Effectiveness of Using Digital Technologies and Digital Labour in Farm Management towards Shaping Precision Farming to Achieve Food Security: A Malawian Perspective

Eddons Munthali[1], Kondwani Munthali[2], Chomora Mikeka[3] & Gregory Kunyenje[4]

[1]Lilongwe University of Agriculture and Natural Resources, Bunda College, Lilongwe, Malawi.
[2,3]University of Malawi, Chancellor College, Zomba, Malawi.
[4]Catholic University, Chiradzulu, Malawi.

ABSTRACT

The use of Information and Communication Technology and digital technologies in farm management plays a vital role in achieving strategic development goals of countries. Digital labour has helped enormously to boost access to large amounts of information, connecting people from remote communities, particularly young people whose innovative potential combined with the power of technology proves to be a force to achieve sustainable development goals. This research aims at determining the effectiveness of digital technology in agriculture through providing site-specific information and employing digital labour to implement precision farming in Malawi. The research objective focused on using rapid 4-in-1 soil tester, testing moisture, acidity, or alkalinity through power of Hydrogen (pH) measure, temperature, and fertility as well as Extension Helper Application, a portal used by extension coordinators to share farm information. The is desk research with qualitative study and slight quantitative figures from digital 4-in-1 rapid soil tester with students utilising study farm plots at Natural Resources College. Analysis derived valuable capabilities such as quick determination of farm specific information. Research found that with digital tools and digital labour, it was easy to see and manage field data, oversee worker productivity, manage resources, view farmer data trends and support decision making. Further, mobile digital tools were found to amplify extension massaging to reach more farmers and enable management to improve coordination of diverse service providers with the right type of data aggregation. Digital tools reduced the use of had written reports during field visits. Quality of collected data improved and frequency of field visits for the extension coordinator as well increased. This research was mainly drawn from action research as well as systematic review of both internal and external desk research. Action research and internal review was based on student plots at Malawi's Natural Resources college and external desk review was based on SANE project with Extension Helper Application. Generally, the findings showed that the use of information and communication technology and digital technology with digital labour support decision making to form policies towards realising Malawi vision 2063.

Keywords: Information and Communication Technologies, Digital technologies, Extension helper application, Rapid 4-in-1 digital soil tester.

Introduction

The use of Information and Communication Technology and digital technologies in farm management plays a vital role in achieving strategic development goals of countries. In Sub-Saharan African economies including Malawi, the principal source of national income continues to be agriculture (Kaczan, 2013). Agriculture is one of the strategic development goals in Africa providing 60 percent of sub-Saharan Africa employment and food security (Ehui, 2018). For Malawi, the economy is predominantly agricultural and the sector is being prioritised for increased productivity and commercialisation (NPC, 2020).

As the world population grows, there is increased pressure on farmers to grow more food (Sridevy & Vijendran, 2015). The population in Malawi is expected to grow to 26 million by 2030 and 42 million by 2050 reaching 47 million people by 2063 (NPC, 2020). 80 percent of this population do not only live in rural areas but also depend on traditional and crude agricultural farming practices.

Thus agricultural production and productivity in Malawi has remained below the country's potential and is insufficient to match people's increasing demand (Kalghatgi & Sambrekar, 2016). That notwithstanding, the agricultural sector in Malawi is also faced with several other problems that include high environmental degradation, low adoption of climate smart agricultural technologies, low access to land and farm input, and poor

land management practices (NPC, 2020). It is thus imperative that Malawi develops and implements strategies to modernise the agricultural sector.

Farm digital technologies can be described as the use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production (*Digital Agriculture: Feeding the Future*, 2017). They provide quantitative data that have been difficult to measure and interpret through the years thereby improving farming economic models (Food and Agriculture Organization of the United Nations, 2017). The resulting combined data is analysed and interpreted so the farmer can make informed and appropriate decisions on the farming strategies to increase food production and keep up with the growing population. As explained by (FAO, 2017) intensive use of modern ICT helps to increase the performance of agricultural extension. Examples of new digital agro-advisory services include SMS-based market information services and facilitation of farmer-to-farmer knowledge sharing with available mobile applications providing market location and price information, farming equipment connections, soil maps, weather predictions and the like. Front line workers are helped with such kind of approach, proving the fact that Information and Communication Technologies (ICTs) possess vital role to agricultural extension planning.

