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Effectiveness of drip irrigation in enhancing smart farming: a micro-study in Oyam district, mid-north Uganda

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Abstract: **This study aims to examine the effectiveness of drip irrigation in enhancing smart farming in the mid-north of Uganda. A descriptive review was adopted targeting one smart farm in the district. Data was gathered by means of an interview guide and a farmers' observation guide, and it was analysed using content analysis correspondingly. The outcomes suggest that drip irrigation does not represent a large fraction of irrigation systems in mid-north Uganda and the world in general; however, a number of new drip irrigation systems are being set-up notwithstanding the very slow pace. Further revelation suggests that farmers can benefit from drip irrigation through gaining knowledge and skills from visits and advises from the frequent visits; being a source of income when the produce are sold; as well as providing food security for families, the adjacent community and the district as a whole. Nonetheless, drip irrigation faces challenges of dearth of commitment by some members of the family, untimely delivery of agro inputs, over cultivation of the land and very expensive inputs. It is obvious that drip irrigation technologies are essential in enhancing smart farming in Oyam district, mid-north Uganda and the country as a whole. The outcomes of the study can be useful as a source for scaling out drip irrigation in the region and beyond especially when mounting a parameter on integration of drip irrigation on community development agendas for small-holder farmers as targeted by the government's agricultural cluster development programme. This article contributes to the budding body of information on smart farming by emphasising obtainable prospects, which can generate more pro-active small scale drip irrigation technologies.**

Keywords: **Drip irrigation, smart farming, farmer, community development, Oyam.**

1. INTRODUCTION

Inadequate Water supplies and low productivity leading to food insecurity are the biggest global threats, especially in the under developed nations. The United Nations Food and Agricultural Organization (2003) indicates that 798 million people in developing countries are malnourished, of which 198 million live in Sub-Saharan Africa. The United Nations Sustainable Development Goals number 1 and 2 is aiming at eradication of extreme poverty and hunger, yet there are 1.2 billion people surviving on less than US$1 per day and in sub-Saharan Africa, half the population lives in poverty (Clover et al, 2003). The United Nations Environment Program (UNEP) noted that above one-third of the world's population lives in countries where there is lack of water to meet a sufficient food. The food production depends majorly on water availability that is why the Ministry of Water and Environment is putting much emphasis on the construction of Valley Dams under 'Water for Production' department and Irrigation Schemes and crops cannot reach their maximum yield potential if they do not get sufficient water.

Worldwide, agriculture accounts for more than 70 % of fresh water drawn from lakes, rivers and underground sources (Diop, 2002). A number of of that water is used for irrigation, but although only 17 % of global cropland is irrigated, that part produces 40 % of the world's food (Bruinsma, 2003). Postel (1999) noted that water productivity needs to be doubled. To handle the global threats of food insecurity, there is need to make irrigation more effective, substituting knowledge and better management of water. It will involve innovating technologies that enable farmers to get more crops per drop, and it will require fixing the flaw of the modern irrigation age: the failure to provide technologies and methods that allow the smallest and poorest farmers to share in the benefits of improved irrigation.

Irrigation has been credited with the rise and flourishing of civilizations such as those in ancient Mesopotamia, Sumeria and Babylon. Developed economies now exist in some regions of the world solely because of irrigation (Sijali, 2001). Over the last century the area of land under irrigation has increased more than six fold, from approximately 40 million hectares in 1900 to more than 270 million hectares in 1999 (UNEP, 1999). Worldwide, 20% of the total land cultivated receives irrigation water to produce about 40% of the world's total food (FAO, 2015a). Sub-Saharan Africa (SSA) has with its 4%, the lowest %age of irrigated land to the total area cultivated globally (Burney et al., 2013), yet Sub-Saharan Africa has the highest record of food deficit. The irrigation sector has largely been focused on large-scale canal or ground water projects or high-quality pressurized sprinkler and drip systems that are too expensive for small-scale farmers (Postel et al, 2001).

The emerging threat to sustainability of agriculture globally requires a paradigm shift in the way irrigation is practiced; the rapid increase of the world population and the corresponding demand for extra water by water users forces the agricultural sector to use its irrigation water more efficiently (Andarzian et al., 2011).This entails adoption of irrigation water management strategy that can facilitate the achievement of the goal of producing more crops per drop of water, which is the use of drip irrigation system and adoption of deficit irrigation scheduling among others (Molden et al., 2003; Kendall, 2011; Igbadun et al., 2012).

