

Makoza, Frank

Working Paper

The effect of mobile network quality on use of mobile application in Affordable Inputs Program of Malawi

Working Paper ICTD, No. 09/24

Suggested Citation: Makoza, Frank (2024) : The effect of mobile network quality on use of mobile application in Affordable Inputs Program of Malawi, Working Paper ICTD, No. 09/24, ZBW - Leibniz Information Centre for Economics, Kiel, Hamburg

This Version is available at:

<https://hdl.handle.net/10419/302572>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

The effect of mobile network quality on use of mobile application in Affordable Inputs Program of Malawi

Frank Makoza
University of Cape Town
Department of Information Systems
Cape Town, South Africa

Email: fmakoza@gmail.com

2024

Abstract

Agriculture subsidy programs increase participation of rural households in food security and nutrition improvement in Malawi. Digital technologies e.g. mobile application (App) and biometrical identification, electronic database have been integrated in implementation of Affordable inputs program (AIP) to support effectiveness and efficient delivery of the program. This paper analysed the effect of mobile network quality on the use of e-AIP redemption benefits app in AIP. The study analysed secondary data using content analysis. The findings showed that network availability was the main cause of network glitches that affected the use of mobile application for redeeming agricultural inputs. The network glitches created further challenges to the agricultural inputs subsidy beneficiaries and stakeholders. The include loss to time, promotion of corruption and late processing of transactions affecting overall goal of supporting food security. The study suggest areas of further research and recommendations for the telecommunications regulator to improve on measuring mobile network performance to include quality of user experience.

Keywords: Mobile application, Affordable inputs subsidy, mobile network quality, Food security, Malawi.

1. Introduction

Agriculture is the primary economic activity of rural communities in Malawi that supports employment creation, food security and nutrition of households (Kabuli, Enokenwa Baa & Davis, 2024). Further, scholars highlight that food security and nutrition are crucial because healthy citizens are able to participate in national development programs in Malawi (Kambewa 2020; Kerr & Patel, 2014). However, part of the population of Malawi remain food insecure and vulnerable due to unstable income, low production, limited access to markets and inadequate farm inputs, effects of climate change that are leading to hush weather conditions and shocks (Chinsinga, 2008; Tostensen, 2017). To overcome some of these challenges, Government of Malawi implemented agriculture subsidy programs (e.g. Targeted Input Program, Agricultural Input Subsidy Program, Affordable Input Program) to support most vulnerable members of communities to access inputs, boost subsistence farming and achieve household food security (Nyirenda, Chigaru, Nyondo, Khonje, Wineman & Muyanga, 2021; De Weerd & Duchoslav, 2022).

The execution of current agriculture subsidy program (i.e. AIP) has been problematic. There are issues of beneficiary identification, supply chain logistics, political interference, corruption, delays in deliveries and inefficiencies in use of technology (Chinsinga, 2008; Chinsinga & Poulton, 2014; Kambewa, 2020; Ragasa, Aberman & Mangote, 2019; Walls, Johnston, Matita, Kamwanja, Smith & Nanama, 2023). The government of Malawi through Ministry of Agriculture has adopted digital technologies (e.g. integrated use of national biometric identity cards, beneficiary database and electronic Affordable Input Program (e-AIP) redemption benefits app, to support addressing some of the AIP challenges (Erlangga, Machuku, & Jun Dahino, 2023; Van der Straaten, 2020). Despite adopting and integration of digital technologies, the infrastructure supporting the use of mobile technologies is also problematic. Studies highlight issues of mobile network quality in urban and rural areas of Malawi (Batzilis, Dinkelman, Oster, Thornton & Zanera, 2010; Luhanga, 2024; Pattnaik, Mohan, Chipokosa, Wachepa, Katengeza, Misomali & Marx, 2020). This paper attempts to understand the relationship between the mobile network quality and use of e-AIP redemption benefits app in the Agricultural Inputs Program (2020 to present). The challenges of inefficiencies in use of mobile technologies in the delivery of AIP have been persistent over the years (see Muyanga, Nyirenda, Lifeyo & Burke, 2021; Nyondo, Khonje, Mangisoni, Ricker-Gilbert & Chilora, 2021). While the issue has attracted interest of the beneficiaries, international development agencies, donors, government officials and politicians, there are few studies (e.g. Luhanga, 2024) that have addressed the issue at the supply level of infrastructure e.g. the quality of mobile network. Understanding of the problem related to mobile network quality and use of e-AIP redemption benefits app is significant for policy makers and government agencies to find solutions and deliver the expected AIP outcomes. Efficient and effective implementation of AIP using technologies is important to support government achieve food security and economic growth (Hemming, Chirwa, Dorward, Ruffhead, Hill, Osborn, Langer, Harman, Asaoka, Coffey & Phillips, 2018; Kerr & Patel, 2014; Mgomezulu, Chitete, Maonga, Dzanja, Mulekano & Qutieshat, 2024; Ragasa, Aberman & Mangote, 2019).

Against this background, the study was guided by the research questions:

- What are the digital technologies that are used in the AIP?
- How does use of e-AIP redemption benefits app affect the processes in AIP?
- What are the challenges for using technology in AIP?
- What is the state of mobile network quality and how does it affect the use of e-AIP redemption benefits app?

The study was exploratory in nature because few studies have looked in detail the link between quality of mobile network and specific mobile applications that are used to support government in delivery of agriculture subsidy program. The objective was to understand the effect of quality of mobile network and use of mobile technologies in AIP especially the e-AIP redemption benefits app in the context of Malawi. Hence, exploratory case study was used in the study (Sutherland, 2016).

The rest of the document is presented as follows. Section 2 summarises the background to the study. Section 3 outlines the research methodology. Section 4 presents the research findings. This is followed by the discussion of the findings and conclusion.

2. Background to the study

2.1. Agriculture production and food security in Malawi

Agriculture production remain the main economic activity that the large part of the population participate in Malawi (Hemming, Chirwa, Dorward, Ruffhead, Hill, Osborn, Langer, Harman, Asaoka, Coffey & Phillips, 2018). The country is endowed with arable land, lakes, rivers, streams and good weather that support growing of crops and rearing of animals. The agriculture sector is predominantly subsistence farming where smallholder farmers engage in agriculture production for household consumption and the surplus produce is sold to generate income for meeting other dairy needs (e.g. transport, clothing, school fees, hospital expenses etc.) (De Weerd & Duchoslav, 2022; Dorward & Chirwa, 2013). Farmers in the country are able to produce crops for consumption including maize, sorghum, beans, peas, groundnuts, potatoes and vegetables. They also engage in livestock production for poultry, pigs, goats and cattle. There are also farmers engaged in aquaculture (Dey, Paraguas, Kambewa, & Pems, 2010; Kaumbata, Banda, Meszaros, Gondwe, Woodward-Greene, Rosen, van Tassell, Solkner & Wurzinger, 2020). The farmers with resources engage in commerce farming to produce cotton, tobacco, sugarcane, tea, coffee, etc. These crops are main source of foreign exchange earnings. Hence, agriculture contribute more than 36% of the annual Gross Domestic product (Sichoongwe, 2023).

Toulon (2014) suggest a duo system of farming practiced in Malawi where there commercial and smallholder subsistence farmers. Commercial farmers include large estate farms and state owned estates in the agriculture sector of Malawi. They enjoy support from commercial lending institutions and government. For instance, there are efforts from government to support private sector to participate in the agriculture sector increase number

of commercial farmers, mega-farms program, production, value adding and exports of agriculture products (Chinsinga, Matita, Chimombo, Msofi, Kaiyatsa & Mazalale, 2024). The commercial farmers contribute towards production of commercial crops that generate foreign income for the country (Mgomezulu, Chitete, Maonga, Kachingwe, Phiri, Mambosasa & Folias, 2024; Sichoongwe, 2023).