Digital Labour

Historically, work has been bound to geographic location where workers were place-based such that when a worker knocks off the labour power goes home as well (Graham et al., 2017a). The Internet has changed much of this in that workers and user of end products of work can be at different locations but still get maximum benefit. Technology has supported changes that have transformed lives. The innovative potential of young people used in farms, combined with the power of technology proves to be a powerful force towards achieving the sustainable development goals (UN, 2019).

Digital labour is thus understood to mean online activity producing value such as producing content for social media platforms (Paakkari et al., 2019). Digital labour has become a permanent part of daily life where it has been intertwined with several facets of human living. For instance, in agriculture web-based application, using cloud computing, have been established where agricultural extension coordinators can be sharing farming information and experience in dealing with interventions to a problem.

Digital labour, as an information and communication technology for development (ICT4D) can be a catalyst to economic development (Graham et al., 2017b). It can help in the exchange of information and experience among key stakeholders in agriculture through value-producing online activity, like exchange of farm content through social media platforms among farmers groups (Paakkaria, Rautiob, & Valasmoc, 2019). There is thus a need to study the role of digital labour in enhancing agriculture in the context of a developing country like Malawi.

This review then, seeks to determine the effectiveness of digital technology in agriculture and determine how site-specific information generated by digital technology be analysed to implement precision farming in Malawi. The researcher endeavour to shape smart farming through analysing site-specific information and employing digital labour to implement precision farming in Malawi.

The article is influenced by two cases which have shown to employ digital labour: Strengthening Agriculture and Nutrition Extension (SANE) Project and the SOIL HEALTH Project which is under One Planet Education Network (OPEN) Sustainable Agriculture Soil Health Project.

Strengthening Agriculture and Nutrition Extension (SANE) Project and Digital Labour

SANE project, which has worked with Malawi government for 5 years through partnership with Department of Agricultural Extension Services (DAES), has strengthened DAES'S capacity (Rivera, 2021; SANE, 2017). SANE has rolled out to 200 extension workers within the USAID and Feed the Future zone of influence aiming at mobilising and working with service providers to deliver agricultural nutrition extension and advisory services by strengthening linkages between extension service providers, and farmers (SANE, 2017).

The AgReach, a research program based at the University of Illinois developed Extension Helper App (EHA) which was rolled out in February 2021. EHA is a portal-based, digital package including an application-based dashboard for superiors to see and manage field data, oversee worker productivity, manage resources, view farmer data trends and support decision making (Rivera, 2021). An extension coordinator for the community, at field level, monitor frontline staff's individual farmer, farmer groups and stakeholder platform visits. An extension worker can collect data during visits and then synchronise the data to a cloud storage system. The coordinator then view progress on the management portal overseeing the broader Extension Planning Area (EPA) and generate field staff productivity reports for the month. The EHA supports frontline workers by streamlining the data collection and reporting.

One Planet Education Network (OPEN) Sustainable Agriculture Soil Health Project and Digital Labour

OPEN is a student-led, expert guided research project. One of its goals is to help small holder farmers and communities adapt to and mitigate climate change impacts while increasing yields through application of sustainable practices (OPEN, 2021a). OPEN delivers Project-Based Learning (PBL) curricula and collaborative software for ongoing global education discussion forums for teachers and students. The activities correspond to working out and bridging digital divide discourse. The project demonstrate application of digital labour where numerous participating schools and experts are sharing experimental agriculture research results with each other including knowledge sharing by asking questions, uploading research data, project images, and videos on agriculture experiments, and addressing issues through online project related collaborative forums (Fuchs & Sevignani, 2013) (Ahmed, 2007).

