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MDR_THESIS

UBERISATION OF MECHANISATION; WHAT ARE THE FEATURES OF AND CONSTRAINTS TO THE FUNCTIONALITY OF MATCHMAKER TRACTOR HIRE PLATFORMS IN GHANA?

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Abstract

Tractor-hire services are integral in Ghana, as they provide farmers with access to much-needed mechanisation services. A vast number of farmers rely on these services for their day-to-day operations. Excitingly, matchmaker tractor-hire platforms, often referred to as "Uber for tractors," have made their debut in the country. It has been argued that such platforms have the potential to revolutionise tractor rental services in Ghana. Knowledge of their mode of operations, what constitutes them, and the constraints they face is crucial. Yet, information on how these platforms operate in the country and their impact on agriculture as digital platforms appear scarce in related literature on the global South. Using Trotro Tractor, one of the matchmaker platforms as a case study, this thesis answers the research question: ***What are the features of the matchmaker platform, and what constraints affect its use?*** As an explorative study, we conducted 23 interviews with actors engaged on the Trotro tractor platform and actors in the local tractor network. Project documents were also analysed. The findings showed that the platform started operations in 2016, underwent several modifications in its establishment and collapsed in 2020. During this time, the platform brought together a novel assemblage of human and non-human actors who delivered tractor rental services to farmers. It reveals the critical role of focal actors (donor agencies) in the translation process of the innovation. On the other hand, the results give grounds for questioning the sustainability of donor-driven initiatives, as the development of the Trotro tractor app on the platform was used to meet donor requirements while farmers and other proposed end users never used it. The findings revealed that the platform faced several challenges and could not introduce any durable changes in the tractor rental market before it collapsed. At least the Uber comparison is not the reality experienced by smallholder farmers. We recommend awareness creation by developers and multistakeholder engagement of the issues surrounding trust among these actors. Developers and practitioners need to understand local realities, for example, farming practices, the literacy level of farmers, other socio-organisational elements, etc, and take them into account when developing such sociotechnical innovations.

Contents

1.0 INTRODUCTION

Mechanisation of agriculture has been identified as one of the main ways through which agricultural production in Sub-Saharan Africa can be increased. Agricultural mechanisation has resurfaced on the development agenda of many African countries, including Ghana (Baudron et al., 2019; Chapoto et al., 2014; Diao et al., 2014). In Ghana, the need to increase agricultural mechanisation has been emphasised by many researchers (Houssou et al., 2013; Kansanga, 2017; Taiwo & Kumi, 2015) over the years as the low level of agricultural mechanisation has been cited as one of the major causes of low agricultural production in the country (with crop yield usually 20-60% lower than the achievable levels) (MoFA SRID, 2019). The call for increased mechanisation is centred on the fact that it allows farmers to overcome some of the difficulty in accessing labour and help them to expand production, which further impact farmers' income levels and livelihoods (Adu-Baffour et al., 2019; Kirui, 2019).

''Agricultural mechanisation has been defined as using animal(s) or mechanical power along the agricultural value chain'' (Daum, Villalba, et al., 2021). In Ghana, tools like pumps, shellers, irrigation equipment, tractors and hammer mills have spread widely throughout and in many African countries (Kirui, 2019). Many researchers, development practitioners and policymakers have elaborated on the importance of the use of tractors specifically and other tools over the years (Adu-Baffour et al., 2019; Diao et al., 2014; Kirui, 2019; Steenwyk et al., 2022). Others, on the other hand, have also criticised agricultural mechanisation, particularly on the marginalisation of labourers resulting from the scale of enlargement of mechanisation.(Daum & Birner, 2020). Daum, Adegbola, et al. (2021) also indicated some adverse agronomic and environmental effects of mechanisation on agriculture, including soil fertility and erosion.

Tractors potentially speed up labour 20 times more than human labour (Steenwyk et al., 2022). Global estimates indicate 200 tractors on average for every 100 km2 of arable land. In Sub-Saharan Africa, the number is as low as 27 tractors per 100 km2 of arable land (Hello Tractor, 2023). In Ghana, the Ghana Data Portal (2023) reports that there are only four (4) tractors per 100 km2 of arable land. Though the International Food Policy Research Institute has noted that this number has been increasing over the years (Chapoto et al., 2014), this number is deficient compared to the global average. As a result, many policies in the past have targeted increasing farmers' access to tractors. In August 2022, the Ministry of Food and Agriculture (MoFA) unveiled and distributed USD 95,495 million worth of agricultural machinery (with most being tractors) to farmers at a subsidised price. Between 2019 and 2020, a total of 8,980 units of various machinery and equipment (with the majority being tractors) were imported and distributed to farmers (MoFA, 2022). Many such initiatives and policies have been employed to increase access to and use of tractors in the country's agricultural sector.

Despite the numerous efforts over the years to promote the use of tractors, the adoption of tractors remains limited, especially among smallholder farmers in Ghana.(Chapoto et al., 2014; Taiwo & Kumi, 2015). This is mainly because the cost of purchasing tractors is expensive for small-scale farmers, while large-scale farmers can afford them (Kahan et al., 2018). This is also the situation in many African countries. This situation further deepens the gap between small-scale farmers, who are usually poor and large-scale farmers (the rich), as the benefit that comes with the use of tractors is only harnessed by the rich. Institutional solutions have been developed

to help small-scale farmers gain access to tractors, though they cannot afford them. One of these solutions is tractor-hire services. In Ghana, it has been reported that about 80% of farmers who use machinery on their farmers access them through such service (Cossar, 2016)

Despite being in high demand, tractor rental services are hampered by many factors: they are ineffective in providing equal access to all farmers, with women and small-scale farmers in disadvantaged positions. This is because farmers activate and operate in their social networks at the community level among themselves and other external agent partners to facilitate tractor access, usually through informal word-of-mouth arrangements (Kansanga, 2017). While such informal networks have been able to provide a lot of services to farmers in Ghana especially in the northern part of the country, they tend to have many disadvantages, including disfavouring vulnerable people, most notably small-scale and women farmers. It has, therefore, been suggested that digital platforms may complement or replace the traditional word-of-mouth process and offer opportunities for more inclusive access.

1.1.0 Matchmaker Platforms and the Process of Accessing Tractor-Hire Service

Digital platforms that seek to offer tractor-hire service to farmers by connecting farmers to tractor owners have been introduced in Ghana recently (Diao et al., 2014). These tractor hire digital platforms are among the increasing introduction of digital platforms in various areas of in the country's agricultural sector. Mentioning a few of these digital platforms introduced in the various sectors, Esoko: providing markets information to farmers, Agrocenta: a mobile merchanting platform connecting farmers with market, Farm radio Ghana: radio and online agricultural extension program providing farmers with broad range of timely information. Examples of matchmaker digital tractor-hire platforms among the recent influx of digital platforms in the agricultural sector include the Hello tractor and Trotro tractor. As a matchmaker digital tractor-hire platforms, they can potentially eliminate the traditional process (word-of-mouth informal arrangements) that threatens equal access for both men and women and small and large farmers as farmers can directly place orders for tractor services on a mobile app and or via USSD short code. The terms ***uber for tractor*** and ***uberization of mechanisation*** have been used to call these tractor hire platforms by the developers of these platforms, as well as by some researchers and policymakers over the years (Daum, Villalba, et al., 2021; Joe, 2017; Roberto & Camacho, 2019; Russell, 2017). The Uber parallel suggests that farmers can access tractors just as easily as city inhabitants can use Uber to request cars, creating a compelling story of change.

However, the demand for Uber cars in the cities is not the same as the demand for tractors in rural areas where the services of these platforms are rendered, as customer density for Uber in the cities is higher than in the village. Also, demand for such tractor hire services is seasonal in many developing countries as farmers practice rainfed agriculture and hence will need the services of a tractor only during the cropping season. Also, unlike driving a car, operating farm machinery is a skill-intensive task, and the quality of the work on the field can be highly variable. Aside these tractor associated factors other issues such as less or the unavailability of network connectivity in some rural areas compared to cities where uber services are rendered

can be a concern, literacy level of farmers required to operate and use such apps is another issue of concern as many farmers in such rural areas are less educated (Daum, Adegbola, et al., 2021; Foote, 2018). These and many other factors might constrain the use of such digital apps.

It is therefore not surprising that even though the informal word-of-mouth network is still surviving in most of Ghana, in a recent interview with the developers of one of these digital platforms (Trotro tractor), it was revealed that though there are success stories surrounding these digital platforms, their platform (Trotro tractor) has halted operations due to some challenges/constraints the platform and it users face. It is, therefore, apparent that these digital platforms are facing some constraints. Understanding these constraints is needed to complement the effort by the government to promote mechanisation in general and for the platforms' performance.

Aside from these concerns, the first study on the matchmaker tractor-hire service, which compared data from Hello Tractor Nigeria and EM3 Agri-Services India, revealed that farmers who accessed services from these platforms did so through booking agents and other third parties due to several challenges (Daum, Villalba, et al., 2021). This casts some doubt on the potential of the platforms to bridge the unequal barriers in accessing tractor services as there is no evidence that agents and other intermediaries and the entire process of accessing services through this platform are fair to smallholder farmers and women. It must also be noted that Daum, Villalba, et al. (2021) identified significant differences in the features (structure, mode of operation and impact made) of the two matchmaker platforms they studied.

Considering the above concerns, it is necessary to understand how these platforms have been operating in Ghana, the dynamics involved, the impact these platforms are making and the constraints that hinder the operation of their work.   This knowledge is needed to complement the efforts made by the government to ensure farmers have access to tractor services and is needed for the upscaling of these tractor rental platforms. Against this background and Using Trotro tractor (one of the matchmaker digital platforms) as a case study, we premise this study on the question, ***What are the features of the matchmaker platform and what constraints affect its use of it?***

1.2.0 Problem Statement

The uber tag to these tools has made them receive increasing attention over the years for their ability to address some of the challenges being faced by poor farmers in the developing world in terms of agricultural mechanisation and their being able to achieve some success in getting small scale farmers to use them and assisting these farmers (Daum, Villalba, et al., 2021; Foote, 2018; Roberto & Camacho, 2019; Russell, 2017). Far from these tales, however, as revealed above, some of these platforms face constraints that hinder their operation and adoption of their services by potential users. Understanding the constraints to using these Uber-like platforms is essential for informed decision-making on addressing and upscaling these services. Also, very little is known about the design features of these platforms, the way they are envisaged to work and how they operate in reality.

In Ghana, there are numerous studies on the access and use of digital tools in agriculture (Agu, 2013; Al-Hassan et al., 2013; Munthali, 2021). These studies have focussed on many digital tools in different aspects of agriculture in Ghana. For example, while Munthali (2021) studied the importance of Interactive Voice Response (IVR) outbound, Data Management (DaM) and social media messaging technology to agricultural extension in Ghana, Al-Hassan et al. (2013) Focussed on the impact of the information communication technology (ICT)-based market information service (MIS) on farm households in Ghana. Despite the numerous general studies on digital agricultural platforms, the matchmaker tractor hiring platforms since their introduction in 2016 have not been very holistically researched (Daum, Villalba, et al., 2021; Roberto & Camacho, 2019). No study has investigated how farmers, or their targeted consumers have used or adopted these innovations, how these platforms operate and the constraints to using these digital platforms. This can be an issue since success stories surrounding it might encourage political complacency if they imply that the platforms have remedied the problems associated with tractor rentals in Ghana (Daum, Villalba et al., 2021). For example, policymakers, donors and more might not seek alternative solutions to address the problems of accessing tractors or even address the issues the platforms face if they are not investigated.

The only study (Daum, Villalba, et al., 2021) which looked at the potential of these platforms in the sub-Saharan sub-region compared data from Nigeria and India and reported geographical differences in the factors they outlined and recorded some differences between the platforms they studied. It is, therefore, essential to learn how these workouts in Ghana. Moreover, their study examined these potentials from a transaction cost economics perspective. While this perspective gives insight into the cost efficiency of using these digital tools, it fails to look at the role of actors in using the platforms, though it acknowledges the presence of multiple actors on the platform. However, the use of digital agricultural platforms is not only dependent on the cost efficiency of the platform. The interactions among actors define access to and use of digital agricultural platforms (Birke & Knierim, 2020; Smidt & Jokonya, 2022). Hence, it is necessary to investigate the matchmaker platform, its structure (actor-network), mode of operation, impacts and its constraints from the actor interaction perspective using the Trotro tractor as a case study. However, one cannot understand these without first understanding the traditional/long-existing informal word-of-mouth arrangement they seek to replace. Hence, we will explore these using the Trotro tractor (one of the matchmaker platforms) as a case study and also study the local rental network it was supposed to replace in one of the areas (Nkoranza South Municipality) the platform operated.

2.0 THEORETICAL FRAMEWORK

This chapter of the study will discuss the theoretical framework adopted for this study and operationalisation of the framework. Following the argument made above that matchmaker platforms are made up of a network of actors and their interactions determine the use of the platform, the Actor-Network Theory and the framework by sumburg (2005) were deemed as appropriate to provide a lens to look through. Each of these frameworks is elaborated upon in this chapter, and we have argued that these frameworks complement each other. In section 2.3 of this chapter, further elaboration on how these concepts are combined and used in this thesis is presented.

2.1.0 Actor-Network Theory (ANT)

For farmers to benefit from the numerous potential that comes with the use of tractors-hire services and for the benefit to be equally distributed, both men and women, smallholder and large-scale farmers, should have equal access and be able to adopt/use tractor-hire services. However, people's ability to access and use digital agricultural services is a function of many factors (Agu, 2013; Tata & McNamara, 2016). These factors relate to adoption differently in different geographical locations (Ankrah et al., 2020; Daum et al., 2021). Daum et al. (2021) conclude that the structure of matchmaker platforms is a significant factor, among others, that influences farmers' ability to access and use such platforms. Its structure comprises multiple actors including human and non-human actors (farmers, agents, service providers, mobile apps, mobile phones, USSD codes, and more) who depend on each other and work connectively to ensure the functionality of the platforms. The multiple actors (re) define one another through interactions on the platform, and their interactions are defined by how the platform is designed. This means farmers' access to and use of these platforms depends on each actor's ability to work, the relationship among the actors and the structure/design of the platform, which also defines the relationship among the actors.

Hence, to holistically understand the features (structure, mode of operation, impact) of this platform and the constraints that affects it uses, one needs to understand the following:

> ***First***, how is the platform structured (how it works, where, when, and who are the actors engaged, and how do they relate to each other)? How does this differ from the structure and mode of operations of the local/traditional actor network?

> ***Second,*** as argued above, the structure of this platform is redefined over time through interactions by the actors engaged in it. This redefinition/evolvement plays a significant role in using the platform later. Hence, to understand the platform's functionality, knowledge of these evolvements is crucial.

> ***Third***, understand the factors that constrain the use of the platform. In this study, we argue that these factors impede the interactions among the actors on the platform. For example, if farmers rely on agents to book services on the platform, trust between these actors is needed for cooperation (Daum, Villalba, et al., 2021). If tractor owners use GPS devices for tracking, then the absence of network impedes this functionality, as GPS device needs the network to function.

To explore the above-posed questions, we employ the ANT. ANT is a sociological theory that emerged in the 1980s and 1990s, primarily developed by Michel Callon, Bruno Latour, and John Law. The theory states that the functioning or adoption of innovations/socio-technical systems depends on interaction between actants and actors. While **actants** affect action, including inanimate objects (thus, non-human actors also have **agency**), **actors** are agents with motivation or willpower, usually humans. In essence, innovations' functionality depends on the interactions (**network**) between human and non-human actors. The theory further states that the actors' agency resides in their connections and relations (networks) with each other and not in the actors themselves. The actors enact themselves or affect each other's agency through their relations and these relations. Thus, actors in the network are (re)defining one another through interactions, which sum up the functionality or ability of people to use the innovation (Akrich, 1992; Mol, 2010). For example, if tractor owners use GPS tracking devices to track their tractors and to know the work done by their tractors on a farmer's farm, then the GPS device becomes a non-human actor like the tractor itself. This shows that multiple interrelated technologies often come together for the usability of socio-technical innovations. In this case, the GPS device will form part of the network of actors and the agency of tractor owners to track their tractors is enacted through their connections with the GPS device on the platform. Hence, their ability to use the platform depends on their connection with the GPS device.

The main goal of ANT is to research and theorise about how networks emerge, what associations they contain, how they move, how actors are enrolled on them, how they come to be as a whole, and how they stabilise temporarily (Callon, 1986; Doolin & Lowe, 2016; Mclean & Hassard, 2004). According to ANT, if any actor is enrolled in or withdrawn from the network, this will have an impact on how well the network functions as a whole(Doolin & Lowe, 2016). However, networks constantly change since social reality is considered complex and fluid.

