Solar-powered Irrigation: Study of Ingotse Village, Kakamega County, Kenya

Simon Ndogo Ndung’a, Tabitha Anyango Omoga and Nancy Masakha Angote
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Ministry of Agriculture, Kenya
About CTA

The Technical Centre for Agricultural and Rural Cooperation (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities.

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Executive summary

Empirical data indicate a positive correlation between agricultural and gross domestic product (GDP) growth in Kenya. Despite experiencing mixed results over the years, agriculture remains the mainstay of the Kenyan economy. The agriculture sector contributes about 30% of the GDP and accounts for 80% of national employment, mainly in the rural areas. Cross-country estimates also show that GDP growth originating from agriculture is at least twice as effective in reducing poverty as GDP originating from outside agriculture.

This case study describes the community of a small village called Ingotse in Kakamega county in western Kenya. Like most rural, food-insecure communities in sub-Saharan Africa, Ingotse village relied on rain-fed agriculture for production of staple crops. Rain-fed agriculture is limited to a 3–6-month rainy season in the Eastern African region over the year; due to climatic changes the Kenya Meteorological Department has predicted poor distribution and reduced rains that are expected to adversely affecting agricultural production and supply.

In addition to potential annual caloric shortages, households in Ingotse village faced other challenges. They were forced to stretch their stores of staple crops to the next harvest but because of late harvest, they had to purchase additional food, mostly at higher prices and their access to micronutrients through home production or purchase diminished significantly during the dry season. Typical smallholder staple production systems are both risky and relatively low return as the commercial value of staple crops is amplified by poor yields and erratic rainfall.

The energy sources available were not sufficient to change the livelihoods of the community. The utilisation of biomass energy posed health risks due to indoor air pollution and indiscriminate charcoal harvesting, which contributed to environmental degradation. The development of solid biomass energy also faced a number of challenges including demand-supply imbalance, indoor air pollution which particularly impacted on women and children, environmental degradation, use of inefficient conversion and utilisation technologies and non-adherence to recommended standards.

With this predicament, farmers in this village raised some funds to sink a borehole. This was done in collaboration with a non-governmental organisation (NGO) known as Water for All which gave the community a solar-powered pump to distribute the water to the homesteads. Water from the borehole was used for irrigation, providing food crops all year round. Women and children no longer had to walk long distances to the river to fetch water; they had extra time in their day for other activities such as doing homework with children.
Introduction

Ingotse village is located in the western part of Kenya, some 21 km from the nearest major town of Kakamega. It covers an area of about 16.2 km² and has a population of 9,439 (4,519 males, 4,920 females) or 1,914 households according to the 2009 census. Despite its relatively high agricultural potential, past economic survey portrayed the area as having high poverty indices (i.e., 56% living below the poverty level).

Agriculture is the main source of livelihood of the people of Ingotse. The community’s agriculture is rain-fed with two cropping seasons that follow a bimodal rainfall pattern. Most farmers are small-scale farmers, with farms averaging between 0.2 to 1 hectares (ha). Small-scale farming accounts for 75% of the total agricultural output and 70% of marketed agricultural produce. There is great potential for increasing productivity in smallholder production system because although they produce over 70% of maize and over 95% of other food crops, adoption rates of improved seed, fertilisers and other technological advancements in crop protection and post-harvest handling is low. However, the sector is faced by constraints and challenges including:

- environmental degradation and deforestation due high population pressure
- erratic weather patterns

Plate 1. Some crops grown in Mr Magomere’s farm under irrigation.
• declining land sizes due to continuous subdivision. In some areas it is less than 0.4 ha per family. This has had negative impact on crop production
• declining area under food crops as land under industrial sugarcane increases – this leads to food insecurity.

The main constraint to development, income generation and food security in the area is inadequate water. Irrigation is especially pertinent in the face of recurrent droughts, floods and prolonged dry spells, which cause food insecurity and famines in the community and have to be mitigated.

Fuelwood is the main source of energy in this community. About 0.4% of the population use grass, 2% use paraffin, 0.3% use solar energy, 0.5% use liquefied petroleum gas (LPG), 4.1% use charcoal, 3.5% use biomass residue, while 1.13% use other energy sources for cooking. The majority (95.2%) of the population use paraffin for lighting while 92.1% use a traditional 3-stone fire as the main cooking appliance. Charcoal production is one of the major consumers of trees and forests in the area. The production reduces the vegetation cover that acts as a carbon sink and therefore promotes climate change. Use of charcoal is the worst use of biomass energy since although it produces high energy it emits a lot of carbon dioxide into the air. The harvesting of the trees also reduces the vegetation cover in the watersheds, reducing the catchment quality and their ecological functions.