OPEN improves production sustainably with accurate real-time monitoring data by integrating smart farm Internet of Things (IoT) technologies. OPEN will provide Internet sensors and network technologies at school and University test plots. It will also deploy new technologies for high-speed Internet connectivity and sensor data network relay systems for participating schools and farm communities (OPEN, 2021a). As claimed by (McKnight et al., 2019), these internet backpack will allow near real time access to data from Internet-connected smart farm agriculture sensors from school and adjacent farm research plots, as well as local on-board storage systems in a way embracing digital labour.

OPEN demonstrates digital labour by designing, deploying, and integrating OPEN infrastructure education program-related Internet of Things (IoT) sensor networks and related technologies with support of OPEN's IoT sensor network experts, other technology experts, and when on board, relevant Malawi partners and ministries (OPEN, 2021b). Prior related technologies and tech programs will be integrated within IoT network systems and community infrastructure programs including Esri GIS Geospatial Mapping, and Virtual Reality and Augmented Reality (VR/AR) visualization technologies.

Methods

This paper first employed desk research to find the effectiveness of digital technologies with focus on Extension Helper Application in farming to achieve food security. This involved analysing SANE project implemented in Malawi at the department of Agriculture Extension services in partnership with AgReach research program at university of Illonois and secondly researcher employed action research with OPEN project using digital tools and digital labour in addressing issues of cite specific information to achieve precision farming utilising technology capability framework.

Natural Resources College (NRC), a constituent college of Lilongwe University of Agricultural and Natural Resources (LUANAR), was provided with 4-in-1 soil tester probe, the digital soil tester shown in fig.1 capable of testing soil moisture, temperature, pH and fertility by inserting the probe into soil about 2-4 inches then check parameters after approximately 10 minutes. OPEN's technical teams will provide internet sensors and network technologies at school and University test plots. In this initial NRC university campus implementation and later to a farm/community garden pilot program, OPEN and its technical partners will deploy new technologies for high-speed internet connectivity and sensor data network relay systems for participating schools and farm communities. Both qualitative and quantitative data collection methods were employed. Qualitative data was collected through literature reading, interviewing DAES coordinator at Lilongwe office as well as through participating students at NRC. Quantitatively data was collected using a digital soil tester, the rapidest 4 in 1 digital soil tester. Research also drew on ethnographic study with students at Natural Resources College.

Two demonstration plots labelled Plot A and Plot B were used. The size of Plot A was 8 m by 5 m while the size of Plot B was also 8 m by 5 m. Using knowledge gained on how to use the 4 in 1 soil tester probes in soil pH, fertility and moisture, data which were collected for 5 weeks and analysed to see if there was any good progress or anything to improve. Data was being recorded in a table whose sample is shown in table 1.

Two crops of *Phaseolus vulgaris* locally known as common beans and *Ipomoea batatas,* sweet potatoes commonly known as Kenya were planted in two plots, each measuring 8 by 5 metres for each crop. One plot was meant for control (plot A) and the other for treatment (plot B). Beans plots were separated by 1 metre and a ridge demarcated the two potato plots.

Training was done on the use of digital soil tester, how to classify soil type and how to arrange for interventions to deal with deficiencies determined by digital soil testing equipment. Researcher and students can see the benefit of using digital agriculture through fig.2 and fig.3.

Fig.1. Rapitest 4-in-1 soil tester

Table 1. OPEN Sustainable Agriculture Weekly Record - Outdoor Diked Plots

Week # 1	Date: April 6 – 11	School (class): *Natural Resource College*						
Local	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
Maximum	AM	AM	AM	AM	AM	AM	AM	AM
Rainfall (mL)	PM	PM	PM	PM	PM	PM	PM	PM
PH		6.8	6.9	6	6.8	6.5	6.7	
Moisture		0.8	1	2.5	1.3	0.3	1.4	
Fertility		Too little	Too little	Too little	Too little	Too little	Too little	Tool little

Treatment plot (Plot B)

(a) Pesticides were applied to both treatment plots.

(b) Manure was also applied to improve fertility on both treatment plots (for sweet potatoes and beans).

