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FEED THE FUTURE INNOVATION LABORATORY FOR SMALL SCALE IRRIGATION (FTF-ILSSI) PROJECT NOTES

# IV. Financial feasibility of developing solar groundwater irrigation in Ghana

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Ghana is home to 32 million people, 13 million of whom live in rural areas and work mostly in agriculture. Although substantial progress has been made, food insecurity still affects a large share of the population; during 2019–2021 more than one third of the population experienced moderate or severe food insecurity, and in 2020 14% of children below the age of five were stunted.

With limited land resources and a growing number of extreme climate-related events, irrigation is considered a key strategy to grow agricultural productivity and improve food security in the country. Expanding irrigation requires not only adequate water resources but also access to an affordable and reliable energy source. At this point, an estimated 74% of rural Ghanaians have access to electricity, according to the World Bank.

Among energy sources for powering irrigation, donors', investors', and farmers' interest is growing in the promotion of solar systems due to their easy deployment in areas without access to electricity, their increased affordability compared to the past, and their lower greenhouse gas emissions as compared to diesel pumps.

## METHOD

The study uses spatial analysis to assess the costs and benefits of solar irrigation on a fine-resolution land grid (approximately 1 km by 1 km) in areas suitable for groundwater development. Groundwater irrigation suitability considers terrain, groundwater table depth, and groundwater productivity and storage as well as distance to agricultural input and output markets. Annual net returns of irrigated crop production powered by solar photovoltaic (PV) technology in each land pixel are estimated, and the internal rate of return (IRR) is calculated as a measure of investment efficiency. This estimation process involves sizing the solar irrigation water pumping system using climate and hydrogeological data. The solar module is sized to meet energy demand for irrigation in peak months, when crop water demand is highest.

## KEY FINDINGS

### *Solar irrigation is profitable but remains expensive*

The estimated financial return of solar irrigation varies by cropping system. Empirical evidence suggests that farmers mainly use irrigation to produce high-value crops. Figure 1 displays sites where solar irrigation is financially feasible (indicated by green) assuming double-cropping of rice (rainy season) and vegetables (dry season).

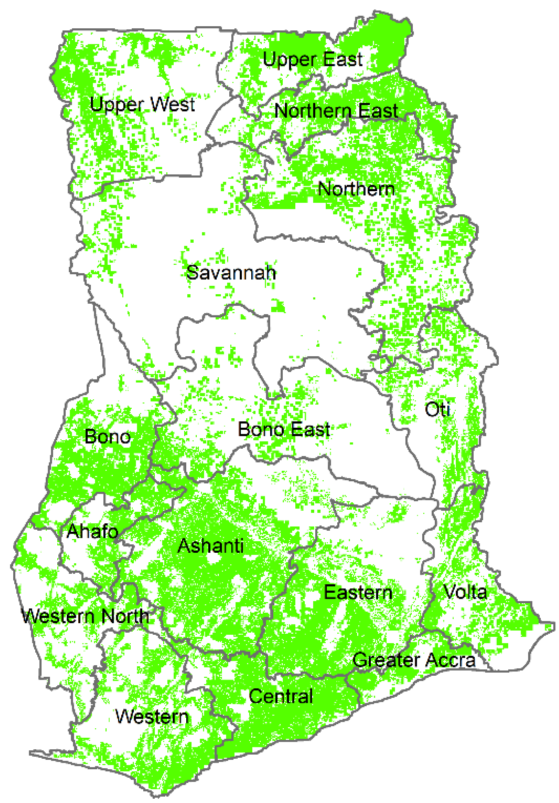


*Figure 1: Land pixels on 1-km land grid with financial feasibility for solar irrigation with double-cropped rice and tomatoes*
*Source: IFPRI.*