Water is scarce simply because of a limited endowment, the growing needs of rapidly increasing population, as well as serious water resources degradation. In addition to this scarcity, Ingotse is vulnerable to rainfall variability; droughts are endemic and floods occur quite frequently. This is despite the fact that Kenya’s socio-economic development goals are dependent on the availability of suitable amounts of good quality water. Sustainable utilisation, development and management of water resources fundamentally underpin the achievement of the long-term socio-economic goals.

The impact of energy constraints on the community’s livelihood

The main sources of energy supply in Kenya are electricity, fuelwood, petroleum and renewable energy (Figure 1). Commercial energy in Kenya is dominated by petroleum, on-grid and off-grid electricity, charcoal and fuelwood. Biomass including agricultural waste constitutes the non-commercial proportion of the energy sector. Kenya consumed a total of 15,108 kilotonnes of oil equivalent in 2008 (IEA, 2011) with an energy use per capita of 468 kg of oil equivalent, which is less than one-quarter of the world’s average per capita. Solid biomass remains the dominant source of energy in Kenya, meeting an estimated 77% of the energy demand.

There is a widening gap between supply and demand for fuelwood. The utilisation of biomass energy posed health risks due to indoor air pollution and indiscriminate charcoal harvesting contributed to environmental degradation. The development of solid biomass energy faced a number of challenges including demand-supply imbalance, indoor air pollution which particularly impacted on women and children, environmental degradation, use of inefficient conversion and utilisation technologies and non-adherence to recommended standards. There was limited knowledge and awareness of liquid biofuels, unavailability of information on feed stocks and technology, the threat of competition with
other land-use systems, maintenance of a balance with rural development with significant gains to society and inadequate feedstock, among others.

The majority of the women and children spent most of their time walking to collect fuelwood and water. This limited women’s economic productivity and children’s performance at school. Insecurity thus became rampant as a result of scarce resources and idleness.

Introduction and adoption of the project

Previously, maize, beans, sweet potatoes, groundnuts, bananas and local vegetables were cultivated at subsistence level, on the other hand, industrial sugarcane which was the main cash crop was characterised by fluctuating prices and low returns on investment, way below the expected monthly wage. For this reason, the community grappled with food insecurity leading to poor well-being as reported by the chairman, Mr Jotham Shikuku:

As a community we were known for growing maize and sweet potatoes and we had enough food for our families. We ventured into growing sugarcane as a cash crop, which takes 2 years before harvesting. With our small land sizes we hardly had enough area to grow food crops since the majority of the land was taken up by sugarcane. The sugar companies (millers) in turn paid dividends as little as a monthly wage at the end of the two years. This could not sustain us. (Chairman)

With erratic weather patterns and the resulting food shortages (as a result of climate change brought about by felling down trees and unsustainable farming methods), the villagers sought help from their local extension workers in order to mitigate this menace.
In order to create an economically vibrant and sustainable community, the Ministry of Agriculture through its focal area development approach established the North Butsotso Focal area in 2005/2006 financial year. Initially the community members were a bit sceptical, not knowing how the programme intended to improve their well-being, but as mobilisation and sensitisation continued, horticulture was promoted as a viable enterprise alongside the industrial sugarcane production. Farmers were organised into common-interest groups (CIGs).

Plate 2. Jotham Shikuku, the project chairman, with Agricultural Officer Nancy Masakha.

Response

To address the perennial food insecurity in the region, the Ministry of Agriculture through the National Agriculture and Livestock Extension Program (NALEP), informed by the broad-based survey and Participatory Analysis of Poverty and Livelihood Dynamics intervened in the community. The intervention strategies included: awareness creation on relevant services on appropriate farming and livestock technologies, promotion of viable opportunities, facilitated establishment of community institutions such as CIGs and trainings of the farmers based on individual group needs.

Moreover, NALEP engaged some of its extension models – collaboration, partnerships and networking – to bring some of the relevant stakeholders on board. With this approach, the
Western Region Christian Community Services, the Western Kenya Community Driven Development and Flood Mitigation Project (WKCDD/FMP) supported the CIG initiatives by acquisition of planting materials and marketing of the produce respectively.

Plate 3. The solar-powered irrigation system in Ingotse.

