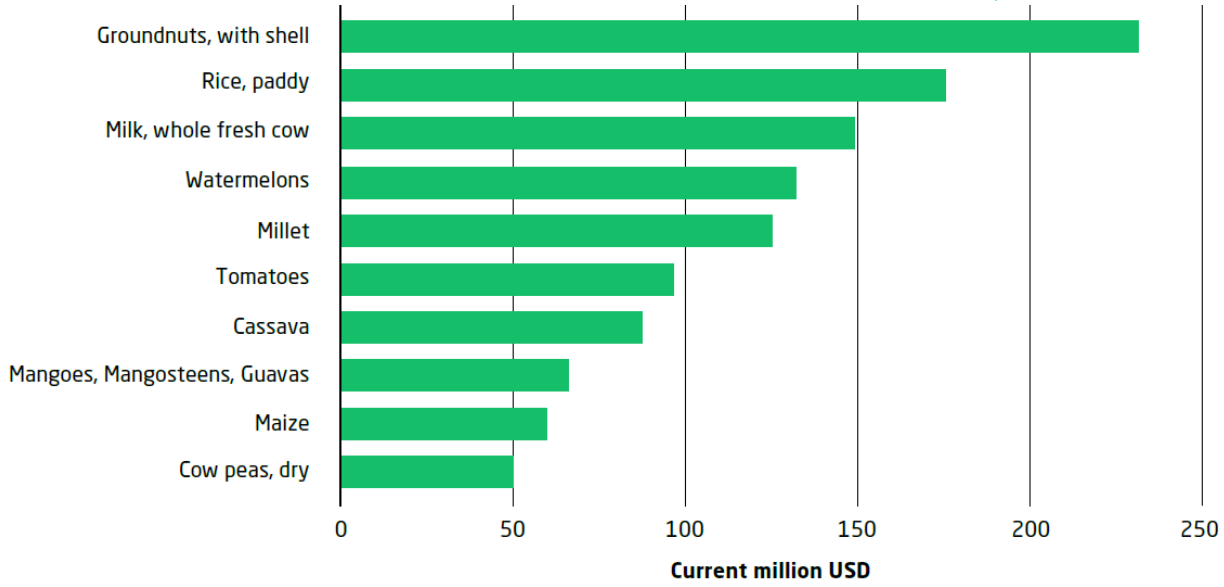


Figure 4: Gross production value of main agricultural products in Senegal (A)

The figure 5 shows the crop calendar for Senegal[18]:

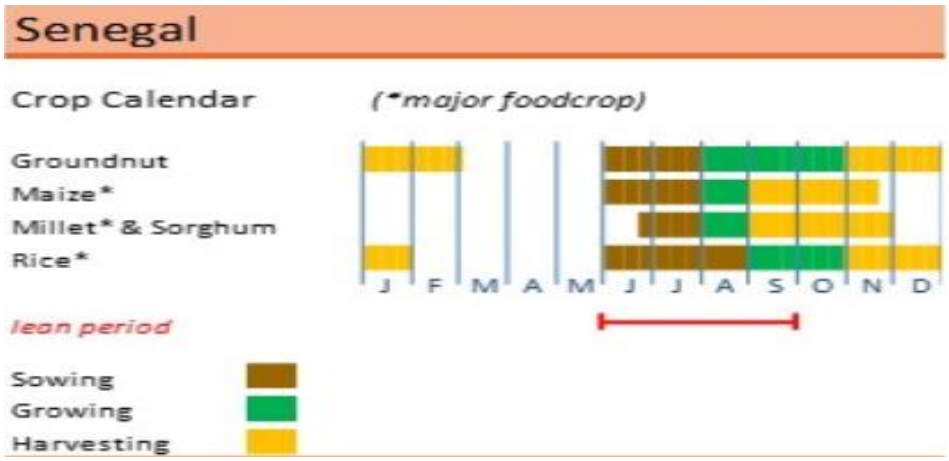


Figure 5: Crop calendar for Senegal

Reference Date: 15-April-2020

3.2. Import

Despite significant growth in recent years, the agricultural sector in Senegal has been unable to meet the food requirements of the growing population. This has resulted in a heavy reliance on food imports, especially rice which is the population's main staple crop with imports accounting for 65% of national consumption at a value of USD 460 million in 2013 (Figure 6). Other notable examples include onions and milk with production deficits of 33% and 41%, respectively.

[18] http://www.fao.org/giews/countrybrief/country.jsp?code=SEN

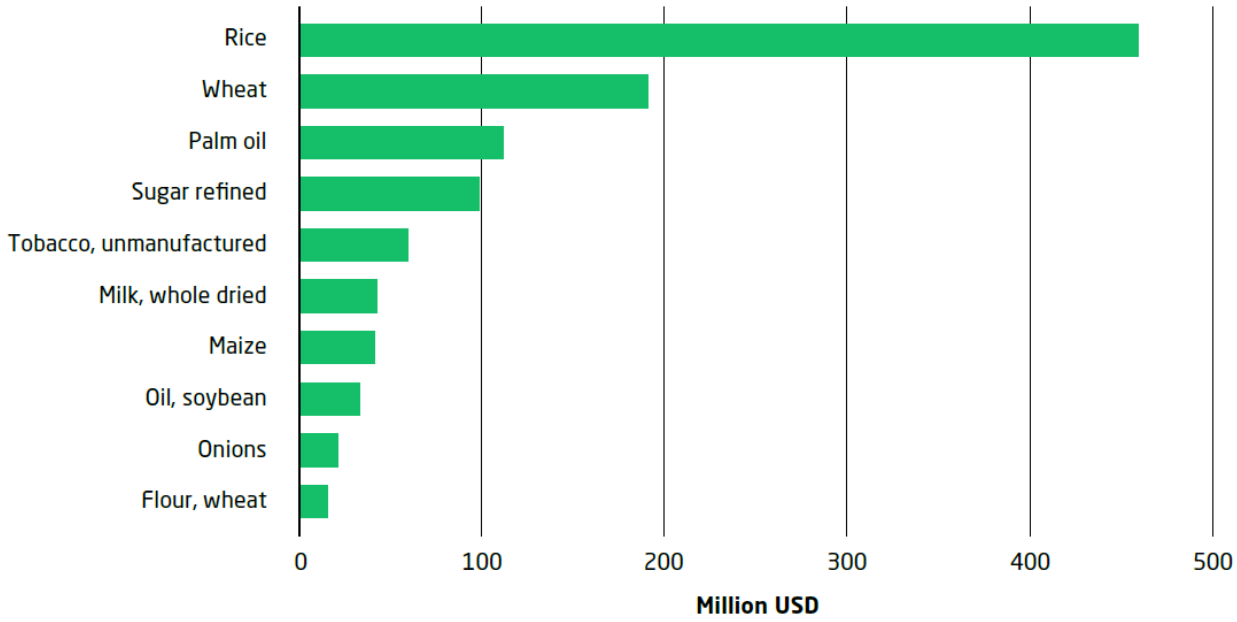


Figure 6: Value of food imports in Senegal

3.3. Market segmentation and Farmer's Profile[19]

Ninety percent of the agricultural lands in Senegal are occupied by small-scale and family-based farms. Commercial agriculture represented only 5% of the land under production in the early 2000s but has been growing steadily, accounting for 10.7% in 2013. Farmers typically hold several plots with plot sizes varying between 1–5 ha. In most cases, crops are only grown during the wet season. Exceptions can be found in areas under irrigation where 2 to 3 growing seasons are sometimes used. Large national and international agribusinesses have had a presence in Senegal since at least the 1930s. The largest farms have concentrated operations in the Senegal River Valley, the land around Dakar and coastal areas, and in the Casamance, although agribusinesses have also begun to invest in more remote areas.

In 2011, the average farming income was estimated at CFA 646,500 (EUR 986) per year. In many cases, this income was further complemented by revenue from other activities (employed or non-employed) as well as transfers received from relatives living in the city or abroad. It can be expected that the farming income will have increased since 2011, however, the overall value remains low given that rural families spent 75% of their income on food and housing. In addition, income distribution is found to be unequal with 85.2% of agricultural households earning less than the average farming income of CFA 54,000 (EUR 82) per month. According to a 2011 survey, poverty is particularly widespread among independent farmers, affecting 61.1% of farming households compared to a 46.7% national poverty rate (Table 3).

Table 3: Senegal — agricultural sector facts and figures (GET.INVEST, 2019)

Parameters	Value
Area cultivated	3.5 million ha
Number of farming households	755,559

[19] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

Main agricultural activities	Agro-pastoralism (combination of rainfed agriculture and livestock), irrigation and pastoralism
Farm types	90% smallholders, 10% agribusiness
Average farmer income	CFA 646,500 per year (EUR 986)
Poverty incidence	61.1% of farming households

Smallholders have limited access to village irrigated perimeters for paddy cultivation, which are mostly in the Senegal River Valley. They use flood recession and small-scale irrigation techniques using surface water to grow vegetables on plots averaging 0.2 hectares. Small-scale irrigation provides 90 percent of the vegetables sold in local markets[20].There are three main categories of smallholder farmers based on land ownership and marketing arrangements in Senegal:

- independent small farmer who owns (or rents) land for farming and is free to sell products to any outlet;
- out grower who is part of a contract farming deal or a larger project, who also owns (or rents) land for farming but is contractually bound to sell produce (permanently or temporarily) to one specific aggregator (or "nucleus estate"); and
- smallholder farmer settled on the land of a larger landowner who is also often the aggregator (or "nucleus estate"); hence, the farmer is contractually bound to permanently sell produce to one specific aggregator (or "nucleus estate").

3.4. Land Ownership[21]:

Senegal's formal law recognizes the following tenure types:

- **Ownership**. Natural persons and entities can own land under formal law and have all freehold rights, including the right to exclusive possession, use, and transfer.
- **Leasehold**. Natural persons or entities can obtain leaseholds of private land or land in the national domain that is transferable. Leases can be granted for terms up to 30 years and are renewable.
- **Land-use allocations under customary practices**. The National Domain Law permits rural councils to allocate territorial land for use under customary principles so long as the land is used productively. Occupants of land for three or more years can apply for use-rights, regardless of competing claims of customary ownership rights.

Most of the land in Senegal continues to be governed in large measure by customary law. In rural areas, land is held communally by families and lineages, although overtime rights have become highly individualized.

3.5. Existing Irrigation Schemes[22]:

[20] http://www.fao.org/3/a-i5365e.pdfhttp://www.fao.org/3/a-i5365e.pdfhttp://www.fao.org/3/a-i5365e.pdf

[21] https://www.land-links.org/country-profile/senegal/#landhttps://www.land-links.org/country-profile/senegal/#landhttps://www.land-links.org/country-profile/senegal/#land

[22] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

The area of land in Senegal with good potential for irrigation is estimated at 497,500 ha and is concentrated around the Senegal River in the North, the Niayes area in the West, and the Groundnut Basin in the center (Figure 7).

