Draft Pre-Feasibility Report for Implementation of Solar Pumps in Somalia

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List of Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
AfDB	African Development Bank
AIIB	Asian Infrastructure Investment Bank
DC	Direct Current
EBRD	European Bank for Reconstruction and Development
EESL	Energy Efficiency Services Limited
EIB	European Investment Bank
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Green House Gas
HP	Horsepower
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
km	Kilometre
kW	Kilowatt
kWh	Kilowatt Hours
LNG	Liquefied Natural Gas
LoC	Line of Credit
MW	Megawatt
NDB	New Development Bank
NFP	National Focal Points
PV	Photovoltaic
R&D	Research and Development
REPS	Rural Electrification Policy Statement
REREDP	Rural Electrification and Renewable Energy Development Project
RHH	Rural Households
SHS	Solar Home Systems
SSAAU	Scaling Solar Applications for Agricultural Use
SSLS	Solar Street Lighting System
SWPS	Solar Water Pumping Systems
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNCTAD	United Nations Conference on Trade and Development
USD	United States Dollar
UL	Underwriters Laboratories

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1. Executive Summary

Background

Somalia is the easternmost country of Africa located on the Horn of Africa. It extends from just South of the Equator northward to the Gulf of Aden and occupies an important geopolitical position between sub-Saharan Africa and the countries of Arabia and southwestern Asia. The capital, Mogadishu, is located just North of the Equator on the Indian Ocean.

Somalia is a country of geographic extremes. The climate is mainly dry and hot, with landscapes of thorn bush savanna and semidesert, and the inhabitants of Somalia have developed equally demanding economic survival strategies. Apart from a mountainous coastal zone in the north and several pronounced river valleys, most of the country is extremely flat, with few natural barriers to restrict the mobility of the nomads and their livestock.

Somaliland, officially the Republic of Somaliland is a self-declared state, internationally considered to be an autonomous region of Somalia. They declared its independence from the failed state of Somalia in 1991, but the world has ignored the declaration. The similar names are rooted in colonial history: Somaliland became known as British Somaliland in the 19th century, while the southern region was Italian Somaliland.

Somalia's Electricity Sector

Somalia has reserves of several natural resources, including uranium, iron ore, tin, gypsum, bauxite, copper, salt and natural gas. The CIA reports that there are 5.663 billion cu m of proven natural gas reserves.

Due to its proximity and geological similarity to the oil-rich Gulf Arab states such as Yemen, energy industry representatives believe that the nation contains substantial unexploited reserves of oil. However, the presence or extent of proven oil reserves in Somalia is uncertain. UNCTAD suggests that most proven oil reserves in Somalia lie off its north western coast, in the Somaliland region. A survey by the World Bank and UN ranked Somalia second only to Sudan as the top prospective oil producer.

Connectivity and Accessibility

Inadequate transport facilities are a considerable impediment to Somalia's economic development. The transport infrastructure of Somalia comprises of approximately 22,000 km of roads; of which 2,559 km are primary roads, 4,850 km are secondary roads, and 14,421 km are rural/feeder roads. Out of the national road network 2,900 km (13%) of streets are paved, 844 km (4%) are gravel, and 18,256 km (83%) are earth.

The country has four major ports, and fifteen major airfields, four of which have paved runways. There are no railways, pipelines or inland waterways. Buses, trucks, and minibuses are the main means of transport for the population. In rural areas camels, cattle, and donkeys are still used for personal transportation and as pack animals.

Climate and Rainfall

Due to Somalia's proximity to the equator, there is not much seasonal variation in its climate. Hot conditions prevail year-round along with periodic monsoon winds and irregular rainfall. Mean daily maximum temperatures range from 30°C to 40°C, except at higher elevations along the eastern seaboard, where the effects of a cold offshore current can be felt.

Rainfall is the most important meteorological element affecting life in Somalia. It is the defining characteristic of the climate and has great spatial and temporal variability. The dramatic variation from season to season - and variations within the seasons - is what determine the successes or failure of agricultural activities.

Soil

Somalia has various soil types, primarily according to climate and the parent rock. The northern part of the country (Somaliland and Puntland) has shallow sandy and/or stony soils and some deeper lime-rich soils. In the highlands around Hargeisa, relatively high rainfall has raised the organic content in the sandy calcareous soil's characteristic of the northern plains. This soil supports some rain-fed farming. South of Hargeisa begins the "Haud" region whose red calcareous soils continue into the Ethiopian Ogaden and support vegetation which is ideal for camel grazing. Deep clay soils are found south of Gebiley in Somaliland.

Groundwater Status

Apart from the people living along the Juba and Shabelle Rivers, the Somali population depends on groundwater for domestic water supply, livestock and small-scale irrigation. The main groundwater sources of Somalia are boreholes, shallow wells and springs.

Boreholes are the most strategic water sources in Somalia, as a majority have water throughout the year and provide water when other sources dry out. The depth of most boreholes in the country is in the range of 90m to 250m; but in some locations the depths can go to more than 400m.

Agriculture and Cropping Pattern

The country have an irrigation potential of 2,40,000 ha. The irrigation sector has undergone major changes since the outbreak of the civil war in 1991, many of the large-scale irrigation systems having been destroyed. Of the remaining infrastructures many are not in use due to lack of maintenance and most of the formerly irrigated areas are now used for rainfed farming and grazing. There has been an expansion of rainfed farming, mainly in the areas of Middle Shabelle and Galgaduud.

Large-scale commercial irrigation was introduced during the colonial era (1880- 1960) and played a major role in pre-war agriculture. Irrigated bananas and fruit trees (limes) were the major crops. Other crops, produced mainly by government-owned farms, were sugar cane, cotton and rice. Most of the private and government-owned farms collapsed in 1990, but several private farms have recovered and diversified into cash crops, such as sesame, groundnuts and rice. However, the technical level of production, mechanization and efficiency of these farms remains low. Unsettled land issues are also constraints on future development.

Financial Feasibility

Somalia has submitted demand for 500 Nos. solar water pumping systems. At an average price of USD 8,443 per 2 HP pumpset, Somalia requires financing of USD 0.6 million to roll out deployment of 500 Nos. solar water pumping systems across the country

Indicative Outputs

S.No.	Particulars	Unit	Value
1	Amount of subsidy	USD	0
2	Amount of loan to be availed	USD	7598
3	Yearly installment towards loan repayment	USD	2793
4	Monthly installment towards loan repayment	USD	233
5	Savings in monthly diesel expenses on an average basis for 20 years	USD	4579
6	Number of hours of solar pump operation required	Hours	1889
7	Number of days of solar pump operation required	Days	270
8	Incremental payback of solar pump w.r.t. diesel pump	years	5

2. Background

2.1 About ISA

International Solar Alliance was launched on November 30, 2015 by India and France to implement the Paris Agreement and the ISA Framework Agreement came into force on December 7, 2017. The headquarter agreement with India was signed on June 6, 2018 when the ISA Secretariat acquired a judicial personality under the Framework Agreement. ISA held its first Assembly on October 3, 2018 and the second one is being held on October 31, 2019. To date, 79 countries have signed the Framework Agreement. ISA aims to provide a dedicated platform for cooperation among solar resource-rich countries where the global community, including bilateral and multilateral organizations, corporates, industry and other stakeholders can collaborate and help achieve the aim of increasing the use of solar energy in a safe, convenient, affordable, equitable and sustainable manner.

The International Solar Alliance (ISA) has been conceived as an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies to enhance energy security and sustainable development, and to improve access to energy in developing member countries. In this respect, ISA has been continuously working towards coordinating joint and collaborative efforts for mobilizing more than USD 1000 billion investments in the solar sector thereby facilitating scaling up of solar deployment in various member countries.

As guided by the Framework Agreement of the ISA, the interests and objectives of the ISA are as follows:

1. To collectively address key common challenges to scale up solar energy applications in line with their needs;
2. To mobilize investments of more than USD 1000 billion by 2030;
3. To take coordinated action through programmes and activities launched on a voluntary basis, aimed at better harmonization, aggregation of demand, risk and resources, for promoting solar finance, solar technologies, innovation, R&D, capacity building etc.;
4. Reduce the cost of finance to increase investments in solar energy in member countries by promoting innovative financial mechanisms and mobilizing finance from Institutions;
5. Scale up applications of solar technologies in member countries, and
6. Facilitate collaborative research and development (R&D) activities in solar energy technologies among member countries.