Smallholder farmers constitute a large part of the population (about 80%) in Malawi (Mgomezulu, Chitete, Maonga, Dzanja, Mulekano & Qutieshat, 2024). Smallholder farming provide a steady form of self-employment, skills development opportunities and supporting food security. Despite their crucial role in social and economic development of the country, smallholder farmers face a myriad of challenges that affect agriculture production output and their well-being. Smallholder farmers lack skills in new agricultural framing practices that contribute to sustainable farming. There are also challenges of declining soil fertility and most smallholder farmers depend on fertilizer to improve their yield (Chirwa & Dorward, 2013; Asfaw, Pallante, Orecchia & Palma, 2018). Further, inadequate resources lead to smallholder farmers to depend on manual labour. Smallholders farmers are also affected with the changes of weather patterns that has seen the rise of floods, droughts and other extreme weather conditions. Lack of collateral affects smallholder famers to access loans that can be used to increase agriculture production (Chirwa, Mvula, Dorward & Matita, 2013; Chinsinga, Matita, Chimombo, Msofii, Kaiyatsa & Mazalale, 2021). These challenges are also affecting nutrition and food security of many households of rural communities. The Global Food Security index score (GFSI) of Malawi is 48.1 and ranked at 91 out of 113 countries (GFSI, 2024). The country has weak capacity to meet food affordability and requires interventions to support household income and agriculture production for the most vulnerable members of communities. Table 1 summarises the GFSI scores of Malawi.

Table 1: Summary of Malawi's Global Food Security Index performance (GFSI, 2024)

| GFSI variable | Value | Rank (out of 113 countries) |
|---|-------|-----------------------------|
| Affordability ¹ | 33.6 | 107 |
| Availability ² | 52.9 | 77 |
| Quality and safety ³ | 52 | 90 |
| Sustainability and adaptation ⁴ | 58.2 | 37 |
| Key 1: The ability of consumers or households to have income to purchase food. 2: The capacity for food production and expand distribution of food when required. 3: Food that is safe, meet the nutrition requirements and available in diverse diets. 4: The exposure to climate change risks and ability to respond and minimize the risks. | | |

As can be seen in Table 1, there are major concerns on food affordability because vulnerable households and communities may for have income to purchase food leading to

starvation and diseases. This can affect their nutrition and well-being (Jones, 2016; Kerr & Patel, 2014). Further, the outlook of food insecurity is predicted to continue in the next few years (see Figure 1 below) (World Bank Data, 2024). This may mean that with the increase in population, more households and vulnerable members of communities will be subjected to hunger and may affect their economic contribution to the country (Mgomezulu, Chitete, Maonga, Dzanja, Mulekano & Qutieshat, 2024).



Figure 1: Estimates of prevalence of food security in Malawi (World Bank Data, 2024)

The Government of Malawi continue to prioritise support for smallholder farmers despite national budget constraints (Mgomezulu, Chitete, Maonga, Dzanja, Mulekano & Qutieshat, 2024; Muyanga, Nyirenda, Lifeyo & Burke, 2021). The Government of Malawi introduced agriculture subsidy programs that have evolved over time (See Table 2). The aim of the subsidy programs is to increase the agriculture production, increase income of smallholders and address food shortages. The subsidy programs include identification of beneficiaries (done through vulnerability assessment reports), budgeting and planning through ministry of Agriculture, the ministry of economic planning and parliament, procurement and distribution through agro-dealers, providing farm input where eligible smallholders farmers and vulnerable households receive farm inputs (e.g. seeds, fertilizer and animals) (Chinsinga, 2008; De Weerd & Duchoslav, 2022; Kerr & Patel, 2014). The agriculture subsidy programs began in 1998 following food crisis because high cost of fertilizer prices and adverse weather conditions. The programmes have evolved to addresses emerging and contextual issues including changes in economic performance (slow growth and high inflation), effects of natural disasters on agricultural production, lack of capacity to generate revenue to finance the subsidy programs and changes in funding models of donors (Dorward, Chirwa & Jayne, 2009; Nyondo, Khonje, Mangisoni, Burke, Ricker-Gilbert & Chilora, 2021). Another contributing factor to the changes of the subsidy programs is government turnover due to electoral cycles.

When new government administration is elected, each administration prefer to rebrand the subsidy program to reflects the political party manifesto or meeting the campaign promises to the electorate. Hence, subsidy programs have political connotations attached to their planning and execution (Chinsinga & Poulton, 2014; Nyondo, Khonje, Mangisoni, Burke, Ricker-Gilbert & Chilora, 2021).

Table 2: Summary of subsidy programs in Malawi (Benson et al., 2024)

| Name of agriculture subsidy program | Year(s) |
|---|----------------|
| 1. Starter Pack Program (for 2.8 million households) | 1998 - 1999 |
| 2. Targeted Input program (for 1.5 million households) | 2000 - 2002 |
| 3. Extended Target Input Program (for 1.5 million households) | 2003 – 2004 |
| 4. Farm Input Subsidy Program (for 1.3 million households) | 2005 - 2013 |
| 5. Farm Input Subsidy Program (for 900,000 households) | 2013 – 2019 |
| 6. Affordable Inputs Program (for 1.5 million households) | 2020 - Present |

As can be seen in Table 2, the Affordable Inputs Program (AIP) of 2020 replaced the Farm Input Subsidy program. AIP main goals are reducing poverty, improving access to farm input, support food security and improving nutrition. The target beneficiaries are individuals and households that have been identified as most vulnerable in communities (e.g. children headed households, widows, orphans, the elderly, young with financial income, the unemployed etc.). The households receive two bags of fertilizer, hybrid maize seed or sorghum or rice of pesticides at reduced prices (Ragasa, Carrillo & Balakasi, 2022). Sometimes the beneficiaries receive livestock e.g. goats (Kaumbata, Banda, Meszaros, Gondwe, Woodward-Greene, Rosen, van Tassell, Solkner & Wurzinger, 2020). The previous subsidy programs used paper based vouchers that were cashed at recommended outlets or selling points that were close to communities of the beneficiaries. However, AIP has integrated use of electronic database, national ID and mobile application to support the process of redeeming the agricultural subsidy inputs and generate real-time information for the subsidy program (Nyondo, Khonje, Mangisoni, Burke, Ricker-Gilbert & Chilora, 2021).

AIP implementation faces challenges like the previous subsidy programs (Ragasa, Carrillo & Balakasi, 2022). These include unstable policies supporting the program, challenges in identification of beneficiaries where some vulnerable members of communities are still marginalized (selection by Chiefs and Village district committee being influence by political affiliation and corruption), sustainability of the program because of over dependence on donor support, procurement and logistical challenges that affect delivery of the farm inputs on time, limited crop diversity where emphasis of few crops as part of the inputs e.g. maize (leaving out other crops such as cassava, beans, sweet potatoes, pigeon peas etc.), dependency on rainfed farming that is affected by changes in weather patterns e.g. floods and droughts, limited mechanization of farming and reliance on human labour which affect production (Chibwana & Fisher, 2010; Ragasa, Carrillo & Balakasi, 2022; Nyondo, Khonje, Mangisoni, Burke, Ricker-Gilbert & Chilora, 2021; De Weerd & Duchoslav, 2022; Tufa, Alene,

Ngoma, Marenja, Manda, Matin, Thierfelder, & Chikoye, 2023). While technologies have been integrated in AIP e.g. biometric ID and mobile technologies to address some of the highlighted problems, there are also challenges of inefficiencies in use of technologies in the AIP program (Nyondo, Khonje, Mangisoni, Ricker-Gilbert & Chilora, 2021). The current study attempt to look at network quality issues because the problem has attracted media attention but received limited attention from scholars to understand the problem.

2.2. Digital technology infrastructure developments in Malawi

Malawi has a population of 20.4 million people and the majority live in rural areas. The country is categorised under very low income (ranked at 172 out of 193 economies) with Gross National Income per Capita of \$1,432 (PPP) (UNDP, 2024). Digital infrastructure is still in the developmental stages. For instance, Malawi has a mobile teledensity of 55.5% and 5.86 million people use internet (DT, 2024). Citizens living in main cities and urban areas have access to internet and electricity. While citizens in rural and remote areas have challenges accessing digital services including internet. The country has two main mobile operators: Airtel Malawi Limited and Telekom Networks Malawi Limited. The mobile-cellular network covers about 88% of the population. Further, 3G network covers 86% of the population and 4G network covers about 70% of the population (ITU, 2024). There are also two fixed telecom operators: Malawi Telecommunications Limited and Access Limited. The infrastructure of Malawi Telecommunication Limited covers the whole country while Access Limited is available in major cities (Batzilis, Dinkelman, Oster, Thornton & Zanera, 2010; Luhanga, 2024; Makoza, 2021).