Hence, from the ANT perspective, understanding the research questions above is understanding the actors engaged on the platform and their network. Using ANT, we can explore these by

Identifying the actors: Here, it is essential to consider all the stakeholders (both human and non-human) involved. These may include the platform owners and developers, tractor owners, farmers, GPS systems, mobile apps, the algorithm used by the apps, payment processing systems, etc., engaged in both the traditional and digital matchmaker platforms.

Map out the network: Once the actors have been identified, the next step is to map out their relationships. This includes understanding the connections between actors and how they interact with one another.

The theory further emphasises the concept of **script and translation**, which refers to how the developer brings the actors' interest to align ('script' of what they should do to each other) and how they practice this aligned text. In this study, it can be likened to the roles of actors based on the platform's usability. The developers of the platform define these roles. The practice of this role determines how people would gain access to the platform, which differs from the platform (Callon, 1984). Here, we will consider how the inscription has changed the process of accessing tractors-hire services by farmers. The concept of **translation** is employed in ANT to

understand how developers bring actors' interests to align and how the network is reconstructed over time. Table 1 summarises the four phases of translation. (Callon, 1986).

Table 1: Description of Phases of Translation

Problematisation	The developer defines problems, objectives, and functions of other actors in the context(Callon, 1986)
Interessement	To enforce and stabilise the interests identified during the problematisation phase, the initiator uses various tools and actions, such as discussions, to persuade the players that the interest defined is in line with their interest. (Callon, 1986)
Enrolment	A successful interessement strategy leads to the enrolment of different actors into the newly established actor network. The actors organise themselves, take up their roles and expresses their interest(Callon, 1986)
Mobilisation	The mobilisation phase revealed whether the actors' commitments to their roles on the platform were fulfilled and maintained after the establishment of the platform (Callon, 1986).

2.1.1 Sumberg's Theory of Constraints to the Adoption of Agricultural Innovations

Sumberg, (2005) developed a framework for analysing constraints to the use/adoption of innovations. The framework claims that constraints to the use of innovations by actors are dependent on two categories of factors. The ***endogenous factors*** reflect the degree of goodness-of-fit between the innovation and the targeted group of potential users (in the case of Trotro actors engaged on the platform). According to the framework, 'goodness-of-fit can, at least in principle, be specified, modified, and verified during the innovation's design and development process' (Sumberg, 2005). In the case of the Trotro tractor platform, we argue that endogenous constraints are constraints or challenges to the platform operation, manifested by affecting the agency of actors on the platform, that could have been, in principle be modified by the actors engaged on the platform by their actions and inactions through the development process.

The ***exogenous factors*** are 'prerequisite conditions' as they are required for adoption but are, to all intents and purposes, outside the control or influence of the innovation-development process'. (Sumberg, 2005) Here, we argue that exogenous constraints are challenges to the platform's functioning, manifested by affecting the agency of actors on the platform, and cannot be modified by the actions and inactions of actors engaged in the platform.

To study these prerequisites and other factors that affect the agency of actors or the relationship among actors we expand the fourth research question to; *What endogenous and exogenous factors constrain actors' agency on the Trotro tractor platform?*

The problem mentioned above led to the formulation of the main research objective to bring to light constraints affecting the usage of matchmaker platforms in Ghana. This led to:

2.2.0 General Research Question
What are the features of the matchmaker platform and what constraints affects its use?

2.2.1 Sub research questions

1. How is the actor network involved in the Trotro tractor platform structured?
2. How has the structure of the actor network in Trotro tractor platform evolved and what processes of translation can be observed?
3. How has the process of accessing tractor rental services been changed by the Trotro tractor Platform?
4. What endogenous and exogenous factors constrain actors' agency on the Trotro tractor platform?

2.3.0 Integrated Analytical Lense

In this thesis, we brought together the strength of two different theoretical frameworks elaborated on above to holistically study the factors that influence the agency of engaged actors on the Trotro tractor platforms. The thesis premise on the argument that sociotechnical innovations like the Trotro tractor are not in isolations but made up of a network of actors and actants. And this network is influenced by endogenous and exogenous conditions. Part of these factors can be altered by the actions and inactions of actors engaged on this network (endogenous) whereas others cannot be modified by the actors (exogenous). The interactions in the network of actors can be understood from the Actor-Network Theory perspective. And the other factors that influence this network can be understood by the exogenous and endogenous factors described by Sumberg, (2005).

Figure1 below. Illustrate this lens applied for this research: An overview of different actors (both human and non-human) brought together by developers of the platform to form an actor-network. In this network are human and non-human actors influencing and (re)defining each other. Illustrated by the dashes in the diagram. The figure also seeks to illustrate that the network among the actors is being influenced by the factors talked about in Sumberg 2005. The figure suggests a reciprocal relationship between the network among the actors and the endogenous factors. Meaning that actors in the network can influence these endogenous factors by their actions as they also influence the actor agency. However, the relationship between the exogenous factors and the network is one-sided, where only the factors influence the network. We, therefore, argue that the functionality and useability of this platform depend on how the structure (actor-network) function together as a whole.

Figure 1; Analytical Lens

Network of Actors
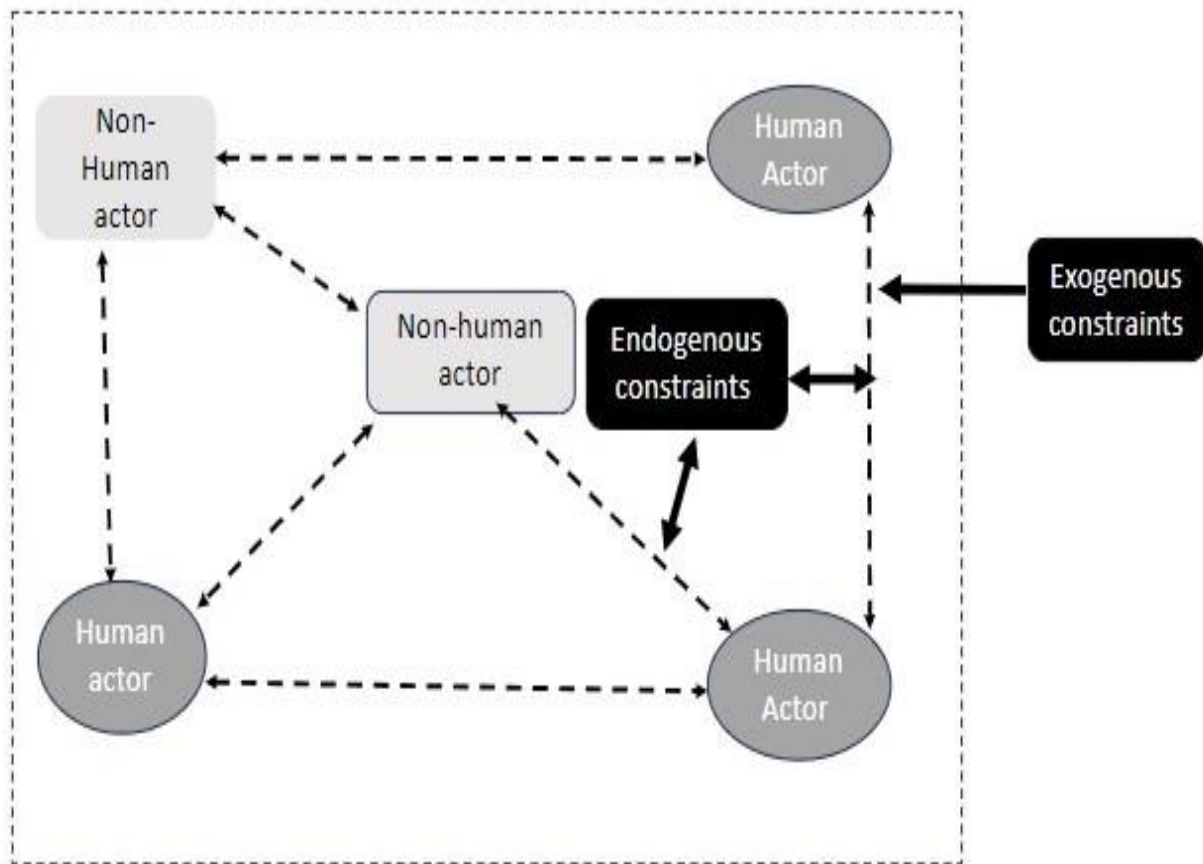
3.0 METHODOLOGY

A discussion of the methodology used in this research is presented in this chapter. This starts by discussing the general method (case study) I employed in this research. Then, a discussion on the specific techniques (interviews, focus group discussions, contents analysis of website and documents) employed for data collection and the sampling method used for reaching our respondents. Then, we end the chapter by presenting the background knowledge of the case Ostudy (Trotro tractor platform) and the specific study area (Nkoranza South Municipality).

This thesis used the case study approach, with the case being the actors engaged on the Trotro tractor platform to rent tractors to farmers in general but with an in-depth understanding of its operations in the Nkoranza South Municipality. It is essential also to note that, since this study is among the first to look at matchmaker tractor-hire platforms in Ghana, this research was explorative. Thus, though our research questions guided us, there was room for initiative and innovativeness in the field. This made it easy for us when we had to change the research focus one month into data collection. The study started with the vision of assessing how actors use the Trotro tractor app and the impact this innovation has had on tractor access in the selected study area. However, the focus on the app alone changed one month into data collection after we realised that the Trotro Tractor app did not function as expected. Thus, though the app existed as part of the broader platform that provided tractor rental services to farmers, it was never used by actors who accessed services from the platform. This rendered a change in the research focus and our interview guide.

3.1 Methods of Data Collection and Data Analysis

This thesis used multiple data collection methods to reach its findings. These methods included interviews, focus group discussions, and content analysis of website and project documents. Once the research population was identified, we started by conducting our interviews. The research population is generally an assemblage of individuals with similar characteristics that are the focus of scientific research (Explorable, 2009). In this study, the population included actors engaged on the Trotro tractor platform and actors in the informal tractor rental services at Nkoranza South Municipality. Because the snowball sampling method was employed in this thesis, most of our actors were identified in the field.

The study kicked off by interviewing developers of the Trotro tractor platform. After the second interview with the developers, we analysed the interview and identified the actors (human and non-human) engaged on the platform. This analysis was done simultaneously with the analysis of information on the platform's website. This helped us to develop a temporal structure (actor network) of the platform. During our third interview with the developers, we presented this temporal developed platform structure to the developers. Consequently, we engaged in a participatory mapping exercise in the third interview, where the researcher and developer tried to map out all the human and non-human actors engaged on the platform, their relations with each other, and their roles on the platform. During this interview, we found that the Trotro tractor app was not used by end users to access services from the platform; hence, we needed

to switch our research focus. Using the snowball sampling method, we asked the developers for a contact list of all the human actors engaged on the platform. We used the snowball method because it is preferable when a researcher has limited knowledge of the study population. Moreover, among the most prevalent sampling methods used in qualitative research data collection. (Etikan & Bala, 2017; Parker et al., 2019). With our limited knowledge of the actors, asking developers for this data was appropriate. Further interviews were conducted with some of the identified actors (members of FBOs and field agents) engaged on the platform.

We ensured that our sampling and interviewing of actors were purposive enough to reach the a diverse set of people, and follow-up probing was conducted to ascertain the information received in our interview. This was done to ensure that there were no imbalances associated with our data snowball sampling approach, which has the tendency of sample balance depending on the gatekeeper, in this case, the developers. (Etikan & Bala, 2017).

With regard to the local network of actors engaged in the tractor rental services in Nkoranza South, the district agricultural office was the gatekeeper for this study. Through our interview with the district director of agricultural extension, we mapped out the actors engaged in the local network and later interviewed representatives of these actors. In what follows, details of the methods employed are presented.

Interview: To gain deeper insight into the networks mapped out in our interviews with developers of the Trotro tractor and the district director of agricultural extension at Nkoranza South, further interviews were conducted with the actors identified in both networks. To understand the impact of the platform in the process of accessing tractor rental services as well as to understand how the platform has evolved over time, interviews were conducted with selected representatives of each of the actors identified through interviews with developers. However, to determine the changes brought by the platform into the process of tractor renting, we first assessed the existing local networks in Nkoranza by also interviewing the actors engaged in this local network as identified by our interview with the agricultural extension director of the district. We employed semi-structured interviews with an interview guide to keep the focus on our research questions, allowing the interview to stay on track. Hence, an interview guide was developed before interviews were conducted with stakeholders. We chose to conduct semi-structured interviews because they allowed us to focus on the topic of interest and check our time while leaving as much room as possible for participants to share what they feel is essential. The interview time lasted between 15mins to 45mins. In total, 23 interviews were conducted with actors in the local network and the Trotro tractor platform.

Focus Group Discussions: The focus group discussion was used as a follow-up after having individual interviews with the FBO members who used services from the Trotro platform. This was to discuss the findings of the individual interviews in a group certain and to see how this sit with them as a group. It also brought the group perspective to the findings as the group navigate the result and made additional contributions to these results. However, it must be noted that we used this section just to confirm the findings in the individual interviews and the data from this section was not analysed for this thesis.

Contents Analysis Of Website And Documents: Documents (Du1) on the establishment of the platform were available with useful information that informed the direction of this study. This document were analysed together with information from the website (Trotrotractor.com) of the platform

Table 2: Overview of people interviewed participants		
Actors on the Trotro tractor platform interviewed		
(D) Developers	Gender	Educational level
D1	Female	Tertiary
D2	Female	Tertiary
D3	Female	Tertiary
Field officers		
F1	Male	Tertiary
F2	Male	Tertiary
FBO members		
FB1	Female	Tertiary
FB2	Female	Senior High School
FB3	Female	No formal Education
FB4	Male	Senior High School
FB5	Male	Senior High School
FB6	Female	No formal Education
Actors in the local network in Nkoranza		
AEA (Agricultural extension director)	Male	Tertiary
TN (Tractor Owner and President of NATOA)	Male	Tertiary
T1 (Tractor Owner)	Male	Tertiary
Tractor operators		
TP1	Male	No formal Education
TP2	Male	No formal Education
TP3	Male	Senior High School
Farmers		
F1	Female	Senior High School
F2	Male	No formal Education
F3	Male	Tertiary
F4	Male	Junior High School
F5	Male	No formal Education
F6	Female	No formal Education
Documents		
DU1		

3.2 Data analysis

The analysis of the data gathered from the interviews with different respondents, project documents, and the website of Trotro tractor was conducted using a coded cards/stickers. A coding system was predetermined before the analysis started using various color codes of stickers and positions (*see figure DA1*). This made the data analysis process easier as predefined categories of themes and variables are established. Then sections of the data that falls under these defined categories are pasted in their respective categories. It was also easy to move around the stickers. We employed timelines for this data, starting with the History of Trotro Tractors, followed by Trotro Tractor in Practice and the Non-Formal/Local Network. These broad themes had specific variables under them. See *figure DA2* illustrating how these themes and variables were employed. Where an information fall under one or two of these variables, the sticker containing this information is passed under both variables and analysed later. Pasted stickers was moved around once they were deemed to be in under another variable.

Also, we mapped out the network of actors coded cards which allowed us to move around the actors in attempt to determine their positions and roles in the network they find themselves. The findings of this analysis are presented in result chapters 4,5 and 6.

