ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 9, Issue 2, pp: (59-65), Month: April - June 2021, Available at: www.researchpublish.com

# Drip irrigation as a smart farming technology: a microstudy of a solar-powered water pump in Lira city, mid-north Uganda

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***Abstract:*** **This microstudy aimed to investigate the adoption of drip irrigation to enhance smart farming technology in Lira city. A descriptive design was employed targeting one farm and data was collected using a transect walk within the site coupled with observations and in-depth personal interviews. All data was qualitative and it was analysed using thematic analysis. The outcomes suggest that the drip irrigation technology and the amount of resources invested have the potential to contribute to smart farming technologies in the city and beyond nonetheless, low adaptation may delay the success of this goal. The outcomes of this study may be used as basis for the city authorities and other neighbouring districts to scale out this technology given that climatic conditions have become very unreliable yet demand for food at both household level and community level is rising. This paper makes a contribution to the growing body of knowledge y highlighting a key prospect for smart farming that can enhance sustainable farming towards food secure households and communities.**

***Keywords:*** **Drip irrigation, technology, smart farming, lira city, water.**

## 1. INTRODUCTION

Worldwide, the largest irrigation potential is reported by India, 139.5 million, followed by China with 70 million hectares and Pakistan with 21 million. While the irrigation potential in Cambodia has never been estimated in terms of physical area, which could be irrigated considering water and land resources, it could be at least 1 million hectares. For those countries without data Bhutan, Brunei Darussalam, Democratic People’s Republic of Korea and Timor-Leste the irrigation potential is estimated as the total area equipped for irrigation, in order to be able to calculate a regional average. The irrigation potential of Southern and Eastern Asia is estimated at, at least, 292.5 million hectares, of which 72% corresponds to India 48% and China 24% (Penati, 2020). The countries in South Asia (including India) account for 58 percent of the total irrigation potential of Southern and Eastern Asia, followed by East Asia (including China) with 25% and Mainland Southeast Asia with 12%, whereas Maritime Southeast Asia represent barely 5%. It is currently estimated that the total water managed area represents 64% of the irrigation potential in the region, ranging from 89% in East Asia, and 84% in Maritime Southeast Asia to 56% in South Asia and 43 percent in Mainland Southeast Asia.

The preceding century has seen unprecedented growth in irrigation projects on a global level. The use of tube well irrigation has decreased the cost of using groundwater, and the subsidization of large reservoirs and canals has been used to achieve food security. Worldwide, irrigated land has increased from 50million hectares in 1900 to 267million hectares today (Gleick, 2000). Much of this increase has been in developing countries. Between 1962 and 1996, the irrigated area in developing countries increased at about 2 percent a year, leading to a near doubling in irrigated land. For example, in 1950 India had an irrigation potential of 22.6million hectares. By 1993-94, this had grown to 86million hectares (Saleth, 1996). Between 1949 and 1998, the amount of land in China under irrigation increased from 16million hectares to 52.3million hectares. This represented a change from 16% to 40% of China’s total farmland (Guangzhi, Yuansheng &

Hansong, 1999). Currently, 75% of all irrigated land is in developing countries. Irrigation has increased the amount of land under cultivation, and the yields on existing cropland. It has also allowed double cropping, and has decreased the uncertainty of water supplied by rainfall.

Despite all of the above benefits, there have also been substantial costs as a result of the construction of water projects and the growth in cropland. These have been costs in the form of capital, environmental degradation, and diminished human health. In many areas there has been the destruction of native habitats, the displacement of indigenous people, soil erosion, a decrease in water quality, and an increase in waterborne diseases, just to name a few of the problems that result either directly or indirectly from the growth in irrigated lands (Wang, Jiang, Wang, Huang & Deng, 2020; Omara & Mwesigwa, 2020)). There is a lot of heterogeneity among land qualities and populations. Not every location is well suited to water development, and the potential benefits of irrigation have not been spread evenly throughout the world. There have been many irrigation projects developed in Asia, which have been mostly successful; for example, Madhya Pradesh in India (SInla, Gilmont, Hope & Dadson, 2019). South America and Africa have had relatively few irrigation projects developed, and the benefits have been minimal.