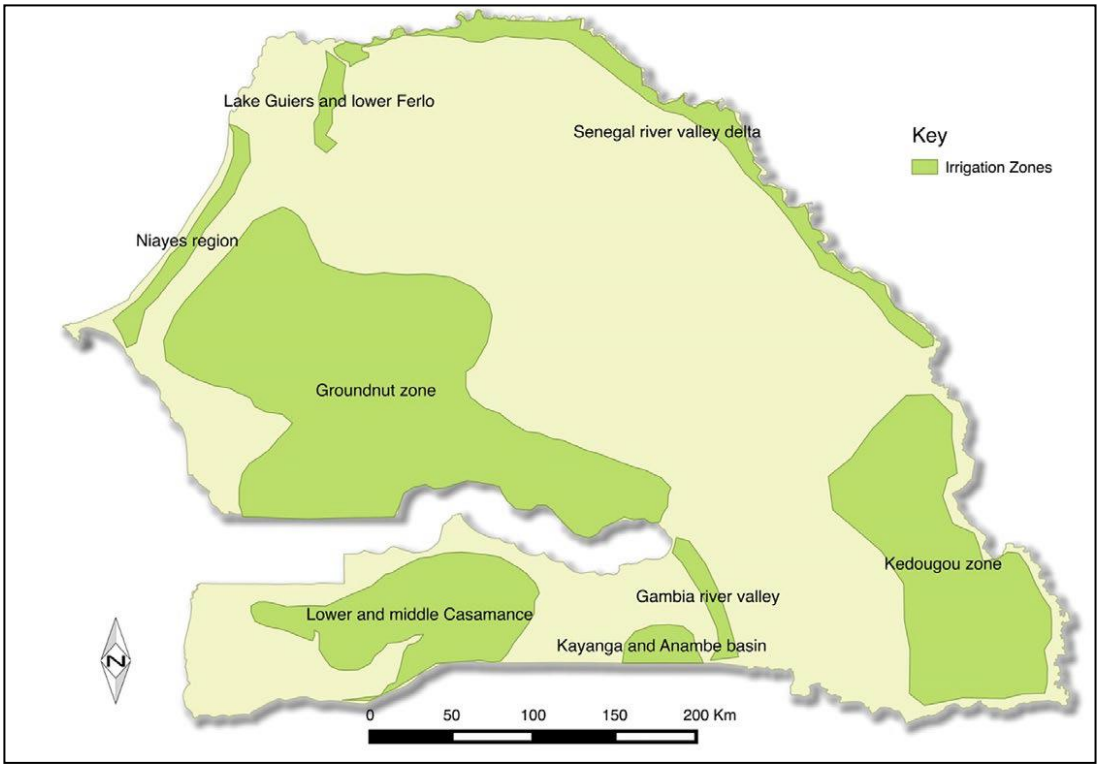


Figure 7: Overview of main irrigation zones in Senegal

The total area currently under irrigation ranges from 88,600 ha to 95,400 ha, including 26,000 ha for horticulture and 62,600–69,400 ha for cereals (predominantly rice). As can be seen from Table 4, significant potential exists to expand the area that is currently under irrigation.

Table 4: Irrigation potential in Senegal

Irrigation Zone	Area (ha)
Senegal River Valley and Delta	228,000
Lake Guiers and Lower Ferlo	75,000
Lower and Middle Casamance	70,000
Kayanga and Anambé Basin	16,000
Gambia River Valley	20,500
Kédougou Zone	13,000
Groundnut Basin	75,000
Total	**497,500**

350,000 ha of lowlands would be irrigable even with basic development (ANSD, 2016)

Approximately 90% of irrigation systems are built around surface water bodies such as rivers and lakes. Notable exceptions are the Niayes region and Groundnut Basin where micro-scale irrigation takes place using groundwater from wells. Electric and diesel pumps are frequently used for moving water with hand pumpsand buckets also utilized for the micro-irrigation.

Limited information is available about the exact number of traditional pumps in operation in the country with a frequently stated number — from sector stakeholders in country — being 25,000. Individual estimates for regions also exist: the number of diesel pumps in the vicinity of Kayar is said to be 1,050, approximately the same in Mboro, and around 8,000 in the greater Niayes region north of the capital. There are 14,000 diesel pumps operating in the country providing irrigation to the lands within the range of 1 to 5 hectares[23].

Within the different irrigation areas, a distinction can be made between three principal types of irrigation systems and market sub-segments:

Medium and large-scale irrigation schemes range from a few hundred to a couple of thousand ha. They are typically developed, financed, and managed by the government (e.g. The state agency for the development of the Senegal Delta and Faleme River, SAED — Société Nationale d'Exploitation des Terres du Delta et du Fleuve Sénégal and also Société de Développement Agricole et Industriel du Sénégal - SODAGRI) with a focus on the production of rice and other cereals. Farmers pay a fee for water use and over time some areas have been handed over to farmer and village groups. Water is typically pumped using large electric or diesel pumps with the application of gravity for transportation through the irrigation canals. Examples are the large-scale irrigation facilities over 500 ha (GA — Grands Aménagements) and medium scale irrigation facilities between 100–500 ha (AI — Aménagements Intermediaires) in the Senegal River and Valley area in the north of the country.

Société de Développement Agricole et Industriel du Sénégal (SODAGRI)- a public limited company is responsible for the management of Niandouba and Confluent dams in the southern region of the country. They own and manage 5 pumping stations with 15 number of electric pumps and 3 diesel pumps to pump water from the said dams to 5,000 ha of lands. The price for water is determined at the beginning of the season based on demand forecast. Farmers pay the bill directly to the Utility company i.e. SENELEC. SODAGRI irrigation scheme covers two seasons i.e. dry and rainy season; For the dry season irrigation period is three (03) months using an electrical pumping station. For the rainy season, SODAGRI uses one or two weeks to complete the need of water of irrigation[24](on average, once every 5 years over the last 15 years) due to the conformation of the rainy season. They run the pumping systems 24/7 during irrigation season.

Group irrigation schemes vary from a few to several ha (less than 100 ha) being organizedorganized by (private) groups, or associations. Diesel generators are commonly used to pump from surface water bodies. This model is frequently applied along the Senegal river valley through private (PIP — Périmètres Irrigués Privés) and village (PIV — Périmètres Irrigués Villageois) schemes and the banana area in the Gambia River Valley. These cover nearly 75% of the land area under irrigation in the Senegal River Valley and Delta (Figure 8).

[23] Collected through interview with Bonergies SARL.
[24] Information collected from SODAGRI through questionnaire and interview, July 2020

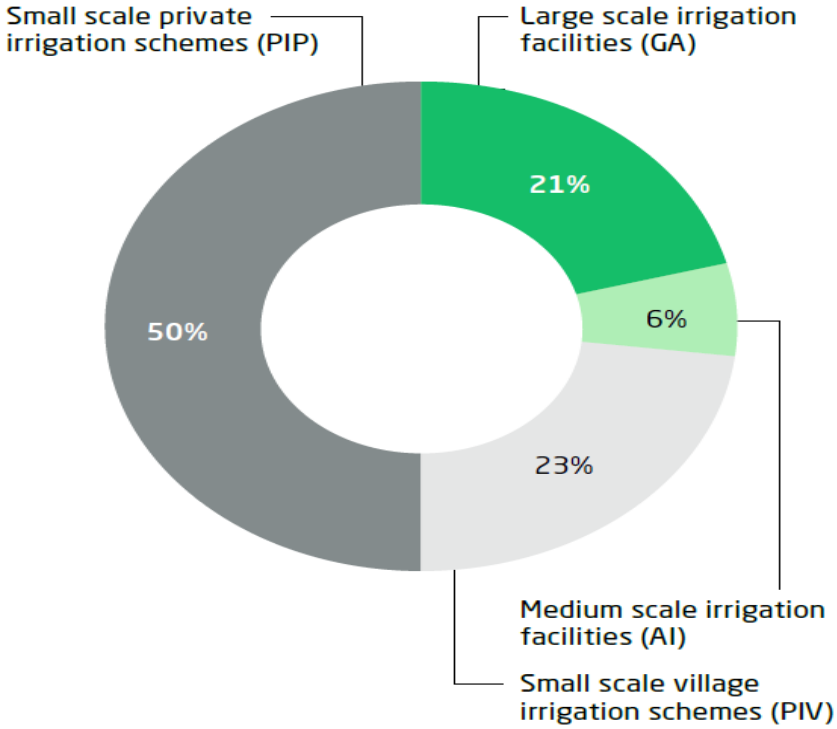


Figure 8: Irrigation schemes in the Senegal River Valley and Delta

Micro-irrigation is practiced on individual plots with average sizes ranging from a 0.1 to 1 ha with the water source typically being a well or a small stream. Irrigation takes place using buckets and manual labor, sometimes aided by small diesel pumps. This type of irrigation is common in the Niayes region (horticulture), Groundnut Valley and Lower and Middle Casamance area (fruit and vegetables) and, in recent years, has been increasing in the Senegal River Valley and around Lake Guiers. This is within the country level context of approximately 75,000 households being involved in horticulture and a further 25,000 in growing fruit trees. Against this backdrop, the estimated irrigation area in this sub-segment is 26,000 ha with 11,000 ha for vegetables and 15,000 ha for fruit trees.

Table 5 summarizes the principal types of irrigation systems as presented earlier and provides an estimated total market potential. Based on these figures, and assuming a market penetration of 25–50% , the market potential for solar PV for irrigation in Senegal can be estimated at EUR 55–111 million with additional growth opportunities as the area under irrigation expands towards its estimated potential of 497,500 ha.

Table 5: Estimated market size for different irrigation segments[25]

Irrigation Schemes	Area (ha)	Number of Irrigation Schemes or Households	Average Size (ha per Irrigation Scheme)	Indicative Pump size (kw)	Indicative SIPS price (EUR)	Total Estimated Market Size (million EUR)
Medium and large	19,000	190	100	100	100,000	19

[25] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

Group	50,000	2,500	20	25	25,000	62.5
Micro (Vegetables)	11,000	74,045	0.15	0.05–0.1	1,000	74
Micro (Fruits)	15,000	26,445	0.57	0.25–0.5	2,500	66
Total	**95,000**					**221.5**

3.6. Institutional setup of Agricultural Sector

Governance of the global agriculture sector is shared between an increasing number of institutions from national to international levels.

Ministry of Agriculture and Rural Equipment (Senegal) (MAER)

MAER is an arm of the Republic of Senegal's Government that provides agricultural services.

UN Institutions. The UN has a variety of mechanisms and institutions that take part in governing agriculture globally. Most predominant is the Food and Agriculture Organization, with the role of conducting and sharing research, advising on policy, developing conventions and guidelines, leading agricultural development programs and acting as a forum for policymakers to meet.

The G-20 and G-8. Neither institution has a formal mandate to deal with food security and agriculture, but the G-8 and G-20 have included these topics in their agendas in the wake of the 2007-2008 food crisis.

Outside of their influence through distributing concessional loans and grants (e.g. ODA), **Multilateral Development Banks (MDBs)** primarily influence the agricultural sector by setting conditionalities and objectives relating to government spending and agriculture projects.

Civil society organizations (CSOs) have recently played a larger role in governance of agriculture at the global scale with increased local, regional and international coordination and inclusion in UN entities15 as well as in partnering with private initiatives for corporate social responsibility and sustainability.

Private foundations and **companies** are increasing their role in agricultural governance.

Nine public agencies conduct agricultural R&D in Senegal. ISRA is a semiautonomous public institution, which allows it to commercialize its research results as a means of generating revenue. This status even allows the institute to create private subsidiaries (that could fund R&D activities), which is an avenue the institute has yet to explore.

3.7. Access to water[26]

Access to water is critical to the livelihoods of the rural population in Senegal, and rainfall is the primary determinant of agricultural productivity. The climate in Senegal is Sahelian, with a rainy season from June to October and a dry season from November to June. Rainfall, which ranges from about 150 millimeters per year in the northern sandy pastoral region to 1,400 millimeters a year in the Casamance, is highly

[26] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019

regionalized and variable from year to year. In areas such as the Senegal River Valley and Peanut Basin, rainfall can vary 500 millimeters or more in a given year, ranging from 150 to 600 millimeters. Every region is receiving less rain due to climate change: in the period between 1965 and 1990, rainfall has decreased by about 200 millimeters per year countrywide. Periods of extreme drought also occur, most recently in the 1970s and 1980s.