Figure DA1: A picture depicting data analysis process having coded stickers on a wall.
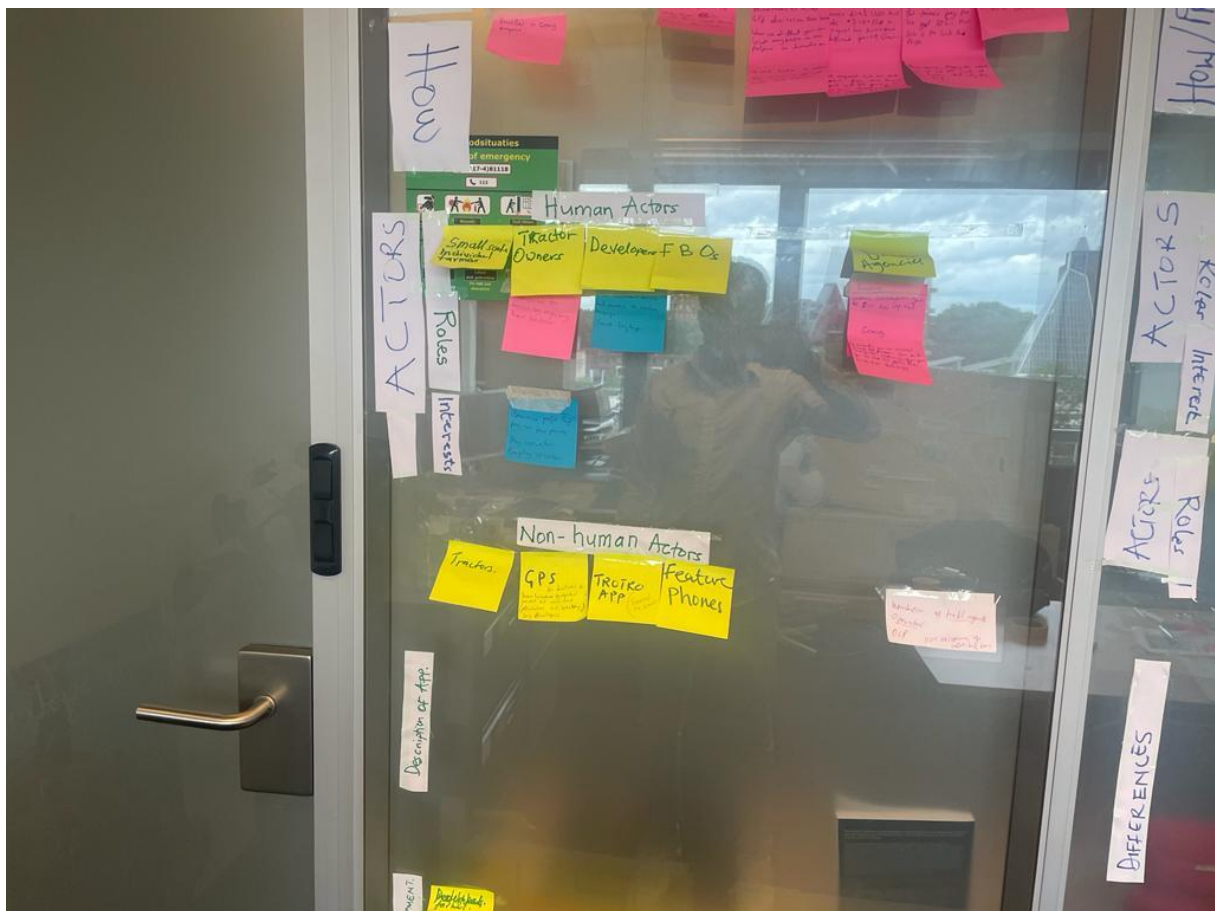
Figure DA2: A picture of themes and variables predetermined for the data analysis.

3.3 Data Management

This thesis follows the Code of Conduct of Scientific Practice (Association of Universities in the Netherlands, 2012) and the Integrity Code of the WUR (Executive Board, 2014). All respondents of this study were asked for their informed consent, either by signing a consent form or giving oral consent. Also, participant's consent was sought before any recordings were made. Thus, the purpose of the study was explained to participant as well as explanations were given to participants on how and what data being gathered from them would be used for. After these participants willingly and free agreed to participate in this study. In cases where pictures were taken, participants consents were sought before it was taken. And if anyone disagreed the pictures were not taken. The recorded data was kept in teams with the researcher being the only one with access.

3.3 Background Information on Trotro tractor Platform.

Trotro tractor is a matchmaker tractor hiring platform that connects farmers to tractor owners and operators for farmers to rent their tractors for working on their farms. Farmers can request, schedule and **prepare** for tractor services**.** The platform also allows tractor owners to track the location, movement, and work progress of their tractors. According to the developer of the Trotro tractor, they developed this platform to solve a problem they identified in the Ghana agricultural sector. Most farmers who needed ploughing services were unable to reach out to the few mechanization centres that existed (Trotro Tractor, n.d.).

As a business entity, it has expanded to five additional countries since its inception in 2016. It now has offices in Ghana, Benin, Zambia, Zimbabwe, and Nigeria. It is currently serving 65000 farmers with about 3200 tractors (Maduenyi, 2022). After registration, farmers were supposed to order tractor services using the same registration process. However, farmers pay for the services using mobile money during the order process. The order hits the app dashboard, and the app automatically allocates the order to the tractor nearest to the farmers' farm location. Tractor owners get a notification and deliver the service to the farmers within 72 hours from the time of the order.

The platform is owned by an agricultural technology company that claims to improve global food and income security by establishing a network of "TROTRO Tractor" owners, which farmers can access via SMS to obtain affordable farm machine services. According to their website, this approach enables small landowners to enhance their productivity.

4.0 RESULTS: LOCAL TRACTOR RENTAL SERVICES

To gain an in-depth understanding of the impact or changes that of Trotro tractor might have introduced into the process of rental tractors we first needed to understand the local tractor rental network prior to the arrival Trotro tractor, mode of operation, actors engaged, and the constraints faced in this local network. We zoomed in on Nkoranza South Municipality, an area where Trotro tractors rendered services to farmers. In this chapter of results, we present to local tractor rental network in Nkoranza South municipality.

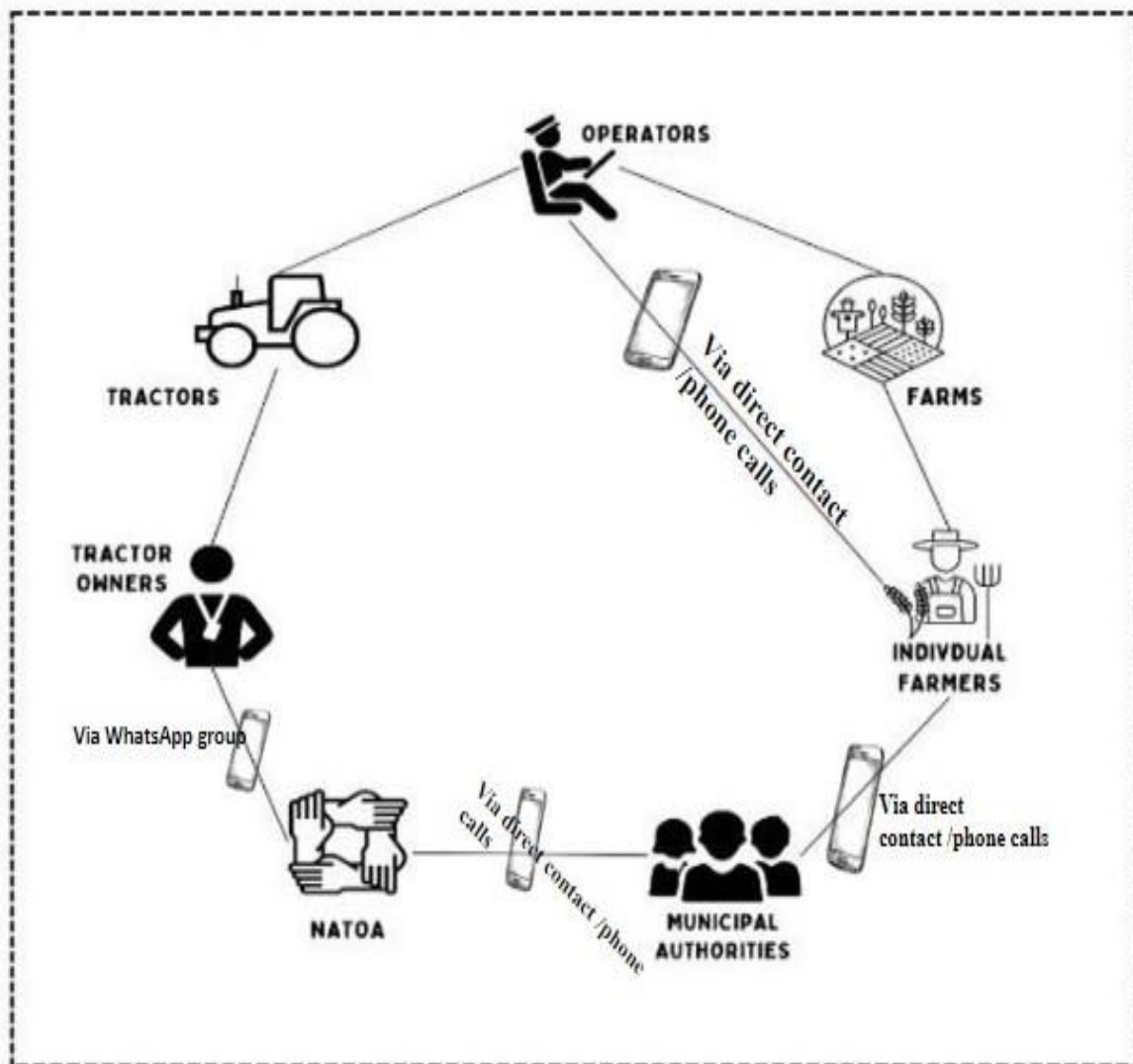Figure 2: Network of actors within the local tractor rental services.

Table 3: Actors, Roles, Interests, that guide the involvement of local network actors.

Actors	Roles	Interest
Tractors	For ploughing	
Farms	To be ploughed and cultivated	
Phones	Used for making calls	
Individual Farmers	Request for service from operators	Ploughing at the right time to obtain a good yield
Municipal Authorities	Establishment of service prices. Forth regulations governing the usage of local roads Enforcement of regulations on road usage	Looking out for the interest farmers and their roads
NATOA	Establishment of service prices Enforcement of regulations on road usage on behalf of tractor owners	Looking out for interest of tractor owners in price setting. Sustainability of road.
Tractor Owners	Give out their tractors for rental services	Making enough profits with their tractors
Operators	Operate the tractors	Earn money

4.1 Local Actor-Network in Nkoranza

Figure (6) below illustrates the intricate network of actors within the local tractor rental services. This network encompasses a diverse range of actors, both human and non-human, each playing a crucial role in this local network's functionality. Among the human actors are individual farmers, tractor owners, tractor operators, the municipal authorities, and a significant entity known as the Nkoranza Tractor Owners Association (NATOA); an association of tractor owners within the municipality. This association has all tractors owners operating in the municipality as it members. It is recognized by the municipal authorities as the official representative body for tractor owners hence the municipality deals with tractor owners through this association. According to the president of the association they meet twice every year for and as many as needed when there are issues to be addressed. Each of the human actors possesses distinct interests and fulfils specific roles essential for the seamless operation of this local network.

The non-human actors on this network are the tractors, mobile phones and the farms. These non-human actors poses agency in the network and perform roles that are essential for the network's functionality. The above table (Table 3) provides a comprehensive summary of these roles, interests, and the inclusion criteria that guide the involvement of local network actors.

As a fundamental actor of this network, Tractor owners primarily provide rental services, while farmers emerge as the consumers of these services. Notably, farm size does not serve as a strict criterion for farmers to access tractor operator services. However, farm size may influence the speed at which one gains access within this network. A tractor operator TP1 explains; [….] If I have two farmers that comes to me for my services, I will always look at the one that will give me more money at the end. And you know the bigger the farm size the more money I make, so

I will first plough the one with larger farm size and later plough that of the smaller farm size. However, if it is only one person at that time then the farm size does not matter. A local farmer F6 expresses concern; We with the smaller farm sizes we only get our farms ploughed after they have ploughed all the large farms. This usually getting to the end of the planting season.

The local network comprises two categories of tractor owners: those hailing from Nkoranza and those originating from Northern Ghana. The former group resides and conducts its operations within the Nkoranza region, while the latter group, primarily based in Northern Ghana, temporarily relocates to Nkoranza solely during the planting season. The district agricultural extension director expresses the importance of having these two groups of tractor owners operate in their district. He (AEA) explains; our local owners rent out their tractors to our farmers but usually the tractors are not enough to render all the services within the planting season, that is why we are always happen when those from the north comes in. Even for that with the two of them combined we are unable meet all the demands, definitely some farmers will not get their farms ploughed by the end of the planting season.

Tractor operators also play a pivotal role in ensuring the practical functionality of these tractors. They are responsible for the hands-on operation of the tractors, using it to plough farmers farms. The network also includes two critical entities: NATOA and the Municipal authorities. These two entities, through a democratic process, establish service prices at the outset of each planting season, which are subsequently communicated to the farming community. AEA explains the process, *just before the planting season begins, the municipality sends a letter to the tractor owners association and request that they propose the price they will take for ploughing an acre; they meet with their members and decide. Then, the municipality will arrange a meeting with them. In this meeting, we deliberate on the proposed price and consider all the reasons given, and then we try to reach a middle point. For example last year, they proposed GHS 300, and after deliberation, we agreed on GHS 250.* Furthermore, the municipal authorities set forth regulations governing the usage of local roads by the tractor operators. The enforcement of these regulations falls under the purview of both NATOA and the Municipal authorities. Operators who fail to comply with these regulations are subject to penalties, including fines and, in some instances, suspension from operating within the area. *We punish our members ourselves before we even report them to the municipality; sometimes, they pay a fine which goes towards repairing the road.* President NATOA (TN).

For the business model of the local network, service prices are established at the outset of each planting season, as previously mentioned. Following this pricing arrangement, farmers contact tractor operators by going to operators houses, making phone calls to them or visiting a designated station early in the morning. Operators Park their tractors at these stations, creating a centralised hub for interactions.

Farmers personally make their service requests to the operators, and the operator retains the discretion to accept or decline based on their business interests. Notably, some operators prioritise specific customers, often those who have utilised their services previously or those with larger farms, as these larger farms typically result in higher revenue. Thus, operators are

paid based on the hectares they plough. Also, this way their owners make more money as the more hectares ploughed, the higher the revenue generated for owners. Farmers compensate the operators once their farms have been worked on. A standard practice within this network is that 10% of the revenue generated from the services provided is remitted to the tractor operators, while the tractor owners retain the remaining 90%. This 90% serves multiple purposes, including covering expenses such as fuel and necessary repairs.

After the planting season, tractor operators relocate their equipment to the northern region of Ghana to offer their services there. This cyclical movement pattern reflects the seasonal nature of agricultural activities and the adaptability of the network to address different geographical needs.

However, it's worth noting that several challenges have been identified within this local network, which will be explored in the following section.

4.2 Challenges Facing the Local Network in Nkoranza

According to the farmers, there is ***very little number of tractors in their area,*** and because they all need these tractors in the same month for ploughing, it is difficult to have all their needs met. Sometimes some farmers do not get tractors to work on their farms; *it happened to me several times, there are seasons I do not get tractors to work on my farmer, but I am not alone in this as many farmers also experience this. We are all looking for services from the few tractors available, what do you think will happen if not this. F6 expresses her concern.* **The AEA also agrees with farmers;** *too much demand against small number of tractors, […] if the government should ask us how many more tractors we want in this area, I would say 50 and above, that is the only way we can plough all the farms in the planting season.*

We want more money so you wish you can plough a lot of farms in the season, but we cannot divide ourselves into two and be working at two places at the same time, the only results is some farmers will not get their farms ploughed at the end of the season and that is normal it happens every year. Tractor operator (TP3)

This situation, According to the farmers further affects crop yield of their farms as they have to cultivate without ploughing. *We get low yield when we cultivate without ploughing but it's the only choice we have in such situations.* (F5)

Though farm size as argued above is not a barrier to accessing services from the local network, it influenced how fast one can get services from operators. Operators worked for farmers with large farm first before they worked for those with smaller farms. According to the farmers (F1, F2 and F6), small farms only get ploughed getting to the end of the ploughing season or sometimes do not get ploughed at all. Interestingly however, almost all interviewed farmers claimed that usually small farms are owned by women hence women do not get access to rental services fast. F3 explains; *it is unfortunate, our women do not have strength so they usually do not cultivate large farm sizes, this make it difficult to access tractor services early.* Tractor operator T1 *agrees with this, yeah it is true, the woman get their farms worked on very late because their farms are small, but that is not our fault, we also need the money to feed our families, so we plough the big farms first, and the men have the big farms.*

Another gender related challenge has identified as to do with the ***issue of bribery***, according to operators, one incentive for them to work on farms include bribing, some farmers bribe them so they can work on their farms first. However, women are described not to be good at giving bribes. *Women do not know how to give bribes, but the men do, women will come to the tractor first but will be there then the man will come and give us something small, we will go and work for the men.* (T1)

Another challenge associated with the local network is ***not having precise measuring method for farm size.*** The actors in this network use traditional measurement methods which are a bit different in different geographical locations. This sometimes bring about disputes as farmers and operators might not agree on the farm size. However, as prevalent as this problem exist, operators and farmers are aware of the differences and compromises when needed. But this usually affect the operators and they express dissatisfaction with it; *Farmers sometimes gives you 1.5 acres as one acre and that is not good, but you just have to accept and work with.* (TP3).

However, farmers also thinks that the operators want to cheat them on their farm size so they can make more money. Farmers believed their measurement is the right way to go. *My farm size is 3 acres, and it has always been, but these operators come and sometimes say that the farm size is larger than three acres. I can understand, they want more money, but they cannot do it in an unfair way. (*F4)

However the tractor owners agrees with the tractor operators and do think that some farmer give farm sizes which are inaccurate for the operators to work on, they claim they incur a lot more cost of operation through this act; there are several reports of such, some farmers do not give the accurate farm size, we end up buying more fuel and spending time on a farm for less payment. But my brother those things are associated with the business and in most cases there is nothing you can do. President NATOA (TN)

Another challenge identified by the AEA, is the ***non-existence of enough collective action*** or group by the farmers. According to the AEA farmers, especially smallholder farmers would have better chance of gaining access to tractor rental services if they joined or formed a group: we always encourage the smallholder farmers to form farmer group so they can make arrangements for ploughing easily but they would not listen to us. He elaborates further, last two years when the assembly got our tractors we wanted to give it out to FBO members first but there are not many FBOs in these area so only few farmers benefitted.