The government of Malawi and developmental partners prioritise digital infrastructure investments to ensure connectivity, access and affordability of digital services (Makoza, 2023). The government is in the process of implementing Malawi ICT and digitalization policy (2021-2026) that attempt to support wealth creation and self-reliant through digital technology. The policy outlines integration of digital technology in sectors for trade, education, financial services and telecommunication (Makoza, 2023). Further, national fibre backbone and national data centres were implemented. Though the World Bank funded program, the country implemented the Digital Malawi Project (2017-2024). The program included development of internet infrastructure to improve access in public institutions (Makoza, 2017). Further, private sector organisations were also engaged to support access and use of internet. Recently, the country implemented public free Wi-Fi in schools, hospitals, markets, airports to support the public in use of internet. Malawi Communications Regulatory Authority (MACRA) is also supporting regulations for pricing of digital services among the telecommunications operators to ensure affordable access of internet in the country (Makoza, 2022).

There are government and non-government led initiatives that use technologies to support agricultural activities of smallholder farmers in Malawi. Chikuni and Kalima (2018) reported on use of mobile phone among smallholder farmers to access market information services. In a similar study, Katengeza, Okello and Jambo (2013) analysed how smallholder farmers used mobile technologies to access agricultural markets. While these studies reported successful use of mobile technologies, there are few but growing studies that have

reported challenges of mobile network infrastructure (from the supply side of the value chain). Batzilis, Dinkelman, Oster, Thornton and Zanera (2010) analysed mobile network infrastructure rollout and performance. Based on call drop rate analysis, their findings highlighted there was better network performance in areas where there was high demand for services. The mobile network operators were improving services quality in both urban and rural areas. However, other measures of network performance (e.g. service availability) were not included in the study. Recently, Luhanga (2024) examined the performance of networks of the main two mobile network operators (Airtel Malawi and Telecom Network Malawi) focusing using handover success rate (e.g. call setup success rates and customer experience). The findings demonstrated that both mobile network operators achieved the key performance indicators set by the telecommunications operator (i.e. Malawi Telecommunications Regulatory Authority). Based on the outcomes of the network performance, it is suggested that the network infrastructure is ready further upgrade to fifth generation (5G) network that can support (Luhanga, 2024). From these examples, it is recognised that there are aspects of mobile network performance that can be assessed in a particular study. However, issues related to applications that rely on network services to support access to public services at a large scale such as the AIP in the context of Malawi are missing. The current study attempt to address this knowledge gap.

2.3. Mobile network performance

Quality of internet services has become an important issue beyond the narratives related to access to internet services because internet is supporting services that affect businesses, individuals and communities. For instance, services that can be accessed online for education, finance and health and e-government services (Makoza, 2023; Makoza, 2023b). Hence, telecommunications regulatory institutions monitor the performance of mobile networks to protect the interest of consumers in ensuring accessible and reliable internet services. There are many ways on how mobile network performance can be assessed in relation to quality of services and user experience (ITU, 2023; ITU-T, 2021; Luhanga, 2023; MCI, 2024; Speedchecker, 2021; SPGI, 2023). For instance, telecommunications standards key performance indicators and measures, user perceptions matrices for network speed for data upload and download, signal strength, latency and jitters in network, assessing network traffic routing and delivery reliability; and the response rate in dealing with reported technical issues and customer complaints (ITU-T, 2021; Noor & Khorsandroo, 2019).

There are factors that can affect network quality of services and users experience related to internet services. These include congestion of network due to large number of users, power outages for base stations, use of outdated equipment that does not support new technologies e.g. 4G or 5G, inadequate regulations for managing spectrum, poor management routing traffic, inadequate internet packet exchange services etc. (Boz, Finley, Oulasvirta, Kilkki & Manner, 2019; Finley, Boz, Kilkki, Manner, Oulasvirta & Hämmäinen, 2017). These factors require to be addressed to ensure quality of services to support internet based applications e.g. mobile apps, online data transmission and shared online databases.

In Malawi, the Malawi Communications Regulatory Authority (MACRA) is responsible for the conducting quality checks to ensure that the minimum quality of mobile network are

met by all licensed operators in the telecommunication sector (Makoza, 2021; Makoza, 2022). MACRA as a regulator has the mandate to sanction network mobile operators that are not meeting the network quality standards as stipulated in the regulations from Communications Act of 2016 and the mobile network operators license. The regulators uses variables including (mobile switching centre availability, radio availability, context activation success rate, call setup success rate, call drop rate, trunk congestion, signaling channel congestion and traffic channel congestion) for assessing mobile network operators performance. For better manageable scope of understanding the context in which e-AIP redemption benefits app was operating, the study selected six variables that were categorised into the following network quality dimensions (ITU-T, 2021):

- **Network Availability:** the measure of time the network devices are up e.g., nodes and base stations.
- **Network Accessibility:** the measure of available channels that can establish connections.
- **Service availability:** measures how long the network devices are active to work together; and
- **Service accessibility:** measure how long network channels remain undisturbed and supporting access of communicating devices.

The variables were selected to understand the supply side of mobile network infrastructure. This was consistent with similar studies that have looked at mobile network infrastructure in the context of Malawi (e.g. Batzilis, Dinkelman, Oster, Thornton & Zanera, 2010; Luhanga, 2024). However, insights into a of specific operations and performance of an application e.g. e-AIP redemption benefits app are still missing in literature. The study will attempt to address this knowledge gap.

3. Research methodology.

The study employed an exploratory case study (Sutherland, 2016) that is used to understand a phenomenon that is not well understood and require new insights. The approach fitted well with the purpose of gather understanding of network quality in relation to use of a mobile app in public service delivery that was not well understood in the context of Malawi. In line with the case exploratory case study, qualitative research approach (Sutherland, 2016) was used where secondary data from multiple sources was collected and analysed. The purposeful selection was used to selected secondary data was used in the study. Only data that was relevant to the study selected (Bowen, 2009). The data included reports and government statements on the AIP. These were sourced from government departments and websites of international development. Online media reports were also included to represent insights from beneficiaries of AIP. Table 3 summarises the data that was analysed in the study.

Table 3: Summary of the documents analysed in the study.

| Description | Source of the document | ID |
|--|--|-----|
| Documents | | |
| First quarter quality of service report (January – March 2022) | Malawi Communications Regulatory Authority | D1 |
| Second quarter quality of service report (April – June 2022) | Malawi Communications Regulatory Authority | D2 |
| Third quarter quality of service report (July – September 2022) | Malawi Communications Regulatory Authority | D3 |
| Fourth quarter quality of service report (October - December 2022) | Malawi Communications Regulatory Authority | D4 |
| Presidential national address on the status of the Affordable inputs programme – 22 October 2022 | Office of the President and Cabinet | D5 |
| State of the national address 2024/25 Budget meeting of Parliament – 9 February 2024 | Office of the President and Cabinet | D6 |
| Affordable inputs program Final report 2020-2021 | Fertilizer Association of Malawi | D7 |
| Affordable inputs program Final report 2021-2022 | Fertilizer Association of Malawi | D8 |
| Affordable inputs program Final report 2022-2023 | Fertilizer Association of Malawi | D9 |
| A report on systematic investigation on Affordable input program implementation for the 2022/2023 and 2023/2024 growing season | Office of the Ombudsman | D10 |
| Report on the monitoring of the 2020/21 Affordable inputs program | Malawi Anti-corruption Bureau | D11 |
| Telekom Networks Malawi (TNM) Ltd Malawi - Feasibility study | GSMA Green Power for Mobile | D12 |
| Websites | | |
| Malawi E-AIP Portal | Ministry of Agriculture | W1 |
| GSM Mobile connectivity index | GSM Association | W2 |
| Online media reports | Online news websites* | W3 |
| Key *Online news websites – include the following: Malawi e-AIP Portal (aip.agriculture.gov.mw/portal) Times Malawi (www.times.mw), Nation Malawi (www.nwnation.com), Nyasatimes (www.nyasatimes.com), Malawi24 (www.malawi24.com) and Malawi voice (www.malawivoice.com). | | |

The selected data was converted in electronic form and stored in a repository (DQA Miner lite). Content analysis (Erlingsson & Brysiewicz, 2017) was used to analyse the data. The process of content analysis was summarised as follows:

- Data was read to be familiar with the documents and noting interesting ideas related to the study.
- Data was re-read and text (words, sentences and paragraphs) was assigned to codes.
- Related codes were grouped into categories and revised based on key ideas emerging from the data.
- The categories were grouped into themes that supported to answer the research questions guiding the study.

The process was repeated to improve the quality of analysis. At the end, a report was produced to summarise the outcomes of the data analysis and answer the research questions.

