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**AFRICAN DEVELOPMENT
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**PROJECT: PROPOSED SOLAR POWERED PUMPING SYSTEMS
FOR IRRIGATION PROJECT**

COUNTRIES: SUDAN

**ESMP SUMMARY FOR THE PROPOSED SOLAR POWERED PUMPING SYSTEMS FOR
IRRIGATION PROJECT**

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Preparation Team	Team Leader:	A. WUBESHET-ZEGEYE, Chief Power Engineer, RDGE1
	E&S Team Members:	E.B. KAHUBIRE, Social Development Officer, RDGE4 /SNSC

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PROJECT NUMBER:	P-SD-FF0-001
COUNTRY:	SUDAN
CATEGORY:	2

1. INTRODUCTION

1.1. Sudan is largely dependent on imported fossil fuels for power generation. Hence, there is an urgency to implement Sudan's Renewable Energy Master Plan (REMP) and reduce Sudan's dependence on fossil fuel. Sudan has abundant wind and solar resources, but largely lacks the capacity to utilize these resources for power generation. A programme to provide grid-connected electric pumps to replace diesel has been launched by the Ministry of Water Resources and Electricity (MWRIE) together with the Northern State Government to promote electric pumping for large scale farms (with an area of 100 ha or more).

1.2. The Solar Powered Pumping Systems for Irrigation Project's intended goal is to use solar water pumps for irrigation to replace either diesel-generated electricity or grid based electricity generation for water pumping for irrigation. The replacement of the diesel pumps is going to generate certain climate related impacts. A diesel generator emits CO₂ during operation and grid based electricity is usually generated with coal, oil or natural gas which also emits considerable quantities of CO₂. In contrast, a solar-based water pump system does not result in greenhouse gas emissions. Extensive use of solar water pumps in irrigation would therefore lead to substantial greenhouse gas emission reductions.

1.3. The main development objective of the project is to reduce the dependency on imported fossil fuels through the adoption of renewable energy for water supply in irrigation to foster economic and social development by increasing crop production in the agricultural areas around the country and promote peaceful environment for water resources use.

1.4. Some of the main features of the solar powered pumping Systems for Irrigation are:

- i) The project is environmentally classified under category 2 considering the nature of the interventions, which are expected to generate evident positive environmental and social impacts.
- ii) An integrated approach of institutional development, research and transfer of technology, conservation agriculture, and water management will bring environmental good practices to the project area.
- iii) The project will not involve any resettlement of populations.
- iv) Under the Climate Change Risk Assessment, the project is classified under category 2, therefore, the project may be vulnerable to climate risk.
- v) The project components and implementation plans should be selected and designed taking into consideration the necessary practical risk management and adaptation measures.

2. CONTEXT

2.1. The proposed project aims at replacing the existing diesel powered pumping systems for irrigation in agricultural areas where the grid has not reached. The project components include:

- (i) Supply and installation of solar photovoltaic (PV) powered pumping systems for irrigation to replace the diesel-powered irrigation water pumping,
- (ii) Supply of additional testing equipment for the solar PV pumps testing laboratory to ensure quality standards, testing and certification, training and capacity building,
- (iii) Project management and supervision that includes supervision of the supply and installation works and supervision of laboratory equipment,
- (iv) Support farmers for use of climate smart agriculture
- (v) The total quantity of the solar powered pumping systems and the project area will be determined and agreed between the AfDB and the Government of Sudan. The Project will take the lessons of the GEF funded (implemented by UNDP) project, into account on designing this project.

2.2. North Kordofan State (NKS) lies in the dry zone of central Sudan between latitudes 15-11 and 45-16 north. It is boarded by six states; Northern state from the north, Khartoum state and White Nile from the east, South Kordofan in the south, South Darfur from the south-west and North Darfur in the west. North Kordofan state covers an area of 244, 700 km², equivalent to 139 square miles and 58.8 million acres of land. The state is divided into four groups: land Algayzan, Garduod sediment, valleys, and mud-cracked. It is largely an undulating plain, with the Nuba Mountains in the southeast quarter. The rainy

season extends from June to September. The population of this state is estimated to be 2,920,992 persons according to 2008 census. They are distributed among the various localities and characterized by heterogeneity according to geographical diversity, environmental, lifestyle, rural, urban residents and returnees.