Lastly, the AEA and the president of NATOA, claims that there have been reports of some ***tractor operators not having enough techniques in the job they do***. According the AEA, farmers complain that sometimes after ploughing some operators leaves large trenches and holes in the farm due to their unprofessionalism. The presidents of NATOA (TN) seems to agree with these complaints but blames it on new operators; Sometimes the new operators they are not that experienced, so they end up leaving large trenches on the farms, which is not good. (TN). Interesting however, the interviewed farmers seem unaware of this problem, while they do not deny it existence, they say they have not experienced this on their farms. F1, stated, this have not happened on my farm before so I cannot say it is a problem for me, but maybe others experienced it.

4.3 Conclusion

This chapter of the thesis presented the results of the local tractor rental network in Nkoranza South. In summary it was revealed that the local tractor rental network in Nkoranza South Municipality is made up of an intricate network of both human and non-human actors who plays vital roles for the functionality of the local market. The association of tractor owners-NATOA and the municipal authorities play a crucial role of setting and regulating prices as well as enforcing road usage regulations. Several constraints impeding the agency of actors in this network were identified. Almost all constraints (operators not well trained, nonexistence of collective actions, issues of farm size measurement, not enough tractors) in this network can be described as endogenous constraints as they exist because of the actions and or inactions of actors. However, one can argue the issues surrounding the number of tractors can be described as endogenous, the actors in there can do very little about it. As tractors are expensive and actors are not able to afford them.

5.0 RESULTS: HISTORY AND EVOLEMENT OF TROTRO TRACTOR PLATFORM

Understanding the history and evolement of the Trotro tractor platform over time demystifies the reasons behind the structure and modus operendi of the platform. We used interviews and platform documentation to analyse how the platform has developed from inception to its current state. How different actors were included, their roles, the structural changes, and their importance. We explored the original design of the platform, who were proposed to be engaged on the and what was the proposed/original business plan of the platform.

5.1 Structure of Trotro Tractor Platform as Designed.

Figure 3: Proposed actor network structure of Trotro tractor at the inception
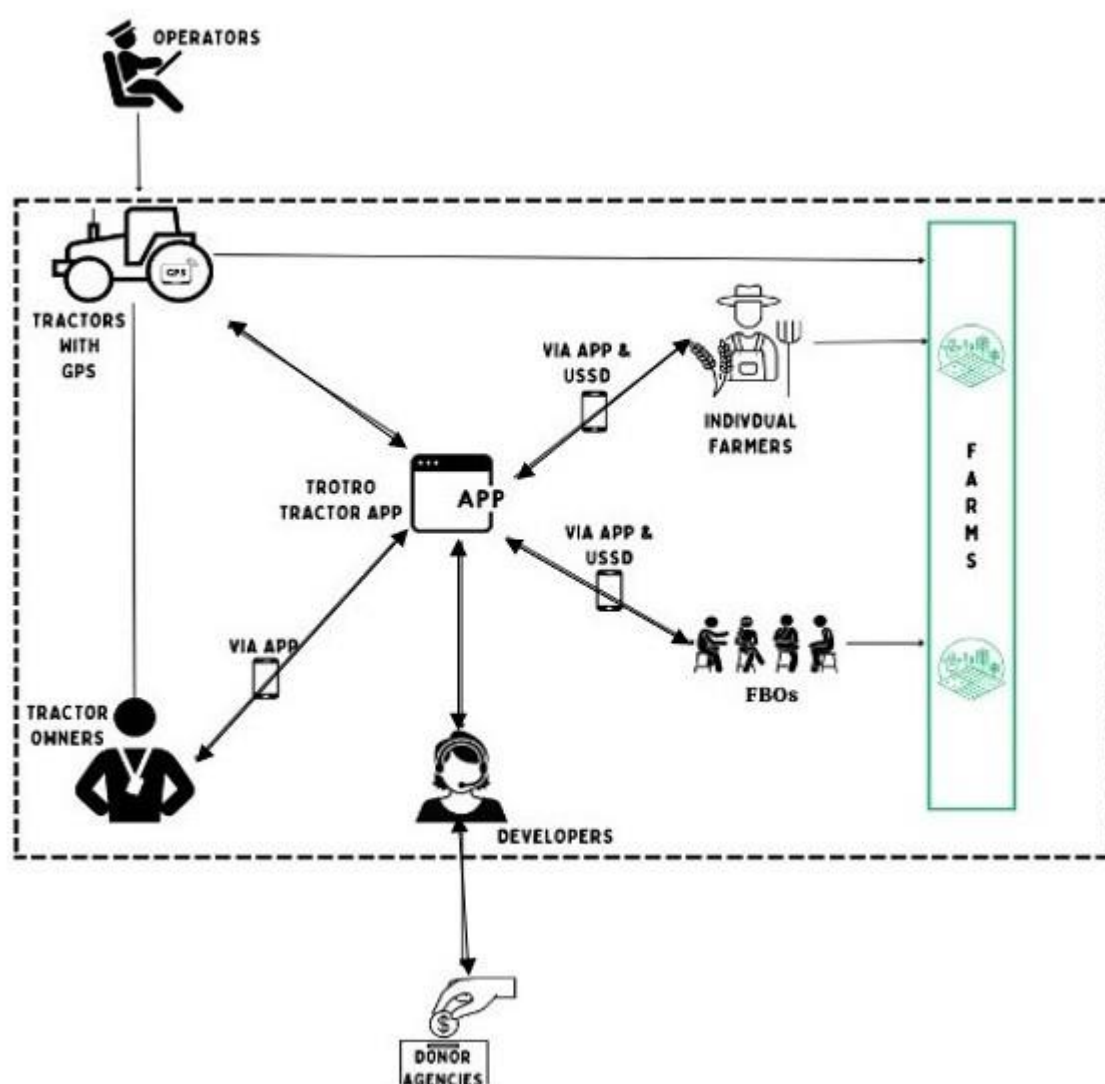
Table 4: Proposed platform Actors, their roles, interests, and inclusion criteria at inception

Actors	Proposed Roles	Interests	Inclusion Criteria
Non-Human Actors			
Tractors	For ploughing, shelling, transporting.		
Trotro Tractor App	Making orders by individual farmers and FBOs Rendering automatic allocations of tractors.		
Mobile Phones	To have the Trotro tractor Apps installed on them. For making orders, USSD short code.		
GPS devices	To track the location and activities of the tractor.		
Farms	To be ploughed and cultivated		
Human actors			
Individual	Request for the platform's services through the Trotro tractor app.	Having access to affordable tractor rental services	All farmers (with special attention to smallholder and women farmers)
FBOs	Request for the platform's services through the Trotro tractor app.	Having access to affordable tractor rental services	All FBOs
Tractor Owner	Register their tractors with the platform and render services via Trotro tractor app	Making profits with their tractors through a transparent and trustworthy platform	Have a working tractor(s) and be willing to give it for services on the platform
Donor Agency	Temporally Groom the business. Temporally Provide financial assistance	Supporting the establishment of an AgriTech company	All interested donor agencies

Developer	Develop App and advertise app	Providing tractor rental service to smallholder farmers	

Source; Field work 2023

The research finding reveals that the Trotro Tractor platform started operations in early September 2016. At its inception the platform was set to engage multiple actors in its operations. Figure 3 provided above presents the Actor-Network/structure of the platform at its inception. Among the identified actors, three played the role of end users and beneficiaries: individual farmers, Farmer-Based Organizations (FBOs), and tractor owners. Individual Farmers and FBOs sought tractor rental services from the platform, whereas tractor owners provided the rental services by registering their tractors on the platform. Other human actors identified at inception included the developers who developed the entire platform, the donor agencies who were expected to provide temporally funding to the platform and groom the platform. This donor agencies were expected to leave the network after the platform was established. The tractor operators though were recognised by developers, the developers did not consider them as core members of the platform as described by D3: *We only wanted to deal with the farmers and tractor owners, by connecting them, so we did not concern ourselves with the operators, we wanted the owners to take care of the operators themselves. In fact, we did not want to have anything to do with them at first.*

Tractors, farms, Phones, the Trotro tractor app, and GPS devices are the five non-human actors that were proposed to be engaged on the platform. The design proposed that the Trotro tractor app will be at the centre of the platform connecting farmers, and FBOs to tractor owners. Farmers and FBOs were supposed to register on the platform through the Trotro tractor app or via the use of a USSD short code whereas tractor owners register their tractors through the app only. **Figure 4** is a screenshot of registration process from the Trotro tractor website that suggests that FBOs, farmers and tractor owners can access the platform through the app.

Figure 4; Registration form on the app
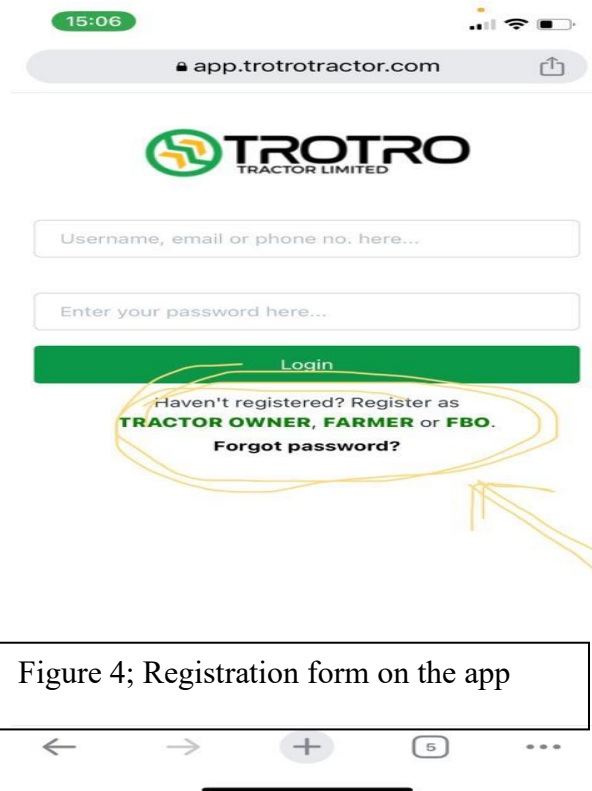
The Trotro tractor app was designed to receive orders from farmers and FBOs and automatically pair these orders to the *nearest tractor* in the location the order was coming from, on a *first come, first serve* bases. The platform design ensured that developers accessed tracking information from the GPS devices attached to each tractor through the Trotro Tractor app. This feature was designed to allow the developers to monitor the location of their tractors and the services provided by them. It was also to ease the work of the Trotro tractor app in pairing orders to the nearest tractors.

The entire process can be seen summarised in project document DU1. Below in Figure 4, is a screenshot from DU1 summarizing the proposed design.

Figure 4: Screenshot of Summary of proposed Trotro tractor operations at Inception

Source: DU1

For its business model, it was designed that farmers will make payment of GHS 100 or GHS 200 per acre of land to have it ploughed, harrowed, or ridged according to their request. With farmers in Northern Ghana paying GHS 100 and those in Southern Ghana pay GHS 200. The design allowed this payment to be facilitated through mobile money transfer when farmers place their order before the service is provided. The Trotro tractor app was supposed to receive the order and automatically pair this order with the ***nearest*** tractor to the location of the farmers' farm on a ***first come, first serve bases***. The tractor owner receives a notification of the order through the Trotro tractor app and approves or deny the order. According to the design the services is rendered to the farmer within 72 hours from the time of the request, as explained by D1 and D2: *in our design we made sure that the services is rendered to the farmers within 72 hours from the time of their request.*

 And *in cases where we are unable to render the services within this amount of time the design is such that the farmer will be informed by us the developers and their monies are refunded to them within the same period (D1, D2)*

In relation to financial compensation, According to D1, D2, and D3, *90% of the amount earned through work done by tractors was to be given to tractor owners, whereas the developers kept 10% of the money. The tractor owners were to use part of their 90% to take care of fuel and other maintenance cost as well as paying their operators* (D3, F1)

A summary of the business model is present in project document DU1, as seen in Figure 5 below.

Figure 5: Screenshot of Summary of the proposed business model of Trotro tractor at Inception
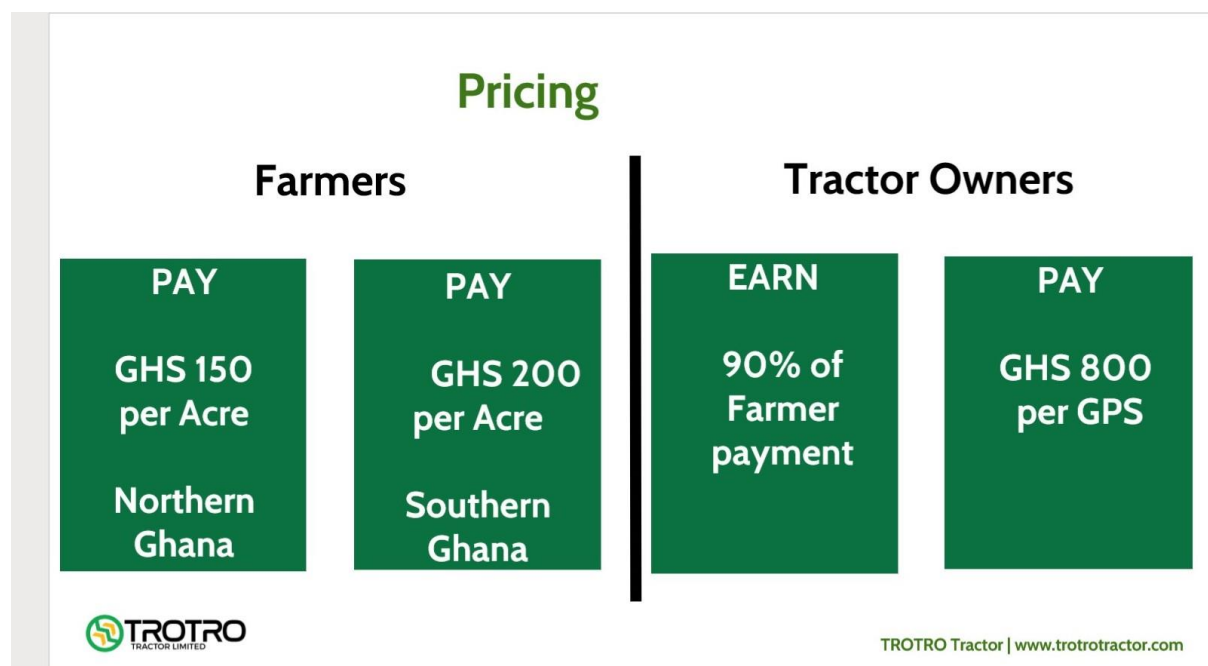
Source: DU1

5.2 Evolvement of Trotro platform

The data indicate that the Trotro Tractor platform underwent multiple changes and restructuring before attaining the national-level structure described below in Figure 6. The subsequent sections will outline the evolvement of the structure (actor-network) of the platform from Figure 3 above (proposed structure of Trotro at inception) to Figure 6 below (National level structure of Trotro at its peak) through an explanation of four phases of translation. It is important to note that these four phases overlapped during the process and are not mutually exclusive.

5.2.1 Problematisation

This phase provided valuable insights into how developers (re)defined problems and identified the principal human and non-human actors. According to project documents DU1 and developer interviews, D2 and D3, the platform's primary goal was to enhance the availability, accessibility, and affordability of tractor rental services for smallholder farmers in Ghana. This was further

elaborated upon by D3: '*This objective was to be achieved by utilising a mobile app designed to address the identified issues within the Ghanaian tractor rental service sector*'. Essentially, the mobile app was intended to restructure the landscape of tractor rental services in Ghana.

At its inception in early 2016, the developers aimed to address several significant challenges:

D3 Claimed that there existed a ***vast disparity between the demand and supply of tractor services***: According to D3 this issue stemmed from a substantial deficit of tractors in Ghana at the time and this resulted in a significant portion of farmers, mainly smallholders and women farmers, being unable to access tractor services. D3 explained, "*We realised that over 60% of farmers were using simple hand tools due to the lack of access to tractor services, and the 40% who did have access were not well organised.*"

Another reason stated by D3 and D2 is ***uneven distribution of available tractors***: as stated by D3, we realised the few available tractors were concentrated in specific regions of the country, while other areas had a limited number of tractors, making access limited in some places. D3 further elaborated that the platform planned to rectify this by registering enough tractors on the platform and matching them with demand across the entire country. D3 '*This way, they try to redistribute the tractors according to demand*'.