Senegal has four major rivers: Senegal; Sine-Saloum; Gambia; and Casamance. Of the river basins, the Senegal River basin is the most important, covering about 37% of the total land area and sharing its water with neighboring countries (Guinea, Mali, and Mauritania).

Senegal's renewable surface water resources are estimated at 24 cubic kilometers per year, and renewable groundwater resources total about 3.5 cubic kilometers per year. Water delivery is managed through a public- private partnership in Senegal, and privatization resulted in a marked improvement in access to water and water quality, with about 90% coverage in areas and 65–75% coverage in rural areas. However, although overall access numbers are high, wide gaps in coverage exist between access to water in Dakar and other cities, and between wealthier and poorer residential areas, and water coverage in some rural areas remains quite low.

Senegal's estimated irrigation potential is about 340,000 hectares, but irrigation covers only 105,000 hectares, with a 60% exploitation rate. In 1997 approximately 85% of water was used for irrigation while in 2020 it was expected to be 91%[27]. Many irrigated areas are poorly managed, allowing excessive runoff and heavy concentrations of salt. High development costs and inadequate user participation in water management have been blamed for these shortcomings.

3.8. Cropping seasons

There are three cropping seasons in Senegal i. **Dry and Hot season ii. Rainy season and iii. Dry and Cold season.** In most cases, crops are only grown during the rainy season. Exceptions can be found in areas under irrigation where 2 to 3 growing seasons are sometimes used.

3.9. Challenges in Agriculture Sector[28]

Various systemic and market constraints hinder the development of crop irrigation in Senegal. Systemic barriers include infrastructure, water availability and quality, power availability and costs, poor marketing and trade policies, and provision of agricultural support services. Market barriers include access to finance and agricultural equipment, farmer knowledge, value chain support, and marketing. Challenges have been detailed in **annex 1**.

4. Electricity Sector[29]

The Government of Senegal has made power sector development a key component of its Plan Sénégal Emergent. Priorities include lowering the cost of generation by reducing dependence on imported liquid fuels and increasing electricity access – particularly in rural areas. Senegal has significant potential to develop solar and wind power – as well as the opportunity to develop its offshore natural gas resources. The Government aims to achieve universal access by 2025 through a combination of on- and off-grid solutions, though the country's rural concessions program faces significant hurdles[30].
Following table 6 shows the generation capacity[31]:

Table 6: Generation capacity

[27] https://www.researchgate.net/publication/273489604
[28] Senegal: Irrigation market brief, 2016
[29] GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019
[30] https://www.usaid.gov/powerafrica/senegal
[31] https://www.usaid.gov/powerafrica/senegalhttps://www.usaid.gov/powerafrica/senegalhttps://www.usaid.gov/powerafrica/senegal

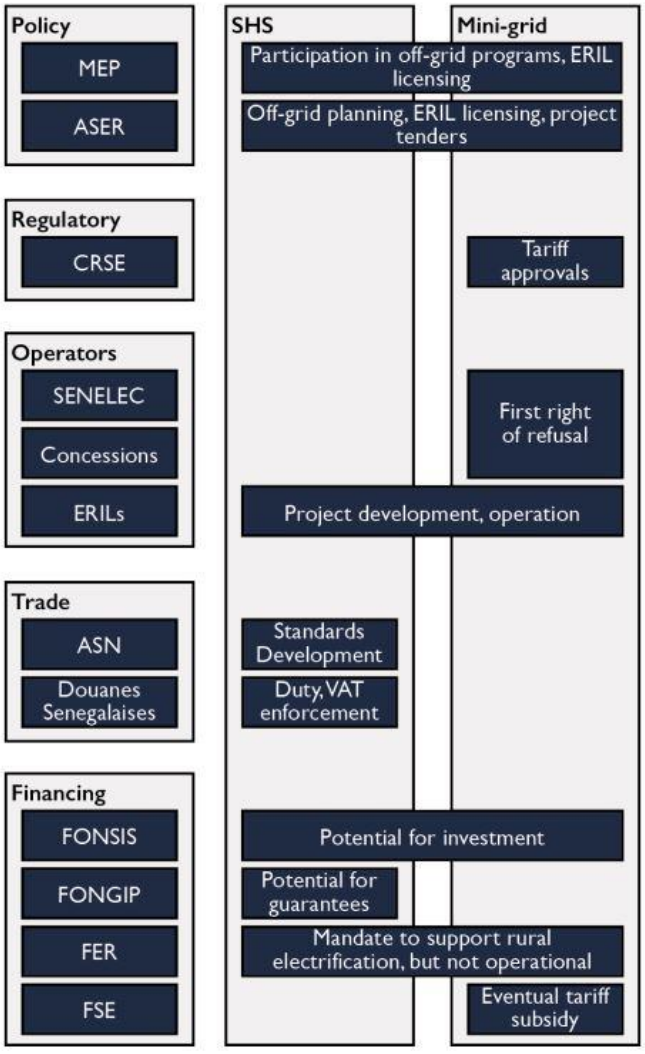
Type	Installed Capacity
Thermal	733 MW
Hydro	60 MW
Solar	50 MW
Total	**864 MW**

Senegal's national electrification rates were as following: **national: 64%; Rural: 43.5% and Urban: 90%.** The Government of Senegal set targets to achieve universal access in 2025. The electrification rate is rising as a result of new connections to the main grid and small off-grid projects. However, consumers and businesses connected to the grid still must contend with highly unstable and unreliable electricity supply, leading to revenue and productivity losses for firms and the economy as a whole.

4.1. Legal and regulatory framework[32]

Figure 9 represents the structure of the GoS's institutional framework for the off-grid electricity sector.

Figure 9: Senegal Off-grid institutional framework



Ministry of Energy and Petroleum (MEP). MEP, formerly the Ministry of Energy and Development of Renewable Energy (MEDER), leads the development of overall sector strategy and policy. Within MEP sits a directorate of electricity focused exclusively on the sector, including the off-grid mini-grid and SHS sectors.

ASER. ASER oversees all rural electrification efforts, including the administration of the PPER and ERIL policy frameworks. ASER also spearheads its own electrification programs, including off-grid mini-grids. Mini-grid work is donor-funded and tendered through an EPC model. Recent projects include a 2018 tender for 78 mini-grids in Matam and Bakel departments and an EPC with the German GAUFF Engineering to construct 300 mini-grids.

National Agency for Renewable Energy (Agence Nationale pour les Energies Renouvelables [ANER]). ANER, which is in the process of being absorbed into Senelec, was chiefly responsible for on-

[32] http://documents1.worldbank.org/curated/en/581421558458547633/pdf/Concept-Project-Information-Document-PID-Project-to-Promote-a-Shift-towards-Lower-Carbon-Power-Generation-in-Senegal-P169744.pdf

grid project promotion, but its off-grid interests included street lighting, public buildings, and pumping.

Agency for Energy Efficiency and Management (Agence pour l'Économie et la Maîtrise de l'Énergie [AEME]). AEME was also recently absorbed into Senelec and oversaw energy efficiency programs.

Electricity Sector Regulatory Commission (Commission de Régulation du Secteur de l'Électricité [CRSE]). CRSE is Senegal's electricity regulator responsible for the preparation of licenses and tariff approvals for all industry actors, including mini-grids. While CRSE is involved in the licensing process, final approval is required from MEP.

Standards Association of Senegal (Association Sénégalaise de Normalisation [ASN]). ASN is responsible for developing and promoting national and international standards. Senegalese Customs (Douanes Sénégalaises). Senegalese Customs is responsible for import inspection and tariffs enforcement, including categorization of SHS and other energy equipment.

Sovereign Funds Strategic Investment (Fonds Souverain d'Investissements Stratégiques [FONSIS]). FONSIS is Senegal's sovereign investment fund. FONSIS has expressed considerable interest in supporting the off-grid sector and has held informational interviews with some actors.

Priority Investment Guarantee Fund (Fonds de Garantie des Investissements Prioritaires [FONGIP]). FONGIP seeks to improve access to credit for small enterprises. FONGIP has a guarantee program in place for pumping projects that replace diesel and has expressed some interest in supporting SHS companies.

Rural Energy Fund (Fonds d'Energie Rurale [FER]). The Rural Energy Fund was created in 2006 through government decree. The fund intended a number of subsidies and loans to banks, developers, and operators to help spur both on- and off-grid rural electrification projects. The fund, however, was never endowed.

Special Fund for Support to the Energy Sector (Fonds spécial de Soutien au Secteur de l'Énergie [FSE]). FSE is used to support a number of energy sector subsidies, including transport of petroleum products. In the electricity sector, FSE is used to subsidize the government's tariff harmonization scheme, providing funds to both Senelec and concession operators to ensure that they can charge the same tariffs. FSE will also offer such subsidies to mini-grid ERILs, though this development has yet to take place.

International donors are very active in Senegal's energy sector and are an important source of funds for both on-grid and off-grid electrification projects. Although Senegal has a donor coordination group, led by the EU and AFD, the group has not been active in the off-grid energy sector.

Economic Community of West African States (ECOWAS) Centre for Renewable Energies and Energy Efficiency (ECREEE). ECREEE supports Senegal's off-grid sector through its Regional Off-Grid Electrification Project (ROGEP), a World Bank-funded project targeting solar lanterns, SHS, solar water pumping, and solar-driven agricultural processing. ROGEP provides technical assistance to the GoS to integrate off-grid models into policy, prepares market intelligence for the private sector, and has a debt fund directed at off-grid companies. ECREEE has also supported companies directly through grants. ECREEE implements the ECOWAS Program on Gender Mainstreaming in Energy Access (ECOW-GEN). In 2015, ECOWAS member states adopted the ECOWAS Policy for Gender Mainstreaming in Energy Access to address existing barriers that may hinder the equal participation of women and men in expanding energy access in West Africa. Currently, ECOW-GEN is undertaking a feasibility study on business opportunities for women in a changing energy value chain in West Africa.

German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ]. GIZ is supporting off-grid in Senegal through two programs. The first, Being Successful in Senegal, has supported off-grid companies to create jobs in rural areas, with some companies hiring dozens of sales agents through the program. The second, Sustainable Energy Program, supports scalable productive use pilots in the areas of milling, pumping, and refrigeration.

Energizing Development Program (EnDev). EnDev has been working in Senegal's off-grid sector for many years, with emphasis on support of the ERIL model. In 2019, they will launch a project to promote SHS distribution through local youth associations.

Dutch Embassy. The Dutch Embassy has given considerable support to ANER's efforts to install standalone solar in public buildings, including a feasibility study for off-grid options to electrify public schools in the Casamance region.

MCC. In December 2018, Senegal signed its second MCC Energy Compact, amounting to $550 million in energy sector funding. Electrification is among the compact's components, and it will focus on increasing access in rural and peri-urban areas of the central and southern parts of the country.

Senegal has one major renewable energy association, the **Council of Professionals of Renewable Energies in Senegal (Conseil Patronal des Energies Renouvelables du Sénégal [COPERES]).** COPERES is involved in policy advocacy and government interface and hosts internal working groups to generate policy reflective of its members' interests. Aside from two off-grid companies, Coser and Bonergie, COPERES is comprised entirely of EPCs and importers, thus its efforts are primarily focused on on-grid development.

4.2. Electricity Generation[33]

In 2011, Senegal's electric network underwent a total of 950 hours of power cuts throughout the year. The same year, the national electricity company SENELEC and the West-African Development Bank signed four agreements totaling almost $100 million of funding to develop Senegal's power sector. Following restructuring, investment and equipment modernization, SENELEC brought that figure down to 24 hours in total in 2018. Every year, the company produces a surplus of 200 megawatts (MW) – approximately equivalent to the power needs of neighboring Mali – which is stored for potential future use or exports. Before 2014, the state-owned company was making losses and was subject to loans, leaving no room for reinvestment in infrastructure. In 2016, it reached a $52 million profit.