2.3. West Kordofan State lies in the Southwestern part of Sudan, is bounded between latitudes 9.5 0 - 13.5 N and longitudes 27.25 - 29. 50E; it is about 760 km from Khartoum. An asphalt road and railway lines connect the State with Khartoum, while flight services are available for the north kurdofan state located about two hours driving to Elnuhud town. The state shares international border with South Sudan in the south, and state boundaries with East Darfur, South and North Kordofan states in the western, eastern and northern parts of the state respectively. the state of West Kordofan enjoy Bakulaimyin natural, the southern part is heavy rainfall and vegetation and tree and heavy clay soils, and the northern part is a medium-range rain and light to prevail and sandy soil (soil Al Quoz) in this side of the state as an area of 111 373 m². The capital of the State is Alfolah City. The area is almost flat with sandy soils covering about 60% of the state. Transhumance dominates socioeconomic activities. Nomadic tribes dominate the population and economy of Western Kordofan. Inhabitants are mainly Baggara tribes, who are mainly cattle owners and Hamar tribes, who are mainly camel and goat breeders. Most of the population is found where water and other services are available. Ecologically, West Kordofan state is classified into three zones: distinctively, the semi desert area in the north and high rainfall woodlands savannah area and is bounded by Bahr El Arab River in the south. The maximum temperature, over the whole state, varies from 420 to 440 C from north to south respectively, while the minimum temperature varies for between 170 C and 240 C, mainly during the months December to February and during the crops growing season (July to October) when temperatures are between 250 and 280C. However, the daily mean temperature the year round varies for between 250 C and 320 C. West Kordofan State is endowed with many natural resources such as:

- Agriculture: The State is characterized by the cultivation of grains such as peanuts, sesame and love watermelon, corn, millet and cotton.
- Animal Wealth: In the Southern part of the Stat is characterized by breeding cows, goats and sheep, while in the north of the state we find camels, sheep and goats.
- Oil Wealth: The State in oil wealth, where there are many fields such as petroleum field and night blue or iron and Srfaye There are also fields where work is under way now, in addition to gold, copper and marble.
- Forest: The State is endowed with the most important forest products that contribute to the national economy of Sudan such as, Gum Arabic as well as Baobab and Tenax and loan trees and buckthorn and Lalob.

3. BENEFICIAL AND ADVERSE IMPACTS

3.1. Social Considerations: The use of SWP for irrigation would result in improved crop yield and decreased cost of crop production leading to increased savings for the smallholder farmers. These expected savings would flourish the local markets and generates more benefits including poverty alleviation and improvements of the wellbeing and livelihood of the participating communities. [The project's positive impacts can be summarized as follow:](#)

- (i) increased agricultural production and productivity;
- (ii) Improved food security and nutritional status of the beneficiaries as a result of the increase in the quantity of food produced once the project becomes operational. Other positive impacts are:
 - a. Improved land conditions due to improved land and water management and conservation activities;
 - b. Enhanced livestock production as a result of increased feed supplies; and,
 - c. Improved soil and water conditions resulting in enhanced land conditions.
 - d. Additional positive impacts will be achieved by increased employment opportunities due to increased economic activities and knowledge base of the technical officers and local communities which will be enhanced through transfer of technologies and capacity building.

3.2. Environmental Considerations: Solar PV systems, once manufactured, are closed systems; during operation and electricity production they require no inputs such as fuels, nor generate any outputs such as solids, liquids, or gases (apart from electricity). They are silent and vibration free and can broadly be considered, particularly when installed on brownfield sites, as environmentally benign during operation.