Irrigated agriculture is the biggest consumer of water resources, accounting for more than 70% of the world's fresh water usage. It plays an important role in global food production, nourishing the urban poor at affordable prices, while providing job opportunities in rural areas (Tiwari & Dinar 2001; Reddy, 2009). Population growth and increased levels of income, however, have caused an increased water demand (Tsur, 2005), making it a more and more scarce resource in many locations throughout the world. With the decline of water availability becoming more evident, it is imperative to allocate and use this essential resource as efficiently as possible. In many arid regions of the world past water resource policies in many countries have fostered the development of irrigation capacities, while attempting to guarantee the supply of water to the residential users (Aishan et al. 2013). Water resource development was based on constant supply augmentation. As this was in many cases associated with high financial and environmental cost, the focal point has shifted towards demand driven water management. Winpenny (1994) described this new viewpoint aptly as ''doing better with what we have'', in opposition to the theorem of steady supply increases.

Sprinkle irrigation is used on approximately five percent of irrigated land throughout the world, the majority of which is in developed countries. It is unlikely to replace the large areas under surface irrigation, (essentially the remaining 95 percent, except for a small amount of trickle). Sprinkle irrigation has a distinct advantage, because good water management practices are built into the technology (Belete & Melak, 2020). Sprinkle irrigation technology can provide the flexibility and simplicity required for successful operation, independent of the variable soil and topographic conditions. Pumps, pipes and on farm equipment can all be carefully selected to produce uniform irrigation at a controlled water application rate and, provided simple operating procedures are followed, the irrigation management skills required of the operator are minimal. This puts the responsibility for successful irrigation in the hands of the designer rather than leaving it entirely to the farmer. Sprinkle can be much simpler to operate and requires fewer water management skills. However, it requires sophisticated design skills and on-farm support in terms of maintenance and the supply of spare parts.

Sprinkle is potentially less wasteful of water and uses less labour than surface irrigation. The technology can be adapted more easily to sandy soils subject to erosion on undulating ground, which may be costly to regrade for surface methods. There are many types of sprinkle systems available to suit a wide variety of operating conditions (Kibaroglo, 2020). The most common for smallholders is a system using portable pipes (aluminium or plastic) supplying small rotary impact sprinklers. Because of the portability of sprinkle systems, they are ideal for supplementary as well as total irrigation. At the forefront of sprinkle developments is the centre pivot machine, which can irrigate up to l00 hectares at a time. These machines are very adaptable.

In the United Kingdom, for example, they have been used on small and irregular shaped fields crossing field boundaries to irrigate several fields growing different crops at the same time. One machine was used to irrigate several farms where the farmers decided to cooperate. Here the farmers' role in irrigating large areas having multiple ownership and minimal inputs should not be underestimated. Libya is a well-known example of their use for irrigating large desert areas. As far as the farmers under the pivots were concerned it rained once a week as the pivot rotated. From a management point of view, sprinkle irrigation provided a relatively simple system to operate and allowed farmers to do the farming. Although the skills needed to operate these machines and to maintain them must not be underestimated, they are no more than those required to keep motorcars running. In most developing countries technicians do this very successfully in the private sectors. This is not so much to advocate the widespread use of centre pivot machines for smallholders but to point out that technology can be very adaptable and can be used in innovative ways when the conditions are right (Cornish, 1998)

Little has been reported on the use of trickle irrigation in sub-Saharan Africa. There is, however, a growing experience of its use in other developing countries. In India, trickle irrigation has been introduced for high value crops (vegetables, flowers, spices) in some of the more arid parts of the country where water is scarce. In 1993 it was reported that over 50,000 hectares were being irrigated by trickle irrigation, this has now risen to over 225,000 hectares (Singh et al, 1993). This substantial increase in the use of trickle methods is not so much a result of market demand but the low-cost of the systems (affordability), which are heavily subsidized by the Indian Government. Over the past ten years more than 100 companies have been set up to produce trickle equipment. Claims of water savings as high as 30-60 percent and yield increase from 20-40 percent have been made. Success was, however, masked by heavy subsidies. Even with subsidies the systems were too expensive for smallest farmers. According to Polak and Sivanappan (1998), trickle systems were thought to be too complicated to operate and maintain and not easily divisible to fit small plots.