Such results were achieved through the PSE, which aimed to make Senegal's energy sector independent and self-sufficient. As part of the PSE, a priority of the plan was to make SENELEC financially strong and capable of investing in key infrastructure to expand capacity. Since the launch of the plan in 2014, $3.5 billion has been raised through a mix of public and private partners. In 2016, the Plan Yeesal SENELEC 2020 was launched, aiming to make the company a motor of Senegal's growing economy. As part of the plan, SENELEC held for the first time ever an initial public offering in January 2018, through the regional stock exchange Bourse Régionale des Valeurs Mobilières, hoping to achieve $52 million to fund its

[33] https://www.africaoilandpower.com/2019/08/09/senegal-to-boost-electricity-production/

development plan. The initial public offering was a major success as it mobilized over $66 million, due to the financial stability of the company, which reassured private individual investors.

Improved financial strength has allowed large investments to increase capacity. In 2015, capacity totaled 510MW. In 2018, cumulative capacity reached 1,200MW in the country, of which 200MW is solar. These expansions have provided the country with comfortable reserves – around 200MW each year – and allows for export to neighboring The Gambia.

Access to power is a major part of the PSE. Currently, foreign oil dominates the energy mix as almost 90 percent of electricity is produced from imported fuel. This translates to high prices, pollution and dependence on other states. Moving towards 2030 and development goals, Senegal wants to increase both the diversity of power sources, as well as economic efficiency. Clean energy is also a decisive factor, as the country aims to double the stake of renewable energy involved in the mix by 2030, in which Senegal projects it will need to produce 2000MW to satisfy local demand.

Figure 10 presents a map of electricity generation and transmission in Senegal.

4.3. Electricity Tariffs

Considering the average electricity prices across the whole ECOWAS region, Senegal sits below the average. The country is ranked 9th out of 15 in terms of the lowest electricity prices (Figure 11). Electricity tariffs have been stable over the last five years with SENELEC (2017a) i.e.0.14 to EUR 0.17 c/kWh which is close to double the global average[34].The pricing of electricity services is established and controlled by the CRSE with tariffs subject to 'price ceiling' regulation. The following figure shows a comparison of tariff among the countries in the region.

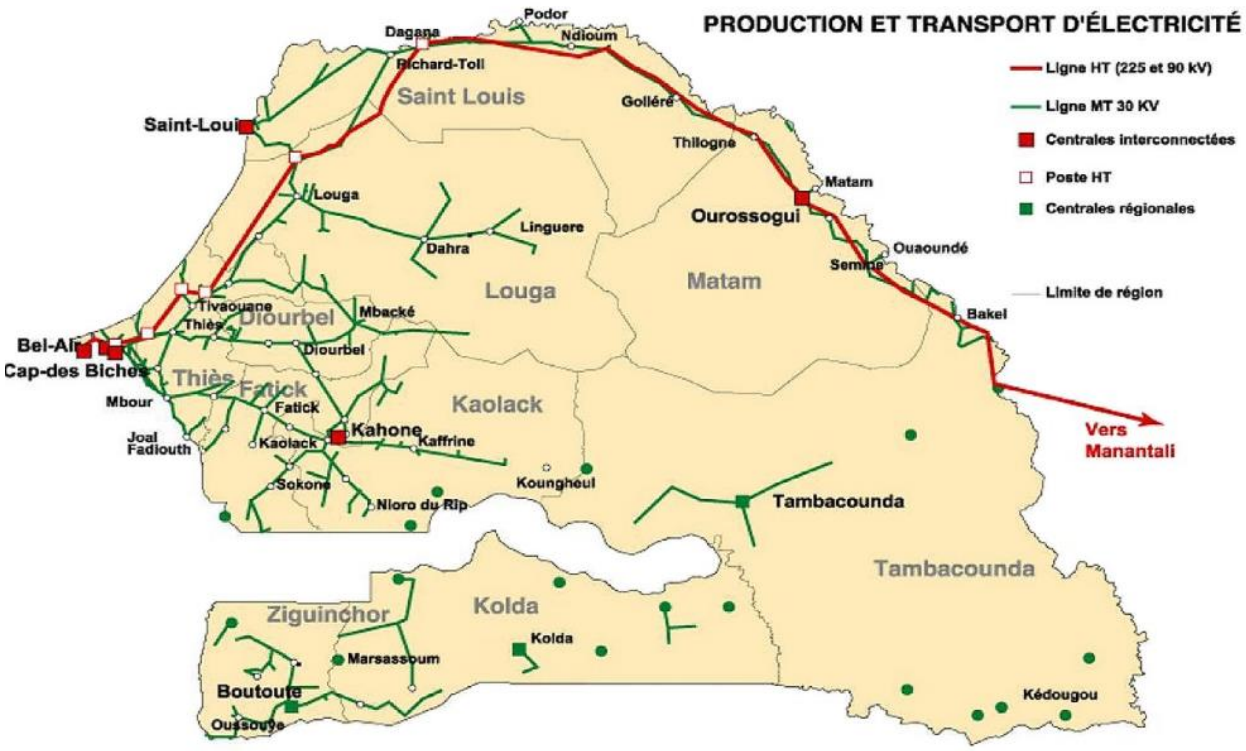


Figure 10: Map of electricity generation and transmission in Senegal

[34] Project Information Document (PID), The World Bank, Date Prepared/Updated: 17-May-2019 | Report No: PIDC26631.

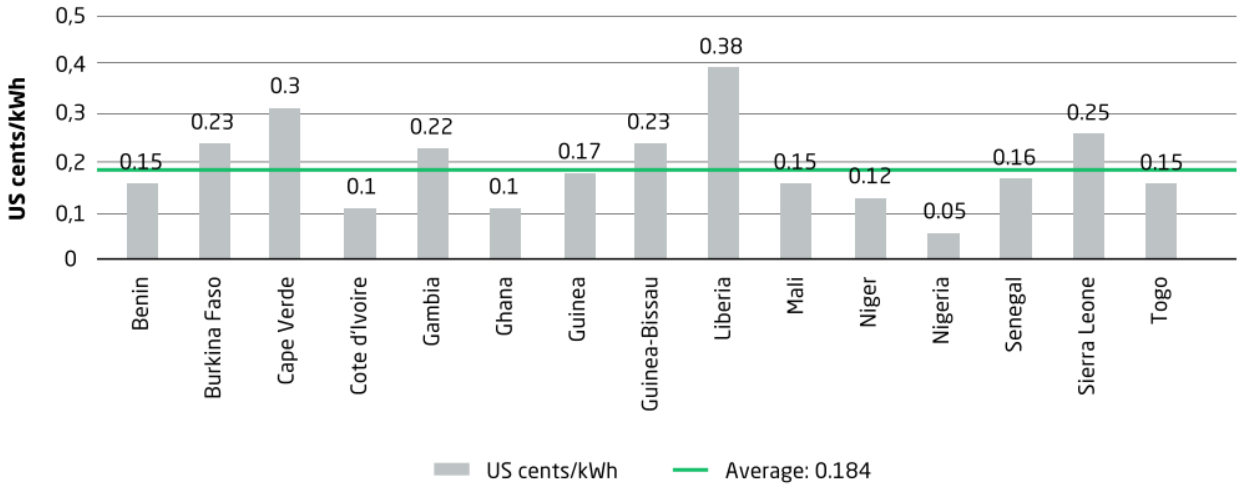


Figure 11: Average electricity price by country

The high electricity tariff of Senegal is a challenge for irrigation to be powered by grid electricity. For SODAGRI day-time electricity cost is 25 USC/kWh and night-time electricity cost is 16 USC/kWh[35]. This opens up opportunity for solar based power generation units. Solar based mini grids can be designed to serve the communities along with powering agriculture. Areas with agriculture and other commercial activities can be identified to install such power plants for electrifying households, business, and irrigation. This will be a huge boost for that target economy. The detailed tariff structure is in Annex 2.

4.4. solar Energy Potential

As part of the Government of Senegal's wider commitment to delivering 100% electrification by 2030, it has been identified that the country has high levels of solar irradiation. Solar has the potential to deliver a clean alternative to supplant the use of diesel irrigation pumps, reducing farmers' costs and CO^2 emissions, increasing profitability, and enabling year-round crop yields in rural Senegal. Average solar irradiation across the country is reported to be within the range of 1600kWh/m2/year to 1800kWh/m2/year (Figure 12 [36]) with an average global daily irradiation calculated at 5.43 kWh/m2/day (REEEP, 2014). This gives excellent prospects for photovoltaic (PV) projects like solar irrigation. The distribution of solar irradiation across the country also covers the key irrigation areas.

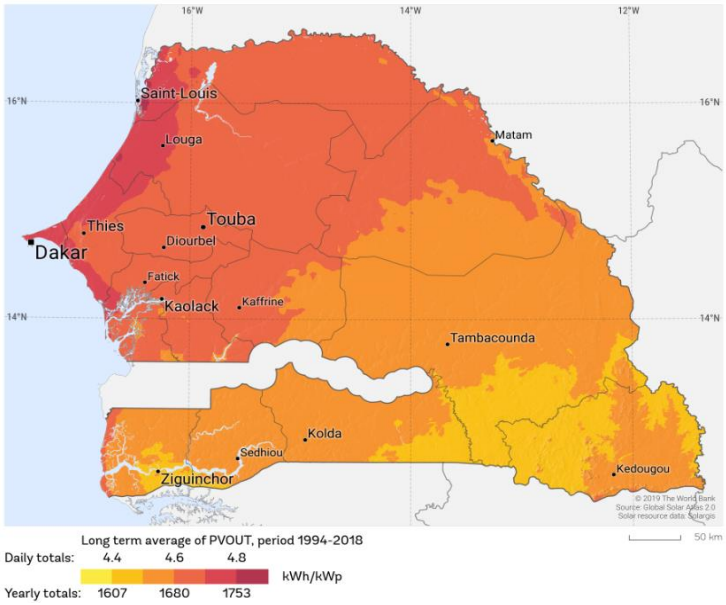


Figure 12: Solar irradiation in Senegal

5. Solar Irrigation Landscape Policy

[35] Collected via interview with SODAGRI, responsible for irrigation in southern region, 10 July 2020.

[36] https://globalsolaratlas.info/download/senegalhttps://globalsolaratlas.info/download/senegalhttps://globalsolaratlas.info/download/senegal

The main pieces of legislation governing the electricity sector in Senegal are the Electricity Law of 1998 (Loi d'Orientation No. 98–29) and the Renewable Energy Law of 2010 (Loi d'Orientation sur les Energies Renouvelables No. 2010-21).

National Renewable Energy Action Plan (PANER), Senegal mentions that from 2008 the energy sector experienced a significant evolution more favorable to the development of renewable energies. Senegal has embarked on a process of promotion of renewable energies, energy efficiency, and access to energy by developing laws and regulations to enable the private sector to invest in the energy within particular[37]:

- Energy Sector Development Policy Letter in February 2008 aims a share of energy at 15% renewables in the national energy balance by 2020;
- Creation of a ministerial department exclusively dedicated to renewable energies in 2010;
- the establishment of the Interministerial Committee on Renewable Energies (CIER) in February 17, 2011 to facilitate consultation and the consistency of the activities related to renewable energies;
- The orientation law on renewable energies and relating to the conditions of purchase and remuneration of Electricity produced by power plants from renewable energy sources as well as conditions for their connection to the network;
- The orientation law on renewable energies relating to the conditions of purchase and remuneration of the surplus electrical energy from renewable sources resulting from production for own consumption;
- the creation of the National Agency for Renewable energies (ANER) to promote the use of renewable energy, including bioenergy in all sectors of activities.
- the signing of memorandum of understanding on July 10, 2012, between the Ministry of Energy and Mines, and the Housing Bank of Senegal (BHS), for the financing of the acquisition of solar kits and compatible equipment for the benefit of households.