Table 1: Expected Impacts during Pre-construction and construction

Component 1: supply and installation of solar photovoltaic (PV) powered pumping systems to replace the diesel-powered irrigation water pumping	
Negative	Positive
Installation of the solar panels	
<ul style="list-style-type: none"> • Work related accidents 	<ul style="list-style-type: none"> • Increased crop production • Reduced cost of production • Reduced CO₂ emission • Employment growth • Boost to local economy
Replacement of diesel pumps	
<ul style="list-style-type: none"> • Disposal of the old diesel sets • Decommissioning of the old site 	<ul style="list-style-type: none"> • Decreased cost of production • Increased household income • Reduced operation and maintenance cost
Component 2: Supply of Additional Testing Equipment for the Solar PV Pumps Laboratory to ensure Quality Standards, Testing and Certification, Training and Capacity Building	
Construction of laboratory building	
<ul style="list-style-type: none"> • Dust • Noise • Health and safety • Drainage • Erosion • Cultural heritage sites 	<ul style="list-style-type: none"> • Testing of solar cells • Quality assurance
Laboratory equipment	
<ul style="list-style-type: none"> • Noise • Gas emissions 	<ul style="list-style-type: none"> • Quality assurance
Component 3: Project Management and Supervision	
<ul style="list-style-type: none"> • No Impact Expected 	<ul style="list-style-type: none"> • Awareness • Use of smart Agriculture that increases climate resilience
Component 4: Support Farmers for use of Climate Smart Agriculture	
<ul style="list-style-type: none"> • Use of chemicals (fertilizers and herbicides) • Salinity • Soil compaction 	<ul style="list-style-type: none"> • Increased crop production • Employment growth • Boost to local economy

Table 2: Expected impacts during operation

Component 1: supply and installation of solar photovoltaic (PV) powered pumping systems to replace the diesel-powered irrigation water pumping	
Negative	Positive

<ul style="list-style-type: none"> No impact expected 	<ul style="list-style-type: none"> Decreased cost of production Increased household income Reduced operation and maintenance cost
Component 2: supply of additional testing equipment for the solar PV pumps laboratory to ensure quality standards, testing and certification, training and capacity building	
<ul style="list-style-type: none"> No impact expected 	<ul style="list-style-type: none"> Health and safety
Component 3: Project Management and Supervision	
<ul style="list-style-type: none"> No impact expected 	<ul style="list-style-type: none"> Awareness Use of smart Agriculture that increases climate resilience
Component 4: Support Farmers for use of Climate Smart Agriculture	
<ul style="list-style-type: none"> Use of chemicals (fertilizers and herbicides) Salinity Soil compaction 	<ul style="list-style-type: none"> Increased crop yield Increased household income

3.3. Solid Waste Impacts

The main environmental impacts of solar cells are related to their production and decommissioning. In regard to pollutants released during manufacturing, IPCC (2010) summarizes literature that indicates that solar PV has a very low lifecycle cost of pollution per kilowatt-hour (compared to other technologies). Furthermore, they predict that upwards of 80% of the bulk material in solar panels will be recyclable; recycling of solar panels is already economically viable. However, certain steps in the production chain of solar PV systems involve the use of toxic materials, e.g. the production of poly-silicon, and therefore require diligence in following environmental and safety guidelines. Careful decommissioning and recycling of PV system is especially important for cadmium telluride based thin-film solar cells as non-encapsulated Cadmium telluride is toxic if ingested or if its dust is inhaled, or in general, the material is handled improperly. In terms of land use, the area required by PV is less than that of traditional fossil fuel cycles and does not involve any disturbance of the ground, fuel transport, or water contamination (IPCC, 2010).

While the use of PV technology provides several environmental benefits compared to traditional technologies, care should be taken that the installation of the solar water pump for irrigation does not increase the use of groundwater so that supplies are depleted. Especially in the case where the initial capital costs are covered by a grant or other financial arrangement, the water supplied is more economical to the users compared to the original situation. This might increase water use.

4. ENHANCEMENT, MITIGATION AND COMPLEMENTARY MEASURES

4.1. The project will bring in to the project selected area a considerable number of positive outcomes from an economic and social point of view. However, the implementation of the project has to be complemented by other smart agriculture interventions such as improved cultural and soil fertility programmes to achieve the intended outcomes. The project should also facilitate the market linkages between farmers and the traders for the agriculture and livestock products in the project areas. It would be of paramount importance for the project to support the technology transfer and the use of smart agriculture by adopting a dedicated training and capacity building programme for the technical staff at the State Ministry of Agriculture and the local farmer's communities.