4. Summary of findings

4.1. What are the digital technologies that are used in the AIP?

The analysis showed that biometric identification, mobile technologies and social media platforms were the main technologies that were adopted and used in AIP. The Malawi Government through National Registration Bureau introduced a biometric identification card system in 2017. About eleven million Malawians were registered and issued with a national identity card that supported identification of beneficiaries and the redeeming of input. The national ID replaced previous forms of identification (electoral voter cards, letter from chiefs or clergy, driver's license and passport) to overcome challenges of corruption, abuse of the systems, wrong identification and fraud. There was strong belief among the stakeholders that biometric identification was secure, portable and easy to enforce when identifying the AIP beneficiaries. However, other sources of beneficiary information were consolidated to create a new database for AIP by the ICT technical team in the Ministry of Agriculture:

“The Ministry through technical support from Presidential Delivery Unit (PDU) specifically, Tony Blair institute (TBI), harmonized the available four data sets (AIP, Unified Beneficiary Registry (UBR), Farmer Organisation's Data and National Agriculture Management Information System), to come up with a data set which would help in capturing potential AIP beneficiaries. The data set was then presented to the Ministry's ICT section, which developed an application to facilitate the updating and validation of harmonized data set to come up with validated household's database.”(D10)

The database had capabilities to store large volumes of data for the transactions of redeeming inputs in the sales points across the country: “PostgreSQL Database which is used as the primary data store or data warehouse for many web, mobile, geospatial and analytics applications. This Database accommodates large amount of data at once which helps to speed up transaction processes” (D8). The database facilitated sharing of information between Ministry of Agriculture and the National Registration Bureau in the process of verifying AIP

beneficiaries. Further, mobile technologies were integrated in the program to support the process of redeeming of farm inputs at the selling points across the country. e-AIP benefits redemption app (a custom application running on smartphones with Android 6 operating system) was used in the AIP. Telekom Networks Malawi Limited provided the connectivity (i.e., 4G network) to support the operations of the app. Figure 2 show the interface of e-AIP benefits redemption app.



Figure 2: Interface of e-AIP benefits redemption app (Source: W1).

The key functions of the e-AIP benefits redemption app were real-time verification of targeted AIP beneficiaries, eliminated printing and distribution of vouchers and support recording of transactions in real-time. The app supported the online and offline process for redeeming farm inputs at selling points or agro-dealers across the country. The agro-dealers used the App to verify the identity of registered beneficiaries, process the selected farm input and provide a record on the transactions to the Ministry of Agriculture so that officials were able to know the exact figures of inputs redeemed at a particular time. Ministry of Agriculture used social media to share information with stakeholders. Facebook page of Ministry of Agriculture was used to publish number of redeemed inputs. Figure 3 shows an example of real time information on farm inputs published by the Ministry of Agriculture.

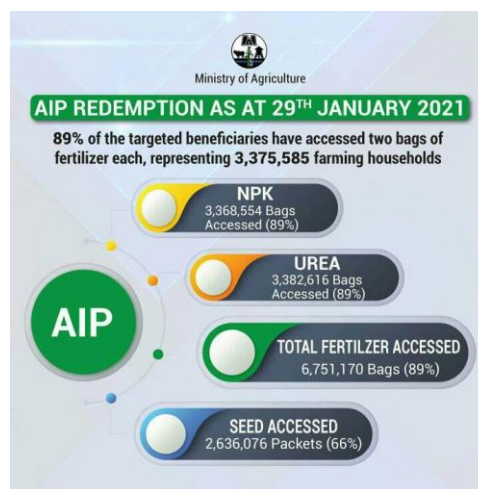


Figure 3: Example of published AIP redemption information (W1)

4.2. How did the use of e-AIP redemption benefits app affect the processes in AIP?

The process for AIP program was long, (including planning, procurement, supply chain and redemption of inputs) as it involved government and many stakeholders. The processes depended on other government activities including production and release of Malawi vulnerability assessment report (establishing the number of vulnerable households in the country), national budgeting (allocation of financial resources to AIP), resource mobilization from donors (lobbying for support from donors and multilateral partners and development partners) and public procurement process (identify and granting contracts to suppliers of agricultural inputs). The initial process implementation began with creating family register and verification exercise involving local chiefs, area development committees and village development committees who identify and verify AIP beneficiaries. The list of the beneficiaries was sent to the district office and later submitted to Ministry of Agriculture for capture in the beneficiary database and verification with the National Registration Bureau. AIP beneficiaries were sensitized of the process for redeeming the inputs. In procurement process, government awarded contracts to suppliers who sourced inputs outside the country. The inputs were delivered to the agro-dealers in extension planning areas (EPA). The AIP beneficiaries redeemed the inputs at selling points. Identification, payment and transaction process were made at the selling point. AIP beneficiaries paid the subsidized (reduced) prices and collected their agricultural inputs once transaction was completed. The agro-dealer submitted the vouchers to Ministry of Agriculture for payment using the e-AIP redemption benefits app. Network availability was crucial to complete the redeeming process. Table 4 summarises the benefits of using e-AIP redemption benefits app.

Table 4: Summary of benefits of using e-AIP redemption benefits App

| Category | Description | Example of statement |
|--------------------------------|--|--|
| Improved access to information | The app supported access to information among the AIP stakeholders e.g. suppliers | “Easier monitoring of sales by company allowing real-time performance analysis of companies” D8 |
| Better information sharing | The app captured information to the online database that was accessible to stakeholders in real time | “The ability for suppliers to view daily sales and cross check with their own records” D8 |
| Efficient transactions | The app supported transactions to be process in a short time | “Faster payment procedure” D8 |
| Reduced corruption activities | The app supported the government to minimize corrupt practices among suppliers, agro-dealers and farmers | “Minimisation of corruption by suppliers, farmers and the Ministry of Agriculture administrative staff in various EPAs” D8 |
| Improved invoicing | The app supported agro-dealers in efficient creation of invoices that were sent to Ministry of Agriculture | “Faster issuing and processing of invoices” D8 |

The use of national IDs and e-AIP redemption benefits app were beneficial to the stakeholders of AIP. For instance, the national ID addressed issues of identification of beneficiaries in relation to their age, gender and origin. The national ID also minimised the duplication of vouchers where each beneficiary could only use their electronic voucher once. Other advantages of using e-AIP redemption benefits app were better management of records where data for the redemption of inputs was recorded in real-time, the electronic transactions were faster between the agro-dealers and smallholder farmers; the arrangement reduced the logics where AIP beneficiaries were able to redeem farm inputs within a reasonable distance from their homes. Government officials were able to access information in real-time and make better decisions. There was improved payment process where suppliers were paid on time after the upgrade of the database and e-AIP redemption benefits app.

4.3. What are the challenges for using technology in AIP?

There were challenges related to use of national IDs and e-AIP redemption benefits app. Some of the problems related to nation ID in the AIP were loss on national ID and beneficiaries could not be allowed to access their inputs without identification. In some cases, the national IDs were damaged because of poor storage infrastructure. There were also challenges of beneficiary verification between Ministry of Agriculture and National Registration Bureau where there were delays in the process. Another problem was lack of awareness of the AIP input redemption among some agro-dealers and the beneficiaries. Lack of awareness contributed to AIP beneficiaries selling their national IDs to street vendors who were purchasing the subsidy inputs for resale at a profit. Table 5 summarises the challenges of using e-AIP mobile app.