5.1. Renewable Energy Act 2010[38]

The regulatory framework in Senegal is mainly comprised of several decrees promulgated on an irregular basis. The two most recent and most important decrees for implementing the Renewable Energy Act were issued in December 2011. They lay down the conditions for purchasing and paying for electricity generated by renewable energy plants, the conditions for connecting these plants to the grid, and the conditions for purchasing and paying for surplus electricity from captive power plants that generate electricity from renewables. However, reduced taxes and customs duties applicable to renewable energy equipment are only considered on a case-by-case basis.

The Government of Senegal, by interministerial order No. 010 158 of 28 May 2020, has just exempted from value added tax (VAT) a list of twenty-two (22) materials used in the production of renewable energy from solar, wind and biogas sources. The order was signed by the Minister of Finance and Budget and the Minister of Oil and Energy.

Decree No. 2011-2013 provides conditions of power purchase and remuneration for electricity generated by renewable energy plants and the conditions of their connection to the grid. It also provides the formula for the avoided cost which serves as a reference for calculating the power purchase price cap. It also contains an elaboration on renewable power purchase obligation and feed-in tariffs for different renewable energy technologies.

[37] National Renewable Energy Action Plan (PANER), SENEGAL, Period [2015-2020 / 2030]

[38] https://www.get-invest.eu/market-information/senegal/governmental-framework/https://www.get-invest.eu/market-information/senegal/governmental-framework/https://www.get-invest.eu/market-information/senegal/governmental-framework/

Decree No. 2011-2014 specifies the conditions for purchasing surplus renewable electricity from self-producers. Among other provisions it sets the maximum intake from renewable energy sources (variable power), the purchase price, as well as conditions for purchases of surplus energy and connection to the grid.

5.2. Action Plans[39]:

For the implementation of its energy strategies, the Government of Senegal has formulated specific action plans for both rural electrification and renewable energy:

- The National Action Plan for Renewable Energy of 2015 (PANER): This has identified the renewable energy potential for Senegal which includes solar as one of the prominent options with average solar irradiation of 5.43 kWh/m²/day. The action plan also commits the followings:
  - achieving a commercial energy independence rate excluding biomass of at least 15% less in 2025, thanks to the contribution of renewable energies and biofuels;
  - operationalization of the legal, regulatory and institutional framework of the sub-sector renewable energies
  - obtaining, a rate of 20% of renewable energies in power installed in 2020.

It has also stipulated following renewable energy target:

Table 7: RE target in National Action Plan

Target Particulars	2010	2020	2030
Installed capacity of power plants renewable in MW (including medium and large hydro)- Grid Connected	68MW	403MW	632MW
Share of renewable energies in% of total capacity installed (including medium and large hydro) - Grid Connected	10.9%	35.6%	31.8%
Share of rural population served by off-grid RE	2%	15%	26%

- The Senegalese Rural Electrification Action Plan (PASER — Plan d'Action Sénégalais d'Électrification Rurale) is a 20-year strategy focused on mobilizing the private sector to increase rural electrification rates. PASER came into force in 2002 and it is administered by ASER. Its target is to achieve a rural electrification rate of 62% by 2022. PASER is divided into three programs, addressing different challenges of rural electrification:

[39] Mostly from GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019, unless stated otherwise

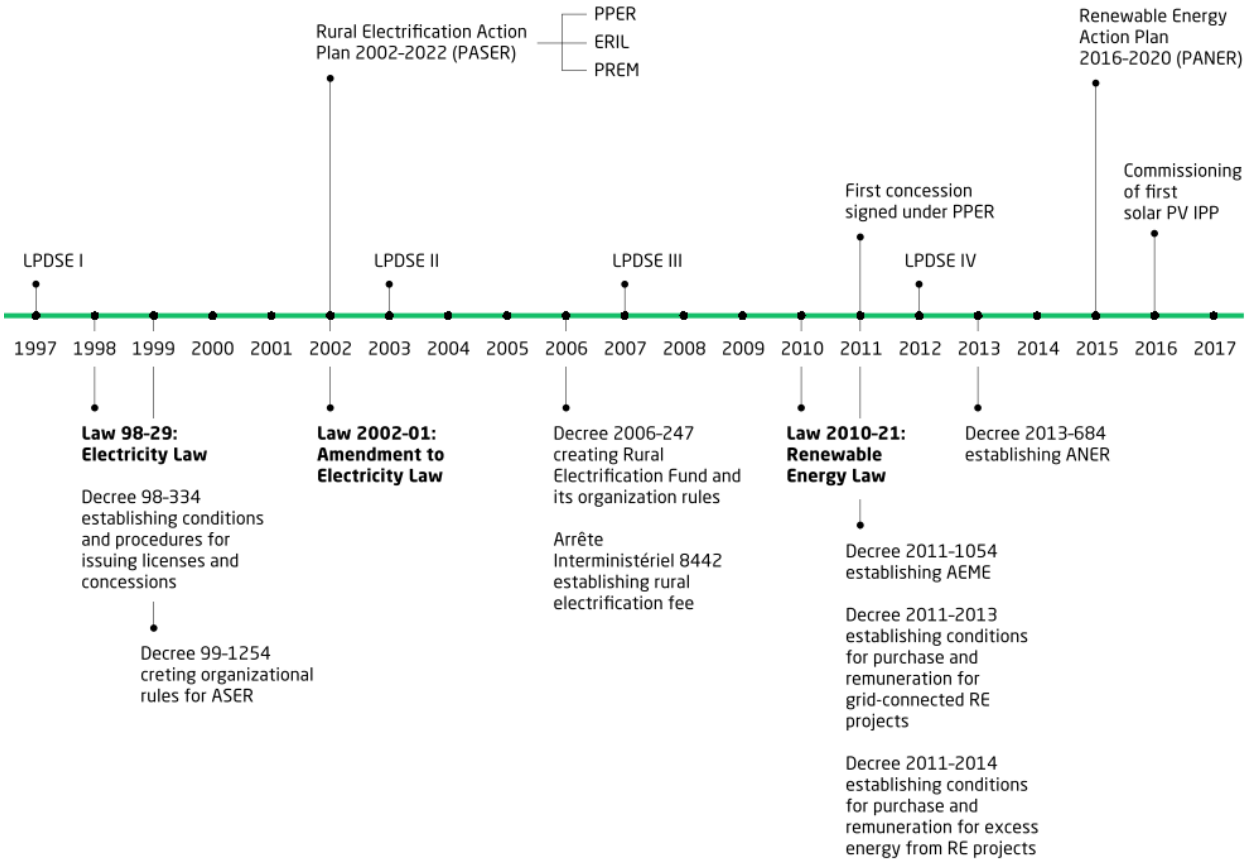


Figure 14: Electricity sector policies, laws and regulations

ASER is currently responsible for three rural electrification programs delivered under the Senegalese Rural Electrification Action Plan (PASER), the aforementioned — Rural Electrification Priority Program (PPER), Local Initiative for Rural Electrification (ERIL), and Multi-Sector Energy Program (PREM).

The Rural Electrification Priority Program (PPER)- the country was divided into 10 concession territories. Contracts to build and operate power infrastructure and to provide electricity services are awarded by technology-neutral competitive tenders for a period of twenty-five years.

The Local Initiative for Rural Electrification (ERIL)- covers village-level concessions by communities, consumer groups or private operators that will not be connected by the PPER concessions in the short to medium term. Typically, ERILs are small areas, often of village size and their usual promoters include Non-Governmental Organisations (NGOs), and community organisations.

The Multi-Sector Energy Program (PREM): The focus areas of PREM are a) to maximize the effects of the energy resource on economic and social development in rural areas, and b) to stimulate electricity consumption for productive and community use in rural areas. The latter includes various forms of productive use for agriculture and livestock management.

Projects that are implemented under ASER's three rural electrification programs are eligible for funding from the Rural model and have had mixed success. On the one hand, the winning bids under the PPER secured a total of USD 52 million of private finance, representing an average of 49% of the total investment. This is significantly greater than the minimum 20% required by the invitations to tender. On the other hand, results in terms of installations are far less impressive. In ten years, the different concession programs realized 6,121 electricity connections, representing an increase of less than 1% in national rural electrification levels.

5.3. Taxation and fiscal benefits[40]

General Taxation

In 2012, the Government of Senegal adopted a new General Tax Code, which covers the different taxes and tax regimes in one document, including amongst other income, corporate, value-added, and withholding tax. Law 2012-31 is complemented by Law 2012-32 which seeks to bring together all taxation issues and topics from different laws and regulations under one General Tax Code. As such, Law 2012-32 repeals and amends one charter and 18 laws, including the 2010 Renewable Energy Law and the 2004 Investment Code. The main heads of Senegal's corporate tax regime are summarized in Table 7.

Fiscal Benefits

Under the new General Tax Code, a number of tax benefits and fiscal incentives exist that may be applicable to the introduction of renewable energy applications in agricultural value chains. According to Article 241 of the General Tax Code, agricultural (and other) companies that invest in solar or wind energy can benefit from a reduction in their income tax of up to 30% of the value of the investment. The tax reduction can however not exceed 25% of the tax payable in a single tax year. Among other items, article 242 of the General Tax Code explicitly refers to solar pumping stations as being eligible for this reduction.

However, situation in practice seems to be different. PRACTICA Foundation reports that the taxes and customs duties on imports Taxes and customs duties payable on the importation of solar pumps stand at 31% of the declared purchase value (table 8)[41]. This is the rate applied for the import of three pumps from the Netherlands shipped via DHL, including customs clearance. A pump shipped from Burkina Faso via Air Burkina Express was exempted from VAT.

Table 8: Import revenues in Senegal

Customs Duties	10%
Statistical charge	1%
Solidarity common levy	1%
ECOWAS community levy	0.50%
VAT	18%
Total	**31%**

During an interview with Bonergie SARL, it was reported that the duties for solar panels are very minimum. However, pumping systems are subject to a total of 24% of government revenues. However, an effort is going on to convince the public authority to consider the pumping system as an agricultural product. Agricultural products are subject to reduced duties and tax of 7%.

5.4. Policy relation- Agriculture and Solar Irrigation

As part of the efforts to improve food and nutrition security, fight rural poverty and achieve a sustainable agriculture in Senegal, the Government attached greater importance to the need to accelerate processes for agricultural transformation in his General Policy Statement of 28 October 2013. Following this effort, the government drafted a Program of Acceleration of the Rate of Senegalese Agriculture (PRACAS)[42].

[40] Mostly from GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019, unless stated otherwise

[41] Intermediate-depth solar pumping irrigation solutions for smallholders in the Niayes region, Practica Foundation, January 2019.

[42] https://p4arm.org/document/programme-dacceleration-de-la-cadence-de-lagriculture-senegalese-pracas-2014-2017/

In line with the Senegalese Emergency Plan (PSE), PRACAS is expected to modernize family farms through professional training of farmers, promote agricultural and rural entrepreneurship, involve young people and women in the agricultural sector with the establishment of agricultural income-generating and knowledge-building jobs, and strengthen the resilience of vulnerable populations.

This component stipulates rice self-sufficiency through irrigated and rainfed rice production, peanut production as part of a value chain approach and the development of market gardening and horticulture, a segment dedicated mainly to exports.