To expand its reach, the ISA has entered into strategic and financial partnerships with the UNDP, the World Bank, the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), the African Development Bank (AFDB), the Asian Development Bank (ADB), the Asian Infrastructure Investment Bank (AIIB), New Development Bank (NDB), and the Green Climate Fund (GCF), IEA, IRENA, Climate Parliament and UNIDO on enhancing cooperation on solar energy deployment to further the mandate of the ISA. The United Nations including its organs are strategic partners of the ISA.

On the request of the ISA, the Government of India has earmarked around US $ 2 billion Line of Credit (LoC) to the African countries for implementation of solar and solar related projects out of its total US $ 10 billion LoC under the Indian Development and Economic Assistance Scheme (IDEAS) to various African and other developing countries. India has set up a project preparation facility which will provide consultancy support to partner countries to design bankable projects.

Following these commitments, India has provided $ 1.4 billion concessional financing to 27 solar projects in 15 developing countries so far. As a co-founding member of the ISA, Government of France through the Agence Française de Développement, has also offered €1000 million for solar projects across ISA member countries. 17 projects have been funded by AFD for approximately Euro 300 million. ISA will similarly persuade other countries to contribute to the cause of solar deployment globally.

ISA is currently working towards coordinating a joint and collaborative effort amongst member countries so that strategies suited to the requirements of individual countries can be formed, and feasible solar technologies can be deployed. ISA is acting as a facilitator to contribute to the solar deployment efforts of individual member country. For this, ISA has formed a framework of programs and initiatives to develop a dedicated approach towards scaling up of various solar technologies. All the Programmes of ISA are member driven. The current programmes of ISA are:

1. Affordable finance at scale
2. Scaling Solar Applications for Agricultural Use (SSAAU)
3. Scaling Solar Mini-Grids
4. Scaling Solar Rooftop
5. Scaling solar supported e-mobility and storage

2.2 About SSAAU Programme

ISA's first programme, Scaling Solar Applications for Agricultural Use (SSAAU), was launched in New York, USA on 22nd April 2016. The SSAAU Programme mainly focusses on decentralized solar applications in rural settings. Major focus areas of the programme include Solar Water Pumping Systems (SWPS), solar drying, solar chilling, solar milling, etc. Other activities under the programme include R&D, capacity building, and developing common standards, facilitate transfer of technology, etc.

More than twenty-one countries namely Bangladesh, Benin, Djibouti, Ethiopia, France, Guinea-Bissau, India, Kiribati, Mali, Mauritius, Niger, Nigeria, Rwanda, Senegal, Seychelles, Somalia, Sudan, Togo, Tonga, Uganda, Vanuatu have been frequently interacting regarding the programme strategy and implementation through the network of NFPs and country representatives via video conferencing. To understand specific requirements of these countries, needs assessment questionnaires have been developed for Solar Water Pumping System (SWPS) and Solar Street Lighting System (SSLS). These questionnaires have been circulated to all participating and signatory countries of the ISA as a first step towards demand aggregation.

The key activities under the SSAAU programme are as under:

S No.	Category	Key Activities
1	Demand Aggregation	▪ Obtaining data for demand aggregation models from various member countries ▪ Bid process management, fixation of price, identification of manufacturer(s)/ supplier(s) for each of the participating member countries
2	Country Strategy	▪ Developing baseline studies and roadmaps for member nations ▪ Constituting global task force for the programme ▪ Facilitating affordable financing for implementation of solar water pumping programme in participating member countries
3	Facilitating Deployment	▪ Facilitating in setting Standards, Performance Benchmarks, Testing and Certification Protocols through identified test centers ▪ Development of base document for global tendering and best practices for procurement, installation and maintenance ▪ Monitoring and Evaluation
4	Outreach Strategy	▪ Development of media outreach strategy for the programme ▪ Organization of workshops and seminars for promotion of SSAAU programme

Table 1: Key Activities under SSAAU Programme

As a part of the demand aggregation exercise, ISA has aggregated a demand of 272,579 Nos. of off-grid solar pumps to be implemented across 22 countries spanning 4 different continents. The key objective of the demand aggregation exercise was to bring down the costs of the system so as to enable implementation of viable and bankable solar pumps projects in various ISA countries.

The demand aggregation exercise comprised of the following sub-steps:

1. Needs Assessment: In collaboration with National Focal Points (NFPs) and Country Representatives, need assessment questionnaires for Solar Water Pumping Systems (SWPS) were circulated to participating member countries
2. Ascertaining Demand: The filled in needs assessment questionnaires were used to ascertain demand of solar water pumping systems including information on type, quantity and technical specifications in each of the participating member countries
3. Demand Validation: Coordinating with National Focal Points and Country Representatives for obtaining country specific data and information and for validation of demand
4. International Competitive Bidding for Price-Discovery: Energy Efficiency Services Limited was hired for management of International Competitive Bidding for price discovery of various types of solar water pumping systems in participating member countries

The results of the demand aggregation exercise are summarized in the figure below:

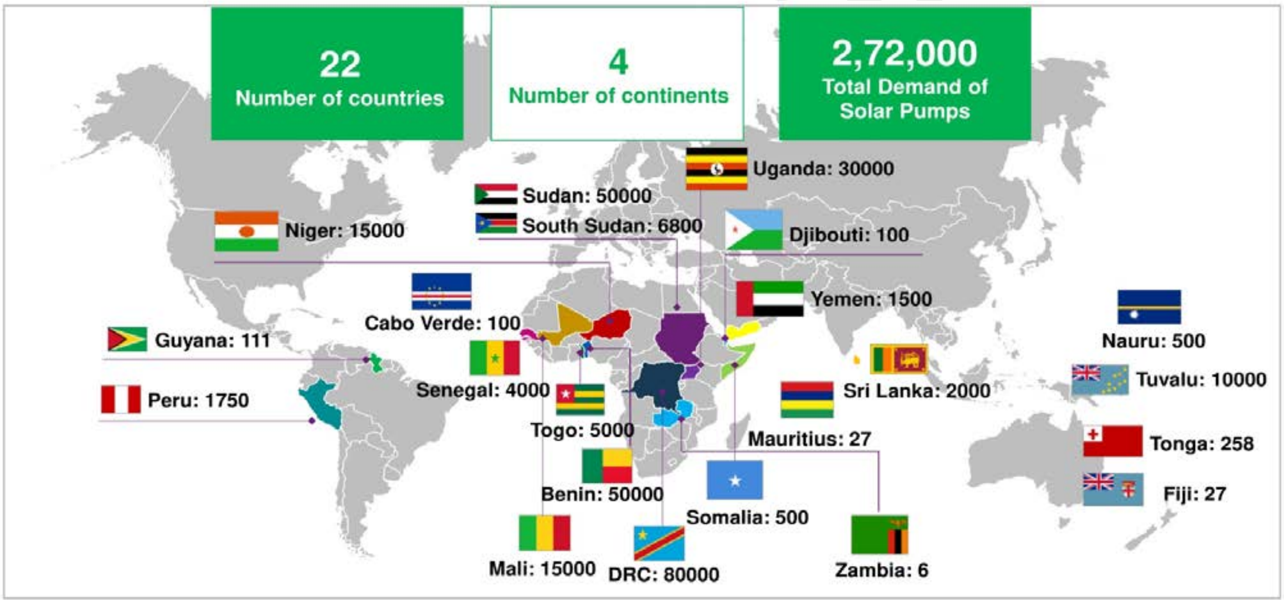


Figure 1: Demand received from various ISA member countries for solar pumps

Subsequent to the demand aggregation exercise, Internal Competitive Bidding was undertaken by EESL on behalf of ISA for price discovery of various types of solar pumps in the participating member countries. The price discovery tender is one of the largest tenders for solar pumping systems globally and is expected to open up huge market opportunity for implementation of solar pump programme in participating member countries. Through this tender, it is expected that local market ecosystem for solar pumps will be developed which will help in greater penetration of technology amongst the farmers. It is envisaged that in the long-run solar pumps would replace the existing diesel pumpsets in these member countries thereby leading to significant reduction in GHG emissions apart from providing a reliable irrigation solution for the farmers. The key features of the International Competitive Bidding for price discovery is summarized as below:

S. No	Category	Description
1	International Standards for Solar Pumps	▪ Internationally accepted IEC and UL standards for various solar pump components
2	Technical and Financial Qualifying Criteria	▪ Technical Qualifying Criteria: Based on experience of supply and installation of solar pump sets and solar power plants ▪ Financial Qualifying Criteria: Based on average annual turnover and net worth
3	Specifications for minimum bidding quantity	▪ Mandatory to bid for 5 countries with a total bid quantity of at least 27000
4	Two separate bid packages	▪ Only supply ▪ Supply and Five-Year Comprehensive Maintenance Contract
5	Two stage evaluation process	▪ Based on technical and commercial evaluation ▪ Award of contract to various bidders based on L1 prices