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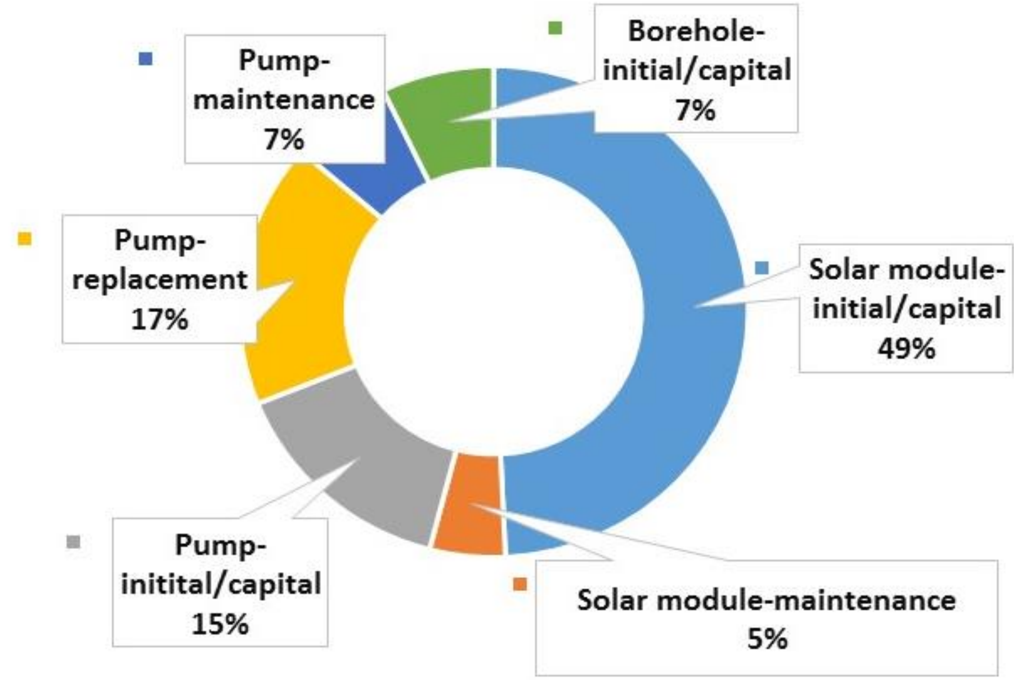


*Figure 2: Cost of solar irrigation by component.*
*Source: IFPRI.*

Tomato is chosen as a representative vegetable crop as it is widely grown in the country. Solar irrigation is considered financially viable when the investment yields a substantial return (IRR>12%).

The average present value of the investment is estimated at US$15,087 per hectare using a lifecycle analysis. This includes the initial/capital costs for the purchase and installation of a solar PV power unit, pump, and borehole, as well as pump replacement and maintenance costs. About 70% of total irrigation system costs are for the initial investment (Figure 2). Among these, the solar module's purchase and installation is the single largest cost component, accounting for almost 50% of total irrigation costs.

Despite the high investment cost, groundwater solar irrigation is feasible in large areas of the country, particularly in parts of the north, south, and central east of Ghana (Figure 1).

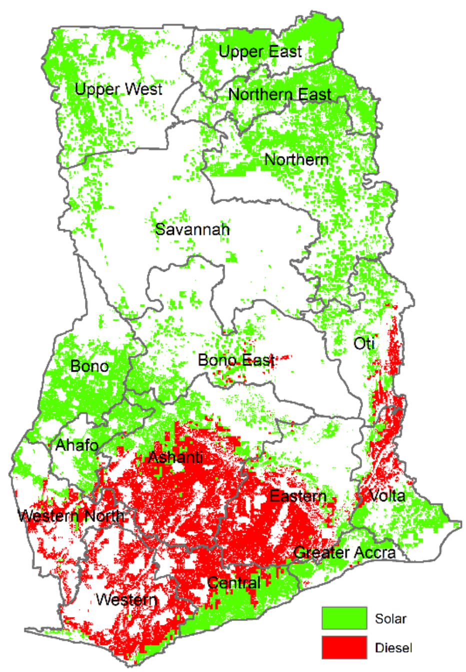


*Figure 3 (a): Cost-effectiveness of solar- versus diesel-powered irrigation*
*Source: IFPRI.*

## *Can solar pumps compete with diesel pumps?*

We use the same methodology to compare the cost-effectiveness of solar- and diesel-powered irrigation. We calculate the initial capital and maintenance costs for diesel pumps; and assess the costs of diesel fuel and pump replacement. Figure 3(a) shows the identified cost-effectiveness of solar- relative to diesel-powered irrigation. Diesel irrigation is found to be more cost-effective in the southwest and in parts of the southeastern border area.

Figure 3(b) shows the cost-effectiveness by region, calculated by summing the hectares of cropland area in each land pixel that are financially feasible for either solar- or diesel-powered irrigation. The Ashanti region has the largest financial potential for all groundwater irrigation development, followed by the Northern, Eastern, and Central regions. By type, solar-powered irrigation has the most potential overall, except in the Ashanti, Eastern, Western, and Western North regions.