Table 5: Challenges of using e-AIP redemption benefits app

| Category | Description | Example of statement (s) |
|-------------------------------------|---|--|
| Inability to identify beneficiaries | Beneficiaries inability to present national ID due to malpractices or loss of the national ID | “It was reported that beneficiaries who did not have National Identity cards but had National Registration Bureau (NRB) forms (Temporary IDs) with barcodes were being denied the opportunity to redeem farm inputs. The Sales Clerks stated that they were advised not to accept the NRB forms” D10 |
| | | “Farmers walked long distances, for example, farmers from Mzama area walked a distance of 28 kilometres and they were using a manual system to capture beneficiaries even scanned National IDs and the process fuelled the tendency of stealing farmers ID's” W3 |
| | | “The village headman took all National Identity cards and scanned them without the farmers' knowledge, and fertiliser was purchased in the names of unsuspecting farmers by some unscrupulous business people who worked with the chief” W3 |

| Category | Description | Example of statement (s) |
|---------------------------------------|---|---|
| Mobile network glitches | Inability to complete the transactions when using the mobile app due to unavailability of mobile network services | “The network glitches reached a highpoint last weekend when the network completely shut down nationwide, causing some beneficiaries to spend nights at Smallholder Fertiliser Revolving Fund of Malawi (SFRFM) depots” W3 |
| | Slow response because of network problems | “Poor network connections in certain areas that resulted in application often timing out” D8 |
| | Prolonged network outages where mobile network services were not available | “person y spent almost six hours waiting to redeem the inputs. Similar trends were also observed in districts of Rumphi, Karonga, Chiradzulu, Dowa, Mulanje, Phalombe, Salima, Zomba, Nsanje and Nkhotakota where the programme had rolled as of Tuesday this week.” W3 |
| Slow transaction processing | Long time to process one transaction resulting in delays and long queues | “Slow transaction time, taking 15-30 minutes to complete a transaction in some cases” D8 |
| Double transactions | Failure to complete the transactions resulting in initiating another transaction | “... a number of beneficiaries failed to redeem inputs as the system was showing that they had already redeemed their inputs and that other beneficiaries who had temporary IDs were being denied access to the inputs” W3 |
| Long technical support response times | Long time to resolve transactions and verify details of beneficiaries | For instance, if it was an issue about electronic system failure, the Ministry would raise it with the ICT personnel at the Ministry’s headquarters ... it was difficult for them to determine the number of cases that are being reported to them, how many were addressed, and how many were referred to other institutions for assistance because there was no effective complaint handling mechanism” D10 |
| Selling national ID | Some beneficiaries sold their national ID to vendors | “... incidences of fraud may increase due to failure by farmers to redeem their subsidised fertilizer at fifteen thousand kwacha. poor farmers will be forced to exchange their identity cards with cash” W3 |
| Overcrowding at agro-dealers | Waiting for network to resume led to overcrowding at agro-dealers premises or selling points | “This is worrisome. I spent nights in the cold because of network problems.... AIP targets poor farmers who travel long distances to access farm inputs and to be turned away due to network is unfortunate” W3 |
| Re-funds to beneficiaries | Some beneficiaries could not get their refunds if transactions were unsuccessful leading to losses | “Outstanding refunds to farmers who were asked to pay in advance for inputs should be addressed promptly to restore public trust and confidence in the program. Transparency and accountability in the administration of the AIP are non-negotiable” W3 |

The challenges related to the e-AIP redemption benefits app were network glitches and false redemptions. Network glitches were unavailability of mobile network when using the e-AIP app that led to inability of the agro-dealer to complete the transactions. During network glitches, the agro-dealers were not able to verify the AIP beneficiaries details stored on the database via e-AIP redemption benefits app and transactions could not be completed. Further, disruptions in mobile network connectivity caused systems to fail in processing transactions because some were regarded as duplicates due to failure of first attempt. The system was developed in such a way that it could only process one transaction per beneficiary ID number. The Ministry of Agriculture took long to resolve false redemptions that agro-dealers manage to report. The delays in resolving false redemption and network glitches caused other problems. These include congestion at the agro-dealers premises or selling points where AIP beneficiaries had to wait for a long time or sleep at the selling point to wait for the network to be restored. The beneficiaries opted to sleep at selling points because of the high cost of transport and long distance from their homes to the selling points. This also created congestion in the selling points and raised safety concerns for vulnerable beneficiaries (e.g., women and the elderly). Figure 4 shows AIP beneficiaries waiting at a selling point.



Figure 4: Beneficiaries waiting for network at an agro-dealer (W3).

Another challenge was that agro-dealers took advantage of the AIP beneficiaries and not refunded the payments for the incomplete transactions. Some AIP beneficiaries did not get correct number of inputs. Some AIP beneficiaries did not use the subsidy inputs because they were late e.g., inability apply fertilizer to crops at specific required times:

“Some beneficiaries did not apply the fertilizer at all because by the time they accessed the fertilizer it was too late for application, as such they sold the fertilizer to vendors” (D10).

Another effect of was loss money for the beneficiaries because of incomplete transactions (e.g., when there was network failure while the transaction data was not yet transferred to the ministry of Agriculture for processing). The agro-dealers could not resolve the issue of failed transactions and had to report to the Ministry of Agriculture. The officials at Ministry of Agriculture took long to resolve the issues of failed transactions and this meant that beneficiaries had to wait longer to get their refunds and affected agricultural activities. The situation created opportunities for corruption in some of the selling points or agro-dealers:

“... the new dispensation corruption will not be given an inch to flourish and thus warned those who are trying to frustrate the programme with their corrupt acts like overpricing, selling underweight quantities of the inputs and demanding kickbacks from farmers that the long arm of the law will catch up with them”(W3).

4.4. What was the state of mobile network quality and how did it affect the use of e-AIP redemption benefits app?

MACRA conducted routine checks three times a year. The results of the quality assurance concentrated are categorised into network availability, network accessibility, service availability and service accessibility. For better comparison results of two main mobile network operators in the country were compared. The values for network accessibility, service availability and service accessibility met the expected standards set by the telecommunication regulator. This was demonstrated in components for network accessibility (i.e., context activation success rate and call setup success rate). Both Airtel and TNM achieved the target values above 98.000 for call activation success rate. Similarly, the two mobile network operators also met the target for call setup success rate of above 90.000. These results indicated that there was adequate devices in the networks to support connection with other devices e.g., telecom must connect with mobile devices with active SIM cards. The values of service availability in terms of truck congestion were also above the target of 2.000 for both Airtel and TNM. Similarly, the values of call drop rate was also above the target of 2.000. This may mean that the network infrastructure services were available, and devices could work together. Service accessibility results showed that for both Airtel and TNM networks, devices were able to stay longer while connected to support communication. Both mobile network operators achieved the values above target for traffic channel congestion (above 2.000) and signaling channel congestion (above 0.500). However, the results of network availability showed that Airtel did not meet above target of 99.700 for radio availability while TNM achieved its target. This may mean that some of the network devices (e.g., nodes and base stations) on the network of Airtel were not active all the time to establish connections with other devices (e.g., mobile phones). This may be attributed to power supply challenges because of loadshedding and fuel running out at some mobile towers or base station sites that operated on diesel generators (D12). Table 6 summarises the mobile network performance of the Airtel and TNM.





Table 6: Summary of network mobile operators performance (MACRA, 2022)

| | | Network Availability | | Network Accessibility | | Service Availability | | Service Accessibility | |
|---|--------|----------------------|---------|-----------------------|--------|----------------------|-------|-----------------------|-------|
| | KPI | MSCA | RA | CASR | CSSR | CDR | TC | THC | SDCCH |
| Month | Target | 99.999 | 99.700 | 90.000 | 98.000 | 2.000 | 2.000 | 2.000 | 0.500 |
| Jan | AIRTEL | 100.000 | 98.800* | 99.480 | 99.400 | 0.310 | 0.000 | 0.130 | 0.140 |
| | TNM | 100.000 | 99.916 | 98.180 | 99.610 | 0.470 | 0.009 | 0.120 | 0.205 |
| Feb | AIRTEL | 100.000 | 99.390* | 99.240 | 99.520 | 0.330 | 0.000 | 0.090 | 0.180 |
| | TNM | 100.000 | 99.892 | 96.980 | 99.670 | 0.460 | 0.184 | 0.060 | 0.175 |
| Mar | AIRTEL | 100.000 | 99.630* | 99.190 | 99.930 | 0.340 | 0.000 | 0.110 | 0.220 |
| | TNM | 100.000 | 99.918 | 97.500 | 99.670 | 0.470 | 0.232 | 0.070 | 0.185 |
| Apr | AIRTEL | 100.000 | 99.560* | 99.470 | 99.898 | 0.350 | 0.000 | 0.120 | 0.200 |
| | TNM | 100.000 | 99.898 | 98.100 | 99.655 | 0.500 | 0.254 | 0.090 | 0.115 |
| May | AIRTEL | 100.000 | 99.470* | 99.680 | 99.240 | 0.350 | 0.000 | 0.270 | 0.390 |
| | TNM | 100.000 | 99.926 | 95.460 | 99.600 | 0.490 | 0.480 | 0.110 | 0.160 |
| Jun | AIRTEL | 100.000 | 99.550* | 99.690 | 99.330 | 0.340 | 0.000 | 0.310 | 0.270 |
| | TNM | 100.000 | 99.937 | 95.970 | 99.505 | 0.460 | 0.496 | 0.230 | 0.185 |
| Jul | AIRTEL | 100.000 | 99.530* | 99.800 | 99.270 | 0.360 | 0.000 | 0.360 | 0.280 |
| | TNM | 100.000 | 99.932 | 98.170 | 99.565 | 0.410 | 0.362 | 0.220 | 0.135 |
| Aug | AIRTEL | 100.000 | 99.540* | 99.710 | 99.380 | 0.340 | 0.000 | 0.330 | 0.270 |
| | TNM | 100.000 | 99.931 | 98.840 | 99.595 | 0.390 | 0.216 | 0.160 | 0.140 |
| Sep | AIRTEL | 100.000 | 98.610* | 99.730 | 99.300 | 0.350 | 0.000 | 0.550 | 0.400 |
| | TNM | 100.000 | 99.802 | 99.390 | 99.625 | 0.360 | 0.154 | 0.110 | 0.145 |
| Oct | AIRTEL | 100.000 | 99.360* | 99.880 | 99.400 | 0.340 | 0.000 | 0.480 | 0.280 |
| | TNM | 100.000 | 99.886 | 99.890 | 99.640 | 0.350 | 0.386 | 0.070 | 0.105 |
| Nov | AIRTEL | 100.000 | 99.350* | 99.830 | 99.280 | 0.370 | 0.000 | 0.310 | 0.440 |
| | TNM | 100.000 | 99.901 | 99.080 | 99.655 | 0.340 | 0.380 | 0.030 | 0.080 |
| Dec | AIRTEL | 100.000 | 99.500* | 99.390 | 99.410 | 0.390 | 0.000 | 0.300 | 0.210 |
| | TNM | 100.000 | 99.870 | 99.390 | 99.635 | 0.370 | 0.384 | 0.030 | 0.085 |
| Key: MNO – Mobile Network Operator; KPI – Key Performance Indicator; MSCA – Mobile Switching Centre Availability; RA – Radio Availability; CASR – Context Activation Success Rate; CSSR - Call Setup Success Rate; CDR – Call Drop Rate; TC- Trunk Congestion; SDCCH – Signaling Channel Congestion; THC – Traffic Channel Congestion. Values: 00.000* Missed target on key performance indicator | | | | | | | | | |