D1 also stated that, ***the unorganized and non-formalized nature of tractor rental*** services as one of the problems they identified from the beginning of the establishment. This can also be seen in project document DU1, as captured '*unorganised and how there exist no formal arrangements in the tractor rental network is a problem we seek to address*'. According to D1, they observed that tractor rental services were disorganised, leading to various issues that hindered the efficiency and fairness of tractor rentals. She added: tractor owners prioritised farmers with larger land holdings, leaving smaller-scale farmers at a disadvantage. Additionally, male farmers had an advantage in accessing tractor rental services due to societal norms that influenced the informal nature of these services We decided to formalize the system by using a mobile app to match orders to tractors based on proximity and on a first-come, first-served basis rather than considering gender or the size of the farmers' farmland.

The problematisation continues even after the platform have started working. This is illustrated in the following problems identified by the developers after the platform started operating.

D1, D2 and D3 claim that they determined that ***providing services to farmers with farm sizes less than 10 acres was not beneficial and sustainable***. According to them this problem was caused by many factors including the significant spatial dispersion among the engaged actors, resulting in extended travel times and elevated operational costs. D3 lamented, '*nearest is relative, sometimes the nearest tractor to the location of the order is very far, resulting in longer traveling time, and high cost being incurred, it was no more sustainable to render services to small farm sizes. We had to do something about it*'. Consequently, the developers modified the eligibility criteria for farmers accessing services through the platform.

Another crucial problem identified was the ***lack of trust***, which encompassed several trust-related challenges:

According to the Developers (D2, D3) there existed ***mistrust among tractor owners and operators.*** According to them, tractor owners do not trust that operators provide the right information on the work done by their tractors, as operators would like to keep part of the monies the tractor earns. This mistrust according to D3 hindered the smooth operation of the platform. The platform proposed and implemented a solution based on tracking and transparency to address this issue. They planned to introduce a GPS tracking device integrated with a mobile app to enable farmers to monitor their tractors' location and work progress in the field. This initiative according to them, aimed to enhance transparency on the platform and, to some extent, rebuild trust. D3 explained, *"We also realised that tractor owners did not trust the operators and the information they provided. Consequently, they were reluctant to lend out their tractors. We assured them of transparency and said we would achieve this through GPS tracking."*

Another mistrust issues identified by developers is the ***falsification of farm and personal information by farmers***. D2 and D3 stated that they encountered a significant issue involving farmers providing falsified farm and personal information to gain access to services from the platform. This according to them resulted from farmers not trusting developers will render services to them if their farm sizes are not big enough. It is also partly because developers limited their services to farm size up to 10 acres and above. To address this problem, the defined solution involved fact-checking by customer service representatives (developers taking up this role) and field agents. As expressed by D3 *"Hmm.. some of them think that when they key in higher farm sizes, we would render services to them fast, so they key in outrageous farm size, you get to the farm and realised the farm size is smaller than what they keyed in."*

Another challenge developers identified was securing funding for the establishment of the platform. The developers planned to present their ideas to donor agencies to obtain financial support. "*We enrolled on the Kosmos AgriTech Challenge to secure funding for our platform*" D3 stated.

We identified seven human actors and seven non-human actors that played an integral role in the actor-network of the platform at that at its peak. The human actors comprise farmers, Farmer-Based Organizations (FBOs), tractor owners, developers, field agents, tractor operators, and donor agencies. On the other hand, the non-human actors encompass tractors, the Trotro Tractor app, GPS devices, farms, mobile phones (including both feature phones and Android phones), the tracker app, and the dashboard. Table 4 provides a description of the key actors and their respective interests in the establishment of the Trotro Tractor platform.

In summary, the problematisation phase saw developers identifying problems and proposing solutions to these problems at the inception of the platform. Identification of problems and attempt to tackle these problems is seen to have continued even after the platform was established. In total five broad problems were identified these include: i. vast disparity between the demand and supply of tractor services, ii. uneven distribution of available tractors, iii. the unorganized and non-formalized nature of tractor rental, iv. lack of trust in the network and v. the profitless in providing services to small farm sizes.

5.2.2 Interessement

The interessement phase provided insights concerning developers' strategies used and activities taken to pique actors' interest in taking on the new roles that were defined for them by the developers.

The developers captured the interest of donor agencies by **pitching the idea** at the AgriTech Innovation Challenge organised by Kosmos Innovation Centre (a donor agency) that had other donors (GIZ, Startup Mentoring, AGRA and more) as sponsors. During this pitch, according to developers, having a digital innovation was a requirement to gain funding, hence the developers proposed the development of the Trotro tractor app to meet this requirement, though they knew farmers will not be able to use the app. One developer (D3) explained; *'the App was never used; when we go to the international front, they normally ask for those things, so as a business, we developed it not for our farmers but for the international front for funding.'* Nonetheless, according to D3 donors provided funding for their platform after their participation in the challenge. Once funding was provided, the developers developed the Trotro tractor app and the dashboard, as well as an alternative USSD code/phone number that can be used by individual farmers, FBOs and tractor owners to register and order services through the dashboard.

According to project documents like posters, DU1 and also confirmed in the interview with D3, **Advertisement (awareness creation) and training** of farmers, FBOs and tractor owners on how to register, how to use the platform, and the benefits associated with using the platform were the strategies employed by developers. D2 and D3 explained that for them to appeal to women farmers, they ensured all jingles and voices used in their adverts were female voices. They also ensured all flyers, posters, and other advertisement materials had women characters in them. "*We made the conscious effort to ensure that most of our advertisement had women characters; this was to get women farmers' interest in our platform*" (D3). Figure 4 below are samples of advertisement flyers and posters developed by Trotro Tractor with the women's character in them. "We also sometimes organised training for only women and for operators our operators as well" (D3). It must be noted that donor agencies funded the training and advertisements.

Figure 5: Samples of Trotro Tractors Advertisement Flyers and Posters

4

Job provision is another interressement strategy employed: In the case of the field agents and the tractor operators, they joined the platform because it was offered as a job to them. Hence, their interest was getting a job. For example, in the case of ***F1'*** the agents joined the platform because he was posted there through the recruitment agency; *I applied for work through NABCO, I chose agricultural technology category, and I was assigned to go and work there, they requested for workers through the platform. That was the first I heard of the platform.*

Provision of subsidies to farmers was also a strategy that was employed. After developers got the commitment of donor agencies, they contracted with some donor agencies to provide subsidies for farmers who accessed services from the platform. In the case of farmers in Nkoranza, the study area, 70% of the cost involved in rendering services was paid by a donor agency, OCP (a fertiliser company), leaving farmers to pay only 30 %. *'I can say that about 90% of the services we provided were donor-funded.' […] Else the small-scale farmers, especially the women, would not have been able to afford the services, the donors provided subsidies for the farmers so that they are able to afford the services however they do this through us'* F1 stated.

To maintain the interest of individual farmers who ordered the services through the platform, ***follow-up calls*** were made to stay in touch with these users and to sustain their interest. D3 explained, *Before every season begins, we go through the data of our customers, call them, ask them how they are doing and find out if they will need our services in the coming season. […] The farmers like to feel cared about, so when we do this, they want it and sometimes request for our services again,*

To summarise, the major interressement strategies employed were: (i) pitching the idea of using mobile technology to bridge the gaps in tractor rental services for smallholder farmers to donors, (ii) awareness creation on the importance of using the platform, (iii) development of Trotro tractor app to meet donor requirements (iv) training for end users of the platform (v) Provision of Jobs for field agents and operators (vi) provision of subsidies to farmers and (vii) follow-up calls to farmers every year.

5.2.3 Enrolment

Figure 6: National-Level Structure/ Actor-Network of Trotro Tractor Platform
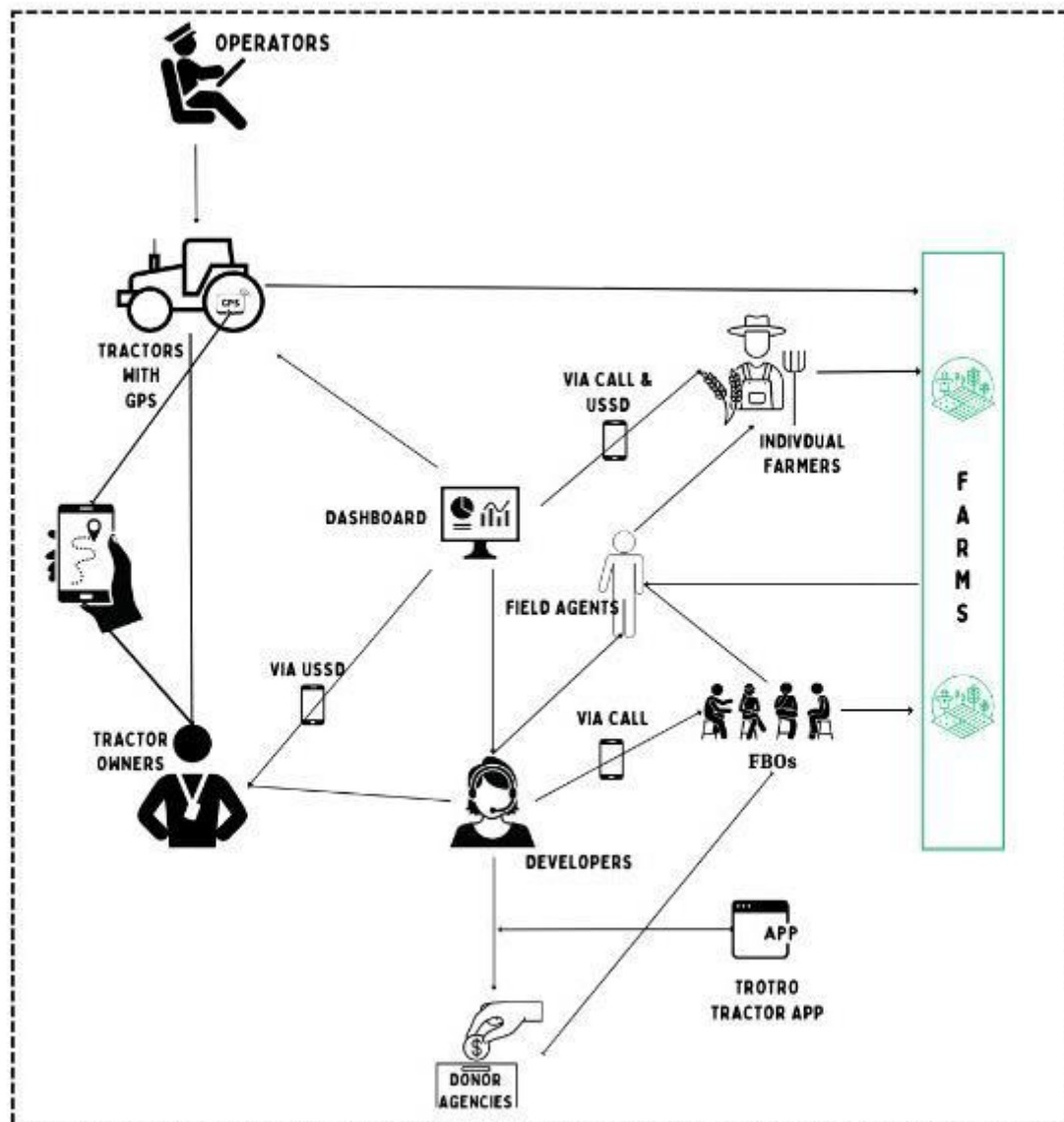
The interressement strategies appear to have been successful given that the Trotro tractor platform has been built and that individual farmers and FBOs may now access tractor renting services through it. A successful interessement strategy leads to the enrolment of different actors (both human and non-human) into the newly established actor network. The next process of interest (enrolment strategies) provides an understanding of the actors' interactions and the changes resulting from the interactions and inherent challenges. Since section 6.3 below is entirely focused on challenges/constraints, we focus more on the interactions and changes roles, and interest in this section.

The result showed that the interaction between actors on the platform led to numerous changes in the platform's structure (the actor network) over the years. The various actors influenced the design of the platform through their interactions. Figure 3 above shows the structure of the platform proposed at the Kosmos Agritech Innovation Challenge in 2016. Figure 6 which is the outcome of the entire translation process, presents the platform's national level structure in 2020 before its collapse. Comparing Figure 3 and 6, one could see that there are some changes take

took place in this process to move from **_Figure 3_**, the proposed structure of the platform at inception to **_Figure 6_** the national structure at the platforms peak which is the outcome of the entire translation process. These changes are grouped into five categories: changes in actors' roles, additional actor roles, introduction of new actors, and changes in inclusion criteria. Table 6 below presents a summary of these changes.

The **_role of some of the actors_** (both human and non-human actors) **_changed over time_**. Developers altered the role of the non-human actors based on their business interests. For example, the Trotro tractor app was never used for connecting actors nor for automatic pairing of tractors to orders on the field, as suggested in Figure 3 above, but served as a tool to attract continued funding from donor agencies, as can be seen in Figure 6 below. Developers knew that targeted farmers were unlikely to use the App, but they continued to create the expectation that benefit farmers directly at its inception. As stated by D3 and D2 it is even difficult for farmers to use the USSD short code, they keep calling us instead, do you think it would have been easy for them to use this app? […] No, they would not use it. Developers therefore assigned a new role to the app. The new role of the app was to attract continues funding from donors. This change helped sustain the business as most of the services rendered through the platform were funded projects. . *'I can say that about 90% of our services were donor-funded.'* *[…] Else the small-scale farmers, especially the women, would not have been able to afford the service'.* (F1). However, according to the developers D1, D2, and D3 this was only possible because the interest and role of donor agencies also changed. The role of donor agencies changed from temporarily grooming a business and providing seed capital to consistent provision of subsidies to some platform users (farmers and FBOs). At the same time, their interest moved from supporting a business to supporting smallholder farmers to access tractor services through a platform supposedly providing equal access. […] Kosmo innovation centre and the other donors even though, we only applied for funding at the challenge, they gave us a resource person who is still part of our board, they still provide funding for our activities after the challenge and they want to see that farmers are accessing services from us, …..that is why they give subsidies to all this farmers D3 expresses this happily.

Over the course of its development, the Trotro Tractor platform **_introduced new actors_**, both human and non-human, into its actor network. These additions included tractor operators, field agents, the Tracker app, and the Dashboard. These new actors were incorporated to address trust-related challenges within the platform. Field agents played a critical role as they served as the physical link between farmers and developers, aiming to establish trust and verify the data provided by farmers when making their orders. As described by the field agents F1 and F2, we traveled to the locations where to orders came from to verify the data that farmers keyed in, it was also a sort of assurance to the farmers that we will deliver the services they have requested for once they see us on their farms. According to the developers this face-to-face interaction helped foster trust among actors(farmers, developers and tractor owners) within the platform. Developers even had to hire their own tractor operators because tractor owners did not trust the existing operators who were not initially part of the platform. D3 "*at first, we did not want to*

deal we the operators directly, we allowed owners to handle all arrangements regarding operators on their own, but over time we realized we needed to employ our own operators".
On the other hand, the Tracker app allowed tractor owners to monitor their tractors' activities on their phones, promoting transparency and trust. This communication relied on GPS devices transmitting location and service data to the Tracker app.

Developers also assumed an ***additional role*** as customer service representatives. Developers (D2, D3) claims that they started initial screening of the data provided by farmers before field agents conducted further checks in the field. According to them, the process included calling farmers to confirm the accuracy of the data they entered when placing orders.

One notable change resulting from interactions on the platform was the ***alteration of inclusion criteria for farmers eligible to access its services***. At the platform's inception, all farmers, especially smallholders, were qualified to use the platform's services. However, at its peak, individual farmers with farm sizes of less than 10 acres were no longer permitted to access these services.   Developers argued that offering services to farm sizes less than 10 acres was economically unsustainable, driving this change. D3 [….] it was no more sustainable to render services to all farmers, ……. we changed the criteria for farmers who would be able to get services from us. We only moved our tractors to farms of 10 acres and above, so unless you have that you do not get our services.

In summary the enrolment focussed on all the changes that happen on the platfrom resulting from actor interactions on the platform. We grouped these changes into four broad groups which included: changes in the role of the actors, additional actor role, introduction of new actor, changes in inclusion criteria and changes in interest.

5.2.4 Mobilisation
The mobilisation phase revealed whether the actors' commitments to their roles on the platform were fulfilled and maintained after the establishment of the platform. At the time of this research, the platform was non-functional. This suggested that roles were not fulfilled and maintained. We found that some of the actors (both human and non-human) did not fully fulfil their role or sustain it. For example, the GPS devices and the tracker app could not perform the tracking roles assigned in areas with no network coverage, while the tractors operated in rural areas, which mostly had issues with network coverage. This means the problem of trust could not be solved entirely. Farmers did not patronise the platform for long. The developers did not succeed in to renew the USSD short code; hence, it was not functional. The Trotro tractor app was out of play store, hence did not exist at the time of this study.