In Africa, irrigation is the widest form of water management. According to a FAO report, the practice covers 6% of the total cultivated area which is low when compared to 38% in Asia, 27% in Caribbean and 12% in Latin America (FAO, 2005). In Africa, 80% of the most practiced irrigation technique in either full or partial control schemes is surface irrigation (Enyew, ewabe & Tsige, 2020). However, more than one million hectares of sprinkler irrigation have been reported, most of it being concentrated in Botswana, Libya, Egypt, Morocco, Tunisia, Zimbabwe, South Africa, Ethiopia and to a lesser degree in Kenya and Zambia. In relative terms, sprinkler irrigation system represents the most widely used technique in Botswana, Zimbabwe and South Africa, benefit that comes from a relatively long tradition in this field (FAO, 2005). Micro-irrigation is concentrated in Egypt and South Africa. In the African continent, about 85% of water withdrawals are directed towards agriculture but this figure varies considerably from one region to another (Suresh, Aditya, Jha & Pal, 2019). The irrigation systems in South Africa and Kenya, have constraints that rural farmers face and the role of government and nongovernmental organization in the uptake of modern technologies in irrigation.

Irrigation has long been seen as an option for improving rural livelihoods by increasing crop production, but massive investments throughout the 1970s and 1980s in sub-Saharan Africa have not borne fruit. Food production targets were not met, development costs were extremely high in relation to returns and there were many technical and management problems that remain unsolved (Elsokkary & Aboukila, 2020). The decrease in real terms of world cereal prices over the past decade has made it difficult to invest in and maintain irrigated agriculture for basic grain crops. Much of this criticism was directed at the more formally structured irrigation schemes usually under the control of a government body. Because of this, attention turned in the 1980s to the informal sector, small scale or smallholder irrigation, which is described as the 'bottom-up' or 'grass-roots' approach to development. There are many smallholder success stories, particularly where farmers have made the investments in irrigation by themselves (Mulugeta, 2019). However, all has not gone smoothly where donors have tried to stimulate development. Donors, funding agencies and national governments, wishing to accelerate the development process, still tend to use a 'top down' approach where only lip service is paid to farmer participation. The pace is forced to meet investment targets and market forces have been ignored (Melvyn, 2001).

Large-scale irrigation started in Uganda by the 1970s. However, long periods of political crisis and violence following independence led such schemes to be left aside mainly until early 2000s. In post-conflict northern Uganda, the irrigation schemes of the Olweny Swamps (Lango Sub- region) and at the foot of the Agoro Hills (Acholi Sub- region) reflect strong strategic issues: developing marginalized areas, capturing votes in reluctant regions, promoting irrigation as a stepping stone towards wealth creation and adapting climate change, etc., (Gay & Torretti, 2015). Irrigation was developed by the Ugandan Government for use especially by indigenous people, since large-scale irrigation schemes were a significant policy among African states in the 1970s. At the time, they were at the heart of the "Green Revolution" that held a major position among the new "development" policies. This paradigm emerged after World War II, dividing the world into "developed" and "developing countries". It was then focusing upon economic growth resulting from the use of fossil-fuel-based technology allowing industrialization of the society including the agricultural sector, a process defined as "modernization" (Rist, 2014).

In mid-north Uganda irrigation scheme was developed based on availability of water. The valley of the Agoro Hills has a long history of irrigation since pre-colonial times (Watson, 1952). The Okura river flow and its tributaries allowed migrating groups to settle as indigenous irrigation systems emerged. In this part of Acholi where droughts occurred frequently and rainfall patterns are lower and less reliable, irrigated crops became an essential security belt for the valley inhabitants. Thus, several irrigation systems were encountered alongside 10 km from the tributaries up the hills toward the plain slopes, before the Okura River turns into a swamp. Land under irrigation is called *joro,* meaning a "soil near a river" or an "inside land", as opposed to the *woko* – the "outside land". The several *joro* are characterized by alluvial and fertile soils put under cultivation every dry season. Land fragmentation is high, as plots are largely under households' control, divided and benefiting patrilineal transmission. On the contrary, the *woko* land is used for shifting and extensive practices as usually encountered in the region, and as such held by lineages which allocate rights to cultivate for their households.