For robustness of the results the local data was compared with infrastructure component of the GSMA mobile connectivity index that assess the performance of mobile internet network

coverage. The findings showed that on overall the population that was covered with high performance mobile internet network coverage was improved in from 49.3% to 54.3% in 2020. However, the value in the subsequent two years and later increased in 2023. It was interesting to note that overall network coverage that measure the national coverage of mobile network also decreased in 2021 and 2022 but increased in 2023 to 74.3%. In 2020, the network performance (that measures the quality of network in relation to downloads, uploads and latency) showed improved performance in 2020 of 41.4% from 35.3%. The performance decreased in 2021 and 2022 but improved in 2023 to 39.1%. Spectrum measure the allocation of bandwidth assigned to network operators. The findings showed that spectrum was improving from 33.3% to 43.0% in 2020. There was also decrease in 2021 and increase in 2022 and 2023. Table 7 summarises the summary of the performance of infrastructure from the GSMA mobile connectivity index.

Table 7: Summary of mobile network Infrastructure performance (MCI, 2024)

| Year | 2019 | 2020 | 2021 | 2022 | 2023 |
|--|------|---|--|--|--|
| Index Score | 29.6 | 30.3 | 35.4 | 35.4 | 36.9 |
| Infrastructure score | 49.3 | 54.3 | 50.9 | 50.7 | 54.5 |
| Network coverage | 70.8 | 72.8 | 67.8 | 69.8 | 74.3 |
| ▪ 2G population coverage | 84.0 | 84.0 | 86.0 | 86.3 | 89.1 |
| ▪ 3G population coverage | 80.0 | 81.0 | 84.0 | 84.4 | 88.7 |
| ▪ 4G population coverage | 55.0 | 59.0 | 64.0 | 68.6 | 74.9 |
| Network performance | 35.5 | 41.4  | 38.0  | 35.5  | 39.1  |
| ▪ Mobile download speeds | 14.2 | 16.1 | 11.6 | 8.3 | 12.5 |
| ▪ Mobile uploads speeds | 19.9 | 25.0 | 21.6 | 18.7 | 25.1 |
| ▪ Mobile latencies | 72.5 | 83.1 | 80.8 | 78.4 | 79.5 |
| Spectrum | 33.6 | 43.0 | 42.8 | 43.8 | 45.6 |
| ▪ Spectrum assigned in bands below 1GHz | 22.1 | 36.8 | 46.3 | 46.3 | 46.3 |
| ▪ Spectrum assigned in bands between 1-3GHz | 50.8 | 52.4 | 59.2 | 62.5 | 62.5 |
| ▪ Spectrum assigned in bands between 3-6GHz | 0.0 | 0.0 | 12.5 | 12.5 | 25.0 |
| Source: GSMA Mobile Connectivity Index (MCI, 2024) | | | | | |

From the results of network quality data, it was clear that network availability could have affected the operations of the input subsidy programs. This was in redemption process at the various rural and remote locations of agro-dealers where beneficiaries redeemed the inputs. The effect of inevitability of the network meant that beneficiaries had to wait for long hours until the network services were restored. In probing further the possible caused of low score for network available, the analysis highlighted power outage at the base stations and challenges of fuel where some locations for network infrastructure relied on generators.

5. Discussion of findings and conclusion

The study set out to explore the effects of mobile network quality on the use of mobile app in the Affordable Inputs Subsidy program (AIP). The study findings showed that technologies were integrated in the AIP. The technologies include e-AIP redemption benefits app, beneficiary database and national ID. The database was used to store information about beneficiaries of AIP who were identified by chiefs and village committees as most vulnerable members of communities (e.g., orphans, children headed households, women and the unemployed youth without steady income). The database was used in verified details of beneficiaries when processing transactions for redeeming agricultural inputs. It further supported sharing information among stakeholders of AIP e.g., Ministry of Agriculture, suppliers of agricultural inputs e.g., fertilizer and agro-dealers. The national ID was used in the identification of registered beneficiaries when redeeming agricultural inputs. The e-AIP redemption benefits app was used in the process for verification of beneficiaries, processing invoices, recording payments and providing real time information on quantities of inputs redeemed and number of beneficiaries accessed.

The findings were consistent with similar studies that have highlighted the significance of digital technologies in agriculture production for smallholder farmers (Chikuni & Kalima, 2018; Katengeza, Okello & Jambo, 2013). The current study goes further to highlight the effect of mobile network quality as part of infrastructure necessary effective use of e-AIP redemption benefits app. Integration of technology into government programs such as AIP that aim to support food security require consideration of infrastructure (Ganesh, Deo & Devalkar, 2024). Hence, national digital policies and regulations should highlight the minimum requirements for mobile network quality so that digital technologies (e.g., mobile applications) may function optimally (Matinmikko, Latva-aho, Ahokangas, & Seppanen, 2018; Sutherland, 2007). Our study highlight the need for consideration mobile network quality when implementing mobile apps and confirm the findings of Finley, Boz, Kilkki, Manner, Oulasvirta and Hammainen (2017).

The findings showed benefits of using e-AIP redemption benefits app in the AIP. These include improved access to information among AIP stakeholders, better sharing of information, efficient transacting, reduction of corruption activities and improved invoicing. Similar studies on technology in subsidy programs highlight benefits related to accurate identification of beneficiaries, improvements in the redemption of agricultural inputs, elimination of fraudulent paper based vouchers and faster means of transacting (Nyirenda, Chigaru, Nyondo, Khonje, Wineman & Muyanga, 2021; Nyondo, Khonje, Mangisoni, Ricker-Gilbert & Chilora, 2021). The analysis also showed challenges for using e-AIP redemption benefits app, and these were inability to identify beneficiaries, network glitches, slow transaction processing, delayed technical support responses, double transactions, delays in refunding beneficiaries for failed transactions. These challenges led to further problems for selling on national ID, overcrowding in selling points and delays in re-funds to the beneficiaries. Understanding of benefits and challenges of using e-AIP redemption benefits app in subsidy program was significant to stimulate dialogue on the expectations of stakeholders and identifying issues that require to be addressed.