Table 2: Key features of Internal Competitive Bidding for Price Discovery of Solar Pumps

The price discovery was conducted for two broad services contract namely:

- Service 1: Supply, Custom clearance, Local transportation, installation, testing and commissioning of complete system & services at Employer's site of Solar PV based Agricultural Pump Set system
- Service 2: Supply Custom clearance, Local transportation, installation, testing and commissioning of complete system at site of Solar PV based Agricultural Pump Set system

The roles and responsibilities of the bidder and the respective member nation as a part of the price discovery tender is summarized in the figure below:

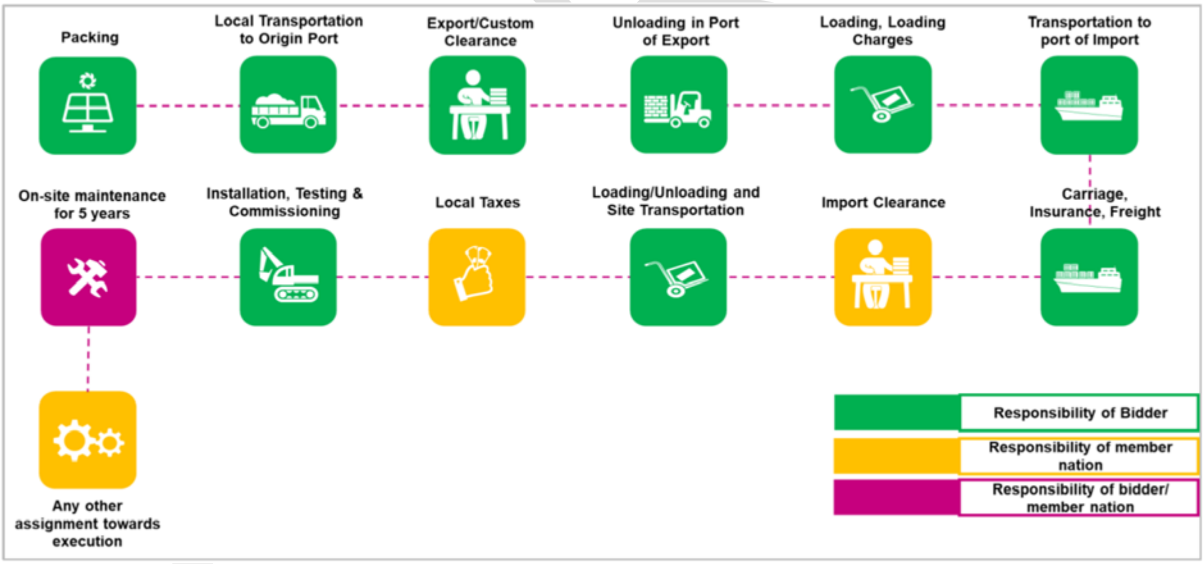


Figure 2: Work Packages and Responsibility Division

Five bidders have participated in the price discovery tender and have submitted the prices for various capacities of solar pumps in the participating member countries. ISA is currently analyzing and evaluating the prices and will subsequently share with the member countries for final decision at their end.

3. Introduction

3.1 About Somalia

Somalia is the easternmost country of Africa located on the Horn of Africa. It extends from just South of the Equator northward to the Gulf of Aden and occupies an important geopolitical position between sub-Saharan Africa and the countries of Arabia and southwestern Asia. The capital and the largest city, Mogadishu, is located just North of the Equator on the Indian Ocean.

The country covers a surface area of 637,657 km^2 with a population of 15 million people officially speak Somali and Arabic[1].

Somalia is a country of geographic extremes. The climate is mainly dry and hot, with landscapes of thorn bush savanna and semidesert, and the inhabitants of Somalia have developed equally demanding economic survival strategies. Apart from a mountainous coastal zone in the north and several pronounced river valleys, most of the country is extremely flat, with few natural barriers to restrict the mobility of the nomads and their livestock.

Somaliland, officially the Republic of Somaliland is a self-declared state, internationally considered to be an autonomous region of Somalia. They declared its independence from the failed state of Somalia in 1991, but the world has ignored the declaration. The similar names are rooted in colonial history: Somaliland became known as British Somaliland in the 19th century, while the southern region was Italian Somaliland.

Somalia is bordering the Gulf of Aden in north, Djibouti in north west, Ethiopia in west, and Kenya in south west, in east it borders the Indian Ocean, and it shares maritime borders with Yemen[2].

Figure 3: Map of Somalia[3]

[1] BBC
[2] Britannica
[3] Nations Online

About three-fifths of Somalia's economy is based on agriculture; however, the main economic activity is not crop farming but livestock raising. The country is having roughly 60 percent are nomadic and seminomadic pastoralists and 60 percent live in rural areas. Most Somalis today live in poverty and vulnerability. 2.3 million live on the margins of food insecurity and 1.1 million are internally displaced. Close to three fourths of the Somali population live in poverty, about 43 percent in extreme poverty, and Gross Domestic Product (GDP) per capita is only US$499 in 2017, have grown less than 2% per year over the last four years.[4]

In culture, language, and way of life, the people of Somalia, north eastern Kenya, the Ogaden region of Ethiopia, and the southern part of Djibouti are largely one homogeneous group. The Somali language belongs to the Cushitic branch of the Afro-Asiatic language family. Despite several regional dialects, it is understood throughout the country and is an official language. The second official language is Arabic, which is spoken chiefly in northern Somalia and in the coastal towns. The major religion in Somalia is Islam. There is a small Christian community in Somalia mainly living amongst Somali Muslims in the Banaadir region. Additionally, some people in the southern part of the country practice traditional faiths, including Waaqism.

Varied cultural life of the Somali includes both traditional activities and many modern interests. Cultural activities consist primarily of poetry, folk dancing, the performance of plays, and singing. These traditional activities still retain their importance, especially in rural areas, and are practiced not only at family and religious celebrations but also at state ceremonies. On such occasions traditional local costume is generally worn. Especially in the towns, traditional culture is rapidly being superseded by imported modern influences, such as television, cinema, bars and restaurants. Urban Somalian cooking has been strongly influenced by Italian cuisine, and young townspeople are much influenced by Western fashion in the way they dress.

3.2 Overview of Energy Scenario

Somalia has reserves of several natural resources, including uranium, iron ore, tin, gypsum, bauxite, copper, salt and natural gas. The CIA reports that there are 5.663 billion cu m of proven natural gas reserves.

Due to its proximity and geological similarity to the oil-rich Gulf Arab states such as Yemen, energy industry representatives believe that the nation contains substantial unexploited reserves of oil. However, the presence or extent of proven oil reserves in Somalia is uncertain. UNCTAD suggests that most proven oil reserves in Somalia lie off its north western coast, in the Somaliland region. A survey by the World Bank and UN ranked Somalia second only to Sudan as the top prospective producer.

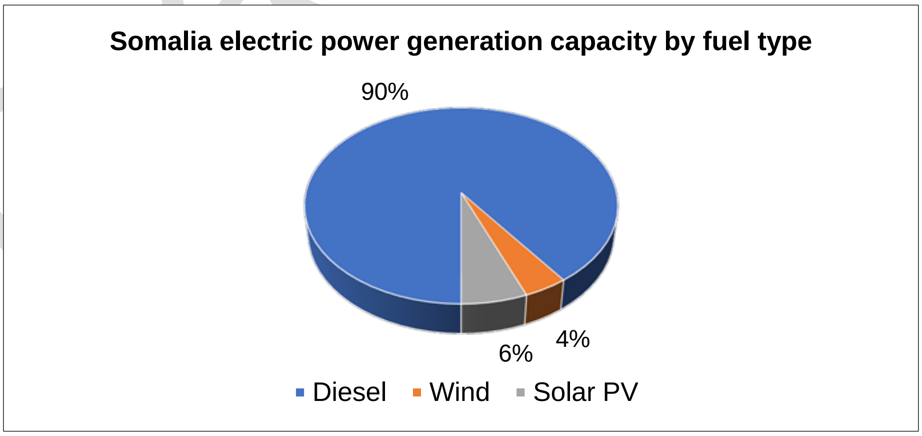


Figure 4: Installed Capacity by source[5] (2018)

[4] World Bank
[5] USAID, IRENA

The Somali energy sector is one of the most underdeveloped in the region. Low electrification rates, especially in rural areas, high cost of power, high technical and commercial losses, dependency on imported petroleum products for electricity generation, and reliance on biomass resources for cooking mean that only a very small fraction of the Somali population has access to affordable, safe, reliable, and predictable energy services. Both public and private sector energy actors are highly capacity constrained, weak legal and regulatory frameworks, limited financing and investment, and lack of data for effective decision making continue to hold back sector development.