Smart farming, through Irrigation technology in Lira District, remains very poor due to lack of knowledge on modern farming. Smart farming (irrigation) in Lira and Northern Uganda are based on traditional irrigation of fetching water with watering cans to sprinkle on crops, divert water from tributaries to the gardens, use of local pump to distribute water. Irrigation, as a smart farming strategy, requires one of the mechanisms to improving food supply to household and the general community especially vegetables, cabbages, carrots, tomatoes, and water Mellon.

The technology used in pumping water on the farm land to boost crop growth and productivity is key to enhancing smart farming in the sub-region and the country as a whole. Irrigation technology is important because it can help a number of stakeholders to assess the existing gaps in the technology, the strength and weaknesses of the irrigation technology to the group members, educate local farmers on the benefit of smart farming to household food security and as a result of the drip irrigation. Indeed, using irrigation technologies allows the soil to remain moist as well as growing crops all year round as if there was natural rain falling every day on the farm something which enhances crop yields and boosts household food security. This study covered three key aspects, namely; the technology used, resources invested, and its contribution to smart farming.

***The technology used***

During the interview with the workers and management, the researcher was able to ask related questions to technologies used by the farmers to distribute water to the farm land. The technologies used were both traditional and modern technologies. Drip irrigation was used where simple irrigation pipes were connected and distributed in the farm to transfer water to the crops. While other farmers were found to be using local pump to spread water in to the garden and hand fetching of water by watering cans.

***Resources invested***

There were not enough resources to manage smart farming especially; labour force, capital to purchase the irrigation tools and equipment. For smart farming to contribute positively toward household food security, farmer's groups and government should embrace on expanding distribution pipes for spreading water in to the farm land. Land fragmentation has affected the development of the project. During the visit, the researcher was able to identify the problem.

**The contribution of irrigation to smart farming technology**

Smart agriculture aims to reduce the heavy workload of the farm workers, hence improving their quality of life. Smart farming deems it necessary to address the issues of population growth, reduces heavy workload, climate change, improved nutrition to the local population, income to the group members, and for study purposes. Smart farming has got the positive aspect to maintain the condensation of the loam soil, provides mineral as well as other nutrition by the assimilation from the pattern, the most feasible ways to grow vegetables like; cabbages, tomatoes, 'Nakatti', onions, and egg plants.

## 2. METHODOLOGY

Upon visitation of the site, a transect walk within the site was taken coupled with observations and in-depth personal interviews. The interview was structured conversation. In other words, interview refers to a one-on-one conversation between an interviewer and an interviewee. An interview may also transfer information in both directions. Open-ended questions with key administrative officers and face to face interviews were used in order to get reliable information for the study. Interest was focused on the level of technology used in distributing and spreading water in the garden and the quality of crop production in the site. This method helped the researcher to get clarified and reliable data. The researcher interviewed 06 respondents in total. Observation refers to a way of collecting data through observing with your eyes what

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International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
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is happening on ground or the phenomenon that is taking place in the field at that particular moment in time. The researchers observed the type of technology used in the farm, the quality of farm products, the nature of the soil and its fertility, culture, and the level of participation by the farmers. The researchers could not ask certain questions which would heart the respondents directly but was able to observe many things such as challenges faced by support staff, behaviours, the relationship among workers and physical development in the site.

## OUTCOMES OF THE STUDY

The outcomes of this study are organised within the framework of the scope as outlined.

### Technologies used on the drip irrigation station

During the visitation the researcher interacted with the farm manager and he managed to describe the processes used to connect the solar panel. The farm manager therefore said that the solar panel was installed with the help of Lira district local government under Northern Uganda Social Action Fund (NUSAF 3) in 2017. NUSAF drilled borehole which is pumped using solar and connected with the underground pipes which takes water to the tank and supply it to the irrigation pipes in the farmland to irrigate the land. The solar technology made it very easy for the farmers to effectively and efficiently pump water to the vegetable farmland. The outcome was witnessed from reduce work load by the group members in manual work and faster efficient supply of water to the farmland. In situation where solar was not in use the group members could water manually to the garden by using watering cans and waiting for rainy season to plant crops. Solar being the source of power remain one of the cheapest and most affordable energy source as does not require monthly subscription or payment of bills but it rely on the sun light. This technology does not require much skills and it is a one-time cost after purchasing a complete solar kits. It has been installed in the same port by use of switch. This technology has made the group members motivated and farmers around the place are trying to copy the idea of installing solar as for practicing irrigation smart farming, and for their home use as well because it’s cheaper compared to using electricity for irrigation.