Interestingly our findings on state of mobile network revealed that TNM mobile network performed well and met the key performance indicators (for network accessibility, network availability, service availability and service accessibility) set by the telecommunications regulator. The Airtel mobile network did not meet the performance targets for network availability (e.g., radio availability). The mobile performance indicators of were consistent with previous studies that have highlighted better performance (Batzilis, Dinkelman, Oster, Thornton & Zanera, 2010; Luhanga, 2023). However, the overall performance of network operators in the country was declining as highlighted in the results from GSMA mobile connectivity index (Recall Table 3). In relation to the e-AIP redemption benefits app, there were insights related to capacity of the server hosting the database, the app designed for 4G network infrastructure and operating on Android version 6. Further, insights reports highlighted outages of network for prolonged period of time that affected the use of the e-AIP redemption benefits app in the selling points. From these findings, it was clear that development of the e-AIP redemption benefits app required to pay attention to infrastructure (e.g., the devices running the mobile application, interoperability, available mobile network infrastructure, and ability to work offline during network outage and resume when network was available). These results showed that there was also a need for improvement in the way network performance were conducted by the regulator. It was important to extend the mobile network performance indicators check both suppliers side and users side (e.g., checking uploads, download speeds, and latencies of the mobile networks). These parameters can support to establish the quality of user experience for mobile network (Noor & Khorsandroo, 2011).

The study was without limitations. Data for mobile network performance of TNM and Airtel covered 2022 only. To address this limitation, mobile connectivity index data was used that covered 2019 to 2023 to have a better perspective of the changes in mobile network performance. Further studies may be conducted to look at the long-term data from MACRA. Further, interviews can be conducted with the officials from the telecommunication regulator to clarify how mobile network performance from the perspective of users or consumers is conducted especially those in rural and remote areas. Such a study can highlight the feasibility of assessing demand side of mobile network performance e.g. quality of user experience (Boz, Finley, Oulasvirta, Kilkki & Manner, 2019; Fiedler, Hossfeld & Tran-Gia, 2010; Matinmikko, Latva-aho, Ahokangas & Seppänen, 2018).

The implications of the findings are the need to enhance performance of mobile networks. As government of Malawi continue to integrate technologies in public services e.g., AIP, it is important to improve policies and regulations for supporting mobile network performance and users experience. The World Bank (2024) suggest that outlook of food security in Malawi will not improve in the next three years (recall Figure 1), hence there should efforts to transform the public services delivery such as AIP using digital technologies (Makoza, 2023; Makoza, 2023b; Nyondo, Khonje, Mangisoni, Ricker-Gilbert & Chilora, 2021) and improve food security in areas of affordability (GFSI, 2024). Part of the digital transformation will require the MACRA as a telecommunication regulator to champion improvement of mobile network performance measurements to include quality of experience (e.g. upload experience, download experience, mobile applications experience, video

experience, audio experience and consistent quality), ensure that right equipment is invested in the mobile network infrastructure, promote entry of new mobile network operators to promote competition, support adoption of broadband through universal service fund as outline in national broadband policy, support mobile network operators to share infrastructure in rural and remote areas, promote partnerships in infrastructure investment of new technologies e.g. 5G networks, fibre networks and Internet Packet Exchange stations. In remote areas, MACRA may also support collaboration between Ministry of Agriculture and mobile network operators to use of alternative communication infrastructure e.g., TV White spaces and utilizing national fibre backbone and national data centres to improve quality of services. The technical team responsible for developing the e-AIP redemption benefits app may do rigorous testing of the application from different locations including rural and remote areas to ensure effectiveness and efficiency of the application and fix all technical issues before rolling out the application. Ministry of Agriculture and National Registration Bureau officials may need to enforce best practices for cybersecurity (e.g., in compliance to the National Cybersecurity Bill of 2023) to protect personal data stored on the beneficiary database. The mobile network operators may invest in alternative sources of energy such as solar to minimize challenges of network availability and ensure that network base station operate all the time. Mobile network operators may also invest in mobile network monitoring tools to ensure that problems are identified and resolved quickly.

In conclusion, the study set out to explore the effect of mobile network quality on the use of e-AIP redemption benefits App in the context of Malawi. The findings confirmed that use of digital technology improved some of the processes for delivery of AIP. The benefits were in improved identification, processing of transactions and sharing of information among AIP stakeholders e.g., Officials from Ministry of Agriculture, National Registration Bureau, suppliers and agro-dealers. However, the study highlight challenges in in the use of e-AIP redemption benefits app which include network glitches that caused congestion in the selling points and in some cases promote corruption. These challenges affected the activities of beneficiaries and agriculture production in addressing food security. The study suggest areas for improvement in assessing performance of mobile network operators to include quality of users experience.

References

- Asfaw, S., Pallante, G., Orecchia, C., & Palma, A. (2018). *Soil and nutrients loss in Malawi: an economic assessment*. Ministry of Agriculture, Irrigation and Water Development, Lilongwe, Malawi.
- Batzilis, D., Dinkelman, T., Oster, E., Thornton, R., & Zanera, D. (2010). *New cellular networks in Malawi: Correlates of service rollout and network performance* (No. w16616). National Bureau of Economic Research.
- Bowen, G. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27-40.
- Boz, E., Finley, B., Oulasvirta, A., Kilkki, K., & Manner, J. (2019). Mobile QoE prediction in the field. *Pervasive and Mobile Computing*, 59, 1-17.
- Chibwana, C., & Fisher, M. (2010). *The impact of agricultural inputs subsidies in Malawi*. International Food Policy Research Institute, Policy Note No. 5, pp. 1-4.
- Chikuni, T., & Kalima, F. (2018). Smallholder farmer's market participation and mobile phone-based market information services in Lilongwe, Malawi. *Electronic Journal of Information systems in Developing Countries*, 85(6), 1-3.
- Chinsinga, B. (2008). *The Malawi Fertiliser Subsidy Programme: Politics and Pragmatism*. Policy Brief No. 22. Sussex, UK. Accessed on 29 March 2024 from www.future-agricultures.org.
- Chinsinga, B., & Poulton, C. (2014). Beyond technocratic debates: the significance and transience of political incentives in the Malawi farm input subsidy programme (FISP). *Development Policy Review*, 32(s2), s123-s150.
- Chinsinga, B., Matita, M., Chimombo, M., Msofi, L., Kaiyatsa, S., & Mazalale, J. (2021). *Agriculture commercialization and rural livelihoods in Malawi: A historical and contemporary agrarian inquiry*. Agriculture Policy Research in Africa, Working paper WP/75, pp. 1-41.
- Chirwa, E., & Dorward, A. (2013). *Agricultural input subsidies: The recent Malawi experience*. Oxford: Oxford University Press.
- Chirwa, E., Dorward, A. (2013). *The role of the private sector in the farm input subsidy programme in Malawi*. Future Agricultures, Working Paper 064, pp. 1-16.
- Chirwa, E., Mvula, P., Dorward, A., & Matita, M. (2013). *Fertiliser use on women's plots: An intra-household view of the Malawi farm input subsidy programme*. Future Agricultures, Policy Brief 57, 1-8.
- De Weerd, J., & Duchoslav, J. (2022). *Guiding principles of AIP reform*. Vol. 43. International Food Policy Research Institute. pp. 1-4.
- Dey, M., Paraguas, F., Kambewa, P., & Pems, D. (2010). The impact of integrated aquaculture-agriculture on small-scale farms in Southern Malawi. *Agricultural Economics*, 41, 67-79.