The electricity access rate is estimated at 15 percent, meaning that around 1.65 million Somalis lack access to electricity services. Urban access is estimated at 35%, and rural access at 1%. With an average household size of 5, this translates to approximately 0.33 million un-electrified households nationwide. Private sector players supply more than 90 percent of power in urban and peri-urban areas using local private mini-grids, having invested in diesel-based systems of between 500 kVA to 5000 kVA installed capacity per mini-grid.[6]

3.3 Electricity Generation

Since the fall of Somalia's central government in 1991, electricity service has solely been taken by private sector. The current installed generation capacity is approximately 111 megawatts (MW). While most power companies rely on diesel generators for electricity generation, interest and investment is growing in hybrid systems that draw on solar and wind energy resources. According to a recent study by the African Development Bank, Somalia has the highest resource potential of any African nation for onshore wind power and could generate between 30,000 to 45,000 MW. Solar power could potentially generate an excess of 2,000 kWh/m^2/year. Somalia has higher tariffs compared to neighbouring countries Kenya and Ethiopia.[7]

Many cities had grids, and service varied in quality according to the availability of fuel. Except for the major cities (Mogadishu, Hargeisa and Kismayo), which had conventional grids, other smaller cities and towns that had electricity relied on diesel generators and minigrids much like those of today. No two cities were interconnected.

According to historical estimates, electricity production in Somalia in 2015 was 339 GWh or just 22.59kWh/capita, compared to the then world average of 2,777 kWh and the African average of 579 kWh[8]. Electricity generation is entirely diesel-fuelled, and supply is from a large number of independent, individual, mostly small power producers operating local LV minigrids. Electricity is extremely expensive and inefficiently supplied, the absence of normal grids causing huge technical, non-technical or financial losses between generation and final use.

There is significant potential in all Somali areas in terms of renewable and alternative sources of energy, such as solar and wind power, but so far, due to both security and funding problems, only very small, timid experiments have been conducted with solar and wind power. Shortages of technical staff, lack of accessible knowledge, the small scale of existing generation, and primitive distribution systems further limit the immediate practical application of renewables for power generation in most of Somalia. The solar energy potential ranges from 5–7 kWh/m^2/day with more than 310 sunny days in a year.[9]

However, the use of solar energy has been rather limited in Somalia because of lack of information and access to end-use devices, and also poverty, which prevents purchase of appropriate generating and endues equipment.

[6] USAID
[7] USAID
[8] AFDB and World Data
[9] UNFCCC

Somalia is also characterised by strong wind, with annual average speeds of 1.5m/s to about 11.4m/s. Many organisations are starting to monitor wind speeds and sunshine hours in hope of developing renewable energy projects in the near future. There is limited hydropower potential, estimated to be around 100 – 120MW, along the Shabelle and Juba rivers, but it remains untapped, due to lack of security[10].

3.4 Sector organisation and policies

The Federal Government of Somalia (FGS) has created a Ministry of Energy and Water Resources in 2014 at Mogadishu. The Ministry solely responsible for the formulation, direction and coordination of the national energy and water resources. Furthermore, the ministry involves policy making, setting standard operation, national planning, regulation, monitoring, and technical support of regional states in relation to energy and water resources in order to promote social and economic development of the country. In service delivery, the Ministry is supported by three autonomous organizations namely:

- Somali Energy Agency
- Somali Water Development Agency
- Mogadishu Water Agency

There is no legislation governing electricity (except in the sense that current legal arrangements in Somalia, including both Somaliland and Puntland, stipulate that laws of the former Somali State that have not been specifically repealed remain in force). Nor is there any element of regulatory framework. On the other hand, the electricity industry is embryonic and would not justify extensive legal and regulatory bureaucracies that would further be impossible to staff with competent personnel. As in most of the country, there is a legal/regulatory vacuum, and the industry is more or less self-regulating, as are many other economic and social activities

3.4.1 Four main issues facing Somalia's energy sector

There are four main issues facing the energy sector, and all four are exacerbated by the perceived lack of security for people and property. Security is a pervasive crosscutting issue.

In effect, there is limited access and low supply because insecurity makes earning income and investing more difficult and riskier. The excessive exploitation of biomass is due to poverty (difficult-to-earn income) and the challenge of importing energy in bulk because of lack of security (e.g. cargo cannot be insured) and low effective demand. The limited penetration of modern energy is due to poverty and lack of security for traders and for buyers of modern end-use devices, and the shortage of personnel is due to insecurity, as qualified people either leave Somalia or hesitate to come, even when wages may be higher than elsewhere.

The four issues are:

- Shortage or lack of qualified personnel,
- Excessive exploitation of biomass,
- Limited access to and supply of electric power, and
- Low penetration of modern energy, especially in rural areas.

[10] African Development Bank

4. Technical Feasibility Assessment

4.1 Assessment Criteria

The feasibility of a solar powered irrigation system depends on a wide array of factors ranging from geographic parameters such as temperature, rainfall, water table depth to site specific parameters such as cropping pattern, land size, planting date, irrigation technique etc. Any feasibility analysis of a solar powered irrigation system would involve both the technical feasibility and the financial feasibility. The technical feasibility would analyze the site-specific conditions to determine whether such system can be installed considering the different technical aspects such as solar irradiance, size availability, panel size, tracking systems, water table depth etc. The technical feasibility would also provide recommendations on the ideal pump size and type considering the dynamics of the site. Once technical feasibility for a given system is established, the costs involved, and the expected returns are calculated using financial feasibility analysis. The below figure summarizes the interplay of various parameters involved in technical and financial feasibility analysis.

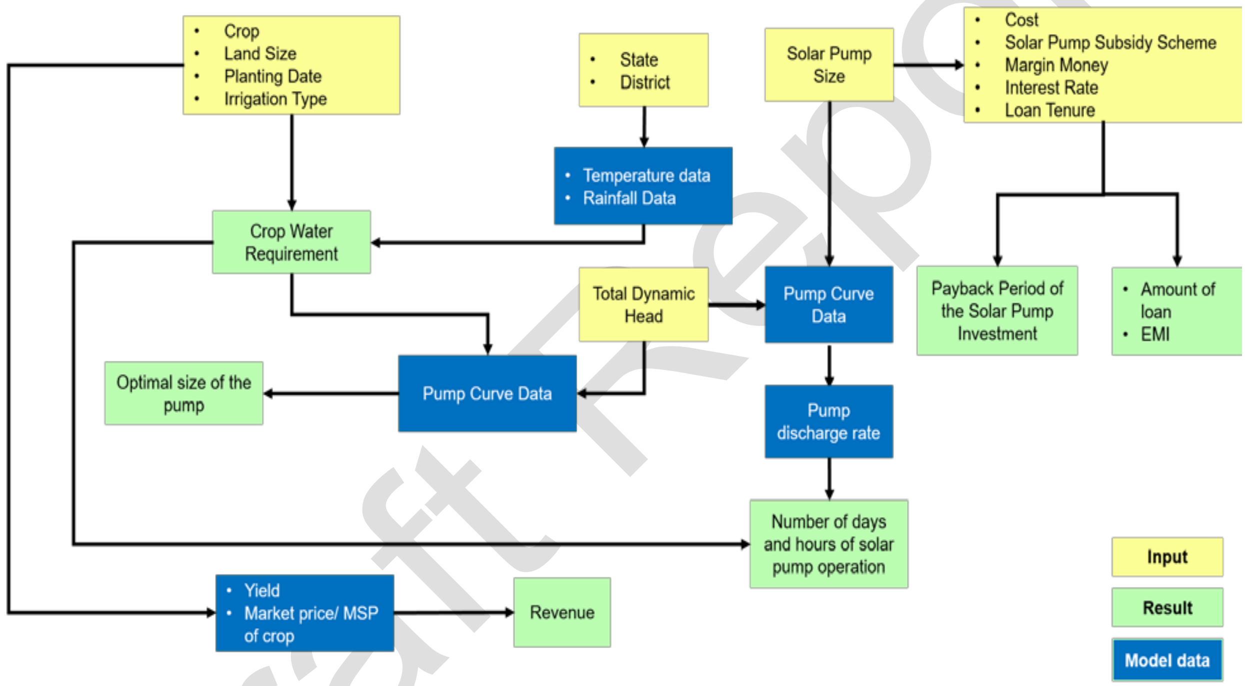


Figure 5: Factors involved in feasibility analysis of solar pump

4.1.1 Total Dynamic Head

The total dynamic head is a very important parameter of a solar pumps which determines the various head losses that the pump must overcome. It is a summation of the suction head, discharge head and the friction losses. The total dynamic head and the desired flow rate of the system are applied to the pump performance curve, which is used for proper pump selection based on required electrical power input and optimum efficiency.