A key outcome of the drip irrigation technology is based on the quality of products such as vegetables that is; the cabbages, Nakatti, tomatoes, onions and eggplants were very healthy as if they were planted during rainy seasons due to consistence flow of water in the garden they produce and availability of market. With this kind of modern farming being practiced, the group members are able to get ready market for the products with good prices.

### Resources used on the drip irrigation site

As a result of mart farming being practice, the outcome is being realized from little capital the group members invested in farming. The group members are earning good money from small piece of land which could have not been possible for other farmers not practicing smart farming and waiting for seasonal rainfall to cultivate crops.

### Challenges hindering drip irrigation in the study area

A number of challenges are faced on the farm, key amongst these are:

a) Theft of solar panels and pipes by the exanimates of Erute prisons and other thieves from out of the area since security is not so tied in the farm and the members do not care so much because it’s a group project. This has led to losses by the farm and the group as well.

b) Inadequate pipes which cannot supply the entire farmland and this has been brought about by some of the pipes being stolen by thieves and others got broken since they were worn out this has also brought losses to the project since the entire farm was not planted with crops.

c) Little water storage facility which is as a result of the small tank supplying water in to the irrigation farmland because the farm is big and needs a bigger tank to accomplish the tasks. This has also brought about half of the farm not being irrigated

d) Poor connection is seen in the pipes supplying water, where all the pipes were not connected with water this has led to limited supply of water in the farm land which has affected the growth of crops in the farm.

e) Weak Security which has promoted theft of the irrigation pipes by thieves and some malicious people in the area. There was actually no proper security and there was no one to volunteer to be a watchman to look after the farm since it’s a group project nobody cared for it.

f) Conflict among group members was witnessed by lack of participation in project activities by some group member. This as a result has led to poor yields of crops and little cultivation of farm land.

g) Stray animals*:* There was a problem of stray animals like cows, goats and pigs which move to dry seasons and this is accompanied by the bad culture of the people from Lango sub-region who damage crops in the farm land since there is no security to watch over the farm especially during leave their cows and to move anyhow looking for pastures to feed on.

h) Pest and diseases which affected the growth and quality of cabbages, tomatoes and could not be sprayed because they were waiting for money from the government to buy the pesticides for them since it was a government project for the group.

i) Inadequate tools especially hands hoes for planting and weeding of crops. This was witnessed by some plot of lands being left without weeding and cultivation and the group members expected the government to supply the hand hoes for them since they brought the project to them.

## 3. CONCLUSION

In conclusion therefore, irrigation in Lira city and Uganda generally is still remain low due to lack of support from both public and private institutions. The challenges of realizing food security are still far from reality. However mid-north Uganda receives little rainfall which requires adaptation of smart farming as a way to boost crops cultivation and supply food in households as well as in the market. The irrigation sector has focused on large scale canal projects that deliver large quantities of water, large groundwater projects and high pressurized sprinkler and drip systems that are too expensive for small holder farmers. But with sensitization of the local farmers and the group members, there can be some positive change to embrace it and develop interest in the irrigation practice. They were very negative about everything because the government just imposed the project on them and they were not made to participate in decision making when they were bringing for them the project.

## 4. RECOMMENDATIONS

a) It is recommended that the group members should come into agreement among themselves and reduce conflicts this way they can realize better yields from their harvest as the saying goes as "united we stand and divided we fall".

b) Group members should put some money aside in the pool for the reserve so that they can use it for maintenance of the farm like for buying farm equipment like hand hoes, replace stolen pipes and the warn out ones other than relying on government.

c) Group members should hire the services of a watchman using money from the reserves so as to watch over the farm and check things like stray animals which damage the crops and thieves who steal the irrigation pipes and the solar panel.

d) There is need to spray the crops with pesticide since they are being affected by pests and diseases which may lead to poor yields other than leaving it naturally this may save the yields from totally being destroyed.

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