Drip irrigation is a water saving technology that delivers water through small holes or emitters in plastic tubes installed on or below the soil surface ala number of directly to the roots of plants. The “plastic revolution” after World War II paved the way for drip irrigation. It made it possible to mass-produce plastic pipes easily and cheaply, and this sped up the use of drip irrigation systems. By the end of the 1960’s, farmers in six countries – Australia, Israel, Mexico, New Zeeland, South Africa and the United States – were using drip irrigation (Sijali, 2001). While only a small portion of worldwide cropland was irrigated by drip systems, at this time, the technology spread fast. According to Postel et al. (2001), this rapid expansion was attributable to the higher crop yields and water use efficiencies gained by drip irrigation. Drip systems have often been associated with capital-intensive commercial farms. The biggest challenge to the expansion to small-scale farmers has been very expensive. The cost of a number of commercially available drip systems is due to components that are optimized for fields of four hectares or larger and designed to minimize labour and management costs. By contrast, early drip systems were simple, but these designs were abandoned because they did not fit the needs of large-scale farmers in developed countries. They are, however, well suited for drip irrigation for small plots.

In sub-Saharan Africa there are a number of constraints on the spread of low cost drip irrigation, such as lack of basic infrastructure, the absence of developed markets, lack of knowledge and poor attitude towards adaptation of new things among the communities in developing countries. With its strong infrastructure and new water policy reforms focused on the poor, South Africa is a logical place to demonstrate the potential of low-cost drip irrigation in the region (Postel et al., 2001). The recent implementation of drip systems in the region has met a deficiency in knowledge of farmers’ preferences concerning such irrigation technologies.

Uganda has a population of approximately 40 million people, with an average annual growth rate of 3%. Correspondingly, pressures on Earth’s finite natural resources, of which arable land is one, are rising in tandem with the growing human population. There are a number of irrigation schemes like Doho in Butaleja, Ngenge in Kwen, Mubuku in Kasese, Wadalai in Pakwach and Tochi in Oyam Districts were started for increasing the agricultural productivity. “It was established as a way of introducing irrigated agriculture so that when the youths left the scheme, they would return home and demonstrate the technology as a mechanism to promote irrigated agriculture,” explains Okasai Opolot, Director, and Crop Resources in the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). Mubuku and Doho are off-springs of the Olweny irrigation scheme in northern Uganda, which was a farmer-led initiative but was not well planned. But over time, and through the political turmoil in the following decades, the schemes collapsed. Specifically, Mubuku Irrigation Scheme taps its water from River Mubuku, which is channeled into the 150 eight-acre farms, which have been parceled out to different farmers. The flood irrigation system is used here; it depends on the natural flow, where the water is directed into farms using the farrows found across the land for the water to have an easy flow into the farms. The Nakasongola region which lies in the cattle corridor has been hit by food shortages after much of the area's harvests failed due to drought in the middle of 2015. The district has had high deforestation rates, with livestock keeping as the main livelihood activity. New evidence from different parts of the world suggests that, with affordable drip systems, small farmers can make the transition from subsistence production to higher value production for the market, thereby doubling their income and greatly enhancing household food security (Postel et al., 2001).

Recent studies have revealed the significance of smart farming from a global scale to a local scale. A number of these studies suggest that smart farming is the way to go seeing the number of dynamics in demographic structure, climate change as well as enormous demand for both household and community-level food. A study by Anena and Mwesigwa (2021) reveals the significance of smart farming but demonstrates that uptake of irrigation technologies is still very low. This low coverage is ascribed to dearth of knowledge on modern farming. In their study, Ogwal and Mwesigwa (2021) reveal how smart farming has faced a number of hurdles built on the pretext that it is not possible to implement yet a few individuals and companies that have experimented with it, are not regretting at all. Moreover, Opio and Mwesigwa (2021) believe that embracing drip irrigation has a deeper potential to accelerate smart farming in the region of northern Uganda and the nation in general. The above studies were all conducted in mid-north Uganda; an issue that attests to the fact that smart farming technologies are very essential in the current and future agricultural development strategies.