The static head, discharge head and the total dynamic head is explained through the image below[11]:

[11] Science Direct

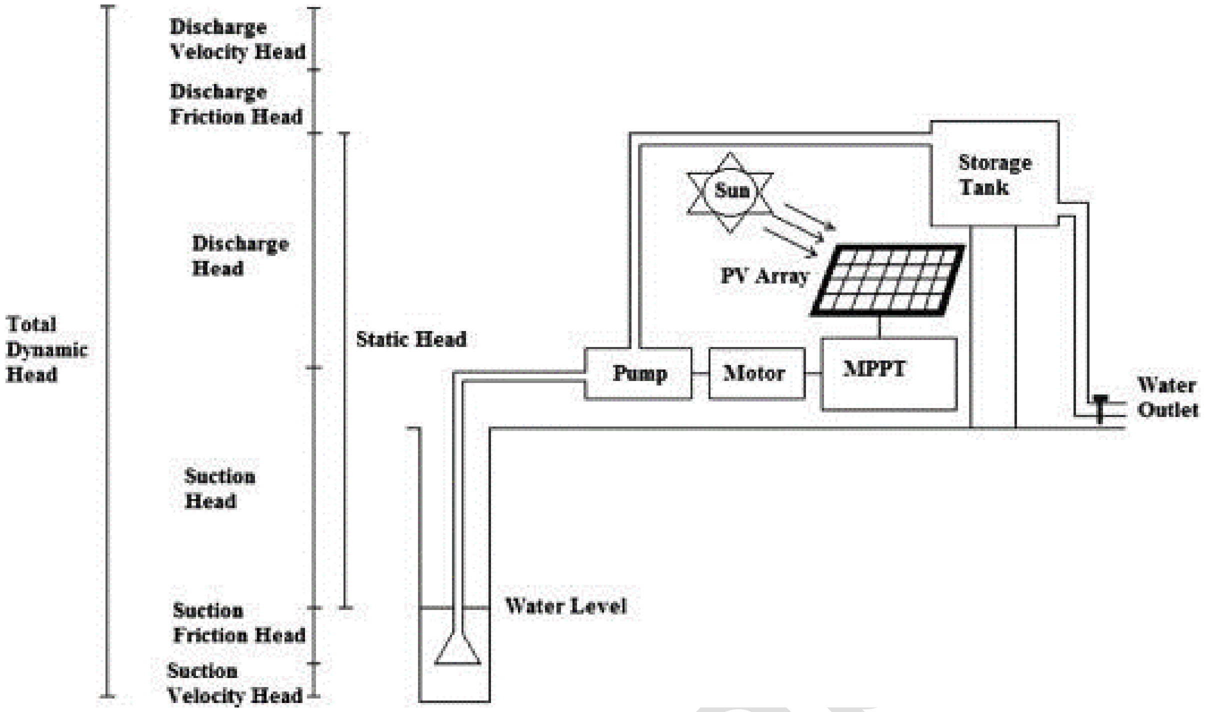


Figure 6: Total Dynamic Head of a solar pump

4.1.2 Pump Curves

The pump characteristic is normally described graphically by the manufacturer as the pump performance curve. Other important information for a proper pump selection is also included - like efficiency curves, NPSHr curve, pump curves for several impeller diameters and different speeds, and power consumption[12]. The performance curve indicates the variation in the discharge rate of a pump with a change in required head and input power. The pump curves are analyzed to determine the optimal size of a solar pump for a given manufacturer and also to assess whether the system will be able to the peak demand requirements of the farmer. The performance curves for a 5 HP AC and 5 HP DC pump is shown as below[13]:

[12] The Engineering Toolbox
[13] Shakti Pumps (DC pump: 5 DCSSP 2700/3600/4600; AC pump: SSP 5000-100-11)

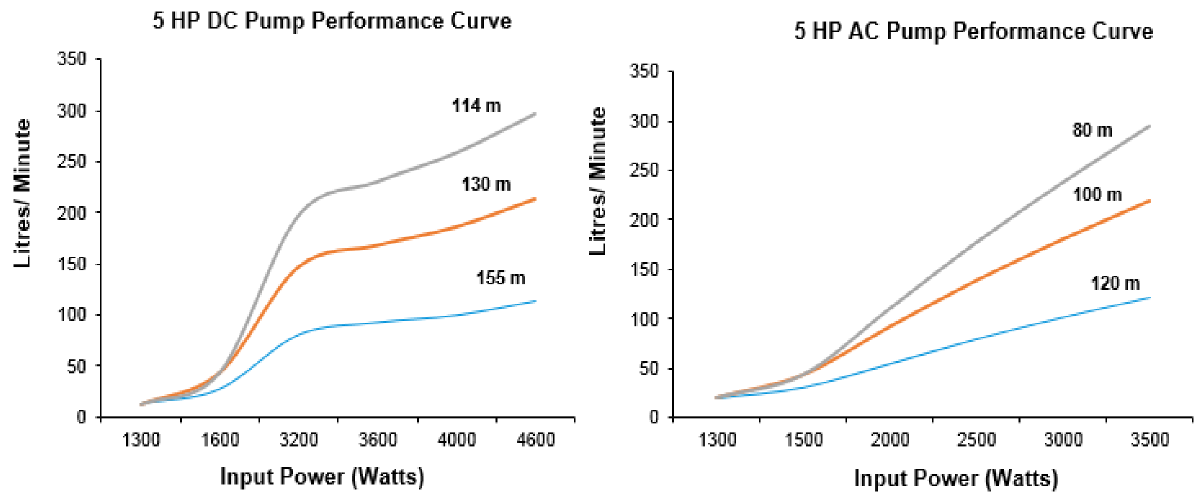


Figure 7: Pump Performance Curves

4.1.3 Crop Water Requirement

The crop water need is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally. The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favourable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

- **the climate**: in a sunny and hot climate crops need more water per day than in a cloudy and cool climate
- **the crop type**: crops like maize or sugarcane need more water than crops like millet or sorghum
- **the growth stage of the crop**: fully grown crops need more water than crops that have just been planted.

The below table showcases the effect of various climatic factors on the crop water requirement:

Climatic Factor	Crop Water Requirement	
	High	Low
Temperature	Hot	Cool
Humidity	Low (Dry)	High (Humid)
Windspeed	Windy	Little Wind
Sunshine	Sunny (no clouds)	Cloudy (no sun)[14]

Table 3: Effect of major climatic factors on crop water requirement

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is cool, humid and cloudy with little or no wind. The influence of the climate on crop water needs is given by the reference crop evapotranspiration (ETo). The ETo is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. ETo is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall, which grows actively, completely shades the ground and which is not short of water[15].

[14] Food and Agriculture Organization of the United Nations (FAO)
[15] Food and Agriculture Organization of the United Nations (FAO)

4.1.4 Pump Sizing

Oversizing would incur unnecessary costs, and under sizing would lead to insufficient performance. This is why each component needs to be properly designed and sized to meet the specific requirements of the project. It is the only way to guarantee reliability and system durability to achieve the desired performance. Similarly, when sizing a solar system, it is recommended to use the 'worst month method'. By sizing the systems for the month with most adverse conditions in the year, it will be ensured that water supply will be enough for all the other months. The worst month in the year will be that in where the gap between the energy required to supply water and the energy available from the Sun is higher. In case the daily water requirement is the same all the year round (meaning too that the energy required is the same all the year round since pump will run for the same number of hours any day), the worst month will be that with least solar radiation[16].

4.2 Country Assessment

4.2.1 Connectivity and Accessibility

Inadequate transport facilities are a considerable impediment to Somalia's economic development. The transport infrastructure of Somalia comprises of approximately 22,000 km of roads; of which 2,559 km are primary roads, 4,850 km are secondary roads, and 14,421 km are rural/feeder roads. Out of the national road network 2,900 km (13%) of streets are paved, 844 km (4%) are gravel, and 18,256 km (83%) are earth[17].