The lack of access to modern energy services is, however, hampering agricultural development and food production.

With rural electrification rates at around 40%, the use of irrigation systems remain low (less than 20% of land suitable for irrigation is currently being used) and post-harvest losses are estimated at between 30 to 40% for fruits, vegetables and milk (ISRA, 2008) due to the lack of proper storage, processing and transportation facilities. In addition, a rural energy source of biogas from converted plant or animal waste that can be used directly for cooking and/or converted to electricity, continues to go underutilized.

Senegal had to import -amounting to 65% of national consumption at a value of USD 460 million in 2013. This dependence on the import market is a huge burden on the country's economy and the situation gets even worse in the time of regional and global crises like COVID-19. It has been always important for GoS to make agriculture self-sufficient and the COVID-19 pandemic has made it more obvious. Therefore, the Government of Senegal has made agriculture and the promotion of a modern and diversified agribusiness sector a priority.

The Government has also directed a number of actions towards the development of commercial agriculture including making structural investments with donor support such as building specialized infrastructure (e.g. post-harvest, processing, storage and logistics), as mentioned in table 9, below.

Table 9: Planned amount of investment for the different agricultural sub-sectors

Sub-sector	Objective	Investment CFA billion (EUR million)
Rice	Self-sufficiency by 2020 with a production of 1.6 bnt of paddy ricewithaproductionof1.6bntofpaddyrice	424.7 (648)
Onion	Self-sufficiency by 2016 with a production of 350 Mt	20.9 (31.9)
Groundnut	Optimization to reach a production of 1 bnt and exports of 100 to 150 Mt	92.0 (140.6)
Off-season fruit and vegetable	Development of the sub-sector to achieve 157 Mt of exports	43.5 (66.48)

The expansion of agricultural activities is directly linked with the expansion of irrigation. Production during the dry-hot and dry-cold season goes down due to the unavailability of sufficient water. Two most popular options for irrigation in Senegal i.e. diesel and electricity are expensive and need to be replaced by a cheaper source of energy. Solar power irrigation could be a green, cheap and sustainable option for irrigation. Therefore, all policy measures in agriculture will have a direct impact on scaling up of solar irrigation systems.

Productive use has seen relatively little attention in terms of government policy, and no comprehensive strategy is being contemplated for the sector; however, this may change[43]. In its latest draft Sector Policy Letter for 2019–2022, the Government of Senegal mentions productive uses as a component toward achieving universal energy

[43] https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Senegal-MarketAssessment-Final_508.pdf

access. Despite the lack of an overarching framework, however, private companies and donors are realizing success.

In Senegal, activity in the sector is dominated by pumping. However, limited development has occurred around solar mills or regarding cold chain applications; these issues may be due to the ease with which pumps align to existing off-grid business models, and the potential for significant cost savings they hold for farmers.

Off-grid productive use in Senegal is dominated by pumping. Solar pumps offer a great deal of potential cost-saving to farmers. Traditional pumping technologies, such as manual pumps, diesel pumps, and even electric pumps, entail high operating costs.

Diesel pumping costs, in particular, may absorb a large portion of farmer revenues, are maintenance intensive, and rely on diesel supplies that are subject to shortages and theft. Despite this apparent potential, no comprehensive study has been conducted for the sector.

Private companies and donors alike are approaching the sector without an overarching framework, but are seeing success, nonetheless. Meanwhile, the GoS views the development of productive uses as a component toward achieving universal energy access. Local banks, especially those experienced in the agricultural sector, like La Banque Agricole du Sénégal (Caisse Nationale de Crédit Agricole du Sénégal [CNCAS]), Locafrique, Banque Atlantique, International Bank of Commerce and Industry of Senegal (Banque Internationale pour le Commerce et l'Industrie du Sénégal [BICIS]), and Orabank, are taking a closer look at the off-grid productive use sector. But their ability to offer favorable terms to the sector, even with an 80 percent guarantee instrument like that of FONGIP, remains unclear.

5.5. Water resources system in Senegal[44]

Senegal has scarce water resources – nearly 1825, m^3 of water per inhabitant, compared with 3,921 in Mali, 9,388 in Guinea Bissau, and 19,242 in Guinea[45]. Figure 15 shows different aquifer systems of Senegal. Despite recent investment by the Millennium Challenge Account (MCA) to rebuild the canals, farms in the Senegal River Valley still face water supply issues due to poor maintenance of water distribution canals. In the southern region, farmers cannot exploit two farming seasons since the land, canals, and dams are in a state of disrepair due to poor maintenance. Pumping stations are not on the power grid and run on fuel. Investments in irrigation infrastructure, such as water retention dams, would allow a growing area to be planted with sorghum, maize, sweet potato, tomato, and rice, with a positive impact on food security and farmers' income and cash flow[46].

[44] https://www.researchgate.net/publication/273489604
[45] http://www.fao.org/3/a-i5365e.pdfhttp://www.fao.org/3/a-i5365e.pdfhttp://www.fao.org/3/a-i5365e.pdf
[46] Senegal: Irrigation market brief, 2016

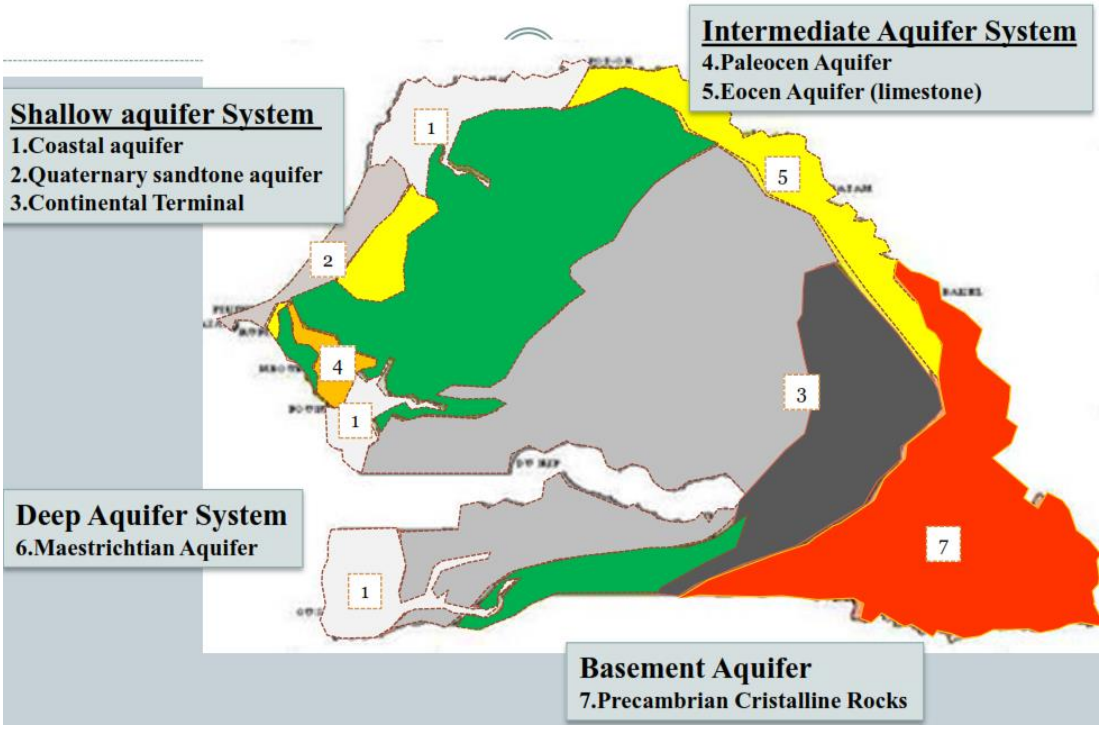


Figure 15: Aquifer systems of Senegal

Water Demand:

Sector wise water demand and demand projection is shown in the table 10.

Table 10: sector wise water demand and demand projection

Sector	1997	2020 (expected)
Domestic and Industry	306 Mm^3/year (15%)	9%
Irrigation	1,224Mm^3/year (85%)	91%
Overall Water Demand	1,530 Mm3/ year	7,000 Mm3/ year

Institutional arrangements for water management in Senegal:

The Ministry in Charge of Water and Sanitation was in charge of coordinating the Water and Sanitation Program with the Directorate of Rural Water, Directorate of Maintenance and the Directorate of Sanitation and the other agencies were the National Sanitation Agency of Senegal (ONAS) and the National Water Company of Senegal (SONES).

- The main texts (Acts, Decrees, Orders) are:

  - Water Production or Collection, Transmission and Distribution and Electrical Energy Act (1965)
  - State domain Code (1976)
  - Establishing the Dewatering Tax (Interministerial Order, 1977)
  - Water Code (1981)
  - Finance Act (defines the functioning of hydraulics National Fund,1991)
  - In 1998, the first texts of Water Code application were promulgated
  - Capture and Reject Authorizations (Decree No. 98-555)
  - Water Police (Decree No. 98-556)
  - Water Higher Council (Decree No. 98-557)
  - Water Technical Committee (Ministerial Order, 1998)
  - Clean Water and Sanitation Public Service Act (2008)

- Sanitation Code (2009).

in conclusion on the examination of the solar irrigation policy landscape, one can say that Senegal has policy instruments for renewable energy which has a clear target till 2030. However, a specific plan/policy instrument for rural electrification in term of renewable energy i.e. solar mini-grid and solar irrigation is required. A solar irrigation potential assessment and a roadmap would help the country realizing the benefit of sustainable energy-based irrigation systems. There is no focused national support for the promotion of solar irrigation except for the exemption from customs duties and VAT on solar equipment on paper, there are no other. No structured, universal, and well-established financing scheme is available dedicated to making the solar irrigation business commercially feasible. Though there is import tax exemption on importing solar pump this is not quite practically applied. Therefore, new policy interventions and application of existing ones are in need.

6. Solar Irrigation- Business Models

Several business model options exist for introducing renewable energy technologies into agricultural value chains. Commonly used applied approaches in Senegal are:

- ✓ **Cash-and-carry model** where the customer purchases the equipment and immediately becomes the owner. Here ownership belongs to the farmers and the suppliers are committed to providing after-sales services as negotiated under warranty clauses. The main disadvantage of the cash-and- carry model is that the average farming income in Senegal is low combined with limited access to traditional forms of credit.
- ✓ **Credit sell,** this is a recent initiative by different renowned suppliers that sell pumping systems for a down payment and recover the remaining amount in terms of monthly installments over the period of several months. Farmers own and operate the pump and suppliers are liable to provide after-sales services. This reduces the burden of higher investment cost by to some extent but the suppliers face problems getting their money back. Therefore, finding good farmers is a challenge requiring formal collaboration among stakeholders including the public and private organizations.
- ✓ **Government initiatives** where public authorities like ANIDA provide concessionary financial support to the farmers to help to purchase solar irrigation systems. Limited information is available on the terms and conditions of such initiatives.
- ✓ **PAYGO small pumps** there is a growing trend of selling small pumps for individual small farmers, women group (less than 0.5 hector land) where small pumps provide water for a fee based on usage. Limited information is available on such a trend.

Though there are multiple traditional business models being used for selling solar irrigation systems and few new business models are evolving, the need for an innovative business model is there. Business models practiced are demand driven but not well planned and structured with national focus. A business model which makes investment secure, purchase easy, and guarantee optimum system performance is required for scaling up of a SIPS installation. A centralized, government driven all-inclusive initiative should be undertaken to build such business models.