Justification of study

The scientific advances in genetics, chemistry and robotics have contributed greatly to the evolution of agricultural technology, agricultural products have to be increased largely due to the rapid increase of the world population. According to (Sylvester et al., 2018), Agricultural products have to be increased by 70% by 2050, when the world population is expected to reach 9 billion people. At the same time, the agricultural sector has to address serious challenges like the issues of climate change, the limited availability of arable lands, as well as the growing need for fresh water. The sustainability of irrigation farming in developing countries is seriously at stake. Countrywide, regional and seasonal water scarcity in developing countries poses serious problems for national governments and the international development community. The challenges of inadequate water are escalated by the increasing costs of new water, wasteful use of already developed water supplies, degradation of soils in irrigated areas, depletion of ground water, pollution of water and its impact on human health, and the massive subsidies and distorted incentives which govern water use.

Apart from these problems, it is clear that the rapid development in irrigated agriculture in developing countries during the past three decades has been achieved with remarkably change in organizational frameworks, irrigation technologies and the institutional setting of agriculture. The economic background of a number of progressive nations teaches us that agricultural wealth contributes considerably to boosting economic development. A number of leading industrialized nations were once principally agricultural. Today, we see that the developed countries still dominate the sector and agriculture largely contributes to the income of the land. The agricultural sector plays a central role in Uganda’s economy, generating some 24% of the Gross Domestic Product (GDP) and accounting for more than half of the country’s export earnings 54%; (World Bank, 2019). Ala number of 70% of the working population is engaged in agriculture which also provides the first job for three-quarters of those aged between 15 and 24 years (Lamb & Brown, 2011). 78% of the Ugandan population live in “rural” areas where farming is the predominant economic activity (UBOS, 2016).

Another importance of farming is its ability to enhance the source of raw materials for the industries that depend on agricultural produce, particularly in developing nations. If farm products are in low supply, it will affect manufacturing and therefore, an increase in prices. Millers, sugar factories, the milk producer, wineries and textile mills among others are dependent on produce from agriculture. At the same time, agro-processing (Mulla, 2013), is the backbone of the manufacturing sector accounting for approximately 60% of its total output. In Uganda, the rural economy relies on farming and related activities. The increasing agricultural surplus due to the growing agrarian output improves social well-being, especially in rural areas. The standard of life of the rural population rises, and they begin eating a nutritious diet consisting of farm produce such as milk, eggs, ghee, vegetables, and fruits. They may get a better lifestyle selling their product and can afford things that they could not have before.

2. METHODOLOGY

Both interview and observation methods of data collection were used. This method of collecting data involves presentation of oral-verbal stimuli and reply in terms of oral-verbal responses and it can be used through personal interviews and, if possible, through telephone interviews (Kothari, 2004). The interview guide involved direct or face-to-face interaction between the respondents and the researcher. The interviews were designed in both structured and unstructured form. The unstructured form ensured that responses were according to actual knowledge on the topic under study, and structured interviews kept the respondents on truck. The advantage of interviews is that it can be used by all categories of respondents and gives room for probing where necessary. Also, observation as a qualitative research technique where researchers observe participants' ongoing behaviour in a natural situation, was employed. Depending on the type of observation research and the goal of the study, the researcher will have varying levels of participation in the study. Sometimes the researcher will insert themselves into the environment, and other times, the researcher will not intervene in the setting and observe from a distance or in a laboratory setting. Ideally, the purpose of this type of research was to gather more reliable insights. In other words, researchers can capture data on what participants do as opposed to what they say they do. Using observational data is best when one of the following situations apply: one needs to gather sensitive information, and if one does not trust secondary sources, at least the participants are often honest with their self-reporting, one needs to understand the how or what of a research question, the topic is new, and you need robust data to explain consumer behaviour, when behaviour in a natural setting is vital to your research question, when behaviour in a controlled setting is critical to your research question, if you are concerned that self-reported data about behaviours will differ from actual actions, even if it's unintentional, and when you need more information about a specific research question to formulate a more complete and accurate survey.

3. OUTCOMES AND DISCUSSION

Drip irrigation does not represent a large fraction of irrigation systems in mid-north Uganda and the world in general; however, a number of new irrigation systems are drip systems. Thus, a number of irrigation companies focus on drip irrigation system design. One of the most popular applications of drip irrigation is the irrigation of vineyards, where the drip tube is hung from the trellis. With relatively thin polyethylene laterals and small orifices, drip systems are more fragile than sprinkler, bubbler, or flood systems; thus, drip irrigation systems require a high level of management expertise.