The country has four major ports, and fifteen major airfields, four of which have paved runways. There are no railways, pipelines or inland waterways. Buses, trucks, and minibuses are the main means of transport for the population. In rural areas camels, cattle, and donkeys are still used for personal transportation and as pack animals.

Figure 8: Road Network of Somalia[18]

[16] Sun-Connect News
[17] Draft discussion paper for Round Table "Transport infrastructure"
[18] Logistics Cluster

There are four partially functioning international airports (Berbera, Hargeisa, Kismayo, and Mogadishu) and many smaller airfields. In the last few years, the private sector has opened up new international routes within Somalia and this has been a growing trend.

4.2.2 Climate and Rainfall

Due to Somalia's proximity to the equator, there is not much seasonal variation in its climate. Hot conditions prevail year-round along with periodic monsoon winds and irregular rainfall. Mean daily maximum temperatures range from 30°C to 40°C[19], except at higher elevations along the eastern seaboard, where the effects of a cold offshore current can be felt.

Rainfall is the most important meteorological element affecting life in Somalia. It is the defining characteristic of the climate and has great spatial and temporal variability. The dramatic variation from season to season - and variations within the seasons - is what determine the successes or failure of agricultural activities.

The year is divided into four seasons as follows:

- **Jilaal**: a warm, sunny and dry season from December to mid-March
- **Gu**: the main rainy season starting in mid-March and running to June
- **Haggai**: a cool, dry and rather cloudy season starting in July and lasting until mid-September; some weather stations along the southern coast and in the north western regions receive significant amounts of rainfall
- **Deyr**: the secondary rain season, from mid-September to November

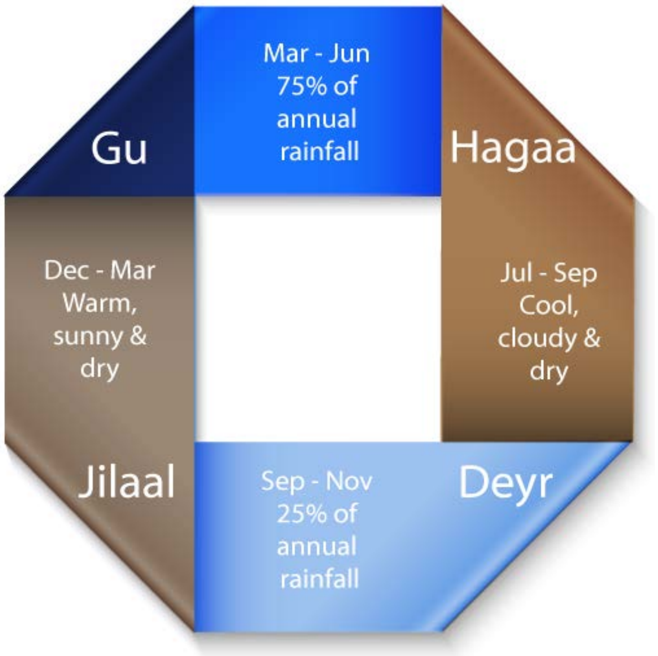


Figure 9: Seasons of Somalia[20]

[19] Somalia: Doing Business and Investing in Somalia Guide
[20] FAO Swalim

In Mogadishu, the summers are hot and windy; the winters are short, warm, and extremely windy; and it is oppressive, dry, and partly cloudy year round. Over the course of the year, the temperature typically varies from 23°C to 32°C and is rarely below 22°C or above 33°C[21].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temperature (°C)	26.3	26.6	28.2	29.0	28.1	26.6	25.8	25.8	26.4	27.2	27.2	26.8
Min. Temperature (°C)	22.4	22.5	24.4	25.1	24.5	23.4	22.9	22.7	23.1	23.9	23.7	23.0
Max. Temperature (°C)	30.2	30.7	32	32.9	31.8	29.9	28.8	28.9	29.7	30.5	30.8	30.6
Precipitation / Rainfall (mm)	179	155	248	128	11	0	0	0	13	102	177	215

Table 4: Temperature Variation in Mogadishu[22]

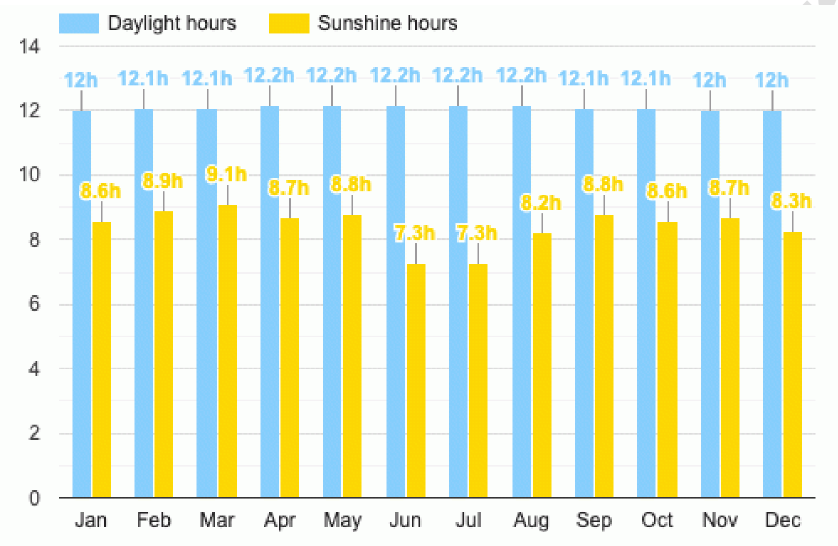


Figure 10: Sun hours in Mogadishu region[23]

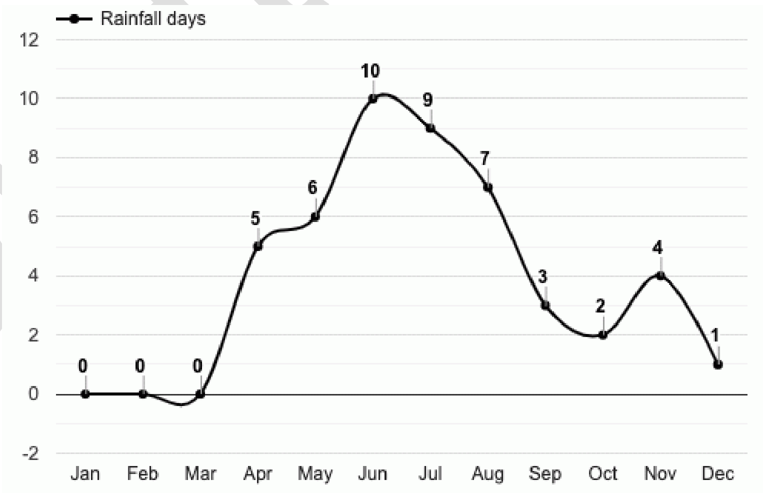


Figure 11: Precipitation Days over the year in Mogadishu region[24]

[21] Weather Spark
[22] Climate Data
[23] Weather Atlas
[24] Weather Atlas

4.2.3 Soil Pattern

Somalia has various soil types, primarily according to climate and the parent rock. The northern part of the country (Somaliland and Puntland) has shallow sandy and/or stony soils and some deeper lime-rich soils. In the highlands around Hargeisa, relatively high rainfall has raised the organic content in the sandy calcareous soil's characteristic of the northern plains. This soil supports some rain-fed farming. South of Hargeisa begins the "Haud" region whose red calcareous soils continue into the Ethiopian Ogaden and support vegetation which is ideal for camel grazing. Deep clay soils are found south of Gebiley in Somaliland.

The central part of the country is dominated by sandy soils along the coast and moderately deep loamy soils with a high content of calcium carbonate and/or gypsum further inland. Prominent in southern Somalia are low-lying alluvial plains, associated with the Juba and Shabelle Rivers. These plains mainly have clayey soils, some of which have poor drainage and/or high content of salts. Some of the riverine areas are also liable to flooding. The inter-riverine areas have both shallow soils (particularly towards the border with Ethiopia) and deep loamy and clayey soils.

The most important agricultural areas are in the south of Somalia and the agricultural production system can be divided in:

i. subsistence rainfed farming, often part of agropastoral production systems, with a typical farm size of 2-4 ha
ii. small-scale irrigation and oasis farming; and
iii. commercial farming, which is mainly large-scale and irrigated[25]

4.2.4 Groundwater Status

Apart from the people living along the Juba and Shabelle Rivers, the Somali population depends on groundwater for domestic water supply, livestock and small-scale irrigation. The main groundwater sources of Somalia are boreholes, shallow wells and springs.