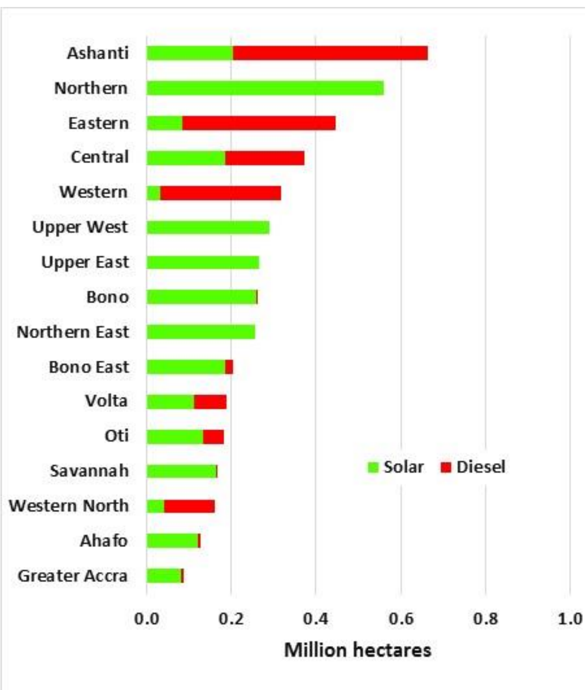


*Figure 3 (b): Areas with financial feasibility under solar- and diesel-powered irrigation by region*
*Source: IFPRI.*

A reference diesel fuel price of US$1.0 per liter is used in the cost-benefit estimation. At this reference price, the total cost-effective area for diesel-powered irrigation is 1.6 million hectares versus around 3 million hectares for solar. As diesel prices have varied considerably in recent years, a sensitivity analysis is performed. Figure 4 presents the results. At a diesel fuel price of US$0.8 per liter, the cost-effective area of diesel irrigation increases to 3.5 million hectares while the solar irrigation area decreases to 1.0 million hectares. Higher diesel fuel prices of US$1.2 per liter and US$1.4 per liter under a "moderately high" and "high" diesel fuel price scenario, respectively, reduce diesel-irrigated area to 0.2 million hectares and no area at all.

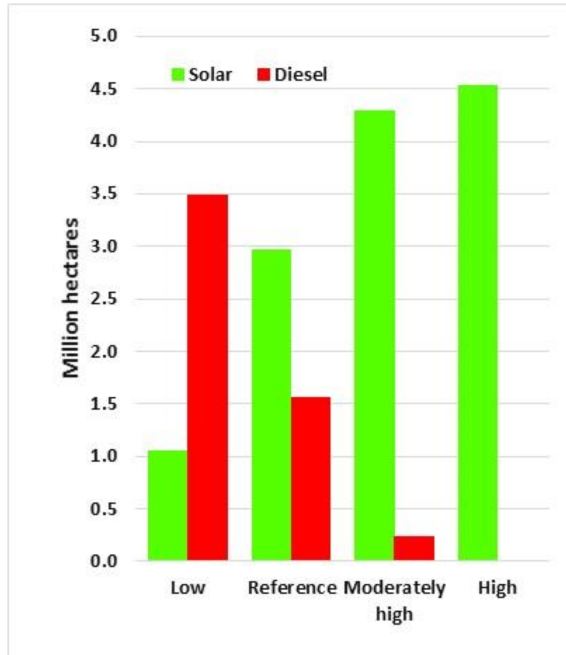


*Figure 4: Sensitivity of cost-effective area for diesel- and solar-powered irrigation to alternative diesel prices*
*Source: IFPRI.*

## CONCLUSIONS

We find that solar-powered groundwater irrigation is a financially viable energy solution across most regions of Ghana. However, the high initial investment cost of solar pumps will require innovative financing tools, such as asset-based finance, to increase smallholder farmers' access to them. Moreover, the cost-effectiveness of solar pumps declines when diesel prices decline, enhancing the attractiveness of diesel pumps, which also have a lower initial capital outlay.

Given the high volatility in diesel prices, solar pumps can help farmers hedge against diesel price increases and help them decouple, at least in part, from joint fuel-food price spikes. While this assessment considered groundwater suitability, more in-depth assessment of irrigation development is warranted to support a national solar road map.

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