The community, because of its impressive performance attracted other international NGOs like Water for All. Led by one of the senior villagers and the chairman of the project, Mr Jotham Shikuku, the villagers commissioned hydrogeological surveys on the area to find out the availability of sustainable groundwater resources. The results were positive. Meetings were held and it was decided that a borehole would be sunk at the nearest school compound as it was in a central location in the village and had 24-hour security. Having it there also meant that school-going children would also benefit from it.

How the project was run
A committee was mandated to look for funds for this project, oversee the sinking and construction and later manage the project on behalf of the community. The community members sought government assistance for this project but the response was delayed due to government bureaucracy.
The borehole

With adequate finances collected from the households over a period of time the NGO Water for All was commissioned to sink and build the borehole system that was manually operated. Users were tired after drawing water as a lot of strength was used to draw the water and then they had to carry the water to a number of destinations. The mechanical parts turned out to be a weak link in the borehole system. Manually operated by varied users, the water drawing mechanism regularly broke down and required money for servicing. The costs of repair started to affect the villagers’ finances and over time, individuals were reluctant to contribute to the cost of servicing, sometimes leaving the borehole system in disrepair for extended periods of time.

Solar-powered pumps

The constant breakdowns led community leaders to search for a lasting solution. The suggestion was either to use a diesel or solar-powered pump to draw water from the borehole to a water tank; the tank would be set high up and gravity would help in water flow to the taps below. The decision on whether to use liquid fuel (e.g., diesel) or solar energy was not a hard one after weighing the pros and cons of each. The liquid-fuel-powered mechanism would require a generator and fuel for running it and would then need regular servicing and fixing in case of breakdown. Another disadvantage was the increasing fuel prices. A farmer using a diesel pump spends up to KES5,000 a day (about US$60) to pump water to a medium piece of land, according to research carried by the farmers.

Solar energy turned out to be the only viable option for the community. A solar pump once purchased and installed will have minimal running costs, unlike liquid-fuel engines. The solar technology is also environmentally clean; being a non-pollutant it emits no climate changing carbon dioxide into the atmosphere. The reduced costs would enable the farmers and villagers to spend their money on inputs and seeds instead of spending it on running the borehole system.

With guidance from extension workers from the ministries of agriculture and water, together with Water for All, the members raised the required funds, which was invested in irrigation apparatus and an extra 25,000 litre raised tank for water storage. It was installed in a nearby school as it was a secure and central place.

Irrigation

The role of smallholder irrigation in poverty reduction has not been studied extensively in sub-Saharan Africa. However, extension workers in Kakamega have been guiding the farmers of Ingotse on farming using the small-scale irrigation system. The farmers plant their staple food (mainly maize and beans) during the long rainy season. If there is a shortage of rainfall in the area, the farmers use irrigation.

The farmers were advised to carry out vegetable production all year round using the available water resource from the borehole; surplus produce was to be sold at the local market. This was effective in increasing both household savings and the intake of certain nutrients like vitamins A and C and decreased the incidence of emaciation among adults and older children. More funds were acquired from selling surplus vegetables at the market to buy alternative foods.
More recently, extension workers have been encouraging some farmers in the community to consider adopting drip irrigation systems – using low-pressure drip irrigation kits that require only 1 m of pressure to irrigate plots of up to 4 ha. Research indicates that drip irrigation is highly recommended as a mode of irrigation in sub-Saharan Africa, it delivers water and in some cases fertiliser directly to the roots of plants, thereby improving soil moisture conditions. Some studies have shown that this has resulted in yield gains of up to 100%, water savings of up to 40–80% and associated fertiliser, pesticide and labour savings over conventional irrigation systems.

**The impact of the project on the community**

One of the project team leaders Mr Jotham Shikuku said:

> This project has brought joy to us and the villagers; my wife no longer complains of the constant backaches that used to be the order of the day due to the number of trips she had to make fetching water from the river, she now spends most her time taking care of her kitchen garden where she has planted vegetables for her own household consumption (project team leader).

> I have found a job…I am fully engaged in farming from which I earn a reasonable income...many people believe I am a teacher…I am presentable enough...people refer to me as madam…Thanks to the solar-powered pump…I have gained social status just because of vegetable farming! (a middle-aged mother of four).

This project has improved food security that is categorised into food availability, access and utilisation.