Boreholes are the most strategic water sources in Somalia, as a majority have water throughout the year and provide water when other sources dry out. The depth of most boreholes in the country is in the range of 90m to 250m; but in some locations the depths can go to more than 400m

Most of the shallow wells are less than 20m deep. The water yield of these sources varies from one area to another, depending on the aquifer. Most shallow wells yield between 2.5 and 10m^3/hr, compared to the yield for most boreholes which ranges between 5 to 20m^3/hr[26]

The development of new groundwater resources in Somalia is fraught with challenges, key among them being poor water quality. Most groundwater sources in the country have salinity levels above 2,000µS/cm, which is over the required standard for drinking water. Many of the shallow wells are also unprotected from the elements, making them vulnerable to microbiological and other contamination.

[25] FAO
[26] FAOSWALIM

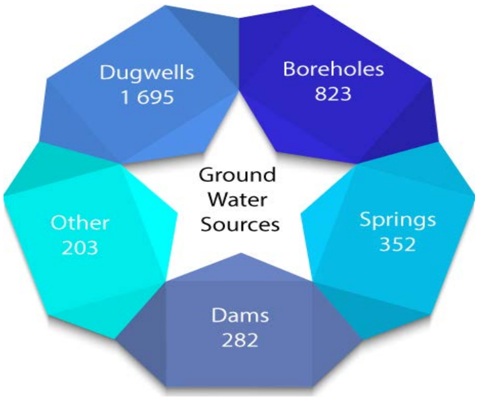


Figure 12: Number of Ground water sources of Somalia[27]

4.2.5 Solar Irradiance

Somalia enjoys bright sunshine throughout the year. The average daily solar energy received on a horizontal surface is about 5-7 kWh/m2/day. The daily average total solar radiation in parts of Somalia, calculated from the relative sunshine duration indicates one of the highest in the world.

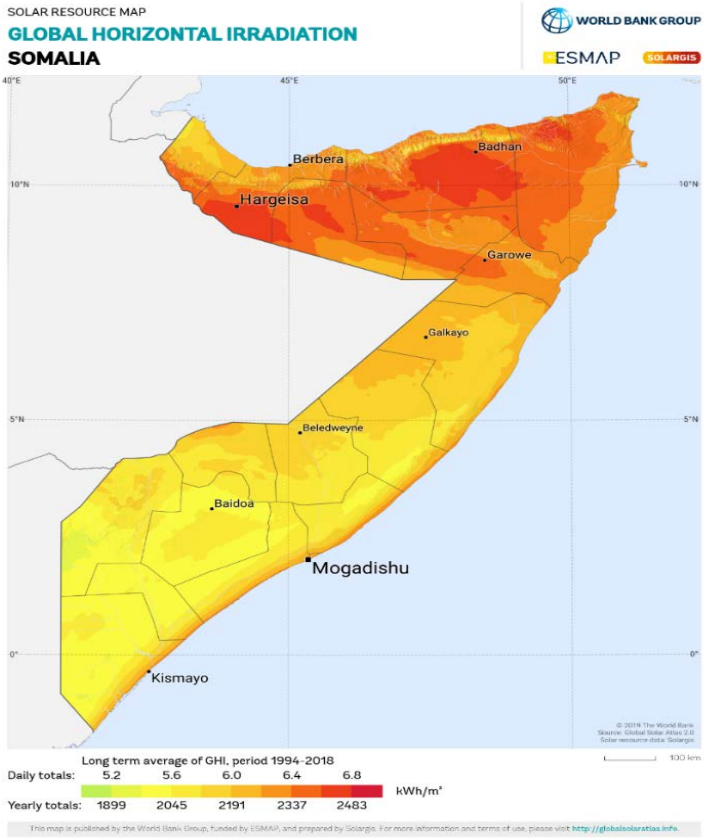


Figure 13: Global Horizontal Irradiation for Somalia[28]

[27] FAOSWALIM
[28] Solar GIS

The solar energy distribution in Somalia is also almost uniform with modest gradients, not higher than 16% between zones with higher insolation and others with less insolation. The average sunshine duration is estimated between 2900 – 3100 hours/year (8-8.5 hours / day)[29]. The temperature is not so high with yearly average of 27°C that in turn adds to the operational life of solar PVs.

4.2.6 Agriculture and Cropping Pattern

The country has an irrigation potential of 2,40,000 ha. The irrigation sector has undergone major changes since the outbreak of the civil war in 1991[30], many of the large-scale irrigation systems having been destroyed. Of the remaining infrastructures many are not in use due to lack of maintenance and most of the formerly irrigated areas are now used for rainfed farming and grazing. There has been an expansion of rainfed farming, mainly in the areas of Middle Shabelle and Galgaduud.

Large-scale commercial irrigation was introduced during the colonial era (1880- 1960) and played a major role in pre-war agriculture. Irrigated bananas and fruit trees (limes) were the major crops. Other crops, produced mainly by government-owned farms, were sugar cane, cotton and rice. Most of the private and government-owned farms collapsed in 1990, but several private farms have recovered and diversified into cash crops, such as sesame, groundnuts and rice. However, the technical level of production, mechanization and efficiency of these farms remains low. Unsettled land issues are also constraints on future development.

The area equipped for irrigation was 2,00,000 ha in 1984, of which 50,000 ha full/ partial control surface irrigation and 150,000 ha spate irrigation. These estimates are still valid today, but much of the infrastructure is not used. The area irrigated is only around 65,000 ha[31].

Irrigated agriculture is mainly practised along the Juba and Shabelle rivers. In their upper sections both rivers have deep riverbeds and pumps are needed for irrigation. In the lower sections the rivers are embanked, which allows for gravity-fed irrigation, especially along the Shabelle. Pumps are used by those who can afford it during periods of low discharge. There are three common types of small-scale irrigation found in the Juba and Shabelle basin:

- Small-scale pump-fed surface irrigation of cash crops. Individual families or small groups usually irrigate 0.5-5 ha close to the river;
- Small-scale gravity-fed surface irrigation of staple and cash crops, with clusters of small-scale farmers irrigating 5-10 ha. Maize is most common, followed by sesame, fruits or vegetables;
- Spate and flood recession irrigation of staple crops. Spate irrigation is called Deschek irrigation and it also includes the areas along the riverbanks, which are often called riverbank farms (5-100 m from river).

When the bi-annual floods begin to recede farmers plant maize in depressions and dry river branches, along the middle and lower reaches of the Juba. Flood recession farming is practised from 500 m to up to 30 km distance from river[32]. The system is quite risky as the floods can return before the crops are harvested.

Annual Averages, US$ million	1986-88	2010-12	2013-16	Deyr 2016 - Gu 2017
Livestock and livestock products	**606**	**3,489**	**3,756**	
Meat (including exports)	366	761	1,051	-
Livestock products	240	2,729	2,704	-
of which: fresh raw milk			2,848	2,353

[29] UNDP
[30] FAO AquaStat
[31] FAO AquaStat
[32] FAO

Annual Averages, US$ million	1986-88	2010-12	2013-16	Deyr 2016 - Gu 2017
Crop Production	**198**	**355**	**751**	**329**
Staple food crops	**127**	**189**	**136**	**62**
Sorghum	36	88	48	25
Maize	55	59	35	23
Sesame Seed	24	15	33	6
Cowpeas		22	15	6
Rice	4	3	3	1
Legumes			1	0
Pulses	7		..	-
Groundnuts	1	2	..	-
Fruits	**23**	**46**	**175**	**56**
Banana	11	26	82	27
Grapefruit and Lime	2	4	26	12
Watermelon		7	32	8
Papaya			23	9
Dates			12	1
Other Fruits	9	9		-
Vegetables	**16**	**13**	**46**	**5**
Tomatoes		2	41	4
Onions		10	5	0
Other vegetables	16		-	-
Forestry	**-**	**-**	**88**	**-**
Frankincense (Boswellia)	-	-	88	73
Other	**32**	**24**	**-**	**-**
Roots and Tubers	25	24	-	-
Seed Cotton	1	-	-	-
Sugar Cane	6	-	-	-
Relative sector ratios, %				
Livestock and livestock products	**75%**	**91%**	**83%**	
Crop Production	**25%**	**9%**	**17%**	

Table 5: Gross Production Values of Livestock and Crops in Somalia, 1986–2017 [33]