Table 6: Changes to the platform's actor network structure

Kind of change	Original design	New design	Reasons

Change in the role of the actors	**Trotro App:** central connection of users and automatic allocation	A tool to attract funding.	Digital apps were required to meet funding criteria.
	Donors: Temporal financial support to developers	Permanent provision of subsidies and funding for farmers	Change in interest of donors
Additional actor role	**Developers:** develop app for actors to use.	Customer service, conduct pairing of request with tractors.	To confirm farmer data
	GPS device; communicate to the Trotro tractor app.	Communicate to the tracker app, communicate to the dashboard.	Enhance monitoring by owners
Introduction of new actors	Not included in original design		
	Tracker app;	Receive data from the GPS and communicate to owners	To foster tracking and transparency
	Operator;	Operate the tractor	To resolve trust issues between owners and operators
	Field agent	Conduct fact-check of data provided by farmers	To resolve trust issues between farmers and developers
	Dashboard; the Trotro app performing this function.	Introduced in place of the Trotro app to Receive orders. Store farmer information. Receive GPS location of tractors.	They needed a server to receive the request and keep data on tractors
Changes in inclusion criteria	**Farmers;** all farmers	Farmers with farm size of 10 acres and above	Unsustainable profit margin for to work on small farm size
Change in interest	**Donor agencies**; providing temporal funding to digital mobile app business.	Supporting farmers to access tractor rental services	Farmers were unable to afford the service, especially

			smallholder farmers
	Developers; providing affordable tractor rental services to farmers with attention to smallholder farmers	Providing profitable and sustainable tractor rental service to farmers	Unsustainable profit margin for to work on small farm size
Source; Fieldwork 2023			

5.3 Conclusion

The evolvement of the Trotro Tractor platform, elucidated through the lens of ANT (translation as described by Callon, (1986)) reveals a multifaceted journey shaped by dynamic interactions between and among actors (both human and non-human actors). Problematisation of the platform resonates with studies in digital agricultural innovations, emphasising the imperative to address critical challenges in the tractor rental service sector (Daum, Villalba, et al., 2021) The platform aims to make tractor services more accessible, affordable, and available, in line with digital agricultural solutions' mission to improve farmers' livelihoods and production efficiency.(Quayson et al., 2020; Tsan et al., 2019)

In the interessement phase, the developers adeptly engaged actors, employing strategies akin to those documented in the literature on the adoption and usage of sociotechnical innovations in agriculture (Kaminski June., 2011; Kumela et al., 2018). Job provision, subsidies, and targeted awareness campaigns are recognised strategies to cultivate interest, adoption and usage of novel sociotechnical innovations (Birke & Knierim, 2020; Fisher & Kandiwa, 2014; Kumela et al., 2018; Tata & McNamara, 2016) The malleability of sociotechnical innovations within agricultural contexts (Akrich, 1992; Jarrahi & Nelson, 2018) is reflected in the adaptability of the platform in the enrolment stage. Five different categories of changes were recorded in this stage namely changes in the role of the actors, additional actor role, introduction of new actor, changes in inclusion criteria and changes in interest. It was interesting to find out that the mobile app (Trotro tractor app) was never used by farmers and tractors owners however served as a tool to attract continues funding from donor agencies. The mobilisation stage revealed that the platform collapsed four years after it establishment.

This chapter of results focussed on the history and evolution of Trotro tractor platform. It presented to us, the proposed design of Trotro tractor, the proposed actors to be engaged on the platform and how this design evolved over time. In the next result chapter, we present how the Trotro tractor platform operated in practice before it stopped operating in 2020. Thus, the outcome of the translation process which is presented in Figure 6 above functioned on the field and rendered some services before it collapsed. In the next chapter we present how this worked

out practical at general/national level and we dive further into how it worked out at the municipal level. We present, who were the actual actors engaged on the platform, how was it structured (actor-network engaged in practice) and how, when it worked. In essences, whereas this result chapter dealt with intent and its evolution the next chapter deals with the practical reality after the realisation of this intent through the evolvement.

6.0 RESULTS: TROTRO TRACTOR IN PRACTICE

In what follows, we present how the Trotro tractor platform operated in the practice. Through interviews with developers and Field agents we first explored how the platform operated at the national level which is the outcome of the translation process explained above, to gain in depth understanding we later focussed on the Nkoranza South Municipality to understand how the platform operated at that level. Both of these findings are presented here in this section. It is important to know that having investigated these two levels of operation we provide an analysis of similarities and differences in operation of the platform at these levels later in the discussion chapter of this thesis.

6.1 Trotro tractor at operations at the National level

Figure 6: National-Level Structure/ Actor-Network of Trotro Tractor Platform
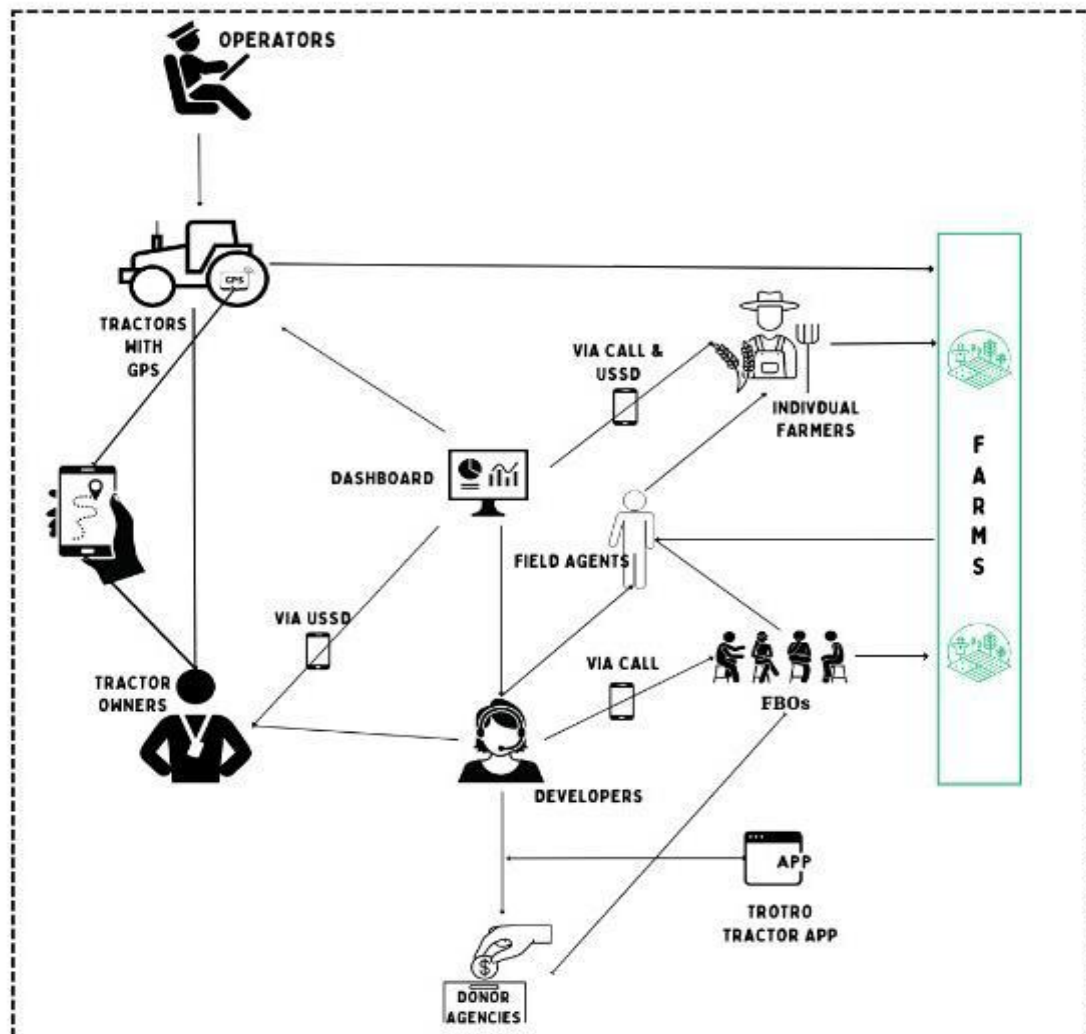
Table 7: Platform Actors, roles, interests and inclusion criteria

Actors	Roles/Functions	Interests	Inclusion Criteria
Non-Human Actors			
Tractors	Ploughing of farms		
Trotro Tractor App	Attract donor funds		
Mobile Phones	For ordering services, Storing tracker app		
Trotor tracker App	For communicating feeds from GPS to tractor owners.		
GPS devices	For tracking activities of tractors		
Farms	To be ploughed and cultivated		
Dashboard	Receiving orders. Storing farmer information. Receiving GPS location of tractors.		
Human actors			
Individual farmers	Request for the platform's services via phone call or USSD	Having access to affordable tractor rental services	Farmers with farm size of 10 acres and above
FBOs	Request for the platform's services via phone call or USSD	Having access to affordable tractor services	All FBOs who needs tractor rental services
Tractor Owner	Register their tractors with the platform and render services via USSD	Making profits with their tractors through a transparent and trustworthy platform	Have a working tractor(s) and be willing to give it for services on the platform
Donor Agency	Continues provision of subsidies to farmers. Continues provision of financial support and grooming to the platform	Supporting smallholder farmers to gain access to tractor services	All donor agencies willing to support
Developers	Develop the apps, Provide customer services (call farmers)	Providing profitable and sustainable tractor rental service.	

	Match orders with tractors		
Field officers	Conduct fact-check of data provided by farmers	Having a Job	Meet job description
Operators	Operate tractors	Having a Job	Having a licence

The interviews with developers D1 and D2 revealed that the Trotro Tractor platform ceased its operations in 2020. According to them, the platform operated in four different regions of the country before it ceased operations. These regions included Volta region, eastern region, central and the bono region. It was revealed that most of its operations were also sponsored by donor agencies. Thus, donor agencies through the platform provided subsidies to farmers. *'I can say that about 90% of the services we provided were donor-funded.' [...] Else the small-scale farmers, especially the women, would not have been able to afford the services, the donors provided subsidies for the farmers so that they are able to afford the services however they do this through us'* F1 stated.

The interviews D1, D2 D3, F1 and F2 revealed that the platform engaged multiple actors in its operations at the national level. Figure 6 provided above presents the Actor-Network/structure of the platform at the national level. Among the identified actors, five played the role of end users and beneficiaries: individual farmers, Farmer-Based Organizations (FBOs), tractor owners, tractor operators and field agents. Individual Farmers and FBOs sought tractor rental services from the platform, whereas tractor owners provided the rental services by registering their tractors on the platform. However, only individual farmers with farm size of 10 acres and above could access services from the platform [.......] for these reasons we only moved our tractors when we had request of 10 acres and above. We did not services anything less than 10 acres D3. We encouraged all the farmers who called us and did not have up to 10 acres of farms to look for other farmers with interest and gather up to 10 acres before we could assist them D1, F1 aand F2. The platform also engaged field agents and some tractor operators, who were employed to facilitate its operations.

Notably, a discovery emerged from the study one month into data collection that no farmer, FBO, or tractor owner ever used the Trotro Tractor app to access services from the platform or to render services on the platform as proposed in the platforms designed. They rather used the USSD short code (*714*85#) or by making call, or through contract D3 explains: the app was never used, [.....] the farmers, owners and FBOs either used the USSD short code or made a

call to us directly or signed a contract (usually supported by donor agencies) with us. In fact, many of the farmers preferred calling us instead. The Trotro tractor app however served as tool that attracted continuous funding from donor agencies.

Beyond the Trotro Tractor app, the interviews D1, and D2 revealed that there were two additional software components were essential to the actor-network: the Trotro Tracker app and the Dashboard. The Dashboard occupied the central role of connecting all actors within the network but did not perform automatic pairing of requests to available tractors. The Tracker app served as a tool utilised by tractor owners and developers of the platform to access tracking information from the GPS devices attached to each tractor. This feature allowed owners and developers to monitor the location of their tractors and the services provided by them.

For its business model, farmers are required to make a payment GHS 250 per acre of land to have it ploughed. It is important to note that according to D1, they only rendered ploughing services: We planned to render other services, but we did not get the types of machinery for those services registered with us. Also all the request we got was for ploughing, so we only ploughed….D1 explained. According to D3, farmers had to pay for the services being they rendered them. This payment is facilitated through mobile money transfer when farmers place their order before the service is provided. However, different payment methods may be negotiated in cases involving contractual agreements.

The moment farmers successfully place a request, the request is transmitted to the platform's dashboard upon placing an order, triggering a confirmation process. Developers from the platform then contact the customer (farmer) to validate the information provided during the ordering process. D3 explained that We called the farmers when they make requests, we try to confirm their farm size and farm location to try and be sure of the information they keyed in. Subsequently, the developers check the dashboard to identify the nearest available tractor to the location of the farm in question and pair it with the corresponding demand. This service is executed within a timeframe of 72 hours from the time of the initial request. D3 stated; we make sure that all services are rendered within 72 hours; if we are unable to do so we refund your monies to you.

6.2 Trotro tractor at Nkoranza South Municipality

Interview respondents revealed that the Trotro tractor rendered services to farmers in Nkoransa South Municipality in the 2018 planting season. A prominent donor agency (OCP, a fertiliser company) collaborating with a Farmers-Based Organization named Ahiayem Farmers Association in the municipality contacted the platform. Subsequently, a contractual agreement was formalised between the donor agency and the platform's developers, stipulating rental services to the FBO's members. As stated by D2: OCP contacted us to render services to the farmers association, so we signed the contract with them and delivered the services. Under this agreement, OCP committed to covering 70% of the cost, whereas the farmers pay the remaining 30%. However, in this case, farmers only paid after their farms had been ploughed, as there is a guaranteed 70% payment. D2 explained; because this was a contract, we allowed the farmers to pay after we have rendered the services, moreover we were assured of our 70%

payment from OCP. However, according to FB1 these services only lasted for one planting season and they did not continue.

After the contract was signed developers deployed two tractors to Nkoranza South. Two operators and a field agent accompanied the tractors. The field agent's role was to coordinate and group the FBO members based on the geographical location of their farms and schedule a date for their farms to be ploughed. FBO members FB1, FB2 and FB3 explained; they grouped us based on the location of our farms and they worked in that area all together on dates that were scheduled for us. Farmers' farms are ploughed on the scheduled date. During the process, the GPS devices attached to the tractors measure the precise farm size and calculate the cost, which was GHS 100 per acre. Farmers then are requested to pay 30% of the total cost involved.: Our GPS devices measured the precise farm size worked on and we asked the farmers to pay their own share of this according to the measurement, F2 explains.

However, according FB1, D3 nad F3 there were a lot of misunderstanding on the farm size measurement and the payment by the farmers. This misunderstanding which developed to become a challenge for the platforms operations, is explained below in the constraints/challenges section.

It was revealed that all the farmers who accessed the platform's services were women, as the Ahyiayam Farmers Association had only women farmers as their members at the time the services were being rendered. As explained by FB5, our association used to be for women farmers only, at that time, and only the members who were all women could access the services of the two tractors they brought. Individual farmers who were not members of the FBO could not access these services officially. FB4 elaborated: We were unable to get the tractors to our farms then because we were not members of the association. Even for me it was worse because I am a man, and then the association was only for women, so there was no way I could get their services.

Contrary to the national level criteria, farmers' farm size was not a criterion for accessing services from the platform. Membership of the FBO was the only criterion to access services from the platform. D3 explained: In Nkoranza, we were contracted to provide services to all members of the FBO, regardless of their farm size. Additionally, we grouped farmers based on the location of their farms, which meant that considering farm size would not have had any cost implications. This was because we were already ploughing on large farm sizes areas once we moved to a particular location.

The FBO members accessed these services through a contract agreement signed and sponsored by a donor agency named OCP on behalf of the farmers. The interaction of the actors engaged in this municipal level provision of service by Trotro tractor is provided in figure 7 below.

In this figure can see the non-human actors engaged on the platform included, tractors, GPS devices, phone, Tracker app, the dashboard and the farms. There were no individual farmers among the human actors, also the FBO had contact with the developers through OCP who signed a contract with the developers on behalf of farmers. Also FBO members were in touch with field agents who also reported to developers directly.