(c) A 10 kg manure was applied on each plot. Calculation was done based on baseline recommendation that 50 kgs manure is applied on a 40 by 50m plot. Manure was just spread surrounding the plant area to avoid the accumulation of acidity.

Measures of pH, moisture and fertility were being observed and recorded weekly providing a comprehensive information and idea about the soil condition. Plant height and local rainfall were not observed. Field notes, interviews and available documents supported qualitative data collection.

The article was written as OPEN project research was progressing during the three months of July, August, and September this was within the semester when students were still in campus. Firstly, Malawi OPEN team was contacted to seek approval for the researcher's inclusion into the project. Malawi OPEN team had already contacted school management to introduce the project and to look for interested students. After the volunteers were identified, they met for three times before the project started. Then the farm coordinator allocated farmland for the project. Discussions ranged from where the plots should be, what to grow on the plots, what should be the plot size,

when to exactly start the project, how to treat the plots before planting, when to start, how the digital equipment can be used to generate information for use in the field's intervention and what, why, when, and how to carry intervention measures. A group of thirty young boys and girls volunteered to carry out the project as a prototype.

Once successful with the prototype, the plan was to recruit more youths and train secondary school students to assist in scaling up the project by extending the services from their communities on how to take care of the soil for maximum yields which will end up in improving food security in Malawi.

Fig.2. Control Plot (Plot A)   **Fig.3.** Treatment Plot (Plot B)

Results

Through EHA, research has shown that digital tools like EHA package help to see and manage field data, oversee worker productivity, manage resources, view farmer data trends and support decision making. It was further established that at the field level, mobile digital tools can amplify extension massaging to reach more farmers and enable management to improve coordination of diverse service providers with the right type of data aggregation. The EHA has reduced the use of had written reports during field visits, improved the quality of collected data and increased the frequency of field visits for the extension coordinator. In terms of determination of cite specific information generated by digital technology, the article focused on using rapitest 4-in-1 soil tester, testing moisture, pH, temperature, and fertility to analyse the implementation of precision farming on digital labour with young college students in Malawi. Researcher's analysis derived valuable capabilities such as having quick results about site specific information and easy to use and easy to adapt technology as well as fast determination of interventions leading to food security.

Research findings contribute to the discourse on the role of information and communication and digital technology with digital labour in the process of sharing knowledge, determining cite specific information towards shaping

precision farming as well as achieving food security and helping to formulate policies towards achieving Malawi vision 2063. Soil fertility indicates measures of too little, ideal, and too much and during initial stages of recording, the tester was recording too little and some days later it was registering ideal for at least five days, a possibility of decomposition of the decayed matters was suspected. Measures of moisture remained between 50 to 80 degrees Celsius, and pH was falling in the range between 6.5 and 7.5 which were normal compared to the baseline values.

Conclusion

The paper highlights the role that ICT, digital technologies, and digital labour play towards achieving strategic development goals of countries. EHA development demonstrated the initiative of Malawi in up-taking agriculture technologies and how extension coordinators can monitor frontline staff's individual farmer, farmer groups and stakeholder visits. It showed how extensions coordinators can collect data during visits and then syncs data to a cloud storage system, view progress on the management portal overseeing broader extension planning area (EPA) and generate field staff productivity reports for that month. Additionally, EHA portal could facilitate and help extension coordinators to manage field data, oversee productivity of workers, manage resources, check farmer data trends and support decision making.

Furthermore, research explored how cites specific information generated by digital technology can be analysed to implement precision farming in Malawi. This was analysed through OPEN project with students at NRC and the use of 4-in-1 Rapitest digital tool which was able to analyse fertility, moisture, pH and temperature. It was able to analyse soil health and help in coming up with intervention decisions necessary to shape precision farming. Additionally, Malawi students and local farmers/community gardeners would learn the latest in networking, Internet infrastructure development, and data analytics as well as geospatial mapping through the application and regular use of pilot sensor networks and related systems. This will be to serve Ministries and Malawi society needs, initially pegged at achieving sustainable agriculture.

Further research is suggested in determining adoption of digital technologies and intention to use EHA to achieve precision agriculture.

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