4.2. The PIU must guarantee linkages and complementarities between components, for instance processing crop residues for livestock production and the use of livestock waste as an organic fertilizer for crop production under irrigation. It is also important that gender inequalities be avoided to maximize benefits among all social spectrums. Therefore, female and children should have special treatment.

4.3. During the construction activities of the proposed solar panels, the contractor shall implement the following mitigation measures, to reduce any nuisances that may affect communities

5. CONSULTATIONS

5.1. Part of the consultation process was implemented at the early stage of the project through the AfDB's officials' visits to the targeted stakeholders with government national level authorities. The purpose of consultations was:

- (i) To generate a good understanding of the project by all stakeholders;
- (ii) To enhance ownership of the project by the government's national level authorities;
- (iii) To understand people's and agency expectations about the project;
- (iv) To understand and characterize potential environmental, social and economic impacts of the project;
- (v) To enhance local benefits that may accrue from the project.

5.2. The consultation process needs to be backed up by more visits to the field when the selected project sites are identified to enable stakeholder's involvement in the project to provide views, hence participating in or refining project designs. In addition, site specific investigations were also needed to gain insight to the likely impacts of the program on the environment.

5.3. Environmental implications and baseline information were discussed with the environmental authorities at the national level during project preparation. Thereafter the project design and environmental evaluation team should visit the selected areas and identify the targeted communities and suitable locations for irrigation, water drilling as well as the location and activities associated with the agricultural production. The public consultation process should identify important aspects that capture the communities' concerns and expectations for the identification of the environmental issues and evaluation of the magnitude and significance of the potential impacts of the project, which were discussed above.

5.4. In addition, relevant Acts and regulations in Sudan, AfDB guidelines, national policy papers, national statistics, relevant reports and documents (see list of references) were collected and reviewed. Relevant information to constitute an environmental baseline for impact identification and assessment has been obtained from these published sources. Sensible impact data should be collected during the baseline study to set the project's targets and monitoring indicators.

5.5. The Projects' information needs to be formally disclosed during these consultation meetings.

6. RESPONSIBILITIES AND INSTITUTIONAL ARRANGEMENTS

6.1. The main stakeholders involved in carrying out agricultural and power projects in Sudan are: The Ministry of Water Resources Irrigation and Electricity (MWRIE) is the Government body responsible for Water Resources development and electric power generation and distribution in Sudan and is considered as the client for this project. MWRIE has been implementing the grid-electric pumps programme together with the Northern States government to promote electric pumping for large-scale farms. MWRE will be the main executing entity for the project.

6.2. MWRE hosts a General Directorate of Electricity Generation Using Renewable Energy. It is through this directorate that the MWRE will contribute to the present project. It is proposed that the MWRIE would establish the national Project Management Unit (PMU) and a Project Implementation Unit (PIU) at the State level with the necessary project steering committees that represent most of the project stakeholders for smooth implementation of the different project components.

6.3. The North Kordofan (NK) and West Kordofan (WK) State Ministries of Agriculture, Animal Wealth and Irrigation (SMoAAI) are the governmental entities which are responsible for the implementation of the Agricultural Strategic Plan in those States. The main target of the plan is to raise the percentage of agricultural land in the country by 70%. The NK and WK SMoAAI act as the body responsible for the overall management of agricultural affairs in these States and are the primary State Government liaison with the Farmer's Union of the State.

6.4. Higher Council for Environment and Natural Resources (HCENR) - The Higher Council for Environment and Natural Resources oversees the application of environmental laws and regulations to all development projects in Sudan and has particular responsibilities in the climate change area as shown in the Environmental and Social requirements section above. HCENR serves as the Designated National Authority (DNA) for the Clean Development Mechanism (CDM) and the Green Climate Fund (GCF). It is

also the NAMA Focal Point and UNFCCC Focal Point for Sudan. With UNDP support, HCENR has been developing standardized baselines for Sudan. HCENR has also developed a Technology Needs Assessment (TNA) for Climate Change Adaption and Mitigation, funded by the GEF.

