Solar-powered irrigation significantly improves diet and income in rural sub-Saharan Africa

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Solar-powered drip irrigation systems significantly enhance household incomes and nutritional intake of villagers in arid sub-Saharan Africa, according to a new Stanford University study published in the *Proceedings of the National Academy of Sciences (PNAS)*. The two-year study found that solar-powered pumps installed in remote villages in the West African nation of Benin were a cost-effective way of delivering much-needed irrigation water, particularly during the long dry season. The results are published in the Jan. 4, 2010, online edition of PNAS.

"Significant fractions of sub-Saharan Africa's population are considered food insecure," wrote lead author Jennifer Burney, a postdoctoral scholar with the Program on Food Security and the Environment and the Department of Environmental Earth System Science at Stanford. "Across the region, these food-insecure populations are predominantly rural, they frequently survive on less than $1 per person per day, and whereas most are engaged in agricultural production as their main livelihood, they still spend 50 to 80 percent of their income on food, and are often net consumers of food."

Burney and her co-authors noted that only 4 percent of cropland in sub-Saharan Africa is irrigated, and that most rural, food-insecure communities in the region rely on rain-fed agriculture, which, in places like Benin, is limited to a three- to six-month rainy season.

"On top of potential annual caloric shortages, households face two seasonal challenges: They must stretch their stores of staples to the next harvest (or purchase additional food, often at higher prices), and access to micronutrients via home production or purchase diminishes or disappears during the dry season," the authors wrote.

Promotion of irrigation among small landholders is therefore frequently cited as a strategy for poverty reduction, climate adaptation and promotion of food security, they said. And while the role of irrigation in poverty reduction has been studied extensively in Asia, relatively little has been written about the poverty and food security impacts in sub-Saharan Africa.

Benin demonstration sites

To address the lack of data, Burney and her colleagues monitored three 0.5-hectare (1.24-acre) solar-powered drip irrigation systems installed the Kalalé district of northern Benin. The systems, which use photovoltaic pumps to deliver groundwater, were financed and installed by the Solar Electric Light Fund (SELF), a nongovernmental organization.

"As with any water pump, solar-powered pumps save labor in rural off-grid areas where water hauling is traditionally done by hand by women and young girls," the authors said. "Though photovoltaic systems are often dismissed out-of-hand due to high up-front costs, they have long lifetimes, and in the medium-term, cost less than liquid-fuel-based pumping systems."

Solar-powered pumps also can be implemented in an easily maintained, battery-free configuration, they added, "thereby avoiding one of the major pitfalls of photovoltaic use in the developing world."

In November 2007, the research team began a close collaboration with local women's agricultural groups in two villages in rural Benin. In Village A, which draws surface water from a year-round stream, researchers worked with residents to install two identical solar-powered pumping systems. In Village B, which relies on groundwater irrigation, water was pumped from 25 meters (82 feet) below the surface. Each solar-powered pumping system was used by 30 to 35 women affiliated with an agricultural group. Each woman farmed her own 120-square meter (1,292-square foot) plot. The remaining plots were farmed collectively to fund group purchases and expenses.

The researchers also chose two control villages for comparison with Villages A and B. Women's agricultural groups in the control villages continued to irrigate by hand, allowing for comparison of the solar-powered drip irrigation systems to traditional methods. "Household surveys were conducted in both treatment and control villages upon installation (November 2007) and following one year of garden operation (November 2008), and included detailed questions concerning consumption and agricultural production, as well as other socioeconomic, health and general questions," the authors wrote.

Striking results

The results were striking. The three solar-powered irrigation systems supplied on average 1.9 metric tons of produce per month, including tomatoes, okra, peppers, eggplants, carrots and other greens, the authors found. Woman who used solar-powered irrigation became strong net producers in vegetables with extra income earned from sales - significantly increasing their purchases of staples and protein during the dry season, and oil during the rainy season. During the first year of operation, the women farmers kept an average of 18 percent by weight - 8.8 kilograms (19.4 pounds) per month - of the produce grown with the solar-powered systems for home consumption and sold the rest in local

markets.

"Garden products penetrated local markets significantly," the authors found. "Vegetable consumption increased during the rainy season (the time of greatest surplus for the women's group farmers) for the entire four-village sample of households."

Survey respondents also were asked about their ability to meet their household food needs. Seventeen percent of the project beneficiaries said they were "less likely to feel chronically food-insecure. In short, the photovoltaic drip irrigation systems had a remarkable effect on both year-round and seasonal food access," the authors said.

Nutrition and sustainability

In terms of nutrition, vegetable intake across all villages increased by about 150 grams per person per day during the rainy season. But in villages irrigated with solar-powered systems, the increase was 500 to 750 grams per person per day, which is equivalent to 3 to 5 servings of vegetables per day - the same as the U.S. Department of Agriculture's Recommended Daily Allowance for vegetables - and most of this change took place in the dry season.

The research team also concluded that, despite higher up-front costs, using solar power to pump water can be more economically sustainable in the long run than irrigation systems that run on liquid fuels, such as gasoline, diesel or kerosene. "When considering the energy requirements for expanded irrigation in rural Africa, photovoltaic drip irrigation systems have an additional advantage over liquid-fuel-based systems in that they provide emissions-free pumping power," they added.

"Overall, this study thus indicates that solar-powered drip irrigation can provide substantial economic, nutritional and environmental benefits,"

the authors said. "With the proper support, successful widespread adoption of photovoltaic drip irrigation systems could be an important source of poverty alleviation and food security in the marginal environments common to sub-Saharan Africa."

More information: Kalalé Solar Electrification Project -- www.stanford.edu/group/solarbenin/

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