[33] World Bank

5. Financial Feasibility Analysis

5.1 Indicative Inputs

S.No.	Particulars	Unit	Value	Source
1	Crop to be Irrigated		Sorghum, Maize	
2	Land Size	hectares	0.5 (for each crop)	
3	Planting date		As per cropping calendar of Somalia	
4	Irrigation type		Flood: Lined canal supplied	
5	Annual average yield of crop	Kg/hectare	Sorghum 499 Maize 398	FAOSTAT
6	Market Price	USD/quintal	Sorghum 1646 Maize 1588	FAO: Food Price Monitoring and Analysis
5	Selected Size of Solar Pump	HP	5	
6	Total dynamic head inclusive of friction losses	meters	140	
7	Cost of Solar Pump	USD	12859.5 [34]	Average of L1 prices discovered in ISA tender for Various categories of pumpsets
8	Subsidy	%	0 %	
9	Margin Money	%	10 %	
10	Loan Amount	%	90 %	
11	Interest Rate	%	33 %	Last data available from World Bank is till 1988; hence 1988 data is considered
12	Loan Tenure	years	8	
13	Cost of diesel pump per HP	USD	1.78	
14	Cost of diesel	USD/litre	1.18	Published reports and articles
15	Hike in diesel prices (y-o-y)	%	3%	Based on global averages
16	Inflation rate	%	6.8 %	World Bank Data
17	Living expense of the farmer (as a % of crop revenue)	%	60 %	Based on global estimates, KPMG Analysis
18	Maintenance costs for diesel pump (as a % of capital costs)	%	10 %	Based on global estimates, KPMG Analysis[35]

5.2 Indicative Crop Water Requirement [36]

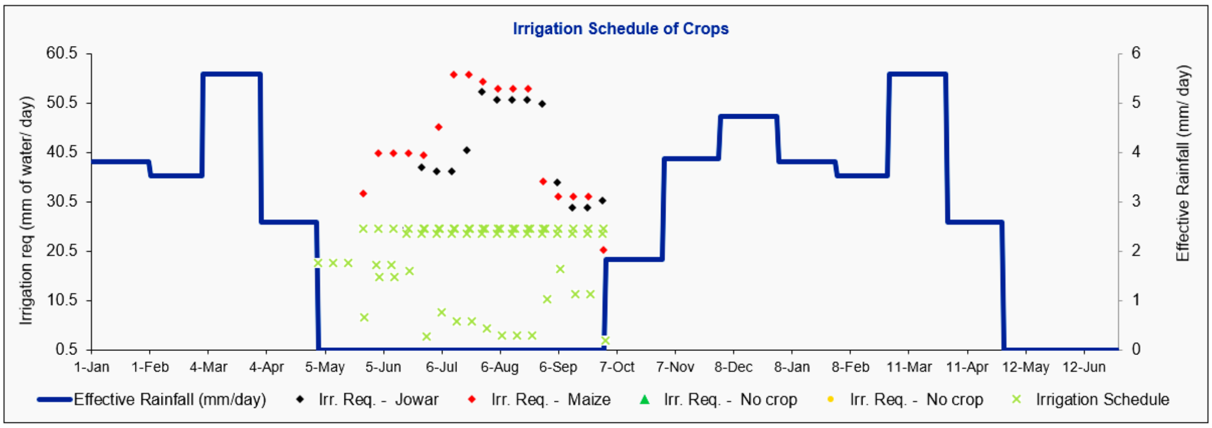
Total crop water requirement (m^3)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-	-	-	70	1,860	2,653	2,328	993	103	-	-	-
Annual crop water requirement (m^3)				8,007							

5.3 Indicative Irrigation schedule

[34] Cost of Solar pumpset includes on-site Comprehensive Maintenance Contract (CMC) for 5 years but exclusive of custom import clearance, duties and local taxes as per ISA International Competitive Bid

[35] The toolkit developed by KPMG for Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH was used to undertake the analysis.

[36] Note: This is just an indicative analysis to be used only for reference purposes. We have taken reasonable assumptions wherever reliable data was not available. A more accurate analysis can be conducted after more data has been obtained from the respective nations.



Irri. Req. indicates the net irrigation requirement (considering rainfall) for individual crops
Irrigation Schedule indicates the consolidated schedule over the time period for all the crops

5.4 Indicative Outputs

S.No.	Particulars	Unit	Value
1	Amount of subsidy	USD	0
2	Amount of loan to be availed	USD	11565
3	Yearly installment towards loan repayment	USD	4250
4	Monthly installment towards loan repayment	USD	354
5	Savings in monthly diesel expenses on an average basis for 20 years	USD	509
6	Number of hours of solar pump operation required	Hours	1828
7	Number of days of solar pump operation required	Days	261
8	Incremental payback of solar pump w.r.t. diesel pump	years	7

Somalia has submitted demand for 500 Nos. solar water pumping systems. At an average price of USD 12849.5 per 5 HP pumpset, Somalia requires financing of USD 6.42 million to roll out deployment of 500 Nos. solar water pumping systems across the country.

6. Recommendations

Following are the recommendations for the implementation of solar pumps in Somalia based on the above analysis and discussions undertaken during the visit of delegation from ISA Secretariat to Somalia:

1. **Number and type of pumps**: Somalia has submitted demand for procurement of 500 solar water pumps. Considering the low levels of electricity access and frequent brownouts/ blackouts especially in rural areas, off-grid pumps are required to be installed. Further large pumpsets presently being used for water lifting from Juba and Shabelle Rivers may be solarized.

2. **Location of pumps:** In the initial phase, it is advisable to select few concentrated areas and install the solar water pumps in order to have a good demonstration effect. For example, solar pumps may be installed at Juba and Shabelle Rivers area where farmer user groups have been formed and are already paying for water irrigation facilities provided by Government of Somalia. If the solar water pumps are scattered across different areas, it will lead to high transportation and maintenance costs. Also, the installation of solar water pumps in a concentrated area will help in better visibility and strong impact of the programme**.**

3. **Financing:** There are limited sources available for the government of Somalia to fund the solar pumps and therefore subsidy shall not necessarily be available for solar pumps. Hence, the financing models envisaged should majorly consider either subsidy from external donor agencies or financing by MFIs/DFIs for the cost of the pump. The subsidy may be required for initial implementation of the solar pumps considering the technology is still new in the country. With the progress of deployment and improvement in costs, the subsidy may be reduced in a phased manner. Further, some amount maybe paid by the farmers upfront while the remaining may be done on periodic basis in the form of loan repayments.

4. **Financing structures:** Considering external financing would be required as mentioned in point 3. above, mobilization of financing should be done by the authorities and suitable financing structures should be developed to enable the deployment of pumps.

5. **Knowledge development:** Number of motorized agricultural pumps deployed in Somalia are very limited and farmers have relied on river water, surface water or hand pumps for irrigation. Therefore, awareness creation and knowledge development of the farmer with regard to deployment of solar pumps is necessary to enable effective adoption and utilization of the solar enabled pumps. Initially these activities may be undertaken by i-STARCs to be developed in Somalia under the ISA's programme.

6. **Ecosystem availability:** Though Ministry of Energy and Water Resources has already implemented solar water pumping systems for drinking water, the solar ecosystem is not well developed in the country. Therefore availability of local manpower for solar and pumps may be a challenge during the initial phase of implementation. However initial training on the operations and maintenance aspects of the solar pumps will mitigate the challenge to an extent.

7. Proposed next steps

1. **Pre-feasibility report**: The pre-feasibility report may be shared with Multilateral Development Banks (MDBs) such as World Bank, EXIM Bank for financing solar water pumping systems in Somalia. This report assesses the feasibility of implementation of solar pumps with reasonable assumptions as detailed in the report. However, to arrive at a detailed feasibility assessment, site specific and other relevant details (such as, applicable taxes, duties, government incentives etc.) are required from the relevant Ministry.

2. **Capacity building**: Post bid process and financing arrangement, Identification of foundations/ institutions in Somalia to assist in the capacity building of farmers and knowledge development of local technicians may be initiated by pump suppliers and through i-STARCs.

3. **Implementation scale**: Considering solar pumps have not been deployed at a major scale in Somalia, implementation may be planned in phased manner for better visibility and strong impact of the programme which may further be scaled to the country level. The roadmap for the same may be prepared by Government of Somalia in consultation with ISA.

4. **Field preparation**: Boring activities may also be suitably initiated by farmers in the area where the solar pumps are planned to be initially implemented.

5. **Supply and project monitoring**: Regular project monitoring for supply and installation of pumps may be undertaken by ISA and NFP Somalia basis field reports and feedback from farmers, suppliers / installers and government agencies.