In recent years, a number of alternative business models have emerged in different parts of the world that can address the challenges faced by traditional business models. These are explained below :

- ✓ **The lease-to-own business model** focuses on providing equipment with a set of services and benefits for the farmer:
  - If the asset or equipment is in need of repair, the service is typically included at no cost to the farmer;

- Most lease-to-own models do not require a down payment, so the buyer has access to the equipment without making a large upfront payment;
- The business model allows the farmer to take temporary ownership of the equipment with the option of withdrawing from the transaction if he/she is dissatisfied;

Unlike traditional microfinance, which provides monetary loans for working capital to informal businesses, a lease-to-own model involves loaning productive assets or equipment to the customer. The asset itself acts as a form of collateral to help reduce the client's risk of spiraling into debt and further poverty. The customer pays a (minimum) fixed monthly or quarterly fee and interest is charged on the declining principal balance. After the balance is paid in full, the customer owns the equipment.

✓ **Credit sells by the suppliers**

Suppliers sell pumps to individual farmers for a down payment and monthly installment over a period of several months. This just reduces the load of paying higher initial investment cost.

✓ **PAYGO models**

Pay-as-you-Go (PAYGO) models are traditionally used for the distribution of solar home systems. Instead of paying for the equipment upfront, customers can buy energy at a fixed price using mobile money. The built-in connection to the mobile- phone network allows the provider to switch the system on or off remotely. Similar to the lease-to-own model, the equipment is transferred to the customer after a certain period of time. The additional advantage of the PAYGO model is that customer payments are based on actual consumption, i.e. if there is no consumption in a certain period, no payment is required.

PAYGO can be particularly relevant to the irrigation sector. In Senegal, the PAYGO model has been piloted by the Sustainable Energy Lab of Columbia University. Under the pilot, a 6.8 kW solar PV system was set up in the Niayes region providing 3-phase AC power to seven horticulture farmers. The power is used to pump water from shallow wells. The PAYGO metering allows smaller payments at a time, incremental growth and Capex costs to be recovered over time, reducing the initial investment hurdle for the farmer. The pre-paid system ensures transparency and accountability for the farmers and the operator and generates revenue from day one to cover operating and maintenance costs. Collecting payment upfront through the pre-paid credit eliminates non-revenue water issues that plague typical unmetered solar irrigation systems.

✓ **Energy-as-a-Service**

Under an Energy-as-a-Service model, energy is sold directly to customers. Unlike lease-to-own and PAYGO models, the ownership of the assets and equipment remains with the service provider. As such, the customer does not have to incur any long-term financial obligations and the service provider is responsible for maintaining and repairing the equipment. Energy-as-a-service can be implemented as a purely private sector approach or as a PPP. Under the latter, different models can be used with varying degrees of private sector involvement. The Energy-as-a-Service model can be particularly relevant in the context of medium and large-scale Solar PV for irrigation and Solar PV for cooling.

✓ **Water-as-a-Service**

Under this model, an SPV can take the role of investor to bring an irrigation system to the farmers. Equity to be injected by the SPV while it will be supported by financial support from a bank/FI or government initiative. The SPV will then sell water as a service to the farmers.

✓ **Ownership Model**

Well-off farmers can put equity in to buy irrigation systems by using financing extended by bank/FI or government initiative. Farmers then can pay back the loan preferably under a long-term loan tenor.

Notably, business models developed for a country can be different based on region, target segment of farmers, etc. however, all the models should be designed centrally and should be in line with each other. This is to avoid the risk of market distortion. Free or subsidy heavy programs should be immediately reviewed and brought under national irrigation program.

7. Solar Irrigation- Technology and market chain

There are approximately 2,000 solar pumping systems have been installed across the country[47]. That has been achieved through some government, development initiatives. It is not easy for farmers to know and buy a solar pumping system in Senegal.

Pump suppliers[48]:

There are approximately more than 10 pump suppliers with good market share. They can be categorized as European Brands, Chinese Brands as well as other Brands from India, Kenya, and Burkina Faso[49].

Suppliers of European brands (Lorentz and Grundfos) : These brands have built their reputation on the quality of the services and products sold, and on the renown of the brands they represent. They are based in Dakar , and are at times represented by secondary distributors in each province. Their ability to build up stock is a major asset. In general, these traders are generally hermetic to products of Chinese origin. Most sales to the market for irrigated agriculture target-rich smallholders and projects supported by institutional funds.

Suppliers of Chinese Brands : They are supported mainly by Senegalese dealers based in Dakar. There are no or few flagship Asian brands, and are often sold as unbranded products. Pumps are purchased online or through intermediaries that deal with China, and with whom they have established a relationship of trust. Product quality is very heterogeneous, and the quality of advice given on the choice or sizing of the pump uncertain. These dealers have a limited stock of pumps due to their limited cash flow, and to reduce the financial risk associated with an excessively large long-term immobilization of unsold products. They are highly capable of adapting to demand in the market.

There is a recent trend of buying small scale solar irrigation pumping systems for the land area below 0.5 hector. These small scale PAYGO pumps are designed for smallholder farmers and women group. These pumps are manufactured by Sun culture from Kenya, mini volanta from Burkina Faso, and Future pump from India.

After-sales services and technical standard[50]

There is no national technical standard and norms for solar irrigation pumping stems. Therefore, the warranty clauses, after-sales terms and conditions vary from one supplier to another. There is also no standard supply contract terms and conditions i.e. delivery terms, payment terms, liquidated damages terms to follow. Common warranty terms for pumping systems is 1 year and solar panel is for 20 to 25 years. Few well-established suppliers have a rural presence to address after-sales services. But most of them do not have a strong presence in the remote areas where there are agricultural activities. However, the market is developing and becoming competitive with the presence of multiple pump suppliers. Bonergie SARL based in Dakar is a supplier of Lorentz pumping systems and other agricultural equipment. They have 5 regional offices and have sold 300 SIPS to the farmers in 8-24 months of credit. They claim to have 72 hours of response timetimetime to address the technial issues. They are also in the process of introducing a digital payment mechanism which allows the farmers to pay the money to Bonergie via mobile banking. This reduces the risk of default payment. They are also collaboratingcollaborating with

[47] Collected through interview with Bonergies SARL
[48] Intermediate-depth solar pumping irrigation solutions for smallholders in the Niayes region, Practica Foundation, January 2019.
[49] Collected through interview with Bonergies SARL.
[50] Collected through interview with Bonergies SARL

Netafim, a leading agricultural equipment supplier, with an aim to provide turnkey solutions for drip irrigation. This will also help in water conservation.

Technical Design[51]:

Since there is no such structured program for solar irrigation, the common practice is- the system is designed by the suppliers. They ask for input data i.e. depth of water and crop patterns from the farmers to design the pumping system. Reputed manufacturers have their respective software which is used to design the pumping system. Suppliers also go for physical inspection before installation of the pumping system. Most of the pumps are submersible and installed to replace the existing pumping system based on diesel. The capacity of the pumping systems varies a lot depending on the water requirement and depth of water. The depth of water in the southern region is not so high while there are regions where water is 80m deep. For 1-2 hectors of land required investment is about 5000 euros5,000euro.

Rice production across Senegal River Valley is done using electric pumps powered by grid electricity. Rice associations are now looking for options not to replace the pumping systems but to replace the source of electricity i.e. solar instead of grid electricity. The technical design and construction of solar power plants to supply electricity with a lesser price than grid electricity are being explored[52].

Challenges:

- Access to finance has always been a problem for the suppliers and technology providers.
- Absence of technical standard is a challenge for the quality suppliers to compete with the suppliers with inferior quality due to the price difference
- Government supported programs are not well structured and typically aimed at international bidders; this hinders the sustainability of the local suppliers and thereby hinders the sustainability of the overall market
- Lack of turn-key solution for overall agro value chain and water conservation is also a challenge
- Identification of credible and trustworthy farmers to sell pumping systems in credit in a challenge
- Lack of smart technology that prevents farmers to pump water unless they make their monthly installments

8. Solar Irrigation- Access to finance[53]

While there are banks, MFIs and private sector organizations working in rural development activities, interest in renewable energy technologies is lagging behind, due to the higher perceived risks and lack of knowledge. Senegal has 25 banks (March 2020) with most concentrating on higher-end, urban-clientele. The market for MFIs is characterized by cooperatives and 'mutuelles', the largest of which have a very extended physical network. In total, there were 81 MFIs with 823 access points across the country. In the case of Senegal, it is observed that the minimum market rate of 12% is significantly higher as compared to other countries in the region like Togo (5.1%), Niger (5.1%), Mali (5.1%), Benin (5.1%) and Ethiopia (8%). Since there is no subsidy or financial support being provided by the government, it is imperative for sound development of financial markets especially in the rural areas so as to provide concessional financing to the farmers[54]. In many countries, lending rates for agriculture are significantly lower as compared to normal lending rates in a bid to boost agriculture productivity.

[51] Collected through interview with Bonergies SARL
[52] Collected through interview with Bonergies SARL
[53] Mostly from GET.INVEST market insights — Senegal: renewable energy applications in agricultural value-chains, 2019, unless stated otherwise
[54] Draft Pre-Feasibility Report for implementation of solar pumps in Senegal by International Solar Alliance (ISA), 2019

Depending on the solar irrigation solution used, the minimum initial investment required is in a range of FCFA 1.5 million and 2.5 million (USD 2,585 to 4,374) for an irrigated area of 3,000 to 3,500 m^2, a cost per hectare of FCFA 5.1 million to 5.6 million (USD 8,850 to 9,720) [55] .Cost breakdown is shown in Table 9. On the other side average annual income of a farmer owning 1-5 hectors of land is USD 1,117 (IFRI 2011) [56] . Therefore, purchasing such SIPS in cash and even in credit at market rate is not possible. Therefore, an innovative business model, government support and enhanced access to finance is in need.

Table 11: Cost of SIPS in Senegal

	Centrifugal (15 m³/j)	Helical (15 m³/j)	Piston (8 m³/j)
Manual drilling (FCFA)	300,000	300,000	300,000
Pump (FCFA)	348,000	732,000	1,012,000
Solar generator	538,000	538,000	270,000
Area irrigated (m²)	3,500		2,250
Drip (FCFA)	768,200		497,400
Irrigation using a watering can (FCFA)	87,500		58,333
Total (FCFA)	**2,041,700**	**2,425,700**	**2,137,733**
Cost FCFA/ha	5,833,429	6,930,571	9,501,036
Cost FCFA/m3	136,113	161,713	267,217
Area irrigated (m²)	3,000		Not applicable
Spray tube (FCFA)	324,300		
Irrigation using a watering can (FCFA)	87,500		
Total (FCFA)	**1,597,800**	**1,981,800**	
Cost FCFA/ha	5,326,000	6,606,000	
Cost FCFA/m3	106,520	132,120	

There are several national initiatives undertaken by GoS to implement scaling up of either agricultural activities with sustainable energy or for any renewable energy initiatives.

Rural Electrification Fund

Provides:

- Subsidies, loans, and guarantees to rural electrification operators;
- Subsidized credit lines with banks and financial institutions;
- Subsidies and loans to developers of productive uses of electricity.

FONGIP

The Priority Investments Guarantee Fund (FONGIP — Fonds de Guarantie des Investissements Prioritaires) was established in 2013 as a PPP with a mission to provide loan guarantees for financing projects in priority sectors and to refinance MFIs to enable them to grant loans to micro, small and medium-sized enterprises (MSMEs), to women's and youth groups at subsidized interest rates.