6.5. The Ministry of Finance & National Economy (MoF) has the general objective of developing the internal resources of Sudan and utilizing them in the most efficient way possible to support growth. The MoF also directs the customs and tax authorities and thus is responsible for taxation and for exempting strategic goods from customs duties and taxes, as for solar panels and Solar Water Pumps as agricultural implements, for example.

6.6. The National Energy Research Centre (NERC) has been active in promoting and developing solar water pumping. NERC has a special department for solar energy equipped with instruments and a mechanical workshop. NERC has already participated in the installation of solar pumps around Sudan and is one of the most experienced entities in this regard in the country. NERC is tasked with the development of Sudan's future energy resources and securing the energy needed for sustainable growth. It is hosted within the Ministry of Higher Education and Scientific Research.

6.7. The Sudan Standards and Metrology Organization (SSMO) is a government body that was established to coordinate Sudan's engagement with the International Standards Organization (ISO), the African Regional Organization for Standardization (ARSO) and the Arab Standards and Metrology Organization (ASMO). SSMO is responsible for the development of technical standards and testing within Sudan and ensuring that equipment meet minimum standards for quality, safety, and functionality.

6.8. The Farmer's Union of the NK and WK States serves as the body representing Farmers' interests within these States and interfacing with these State's Governments. The Union coordinates with the NK and WK State Ministries of Agriculture on matters relating to farmers' demands and implementation of national programmes which impact farmers in these States, such as the awareness raising about the new technologies in crop production. The head of the Farmer's Union also represents the Union at workshops and stakeholder consultations giving a unified voice to farmers.

6.9. The Commercial Banks provide general loans and finance to clients and in the case of solar water pumping for irrigation it is proposed that the Commercial Banks will combine to form a fund (mahfaza) to support solar water pumping for irrigation under unified terms as has been implemented in the Northern State. The CBs in the NK and WK States are expected to participate include, but not limited to: Bank of Sudan, Agricultural Bank, Northern Islamic Bank, Agricultural Bank of Sudan, Al Nile Bank, Sudanese Islamic Bank, Baraka Bank, Al Shamal Islamic Bank, Farmer's Commercial Bank, Family Bank etc.

7. IMPLEMENTATION ARRANGEMENTS

7.1. The project is proposed to be nationally executed by the Ministry of Water Resources, Irrigation and Electricity (MoWRIE), under the National Implementation Modality (NIM). AfDB will be accountable for the disbursement of funds and the achievement of the project goals, according to the approved work plan. A Project Coordinator (PC) will be appointed by the MWRIE, to coordinate project operations and support the NPMU with overall administration, oversight, coordination of activities and maintaining a liaison with AfDB. The PC will: (i) coordinate the project activities with activities of other Government entities; and (ii) certify the expenditures are in line with approved budgets and work-plans.

7.2. The project includes funding for grant mechanism which will be operated by MWRIE and the Central Bank of Sudan (CBS) in parallel to the project. The selection procedures and eligibility for how targeted beneficiaries can access grant subsidies under component 1 will be done according to transparent and pre-defined criteria established under year 1 of the project and codified as part of the establishment of the national PV fund.

7.3. The funds may either be directed to the Central Bank's national PV fund (at the request and formal delegation of MWRIE) and will then be disbursed or advanced against the eligible purchase of each individual solar PV pump and then reconciled on a regular (e.g. quarterly basis) following certification by the Project Board (PB) that proper procedures were followed for selection of beneficiaries. Alternatively, a dedicated Bank account for the grant subsidies (budget line) will be set up at the AfDB Sudan country office and then the funds could be advanced or disbursed to MWRIE (or the CBS based on their delegation) following the same procedures and rules.

7.4. For the implementation of the ESMP the institutional arrangement proposed for the project implementation will be considered as the client, therefore the responsibility to implement these mitigation measures lies ultimately on the Project Management Unit (PMU), which will delegate the M& E officer to oversee the implementation of the environmental agenda (ESMP), during the project implementation.