Plate 4. Paul Owino (second from left) explains how the low-pressure drip irrigation system works.
Food availability

Defined as the availability of adequate and stable supply of food, the additional irrigated land dedicated to vegetable production significantly altered local vegetable availability. During the first year of garden operation, the use of the irrigation systems did not displace other agricultural production, as over the long rainy season farmers planted their traditional staples of maize and beans.

With irrigation and trainings in good crop husbandry…Ingotse can feed its people and even serve external markets…see how the farm is green…would you believe this land used to lie fallow? …This is a land of plenty… – a farmer

Food access

Defined as the ability to obtain (physically or economically) appropriate and nutritious food, food access (both via home production and purchase) increased dramatically for the households using irrigation, most of whom were net producers of vegetables. The extra income earned from sales went towards purchase of additional staples and protein during the dry season.

What I get from this farm KES5,000 per week – is much better than what I earn as a government employee…This weekly benefit is better than waiting for a long time. Our lifestyles have changed, no school fee problem and we have adequate food and social status has improved (a civil servant).

Food utilisation

Food utilisation is defined as the ability to consume and benefit from nutritious foods. Through the use of solar-powered irrigation project, there was an increase in vegetable intake in the community. It is hard to directly quantify the health and nutrition status impacts of the irrigation systems, as no specific tests were carried out as part of project impact assessment, previous studies have shown that changes in nutritional intake from vegetable gardens in the developing world can have significant impact on height-for-weight ratios and a variety of biochemical indicators due to their protein, vitamin and mineral contributions to the diet.

Improved nutrition at the household level was yet another success story associated with this intervention. From the sale of vegetables, members have increased purchasing power and were able to buy food and educate their children with ease. As a result, health status, school enrolment and retention were reported to have increased, as depicted below:

Look at us…we are healthy, our children too are eating well…and what we don’t have at home, we buy from the markets…In this village you would see many children and youths idling around instead of being in school… Some would get to drug abuse at a tender age. The situation is changing… I am now able to pay school fees for my children and this has earned me some status in the village. (a mother)
Project sustainability

After the commissioning of the project, the community elected a committee led by a chairman to oversee the daily running of the project. On a monthly basis, each household connected to the water pays a maintenance fee of KES100 (€1). This caters for maintenance and repair of the pipe network. If the solar equipment and the pump are not working properly or in the case of failure, the community calls the Water for All technicians who repair the system at no charge. The contacts (telephone numbers) of Water for All are clearly publicly displayed so that any person can report any problems detected on the system. This has made it possible for the community to call the technicians at any time. The technicians have always responded quickly once they were called upon.

Environmental sustainability

The environmental sustainability of the solar-powered irrigation system depends upon proper adaptation of the design to local conditions. At Ingotse village, the sun shines all year round and hydrogeological surveys of the area have shown availability of sustainable groundwater resources, meaning this project is sustainable. The system is also used as an informational billboard to pass crucial information to the community e.g., on the importance of washing hands. This has reduced the prevalence of opportunistic infections ultimately leading to a healthier and more productive community.

Plate 5. The system publicly displays Water for All telephone numbers that the community can call for repairs.
Economic sustainability

Comparing the two irrigation systems, (the solar-powered irrigation system and the liquid-fuel-powered) based on research earlier carried out by the members of the self-help group, it was found that though the initial installation costs might be higher for solar-powered mechanism, subsequent maintenance and management costs were minimal. Moreover, due to group dynamics trainings given to the community, every household shares in the cost of maintaining the system.

Project scalability

Due to the impressive results of this project on the community, the County Government of Kakamega sent a team of experts to conduct a feasibility study of the project with the intention of up-scaling it. It is expected that once the team completes its findings, the project will be replicated in the 60 wards that form Kakamega County.

The message from this community to others

The Ingotse community is proud of this innovative project. It has seen improved community livelihoods and increased disposable income in the farmers’ pockets. Asked what his message was to other communities around the world, Mr Shikuku said, “no single cent was lost in investing on this project. I would call upon all governments and well-wishers to replicate this technology to the needy communities”. The community welcomes other communities and policymakers to come and learn from them.
Conclusion

Users of the solar-powered irrigation systems fared relatively well: their standard of living increased relative to non-beneficiaries, their consumption of vegetables increased to the recommended daily allowance and the income generated by production of market vegetables enabled them to purchase staples and protein during the dry season. Overall, this story shows that solar-powered irrigation can provide substantial economic, nutritional and environmental benefits to populations in this region. This will be further improved if the members were to invest in the more economical drip irrigation.

Plate 7. The system is also used as a billboard to pass crucial information to the community on hand washing.
References


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