Figure 7: Structure/ Actor-Network of Trotro Tractor Platform an Nkoranza South
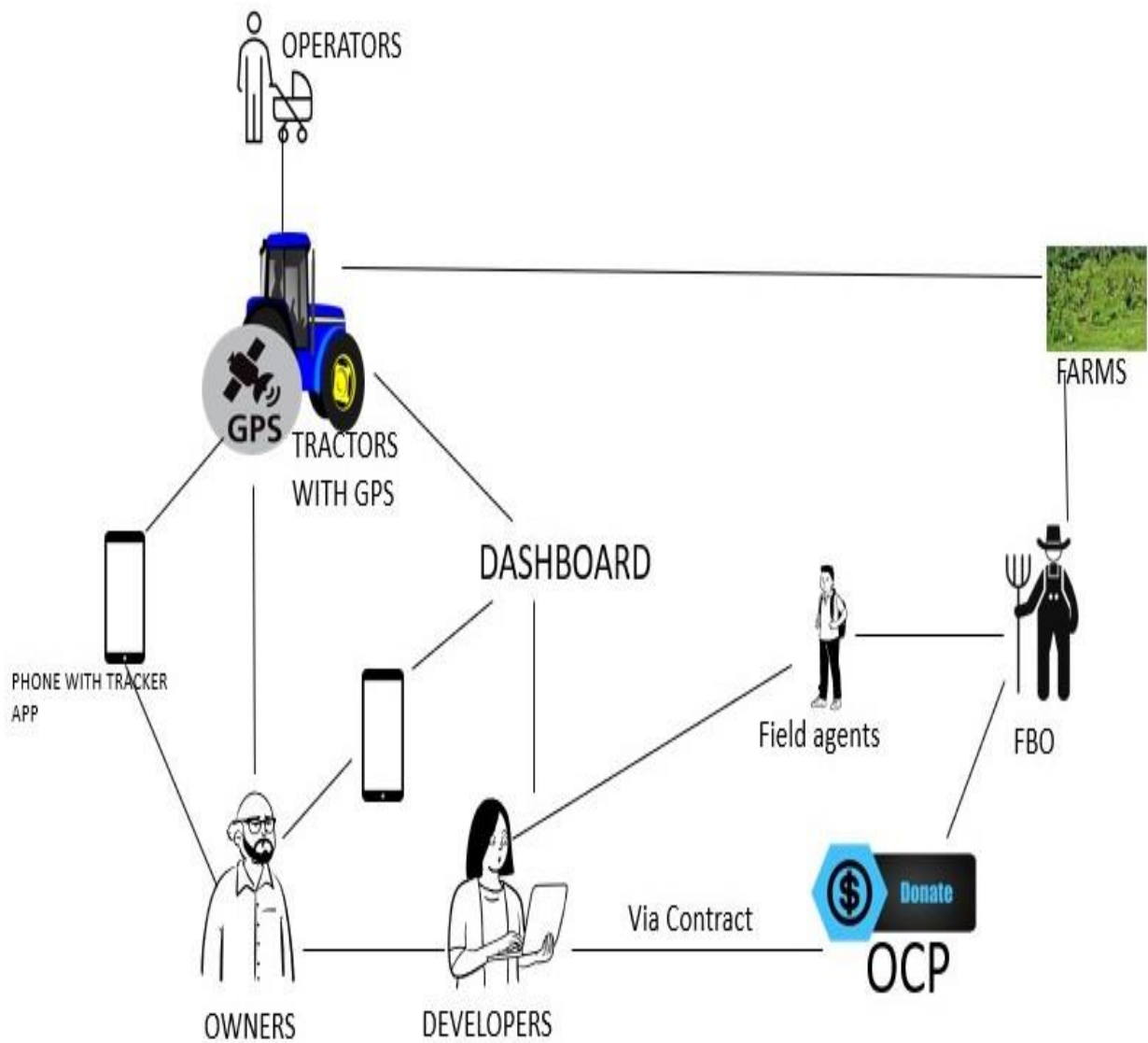
6.3 Constraints/Challenges to Trotro tractor in practice

Here, in this section, we present the challenges and constraints to using the platform identified through our interviews and project document analysis. It is essential to know that the challenges and constraints identified at the national and municipal levels are presented here as one. In some cases, when necessary, examples are presented to clarify the differences between the levels, thus, when the constraints do not cut across both levels. Here we present these constraints and challenges under the main themes identified in our interviews.

6.3.1 Incompatible Business Model

One of the constraints to the platform's functionality identified through our interviews with TN and T1 is the incompatibility of the platform's business model with the local tractor rental service. Tractor owners in the local network, TN and T1, feels they would be in a disadvantaged position when they register their tractors with the platform and hence would not register their tractors on the platform. It was revealed that the cost incurred by owners for using the platform to rent out their tractors is almost two times that of operating in the local network. The Trotro tractor platform requires that 10% of the amount paid for the request be given to the owners of the platform and another 10% to operators. D1 stated: 10% of the income comes to us, the platform developers; that is what we earn for connecting these stakeholders to themselves. However, the tractors owners also have to pay the operators, which is usually also 10%. This means the owners lose 20% of income on these two items when registered on the Trotro platform. On the other hand, owners only pay their operators 10% of the revenue generated in the local network without making payments to any developer. T1 explains; Here in our local market, we only pay 10% of our income to our operators, and we decide what to do with the rest of our money. Though tractor owners on the Trotro tractor platform enjoyed the benefit of tracking, which allows them to track their tractor service to some extent, that also comes for GHS 800 per year. All these costs together was a disincentive for some owners to give out their tractors to the platform, especially when demand still existed in the local network. TN expresses this: *I will never give my tractor to such platforms when they approach; I think I will make more profit operating in our local market. I do not have to give part of my money to any platform here. Also, there is high demand here, and the tractor will work the same if I operate here or give it to them. So, you see, there is no need.*

6.3.2 Inadequate registered tractors on the platform.

Another constraint the developers D1 and D2 identified is the inadequate registered tractors on the platform. As mentioned above, the platform's business model was unable to convince owners to register their tractors on the platform. According to the developers, the platform did not have enough tractors to work. Enough tractors registered on the platform is the essential prerequisite for the platform's functioning. Inadequate tractors on the platform led to the inability of the platform to redistribute the available tractors for the benefit of farmers as they wanted in the ***problematisation phase*** above. D3 explains; that not enough tractors were registered with us, making it difficult at times to even render services to all the requests we got. This situation contributed to many constraints explained below: (i) inability to meet all demands, (ii) large spatial distance between tractors and farms.

6.3.3 Seasonality and Existence of High Demand

Another constraint developers revealed in the interviews is the seasonality and existence of high demand. According to D3, the demand for services from the platform was seasonal, as farmers usually practice rainfed agriculture. "*Most farmers requested services in the same month during the planting season: All the requests for our services come in around the same months, thus the planting season, you know our farmers depend on the rain for cultivating their farms. So they all want to plough one month before the rainy season begins".* (D3) According to her, this led to a high demand for services in the same month, which resulted in the platform being unable to meet these requests, hence refunding farmers' money back to them. D3 explains in every season, we have to end up refunding monies that were paid for requests made for services back to their owners and you know that is not good for business; it sends out the wrong signal.

Developers also indicated that, due to the high demand for tractor rental services in general, anytime developers undertake an awareness creation exercise (one of the interressement strategies), the farmers request services in their numbers. The platform is unable to meet the request due to the inadequate number of tractors on the platform and other reasons explained below. The developers (D2, D3) claim that these situations had two consequences for their platform. First, according to D2, the seasonality of demand led to little or no requests after the planting season, hence challenging to sustain the business and pay all employees. Second, D3 says the inability to service most requests causes farmers to lose **trust** in the platform. They, therefore, do not request services from the platform again. '*The demand comes in hundredfold after such programs. We are unable to work with it all; then, farmers do not request again. We have to embark on another advertisement again in another place, then the circle repeats itself.'* (D3)

6.3.4 Conflict on Farm Size Measurement.

Another challenge that the platform faced was the conflict surrounding farm size measurement. The Trotro tractor platform has enhanced measurability by introducing GPS tracking devices and the Trotro tracker app. Whereas this benefits tractor owners to some extent, developers (D1, D2 and D3) and FBO members (FB1, FB2) claim there still exists a conflict between farmers and developers on what goes into measuring farm size. In the local network, farmers use traditional methods to determine the size of their farms. Differences exist between the GPS measurement and the traditional method. The area measured as an acre in the conventional method was usually bigger than what the GPS devices calculated as an acre. This discrepancy causes disagreement between farmers and developers. This inability of developers to address this discrepancy in most cases results in trust issues as farmers felt developers were cheating them.

6.3.5 Trust/reliability issues

The developers also identified mistrust among actors as one of the constraints the platform faced. As mentioned above, the introduction of tracking and field agents all connect with

dealing with the trust issues that existed among actors. According to D1, tractor owners and the developers do not trust the tractor operators, so it became a challenge when they have to rely on operators for information on work done. Farmers also did not trust developers would be fair in assigning tractors to their request, especially when their farm sizes were not big. […] Trust is a big issue. Even some of the farmers do trust that we will render the services base of the first-come, first served bases. (D1). D1 further claims that this caused some farmers to provide misleading information about their farms to get quick services from developers. Farmers were also sceptical in making payments before services were rendered to them. This hindered some farmers from requesting services from the platform. 'Farmers needed the human touch; we realised we could not sit in our office in Accra and ask farmers to pay money to us before we came and offered services to them' (D1).

6.3.6 Issues with network connectivity

Developers D2 and D3 claim that low network coverage in rural areas constrained the platform's tracking function and transparency ability. As stated in the problematisation phase above, the introduction of tracking in the platform addressed, to some extent, the mistrust between owners and operators and fostered transparency. However, according to them, this functionality could not be achieved in areas with low network coverage. They claim the GPS devices in the tractors did not have a reliable network in some cases, making tracking difficult. Owners and developers, therefore, had to rely on operators for information in such situations; *'when tractors move to communities with low network coverage it is difficult to communicate with our tractors we have to rely on operators for the information'.(D2, D3).* According to the developers, relying on operators for information in the absence of network made it challenging to resolve the trust issues. They claim operators could not be trusted: '*[…] also relying on operators for information in the absence of network is sometimes tricky, the operators cannot be trusted, sometimes they will work on other farms and will not report that to us. However, we have to manage taking information from them in the absence of network coverage, which, by the way, happens quite often.'* (D2, D3)

6.3.7 Spatial Dispersion of Actors

D3 also identified the spatial dispersion of actors as a constraint that affected their business at the national level. According to D3 the distance between actors at the national level led to incurring high costs in rendering services by developers and tractor owners. As stated above, the redistribution of tractors (a proposed action at the problematisation phase) was affected by the smaller number of registered tractors on the platform. According to D3, this also led to long distances between tractors and farms, as tractors are mainly positioned far away from places where requests come from. Though requests were paired with the nearest available tractors, developers claimed that 'nearest' did not always mean tractors were close enough to farms; *'You realised that the word nearest is relative, sometimes request may come from let us say Madina and the nearest tractor is around Kasoa, though it is the nearest, the distance is still far'.* (D3) Developers claim that the cost made the business unsustainable for the owner, especially if the tractors must travel far to work on smaller farms. To deal with these, developers stopped

rendering services to farmers with farm sizes of less than 10 acres. Farmers with smaller farm sizes had to find other farmers in their area to accumulate demand to 10 acres and above before requesting services from the platform. This has become a constraint not only to smallholder farmers but also to the platform's functionality, as most farmers usually seek services from their local network after a failed attempt to get services from the platform. According to D3, *those who return to the platform usually falsify their farm data to get the tractors to their farms, repeating the cycle. Trying to solve this, we employed field agents to check this falsified data. Hence we incurred extra costs.* (D3) Also, there exited high distance between farms and places of repairs as sometimes tractors develop faults in the field and would have to travel back to the cities for repairs. This usually led to the loss of time, which affected output and efficiency of service; *'sometimes the tractors move to rural communities then it gets fault, by the time it gets to back to the city for repairs we lose fuel and time, farmers do not joke with their time, [...] they will leave you and go for another tractor because they do not want to behind the season.'* (D3). It must be noted that this particular challenge was not applicable at the municipal level, as there was arrangement at the municipal level through the contractual arrangement. Farmers were grouped based on the location of their farms, so tractors did not have to travel long distances from one farm to the other F1 clarifies.

6.3.8 Non-awareness of Existence

The interviews revealed that the platform was not known at the municipal level, which limited its use after the contract with OCP ended. Awareness creation has been described above as one of the interressement strategies developers employed to enrol actors on the platform. Contrary to the fact that awareness creation pulled demand from farmers to the platform at the national level, almost all interviewed farmers in Nkoranza South were unaware of the existence of the Trotro tractor platform in their municipality. Farmers in the local network claimed no platform like Trotro tractor exists. F3 asked his friend nearby, *teacher, have you heard of any platform that rents out tractors to farmers in our area? Not here, nothing like that exists, infact we would like to use it if it existed. F1 also expresses surprise; "this is the first time I have heard of such a platform, it seems like something good that can help us, but to the knowledge, they do not exist in our area".* Surprisingly, members of the FBO (except for the FBO leader) who received services from the platform were unaware that the Trotro tractor platform provided the services. This unawareness is why farmers did not request services from the platform after the contract ended. Farmers thought the donor agency OCP was the one that provided the services for them. *We do not know of any platform like that; OCP was the one who brought the tractors for us. We would have been happy to use this platform if we knew of it.* (FB2, FB3)

6.4 Conclusion

This section presents the results on how Trotro tractor operated in practices. We looked at the actor-network of the platform at the National level and later dived into the structure at the municipal level. It was revealed that the platform brought together a new socio-technical assemblage of both human and non-human actors with the aim of rendering tractor rental services to farmers. Each of these actors played crucial roles on the platform. Notably, the

farmers from Nkoranza who accessed services from the platform were all members of an FBO and they did not contact the platform directly. Rather, a donor agency signed a contract with the platform on behalf of the FBO. Also this section presented the constraints affecting the agency of actors on the Trotro tractor platform. We identified both exogenous and endogenous constraints to impede the agency of actors. Apart from the existence of high demand and seasonality of the demand, and the spatial dispersion of actors that are exogenous constraints, the remaining identified constraints are endogenous. Thus, they existed because of the actions and inactions of actors engaged on the platform.

7.0 ANALYSIS

The findings of the thesis is presented above in three different result chapters. In what follows detailed analysis of these findings is presented. We look at how these results contributes to answering our research questions. As a result, this section is grouped under the research questions posed above, chronologically. This analysis is followed by a discussion chapter which situates the findings in broader literature.

7.1 How is the actor network involved in the Trotro tractor platform structured?

It was revealed that the structure of the Trotro tractor platform was made up of multiple actors. This structure influenced the functionality and usage of the platform. Thus, the findings revealed the Trotro tractor platform, formed a new sociotechnical assemblage of actors (both human and non-human) with visions, interests existing in a codependent relationship. Each of these actors played a role towards the functionality and usage of the platform while safeguarding their interests and motivation. This actor included seven main human actors and seven non-human actors, connected in a network where they influence each other's agency (see Figure 6 above). As argued in section 2 above, the structure was looked at from the perspective of who is engaged in the platform and how the platform works. We discuss under this section the implications of how the platform functions (which emerges from the interaction of actor-network); when necessary, we juxtapose these implications against the narratives surrounding the platform and then further discussions on the role of both non-human and human actors on the platform are presented.

Regarding the platform's functionality, the current structure (as shown in Figure 6) did not make it possible for end users (specifically farmers and FBOs) to access the platform through an app. The platform's structure does not allow the Trotro tractor app portrayed to be the centre of accessing the platform's services to perform this function but rather served as a tool to attract continues funding from donors. Consequently, individual smallholder farmers with farm size less than 10 acres are excluded from accessing services from the platform as they do not meet inclusion criteria (see Table 6). This contradicts the portrayed story that the platform provides opportunities for smallholder farmers. These findings are consistent with Daum, Villalba, et al. (2021) who uncovered that the portrayed image of smallholder farmers using matchmaker apps to access services was inaccurate. They further argued that the owners used matchmaker apps instead of farmers to give out services. In the context of the Trotro tractor, this is confirmed; however, here, owners use another app (Trotro tracker) for tracking and monitoring the work done by their tractors. Nonetheless, the structure allowed farmers to access tractor rental services using the USSD short code at the national level and provided room for FBOs to access services through contracts which donor agencies sponsored. These opportunities do not exist in the local network.

Measurement and ensuring transparency are positive factors that are improved to a certain extent in the actor-network of Trotro. As argued above, the GPS devices ensured precise farm sizes were measured. It also allows owners to track their farm activities, fostering trust to a certain extent. However, as GPS devices network coverage, the absence of a network in rural areas hindered this functionality to some extent.

7.1.1 Role of Non-human actor:

The importance of non-human actors cannot be over-emphasized. The notion of inscription offers a framework for delineating the material capabilities that developers initially embed into non-human actors. As per Akrich, (1992) perspective, inscription suggests that these non-human actors perpetuate the developer's presumptions, interests, social and economic dynamics, and concepts. One can, therefore, argue that the agency of non-human actors is defined by the developers through their inscription. Their agency comes to the light more when they enable actors/actants and constrain others (Jarrahi & Nelson, 2018). On the Trotro tractor platform, we observe that, except for the tractors, the role of non-human actors was either bridging or serving as a hub to connect the other actors (see table 7 above). However, through this role, they enable the work of other actors on the platform while their actions and inactions also sometimes constrain other actors. For instance, the dashboard served as a hub that received request from farmers, it also received inputs on the location of tractors, it also enabled developers to meet to make pairings based on the information it provided. Though the dashboard did not conduct the automatic pairing by itself, the dash gave the needed information for developers to do the allocation manually. In this context, the agency of the dashboard is found in its ability to enhance the work of developers and farmers. On the other hand, the failure of the GPS device to function due to network issues in rural areas constrains both owners and developers' ability to monitor the location and work done by tractors. It also constrains the Tracker app's ability to communicate information, as no feeds are given to it.