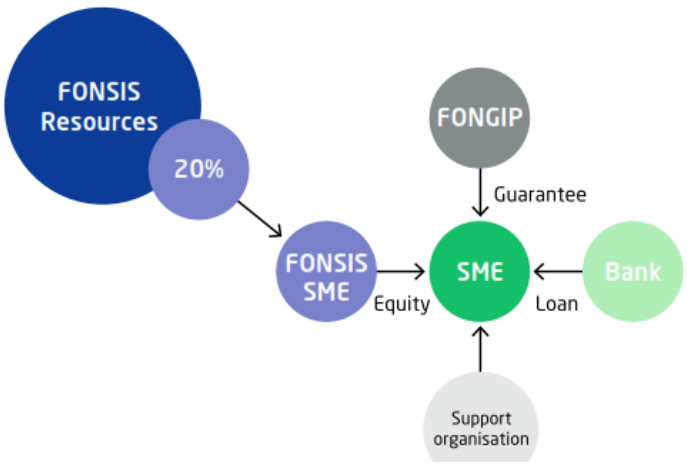


Figure 16: Investment structure to support SME's in Senegal

FONSIS

The Sovereign Strategic Investment Fund (FONSIS — Fonds Souverain d'Investissement Stratégique) was established in 2013. The mission of FONSIS is to promote the role of the State of Senegal, as an investor

[55] Intermediate-depth solar pumping irrigation solutions for smallholders in the Niayes region, Practica Foundation, January 2019

[56] https://www.ifpri.org/publication/economic-accounts-agriculture-and-farm-income-senegalhttps://www.ifpri.org/publication/economic-accounts-agriculture-and-farm-income-senegalhttps://www.ifpri.org/publication/economic-accounts-agriculture-and-farm-income-senegal

and partner of the private sector, with the aim of supporting direct investments and accelerate the economic and social development of the country.

Renewable and Efficient Energy Fund

An innovative national financing vehicle developed by FONSIS, AfDB and the Global Green Growth Institute (GGGI). The fund aims to accelerate the development of renewable energy projects.

CNAAS

The National Agricultural Insurance Company of Senegal (CNAAS — Compagnie Nationale d'Assurance Agricole du Sénégal) is a PPP between the State and private sector insurance companies with a capital of CFA 1.5 billion (EUR 2.3 million). CNAAS specializes specializesspecialises in agricultural insurance and plays an important role in alleviating the risks inherent in agricultural production and thus boost credit-worthiness.

LBA

(LBA- La Banque Agricole) which is the new of ex CNCAS, is the Agricultural Bank of Senegal, provides short-term credit to smallholders mostly for their traditional agricultural activities. LBA is currently the main source of financing for small farmers, followed by economic interest groups, credit and savings associations, and NGOs. Most of the loans obtained are seasonal loans to finance inputs. LBA support also the financement to provide tractors and other motor equipments used in Agriculture.

International Support

Senegal benefits from the strong support of international organizations. The World Bank provides support to Senegal for its National Rural Electrification Program 2015 – 2025. In addition, Senegal is a beneficiary of Power Africa, an American program launched by Barack Obama in 2013, which aims at improving access to reliable and less costly energy. USAID is working with Senegal's Ministry of Energy to assess Senegal's rural electrification efforts and come up with recommendations to accelerate the process. The agency also provides transaction advisory to private sector off-grid companies and rural concession holders in order to help them in developing their activities and strengthening their business models. Development Finance Institutions also represent a major source of financing and support for the renewable energy sector in Senegal. Proparco took part in the financing of two major solar plants over the past years. GIZ, a German development agency also provides support to Senegal in the development of renewable energy and energy efficiency projects.

Therefore, a lot of independent efforts from national and international organizations are underway. There is a clear need for collaboration and centralization of all efforts to make a real impact on the ground. Details of National and international supports for Senegal renewable energy sector are in Annex-3.

9. Solar Irrigation- Capacity development

Different stakeholders are differently exposed to sustainable energy systems and therefore, knowledge varies from sector to sector. However, every stakeholder of Senegal needs capacity and knowledge enhancement on renewable energy systems in the particular solar irrigation system.

Farmers: During an interview with a technology supplier, it was mentioned that most of the farmers are not aware of the benefit of a SIPS. In some areas where some piloting has been done or there is a presence of SIPS suppliers, farmers tend to know about such system. Then again, smart operation and maintenance, know how about available financing schemes are not well communicated.

Investors: During an interview with COPERES[57], it was mentioned that there are some private sector entities that are looking for a business model to finance sustainable means to save irrigation costs and

[57] COPERES is an association which brings together operators from the private sector from the different renewable energy sectors

provide more reliability. A few of them are aware of SIPS and its benefits. Potential investor should be identified and organized for capacity building activities. Investors should know about everything within the value chain to be convinced to take the risk of putting their equity in the business. SIPS system, its operation, benefit, demand aggregation, business model, and financing availability should be well understood by the investors.

Technology Providers: Suppliers of different SIPS also need capacity development. They need knowledge about system optimization, smart irrigation techniques, smart transaction mechanisms etc. Rural existence of such suppliers is key to provide fast after-sales services. Knowledge of smart after-sales service is also in need. Learning about different business models of SIPS would give an extra edge to the suppliers to hit the right segment of the farmers with the right business propositions.

Public Authorities: SIPS sector is governed by different ministries and therefore, a synchronization among them is required. To take them on the same page, related policymakers should have basic knowledge about the technology, detailed knowledge on business models, the status of the supply chain, socio-economic conditions of the farmers, etc. In Senegal, internal and external coordination among ministries and directorates need an enhancement. Most of these institutions display major weaknesses which prevent them from being fully effective, including insufficiently skilled staff and weak managerial and technical capabilities.

Financial Institutions: Access to finance is key in scaling up of any renewable energy technology. Unfortunately, most of the commercial banks in Senegal lack the knowledge about solar irrigation system. They perceive renewable energy systems as risky products and therefore, reluctant to provide financing. Knowledge of benefit of SIPS, deferent business models, and government support can motivate FIs to finance SIPS technologies for longer term.

However, knowledge level and need for capacity building in renewable energy technologies in Senegal are not recently reported. In July 2012[58], ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) implemented a Capacity Building Needs Assessment in the entire ECOWAS region[59]. This noted the following:

- The main barriers to effective capacity building in the renewable energy and efficiency sectors are the quality of training, bad regulations and lack of financing.
- The barriers to the capacity building are the lack of funds. In order to improve education, the funds allocated to education should be increased and educational programs more relevant to the need of the countries.
- The Funds related to the operating of the training centers should be doubled to make the centers efficient.
- Policymaking authorities lack human resources and requires skill development activities.

10. Recommendation

This section recommends an action plan to the Government of Senegal with an aim to create an enabling environment for solar irrigation business. Subject to validation and consultation with different stakeholders the action plan would help to scale up of solar irrigation system in the country. The proposed action plan devises the actions in immediate, medium and long-term measures.

Measures (I= Immediate, M= Medium, L=Long term)	
Category	**Actions**
Policy and Regulatory	Development of a road map for implementing solar irrigation program by conducting a region-wise solar irrigation potential assessment **(M)**

[58] No updated need assessment was found in the web.

[59] http://www.ecreee.org/page/capacity-needs-assessmenthttp://www.ecreee.org/page/capacity-needs-assessmenthttp://www.ecreee.org/page/capacity-needs-assessment

	Launching a National Solar Irrigation Program by - Formation of a common platform among key ministries with a clear distinction of responsibilities to steer the SIPS program Setting/empowering up of an institution to be single point service provider for SIPS (including other off-grid renewables) investors and other stakeholders **(I) (M)**
	Reconsidering the subsidy provided for diesel. Solar pumps are already competitive and be more profitable in comparison to the fuel pumps and grid electricity-powered pumps if subsidies are reduced progressively and eventually eliminated. **(I)(M)**
	Subsidies and other financial incentives for the introduction of solar irrigation systems can be combined with the obligatory use of highly efficient irrigation systems, as well as (ground) water monitoring. **(M)**
	Short training programs for policy makers in Energy Policy and Planning and Renewable Energy and Energy Efficiency Project Analysis with easy-to-use tools**(I)**
	Targeted training and awareness measures for agricultural officers and the farmers in remote areas of the country **(M)**
	Inclusion of solar-powered irrigation in curricula for agricultural extension services, irrigation managers, technicians and technical government staff**(M)**
	Conduct awareness campaigns for farmers' associations and agricultural extension workers on the basics of solar-powered irrigation (advantages, disadvantages, choice of system, financial implications, choice of crops, etc.). **(I)**
	Development of policy and infrastructure for end of life treatment of SIPS equipment **(L)**
Technology	Development and adoption of national technical standard including terms and condition of a supply contract, O&M contract, after-sales services. This should also be implemented in the clauses for importing equipment to prevent poor quality equipment in the market. **(I)**
	Development of technical testing facility and R&D facilities
	A certification scheme for national suppliers, to undergo a transparent qualification procedure to become certified.**(M)**
	Development of context-based system design by considering: - Crop pattern/ agro context - Alternative use of solar energy from SIPS during off-peak season will boost the business model with enhanced profitability. Mini-grid based SIPS and multiple-use solar applications – such as rice huskers, processors and cold storage are already being practiced. However, to ensure that the solar pump is coupled effectively with other on-farm applications, new products and developments are needed. - Whole irrigation system should be considered, not just optimizing one component i.e. SIPS, but the entire system. Does the design of the pump meet the water needs of the farmer's irrigation schedule? What kinds of crops can best be grown in the soil and with the water available? What are the actual water requirements? How could the management scheme be improved? **(M)** For SODAGRI and SAED, the electric pumping systems can be easily complemented by solar energy. This does not necessarily need to replace the pumping systems but feed electricity from solar power plants to the grid and thereby reducing the cost of energy by a big margin **(M)**.

	Setting up/ development of a regional/national technology Center for the development and promotion of Renewable Energy**(M)**
	Capacity building strengthening (equipment and teaching staff) for national technician training centers and the development of the regional centers; **(M)**
	Introduce training modules on RE in the various training programs of higher institute as well in technical training centers;**(M)**
	Awareness campaigns on SPIS in agricultural colleges and any other educational institutions that teach agriculture, water and energy-related subjects or rural development;**(I)**
	Training-of-trainers courses for polytechnic lecturers/secondary school teachers/ vocational training centers on solar applications of PV systems, with an emphasis on solar- powered irrigation. E-learning can supplement face-to-face courses;**(M)**
Access to finance	Centralization of all development financing activities under common umbrella i.e. under a national program for solar irrigation. This will help different existing efforts to be more structured and planned without duplication and gap. **(I)**
	Development of one or two financial institutions which will be at the center of renewable energy financing and implementing activities; these should be well backed by the government and development sector financing can be challenged through these FIs. They may also play the role for single point service providers as mentioned before. **(I)(M)**
	- Development of green fund, guarantee schemes Exploring standard subsidy and concessionary financing schemes which should create a balanced market without distortion
	Support financing institutions (such as microfinance institutions) that are already familiar to farmers**(I)**
	Short training programs for financial institutions in Energy Policy and Planning and Renewable Energy and Energy Efficiency Project Analysis with easy-to-use tools; **(I)**
Business Models	Development of innovative sustainable business models. Few models are being practiced in Senegal. This report also explains some models practiced in different parts of the world i.e. - The lease-to-own business model - Credit sells by the suppliers - PAYGO models - Energy-as-a-Service - Water-as-a-Service - Ownership Model Please refer to chapter 6 for details. **(M) (I)**
Water Management	Adopting FAO recommendations[60] while considering designing of SIPS systems- - Establish a water accounting system - set limits to water allocations - encourage and support all users to maximize the net benefit of allocated water incorporation or smart water management technologies **(M)**

[60] The benefits and risks of solar-powered irrigation- a global overview, FAO and GIZ, 2018

Follow our activities on
Facebook and Twitter

www. gggi.org