The researchers visited a small scale Drip irrigation participant which is found in Barcal "A" Village, Wirao Parish Aber sub-county, Oyam District. The participant started the smart farming in 2019 through her personal initiative after visiting a participant who was engaged in Drip Irrigation and that participant was producing vegetables throughout the year which inspired her so much. She has not yet received any support from the government. It has an area of 8 acres of land which is customarily owned, and divided into one acre for seed Nursery, one acre for growing vegetables throughout the year, three acres for banana plantation, one acre for fish farming- two fish ponds, stocked (aquaculture) and 2acres for the mother garden for clown coffee-first of its kind in Lango sub region. It was revealed that the source of water for the drip irrigation is a drilled deep borehole with installed submersible pump, connected to the national grid which pumps the water into 10,000 litre plastic tank installed at the Centre of the garden. The crops that receive water are; Egg plants, assorted vegetables, onions, Banana, Coffee, tomatoes, and assorted tree seedlings. The Fish ponds also benefits from the source of the water where the water is pumped into the Ponds on a monthly basis.

Further revelation indicated that the participant has benefited from drip irrigation through gaining knowledge and skills from visits and advises from the frequent visits, being a source of income when the produce are sold; as well as providing food security for families, the adjacent community and the district as a whole. Here, the specific components of the technology that were covered were the source of the water, mixed farming or integrated agriculture and type of irrigation. The source of the water is the drilled deep well with an installed submersible pump. The pump is connected to the grid through the main house where the switch is installed, when the water is needed, it's just pumped into the plastic tank of 10,000 litres which is in the centre of the garden. This water helps in the integration of the agriculture or the farm. The farm has fish farming, Nursery bed, Coffee's mother garden, banana plantation and vegetable gardening. The farm has Drip Irrigation which comes from the borehole through the pressure pipes to the tank then to the garden. The type of irrigation is a simple drip irrigation. Drip (or micro) irrigation, also known as trickle irrigation, functions as its name suggests. In this system water falls drop by drop just at the position of roots. Water is delivered at or near the root zone of plants, drop by drop. This method can become a water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized. The field water efficiency of drip irrigation is typically in the range of 80 to 90 % when managed correctly.

While the participant has benefited from the drip irrigation, she has encountered a number of challenges which need to be addressed and the challenges included pest and diseases which affect their production, lack of commitment by some members of the family more especially the husband who has very limited time for the project, untimely delivery of agro inputs, over cultivation of the land and very costly inputs. These challenges can be overcome by sensitization of the family members about benefits of the smart farming like high yields, use of fertilizers and pesticides, government should also provide agro in puts at the right time, when subsidized. In modern agriculture, drip irrigation is often combined with plastic match, further reducing evaporation, and is also the means of delivery of fertilizer. The process is known as fertigation. Deep percolation, where water moves below the root zone, can occur if a drip system is operated for too long or if the delivery rate is too high. Drip irrigation methods range from very high-tech and computerized to low-tech and labour-intensive. Lower water pressures are usually needed than for a number of other types of systems, with the exception of low energy centre pivot systems and surface irrigation systems, and the system can be designed for uniformity throughout a field or for precise water delivery to individual plants in a landscape containing a mix of plant species. Although it is difficult to regulate pressure on steep slopes, pressure compensating emitters are available, so the field does not have to be level.

From the outcomes of this study, it is clear that drip irrigation technologies are essential in enhancing smart farming in Oyam district, mid-north Uganda and the country as a whole. No wonder, related studies have demonstrated this notion, for example, in their study, Anena and Mwesigwa (2021) attest the significance of smart farming through adoption of irrigation technologies is still very low. This low coverage is ascribed to dearth of knowledge on modern farming. This study was conducted in the region of the current study and so collaborating with the outcomes of this study. In addition, Opio and Mwesigwa (2021) have demonstrated how embracing drip irrigation has a profound potential to hasten smart farming in the region of northern Uganda. That is why those that have adopted drip irrigation technologies testify a wide range of benefits in terms of increased production and greater annual profits.

4. CONCLUSION

Irrigation is one of the ways to improve standards of living for farmers, which rely on technical ways of supplying water to the plant or crop. The water-energy-food nexus is now guiding brand new approaches to make irrigation a sustainable practice from various viewpoints. A number of importantly is the capacity of ensuring sufficient and healthy food supply for an ever-growing world population, i.e., food security and safety. Water for production through Irrigation is a basic commodity but it is not to forget that, without soils in good productive conditions, agriculture would not produce even if there is enough water to grow plants for food production. Hence, the knowledge, skills and attitude change towards the usage of Drip Irrigation for all the farmers must always be emphasized.

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