- Dorward, A., & Chirwa, E. (2013). *Targeting in the farm input subsidy programme in Malawi, 2006/07 -2011/12*. Future Agricultures, Policy Brief 61, pp. 1-9.
- DT (2024). Digital 2024: Malawi. DATAREPORTAL. Accessed on 26 June 2024 from: <https://datareportal.com/reports/digital-2024-malawi>
- E-AIP Portal (2023). E-AIP Portal. Accessed on 26 June 2024 from: <https://aip.agriculture.gov.mw/portal/>
- Erlangga, E., Machuku, O., & Jun Dahino, C. (2023). A review article on the impact and challenges of mobile phone usage on agricultural production in Africa. *Cogent Food & Agriculture*, 9(2), 2273634.
- Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. *African journal of emergency medicine*, 7(3), 93-99.
- Fiedler, M., Hossfeld, T., & Tran-Gia, P. (2010). A generic quantitative relationship between quality of experience and quality of service. *IEEE Network*, 24(2), 36-41.
- Finley, B., Boz, E., Kilkki, K., Manner, J., Oulasvirta, A., & Hämmäinen, H. (2017). Does network quality matter? A field study of mobile user satisfaction. *Pervasive and Mobile Computing*, 39, 80-99.
- Ganesh, M., Deo, S., & Devalkar, S. K. (2024). Leveraging digital technology to improve monitoring and planning in public sector supply chains: Evidence from india's food security program. *Production and Operations Management*, 33(4), 861-879.
- GFSI (2023). Global Food Security Index. Accessed on 26 July 2024 from: <https://impact.economist.com/sustainability/project/food-security-index/explore-countries/malawi>
- Hemming, D. J., Chirwa, E. W., Dorward, A., Ruffhead, H. J., Hill, R., Osborn, J., Langer, L., Harman, L., Asaoka, H. Coffey, C., & Phillips, D. (2018). Agricultural input subsidies for improving productivity, farm income, consumer welfare and wider growth in low-and lower-middle-income countries: a systematic review. *Campbell Systematic Reviews*, 14(1), 1-153.
- ITU (2023). Framework of Internet related performance measurements. Accessed on 26 June 2024 from: <https://www.itu.int/rec/T-REC-Q.3960-201607-I>
- ITU (2024). Digital Development Dashboard. International Telecommunication Union. Accessed on 26 June 2024 from: <https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx>
- Jones, D. (2016). On-farm crop species richness is associated with household diet diversity and quality in subsistence and market-oriented farming households in Malawi. *The Journal of Nutrition*, 147, 86-96.
- Kabuli, A., Enokenwa Baa, O., & Davis, K. (2024). *A landscape analysis of youth engagement in agripreneurship in Malawi*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Diversification in East and Southern Africa. pp. 1-26.

- Katengeza, S. P., Okello, J. J., & Jambo, N. (2013). Use of mobile phone technology in agricultural marketing: The case of smallholder farmers in Malawi. In *Technology, Sustainability, and Rural Development in Africa* (pp. 102-112). IGI Global.
- Kaumbata, W., Banda, L., Meszaros, G., Gondwe, T., Woodward-Greene, M., Rosen, B., van Tassell, C., Solkner, J., & Wurzinger, M. (2020). Tangible and intangible benefits of local goats rearing in small farms in Malawi. *Small Ruminant Research*, 187, 1-8.
- Kerr, R. B., & Patel, R. (2014). Food security in Malawi: disputed diagnoses, different prescriptions. In *Food Security and Development* (pp. 221-245). Routledge.
- Luhanga, L. (2024). Examining handover success rates in mobile telecommunications: Insights from Airtel Malawi Plc and Telekom Networks Malawi (TNM), Malawi. *i-Manager's Journal on Wireless Communication Networks*, 12(2), 1-9.
- Makoza, F. (2017). Power relations among stakeholders in the implementation of National ICT Policy: Case of Malawi. Unpublished PhD Thesis, University of Cape Town, Cape Town, South Africa.
- Makoza, F. (2021). Critical analysis of Telecommunications regulatory governance in Malawi. *International Journal of Interdisciplinary Telecommunications and Networking (IJITN)*, 13(1), 49-67.
- Makoza, F. (2022). Analysing a transnational advocacy network of internet data affordability in Malawi. *International Journal of Political Activism and Engagement*, 10(1), 1-18.
- Makoza, F. (2023). Analyzing policy change of Malawi ICT and Digitalization policy: Policy assemblage perspective. Working Paper ICTD, No. 08/23, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg. pp. 1-22.
- Makoza, F. (2023b). *The effects of media narratives on national identity cards system strategies of Malawi* (No. 05/23). Working Paper ICTD. ZBW – Liebniz Information Centre for Economics, Kiel, Hamburg. pp. 1-20.
- Matinmikko, M., Latva-aho, M., Ahokangas, P., & Seppänen, V. (2018). On regulations for 5G: Micro licensing for locally operated networks. *Telecommunications Policy*, 42(8), 622-635.
- MCI (2024). GSMA Mobile Connection Index. Accessed on 04 July 2024 from: <https://www.mobileconnectivityindex.com/>
- Mgomezulu, W., Chitete, M., Maonga, B., Dzanja, J., Mulekano, P., & Qutieshat, A. (2024). Agricultural subsidies in a political economy in a political economy: Can collective action make smallholder agriculture contribute to development? *Research in Globalization*, 8, 1-10.
- Mgomezulu, W., Chitete, M., Maonga, B., Kachingwe, L., Phiri, H., Mambosasa, M., & Folias, L. (2024). Does shifting from subsistence to commercial farming improve household nutrition and poverty? *Research in Globalization*, 8, 1-8.

- Muyanga, M., Nyirenda, Z., Lifeyo, Y., & Burke, W. (2021). *The future of smallholder farming in Malawi*. Working Paper No. 20/03, Mwapata Institute, Lilongwe, Malawi. pp 1-51.
- Noor, R., & Khorsandroo, S. (2019). Quality of experience key matrices framework for network mobility user. *International Journal of Physical Sciences*, 6(28), 6521-6528.
- Nyirenda, Z., Chigaru, F., Nyondo, C., Khonje, M., Wineman, A., & Muyanga, M. (2021). *A Rapid Assessment of the Implementation of the 2020/21 Affordable Inputs Program in Malawi*. Working Paper No. 21/04, Mwapata Institute, Lilongwe, Malawi. pp. 1-24.
- Nyondo, C. J., Nyirenda, Z., Sentala, T., Muyanga, M., Mkumbwa, S., & Burke, W. J. (2021). *The 2020/21 Affordable Inputs Program: Key Implementation Issues and Messages*. Policy Research Brief No. 12. Mwapata Institute, Lilongwe, Malawi. pp.1-6.
- Nyondo, C., Khonje, M., Mangisoni, J., Burke, W., Ricker-Gilbert, J., & Chilora, L. (2021). *Lessons learnt: promises, achievements, shortcomings and pitfalls of input subsidy programs in Malawi*. Mwapata Institute, Lilongwe, Malawi. Working Paper 21/05. pp. 1-29.
- Pattnaik, A., Mohan, D., Chipokosa, S., Wachepa, S., Katengeza, H., Misomali, A., & Marx, M. A. (2020). Testing the validity and feasibility of using a mobile phone-based method to assess the strength of implementation of family planning programs in Malawi. *BMC Health Services Research*, 20, 1-9.
- Ragasa, C., Aberman, N., & Mangote, C. (2019). Does providing agricultural and nutrition information to both men and women improve household food security? Evidence from Malawi. *Global Food Security*, 20, 45-59.
- Ragasa, C., Carrillo, L., & Balakasi, K. (2022). *Farmer's perspectives on the implementation of the Affordable Inputs Programme: Insights from nationally representative households and community surveys*. Project note, International Food Policy Research Institute, Lilongwe, Malawi. pp 1-8.
- Sichoongwe, K. (2023). Is it time for Malawi to change its economic growth engine? Evidence from new structural economics. *Journal of Management Small and Medium Enterprises*, 15(3), 83-494.
- Speedchecker (2021). Malawi November 2021 Speed checker. Accessed on 20 November 2023 from: <https://insights.speedchecker.com/africa/malawi/mw-november-2021/>
- SPGI (2023). Global network speed index. Accessed on 20 November 2023 from: <https://www.speedtest.net/global-index/malawi#fixed>
- Sutherland, E. (2016). The case study in telecommunications policy research. *Info*, 18(1), 16-30.
- Tostensen, A. (2017). *Malawi: A political economy analysis*. Norwegian Institute of International Affairs.
- Tufa, A., Alene, A., Ngoma, H., Marennya, P., Manda, J., Matin, M., Thierfelder, C., & Chikoye, D. (2023). Willingness to pay for agricultural mechanisation services by smallholder farmers in Malawi. *Agribusiness*, 40, 428-276.

- UNDP (2024). Human Development Reports – Malawi. United Nations Development Programme (UNDP). Accessed on 18 June 2024 from: <https://hdr.undp.org/data-center/specific-country-data#/countries/MWI>
- Van der Straaten, J. (2020). Identification for Development It Is Not: ‘Inclusive and Trusted Digital ID Can Unlock Opportunities for the World’s Most Vulnerable.’-a Review. Available at SSRN 3742736.
- Walls, H., Johnston, D., Matita, M., Kamwanja, T., Smith, R., & Nanama, S. (2023). The politics of agricultural policy and nutrition: A case study of Malawi’s Farm Input Subsidy Programme (FISP). *PLOS Glob Public Health* 3(10): e0002410. <https://doi.org/10.1371/journal.pgph.0002410>