International Water Management Institute

TECHNICAL BRIEF

Suitability for farmer-led solar irrigation development in Mali

Introduction

Approximately 72% of Mali's population is engaged in farming and agriculture is a major economic sector (FAO 2017a). Agriculture is predominantly rain-fed and hence vulnerable to variability in rainfall. Crop yields are affected by dry spells and droughts leading to loss of income and food insecurity. According to the Food and Agriculture Organization of the United Nations (FAO), only 5.3% of the agricultural area was under irrigation in 2011 (FAO 2016). Investments in motorized water pumps to irrigate fields could benefit 4.7 million farmers and generate net revenues up to USD 39 million per year (Agwater Solutions Project 2012). As the price of solar photovoltaic panels is decreasing rapidly, solar water pumps are becoming an affordable, climate-smart solution for small-scale farmers across Mali.

Identifying suitable locations for solar pump-based irrigation enables the private sector to develop and extend their markets. Furthermore, it supports governments and donors to prioritize areas for small-scale irrigation development and increase the rate of success. The Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI) project and the CGIAR Research Program on Water, Land and Ecosystems (WLE) carried out suitability mapping to identify areas in Mali where there is a high potential for scaling solar water pumps for developing irrigation. The study was further refined with financial support from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Mapping suitability

The suitability framework developed by IWMI (Schmitter et al. 2018) was deployed in Mali to assess the potential for scaling solar water pumps. The methodology combines spatial information datasets that are available in the public domain (open source). Such data include solar irradiation, groundwater levels, aquifer productivity, groundwater storage, proximity to rivers, proximity to small dams, crop and land suitability, and travel time to markets. The suitability maps are reclassified and then combined using user-defined weighting factors. Areas that are unsuitable for agricultural production, such as a natural parks, forests, permanent meadows and pastures, are excluded.

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A user of the methodology can assess the suitability of an area for solar irrigation using various combinations of solar pump models that differ in solar irradiation requirement, dynamic head, and available water resources (surface water and groundwater at different depths). Considering smallholders' access to land and affordability of the technology, two specific solar photovoltaic pumps were selected: 0.5 kWh m^{-2} with a lift capacity of 7 meters (m), and 1 kWh m^{-2} with a lift capacity of up to 25 m. Based on these specifications, suitability was assessed for five different available water sources: (i) shallow groundwater up to 7 m, (ii) groundwater up to 25 m, (iii) surface water only (proximity to rivers and small reservoirs), (iv) combination of surface water and groundwater up to 7 m, and (v) combination of surface water and groundwater up to 25 m.

Key results

Depending on water resource availability, the total area suitable for solar-based irrigation varies between 0.69 and 4.44 million hectares (Mha), representing 11-69% of Mali's agricultural lands (FAO 2017b) (i.e., excluding permanent meadows and pastures) (Table 1).

	Water resources				
Region[a]	Groundwater ≤ 7 m	Groundwater ≤ 25 m	Surface water, and small reservoirs	Surface water, small reservoirs and groundwater ≤ 7 m	Surface water, small reservoirs and groundwater ≤ 25 m
Bamako	1	1	-	1	1
Gao	50	50	7	57	57
Kayes	657	1,128	19	664	1,135
Kidal	-	-	3	3	3
Koulikoro	460	678	78	499	716
Mopti	495	501	134	585	590
Segou	220	220	276	463	463
Sikasso	308	1,062	125	385	1,125
Timbuktu	316	316	43	345	345
Total	2,507	3,956	685	3,002	4,435

Note: [a]Mali was initially divided into eight regions and a district capital. However, the number of regions was increased to 19 in 2012, although most of the new regions have not been implemented to date.

Solar pump suitability as a function of the water resources at the *cercles* level (regions in Mali are divided into cercles, the second administrative unit in Mali) is shown in Figures 1 to 5. Groundwater up to depths of 7 m can be found adjacent to the river network in south-western Mali and the central Niger Delta, making Kayes, Mopti and Koulikoro the most suitable regions (Figures 1 and 4; Table 1). Suitability in Kayes and Sikasso increases to an area over 1 Mha when groundwater pumping is extended to depths of 25 m (Figures 2 and 5; Table 1). The least suitable areas are located when only considering surface water (and hence proximity to rivers and small reservoirs) (Figure 3). Timbuktu, Kidal and Gao regions, which are mostly desert, are the least suitable for the two pump types selected given deeper groundwater availability and limited market access. However, in these regions, investments in solar pumps is still possible, although this will require considering the deeper groundwater levels in combination with further development of road infrastructure and market access. Throughout the regions, solar irrigation development in Mali requires a holistic approach to ensure it is environmentally sustainable (Box 1) and socioeconomically inclusive.

Box 1. Additional considerations for solar irrigation development.

The maps show the potential for upscaling solar irrigation to improve agricultural production based on water availability, land and crop suitability as well as market access. However, when upscaling solar irrigation, several environmental issues should also be considered: impact on groundwater abstraction in relation to annual groundwater recharge, water quality in terms of suitability for irrigation and potential pollution, greenhouse gas (GHG) emissions from agricultural intensification, and soil and biodiversity degradation, among others.