8. ESTIMATED COST

8.1. The cost of ESMP implementation is proposed to be part of the bill of quantities of the project design. Most of the actions (mitigation and enhancement measures) that are proposed should be assured under each activity (construction and/or/operation) as routine best practices that should be included in the Bill of Quantities (BOQ) of each contract. The estimated costs are divided by the ESMP main activities that will be implemented in all components during the project life. The cost of implementation and monitoring of the ESMP is initially estimated at around USD 100,000 and this cost could be adjusted during the preparation of the project's feasibility study.

9. IMPLEMENTATION RESULTS SCHEDULE AND REPORTING

9.1. The project will be implemented during five years (5). Most of environmental impacts will be born at earlier stages of the project implementation, when construction activities will be carried out. Then, during the operation phase the environmental issues will mostly be based on the water quality assurance and fertilizer and pesticides

9.2. The contractor shall report to the PMU on a monthly basis the progress in the construction activities. A quarter site visit meeting shall be conducted jointly by the Client, and the contractor. The PMU should recruit an environmental officer to oversee the implementation of the ESMP over the course of project implementation. The Monitoring and Evaluation officer reports on the project's performance indicators on a regular basis.

9.3. The HCENR is proposed to undertake external monitoring on the implementation of the ESMP recommendations and report the findings to the MWRIE.

9.4. Quarterly reports shall be submitted both to the Client and to the AfDB by the PMU.

10. CONCLUSION

From the ESMP analysis, it could be concluded that:

- The implementation of the project is expected to result in more positive impacts on the environment as well as on the socio-economic status of the communities in the targeted selected States rather than negative impacts.
- The expected negative impacts are expected to occur during the civil works that will be undertaken on component 1 and inappropriate agricultural practices within the target communities.
- Minor beneficial impacts are expected under component one, being mostly related with employment during the construction phase.
- More beneficial impacts will accrue during the operation phase and will mostly result in better crop production (reduction of crop failure) and therefore increase agricultural trade and reduction of activities that threat biodiversity and nature conservation.
- Awareness and training activities and farmer's assistance (technical assistance, through extension services) will be the tools to be used to transfer knowledge and messages to improve agricultural production and resilience.
- The participatory approach will be used to engage communities in all project implementation stages.
- It is strongly recommended that the ESMP be implemented during the construction and operation phase, as this will enable the Project to contain the adverse direct impacts of the project within acceptable limits. The positive outcomes will maximize the benefits for the society as well as for conservation.
- The project is environmentally classified under category 2 considering the nature of the interventions, which are expected to generate evident positive environmental and social impacts.
- An integrated approach of institutional development, research and transfer of technology, conservation agriculture, and water management will bring environmental good practices to the project area.
- The project will not involve any resettlement of populations.
- Under the Climate Change Risk Assessment, the project is classified under category 2, therefore, the project may be vulnerable to climate risk. Climate risk mitigation measures recommended

include the use of smart agriculture such as the use of efficient irrigation methods such as center pivot systems, drip irrigation, and sprinkler irrigation wherever possible. Other mitigation measures include the use of high yielding varieties, disease resistant varieties, and heat resistant varieties.

- The project components and implementation plans should be selected and designed taking into consideration the necessary practical risk management and adaptation measures.
- It is important that the MoWRIE to put in place proper disposal plans during decommissioning of the solar panels at the end of their lifecycle. The solar PV panels that will be used in the project will have a life span of 25 years. Disposal of wasted solar PV modules is very important because if not properly decommissioned, the greatest health risk from end-of-life crystalline solar modules arises from lead containing solders. Under the right conditions, it is possible for the lead to leach into landfill soils and eventually into water bodies.

11. REFERENCES AND CONTACTS

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FOR AfDB

- 1) A. WUBESHET-ZEGEYE , Chief Power Engineer: A.WUBESHET-ZEGEYE@AFDB.ORG
- 2) E.B. KAHUBIRE, Social Development Officer: E.KAHUBIRE@AFDB.ORG