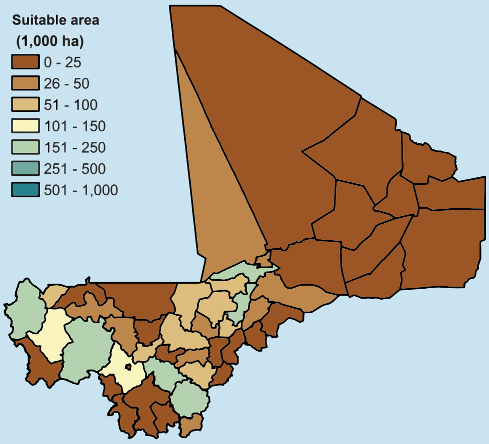

Figure 1. Shallow groundwater up to 7 m.

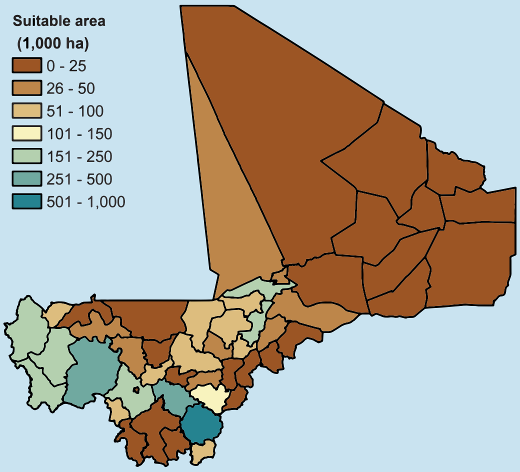

Figure 2. Groundwater up to 25 m (0-7, 7.1-25).

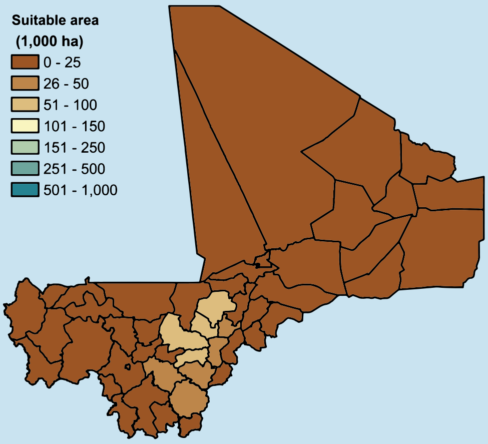

Figure 3. Surface water and small reservoirs.

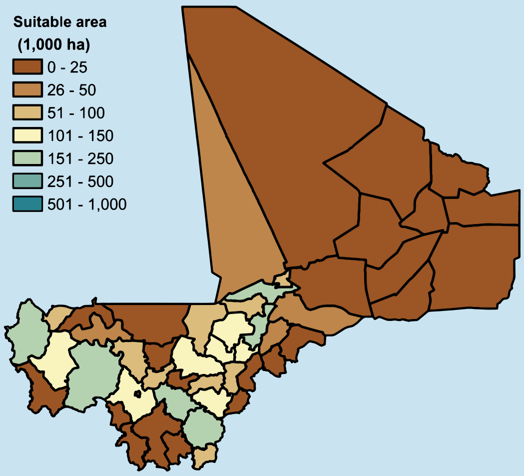

Figure 4. Surface water, small reservoirs and groundwater ≤ 7 m.

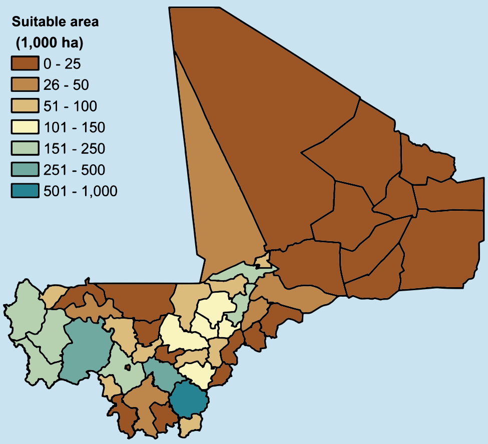

Figure 5. Surface water, small reservoirs and groundwater ≤ 25 m.

Key messages

- The total area suitable for a pump that can lift water up to 7 m with a minimum irradiation requirement of 0.5 kWh m^{-2} is 2.5 Mha. This area increases to 4.4 Mha for pumps with a minimum requirement of 1 kWh m^{-2} that can lift water from depths up to 25 m.
- The presence of the inland Niger Delta makes Mopti and Segou the most suitable regions for solar-based pumping from surface water.
- Kayes and Sikasso are the most suitable regions when considering solar photovoltaic pumping from groundwater up to depths of 25 m.

While these figures show the potential for solar photovoltaic pumping, the suitable areas could be expanded through investments in infrastructure to increase access to markets for produce. Development donors and nongovernmental organizations, as well as some private sector actors, have piloted projects to develop solar pump markets in a number of sub-Saharan African countries. With the growing interest in irrigation expansion for smallholders in the region, suitability mapping can help to ensure that such programs target the right people, in the right places and with the right technologies.

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The International Water Management Institute (IWMI) is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a real impact on poverty reduction, food security and ecosystem health. Headquartered in Colombo, Sri Lanka, with regional offices across Asia and Africa, IWMI is a CGIAR Research Center and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE).

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