7.2 How has the structure of the actor network in Trotro tractor platform evolved and what processes of translation can be observed?

As argued in section 2 above, the ANT helped us to uncover the intricacies of the technological process underlying the Trotro tractor platform. It allowed us to understand the network of association among actors engaged on the platform and bring to light the sequence of actions, processes, and transformations enacted through the interactions among the actors. This resulted in the establishment of the platform's structure and modus operandi until it eventually ceased functioning. This position is also shared by Heeks and Stanforth (2015), who similarly affirmed that the application of ANT helped to open the "black box" of technological process and further disentangled the network of actors and the process by which actors' interests and identities are translated into the functionality of these network.

As shown in section 5.2.1 above, this process starts with developers initially identifying and defining problems to the establishment or achieving temporal stability of the platform. In this case, developers of the platform defined several problems and implemented proposed solutions (for instance, they identified the uneven distribution of tractors as a problem and proposed to register tractors and march them to demand). Nevertheless, it became evident that not all proposed solutions yielded the expected outcomes. Typical examples are the issues concerning trust and uneven distribution of tractors, which persisted as a constraining factor, defying the implemented solution.

A salient aspect of the translation process of the platform lies in the several changes that were made to the structure of the platform and the impact of these changes on the platform's functionality before it collapsed. These modifications were categorised into shifts in interest,

changes in roles, picking up additional roles, and enrolment of new actors (see Table 6 above). As suggested by ANT, if any actor is enrolled in or withdrawn from the network, this will impact how well the network functions as a whole (Doolin & Lowe, 2016). These dynamics were evident in the Trotro tractor case (as shown in section 5.2.3). Here, the enrolment of actors on the platform, the shift in actors' interests, and the other changes affected the functionality of the whole platform. For example, enrolment of the Tracker app bolstered transparency on the platform to a certain degree, persuading some tractor owners to register their tractors. This proved pivotal, given that tractors constituted a fundamental prerequisite for the operation of the whole platform. Another example was the shift in interest of developers from the provision of tractor rental services to smallholder farmers to the provision of service to farmers with more than 10 acres of farm to farmers. This alteration in focus fundamentally changed the essence of the whole platform, affecting the criterion by which farmers accessed services from the platform and influencing profit accrued by owners on servicing a request. This shift played a vital role in an attempt to bolster the platform's sustainability, as developers believed it helped them gain some profit over time.

The role of power in the translation process is notable, particularly where developers had to develop the Trotro tractor app (even though they realised the app was unlikely to be used in the field) to meet the criteria for funding from the Kosmos AgriTech Innovation Challenge (See section 5.2). Callon (1986) argues that the process of socio-technical innovations would come to a standstill if the existence of influential actors with vested interests were disregarded. In this context, the platform's development would have been halted at the beginning if developers did not meet the requirements of these donor agencies, prompting them to provide inaccurate information. Consequently, if developers had not been able to sustain the interest of donors over the years, the platform would have collapsed earlier as developers and field agents claim 90% of all their activities and operations were funded by donors through subsidies, thereby capturing some farmers within the platform's network. Hence, capturing the interest of an actor with power, predominantly through financial means, sustained the business.

7.3 How has the process of accessing tractor rental services changed by the Trotro tractor Platform?

This section discusses the impact or changes the Trotro tractor platform introduced to the process of accessing tractor rental services, with reference to Nkoranza South Municipality and the national level in general. It is clear that not much work was done by the Trotro tractor in the Nkoranza South Municipality. They only provided services in one season; nevertheless, some essential impacts were identified, which are discussed below.

Measurability: The platform introduced measurability into the process of accessing Trotro rental services. The introduction of the GPS device (as shown in section 5.2) for monitoring and taking accurate measurements of farm size helped tractor owners and developers to get accurate information on work done by their tractors. This fostered trust between owners, developers and tractor owners to some extent, but this measurability could not address the long-

standing conflict between farmers and operators on farm size measurement. Instead, it worsened it as this became another source of conflict in the process. This was, however, not surprising as Foote, (2018) and Daum, Villalba, et al. (2021) have argued that farmers in rural Africa (sub-Saharan region) do not trust the digital app and its use. Therefore, farmers were expected to oppose the measurement from the GPS devices, especially when awareness creation was not prevalent in the area. However, the innovation adoption process is entirely information-seeking, demystifying the innovation's advantages to the farmers. This problem could have been partially addressed by active information sharing.

Trotro tractor platform's first come, first served mode of operation did promise to introduce transparency to a certain extent; this transparency is also associated with owners' ability to monitor the work done by their tractors. Quayson et al. (2020) found that digital farming technologies foster transparency among actors in the agricultural value chain. Kansanga (2017) found that the traditional network did face transparency and fairness issues. These were found to be present in the local network at Nkoranza, as operators select the farmers to serve based on their discretion, which is sometimes influenced by bribery, gender, and farm size of farmers (see section 4.2)

On the other hand, against the original purpose (providing affordable tractor rental services to farmers with attention to smallholder farmers) for its establishment, the Trotro tractor platform introduced a barrier for smallholder farmers. Only individual farmers with a farm size of 10 acres and above can access services from them. The result of this act is that it prevents smallholder farmers from accessing tractor rental services individually. Consequently, Trotro tractors, by this act, are further widening the gap between the large-scale farmer (usually the rich in society) and the poor (smallholder farmers) as the benefit associated with tractor rental services can only be harnessed by the large-scale farmers. In conclusion, there were some temporary and very localised changes stimulated by the platform, but in the end, the platform did not change anything durably.

7.4 What endogenous and exogenous factors constrain actors' agency on the Trotro tractor platform?

The ANT as a theoretical framework provided room for us to access constraints from each actor's perspective. Several constraints were identified to have contributed to the collapse of the platform. Sumberg, (2005) argued that there are two forms of constraints to the use and adoption of innovations: the endogenous and exogenous constraints. It was clear that some of the constraints faced by the platform resulted from the actions and inactions of actors, whereas others were beyond the control of the actors engaged on the platform.

Section 6.3 above presented the identified constraints to the functionality of the platform. It can be argued that most of the constraints identified above (mistrust among actors, smaller tractors registered, incompatible business model, conflict on farm size measurements) are endogenous and could be addressed by actions of actors engaged on the platform. It can also be clearly seen that some actors (especially developers) had taken steps to mend most of these factors, yet the interconnectedness and multifaceted nature of some of these constraints rendered their actions

ineffective. For instance, developers tried to tackle the trust issue between developers, tractor owners and operators by introducing the GPS and tracker app to ensure monitoring and transparency. This action, though helped to promote trust to some extent, but the problem remained because an external/exogenous constraint (network availability) interfered with the functioning of the GPS devices. This made monitoring impossible in most cases.

On the other hand, endogenous constraints existed because of the inactions of actors. The smaller number of tractors registered on the platform could be addressed if developers developed a business model that was beneficial to both developers and tractor owners; the cost involved for tractor owners on the platform was two times higher than the cost for those in the local network. Developers could have reduced their 10% charge to incentivise owners. Issues with network connectivity are another example of a constraint that developers could address. Developers could enable offline tracking using other tracking means. Farmers and developers could also attempt to agree on farm size measurements and prices for working on them. Nevertheless, none of these actors attempted come to an agreement about this issue.

On the Exogenous factors, the existence of high demand and seasonality of the demand is something that cannot be addressed by the actors engaged in the platform. The existence of demand in itself is one of the main reasons for the establishment of the platform. However, the compounded with its seasonality make it more complex and challenging to deal with. Addressing this demand is a prerequisite for the continuous operation of the platform. However, the platform cannot address all the requests they receive. Another endogenous constraint is the spatial dispersion of actors; this is peculiar to rural areas, which the platform and its actors cannot change.

8. DISCUSSION

This thesis aimed to investigate the matchmaker platform, its structure (actor-network), mode of operation, impacts made in the process of renting tractors and its constraints from the actor interaction perspective. We do this by understanding the platform's structure in the sense that the actors engaged on it, how, when and where the platform operates. And how this differs from the structure of the informal tractor rental services. We further investigated the history of the platform in order to gain insight into the reasoning and motivation behind the platform's current structure and modus operandi. Hence, we accessed the development and evolvement of the platform over time. Having understood the platform's structure, we aimed to disentangle the impact of Trotro tractor operations in the life of intended beneficiaries in terms of the differences and changes introduced by the platform in the process of accessing tractors on by these beneficiaries, specifically in Nkoransa South Municipality. This enabled us to understand the factors that constrain the platform's ability to achieve this impact.

Although the observations and analysis presented in this case study may be context-specific to the Trotro tractor project, they provide crucial insights, lessons, and opportunities to discuss broader issues related to digital agricultural platforms, donor-driven development projects, and technology shaping, ICT hyping and information and communication technologies for development. (example Akrich, 1992; Birner et al., 2021; Daum & Birner, 2020; Tsan et al., 2019). In what follows, we present some of these broader discussions that this thesis contributes to. We later present a reflection on the entire process of this thesis, looking at the methodology employed to answer the research questions, what went right and wrong and what could have been done differently.

8.1.1 Beyond the digital agricultural hype: the poor competitive capacity of ICT platforms

The results make it clear that the platform faced several constraints despite the success tales surrounding it. It was also apparent that not much impact has been achieved by the platform in terms of changing the process of accessing tractor-hire services, as the platform could not compete with the local network. This confirms the arguments made in the literature of science and technology studies that novel technologies compete with the sociotechnical regime (Geels & Schot, 2007), and in many circumstances, these novel technologies do not find the space to flourish. It was also observed that, in contrast to the hype around the platform, portraying the platform as using a mobile app (Trotro tractor app) to replace the human role of linking farmers to tractor owners through automatic pairing, the app was instead never used for that purpose and humans still did the pairing of request with tractors. However, they received orders through other digital means. However, one can argue that the hype may have stemmed from the inception stage of the platform, as it was discovered in the section on evolvement of the platform that this was the proposed mode of operation of the platform. This finding resonates with the arguments made in literature about the hype about the ICTs for development, especially in the agricultural sector. Abdulai et al., (2023) argued that digital agricultural innovations have not lived up to expectation in northern Ghana as has been portrayed by NGOs and private sector projects in the area. They argued that full-scale digitalisation remains a distant goal in northern Ghana, and the transformation claims by NGOs and private sector players are disconnected

from smallholders' lived realities. Such hypes are quite common in the donor driven development projects due to the continues need for new labels or option to invest in by investors. This is confirmed by the Trotro tractor case as the platform did not deliver durable changes in renting tractors before it collapsed, however, it promised to do so. In fact, in the case of Trotro tractor one can conclude the rhetoric around this platform portrayed at it inception and by researchers and developers compelling the platform to Uber (as easy as one orders for uber, the same way farmers can order for tractors) is far from the reality on the ground- at least not yet the reality in Nkoranza South.

8.1.2 The challenges of donor-driven development

Wessells (2007) noted the pivotal role of focal actors in the translation process of an actor-network. In developing the Trotro tractor, the developers and donor agencies played a crucial role in getting the platform to achieve temporal stability. Developers enrolled all the non-human actors that were essential for the platform's operation. They also persuaded the donor agencies to provide funding for the platform's operations. On the other hand, the donor agencies contributed massively towards the enrolment of other actors following their enrolment. Their provision of seed capital is pivotal to funding the development of all necessary software (tracker app, dashboard, Trotro tractor app). Their continued funding for training activities and advertisements further enticed actors such as farmers and tractor operators to enrol on the platform. The sustained request/participation from farmers during the four years of operation of the platform, especially FBOs on the platform, was partially attributed to donors providing subsidies to these farmers. This multifaceted support played a substantial role in ensuring the platform's attempt to attain sustainability for the four years of its existence. On the other hand, one can argue that the development of the Trotro tractor app was not necessary for the platforms functionality if it was a requirement by donors for the qualification for funding as the app's only function in reality was to attract funding but not for usage by farmers. The fact that it developers knew farmers would not be able to use it yet they developed it to meet donor requirement cast some doubt and gives room to question donor driven projects in Africa which seem to be very rampant in the development industry. Many critical literatures in the past and present have questioned donor driven projects, their impact and sustainability over time (Dijkzeul, 2021; Jalkh et al., 2020). The question one asks is, would developers have developed this app if it was not required by donors? And could the resources that was invested in this app not have been used on a different thing to improve access to tractor services? For example investing in socio-organisational options like organising women in FBOs.

8.1.3 Unpredictable development path

Although the developers and mode of operation did change over time, this evolution over time confirms a fundamental principle of the study of science and technology, as argued by Latour, (1991): in establishing sociotechnical innovations, an action taken by one actor at the inception of the innovation is never sufficient to predict the path the action will take. Instead, the path depends on what successive actors do with the action. This is also seen in the case of Trotro tractor; there is a clear difference between the proposed structure of the platform and the structure that operated in practice. Clearly, the actions and interactions of later actors reshaped

the entire structure and mode of operation. Even the developers themselves changed some ascribed roles they assigned to some non-human actors later along the process. For example, the role (connecting farmers to tractor owners and performing automatic pairing) of the Trotro tractor app as proposed, was changed later to serve as a tool to attract continued funding. This new role played a big part in the platform getting contracts from donors, which formed a large part of all the work done by the platform. This was also the case for some human actors; for example, field agents were not part of the proposed actor-network of the platform, but a later action by developers to include them, helped to some extent promoting trust and checking misinformation on the platform, which was also a crucial aspect of the platform's functionality.

8.1.4 Inclusion and exclusion of actors

Another interesting dynamic in this thesis that have gained much attention in recent years in digital agricultural innovation literature under the umbrella of ICT for development is the issue of inclusion and exclusion of actors. It is a common trend today that the use of digital technologies helps to improve smallholder agriculture in Africa and there are expectations of these technologies benefiting everyone in some (Lajoie-O'Malley et al., 2020). However, many critical literature have argued that there is unequal distribution of benefits and harm associated with these technologies (Putman et al., 2023; van der Burg et al., 2019). People have related this unequal distribution of profit and harms associated with digital innovations to the mechanism of social inclusion and exclusion (who is in or out) adopted by many(Graham & Sweller, 2011; McCampbell et al., 2021). McCampbell et al., (2021) argued that inclusion and exclusion is more complex than the simple dichotomy of in and out and in platform with digital innovations there are more (intersection of access, design choices, etc) to this than then simplistic view. And in this thesis the nuance of inclusion and exclusion is clearly shown in both the Trotro tractor platform which with novel sociotechnical innovations and the local tractor rental network as well. Though the platform promised to make tractor rental service more inclusive, it could not sustain this ambition over time due to challenges. The platform inclusion criteria for farmers to access services from them changed with time. It moved from all farmers to farmers with farm size of 10 acres and above. Not only did this design change have a complex effect on access but the decision itself was a function of many factors ranging from cost associated with rendering services, spatial dispersion of actors and sustainability of the platform. The effect of this change in inclusion criteria was also not just about excluding farmers with farm size less than 10 acres from gaining access to the services being rendered, but also many women were excluded from the process as it is believed that most of the farmers with smaller farm sizes were women. On the other hand, the decision contributed to the attempt by the platform to make their business sustainable.

8.1.5 The role of trust

A salient issue that is apparent in this thesis is the role of trust in the adoption of novel sociotechnical innovations. The result of this thesis make is clear that one has to deal with trust issues especially when dealing with new digital innovations. It was apparent that a lot of the effort of the developers of the platform went into tackling and managing trust issues that existed

among the actors on the platform, yet they were unable to solve or eliminate completely the problems associated with trust. Many researchers have emphasized the importance of trust in the adoption and usage of novel innovations especially digital innovations (Jakku et al., 2019; Jayashankar et al., 2018; Mondego & Gide, 2018; Ramírez Gómez et al., 2020). Jakku et al., (2019), Foote, (2018) and Daum, Villalba, et al., (2021) argues that smallholder farmers have difficulty trusting digital innovation especially when they have very little information about the new innovation. In the case of Trotro tractor farmers did not trust the platform to render fair services to them. They doubted the measurement of the GPS devices and these doubts contributed to the platforms inability to gain continuous patronisation of it services from farmers. It is also quite clear that part of the reasons for the existence of such mistrust has to do with the unavailability of information on the mode of operation the platform. Contrary to the developers claim of undertaking advertisement campaigns at the national level, it was evident that farmers in Nkoranza had little information on the platform and its operations.

8.2 Recommendations

In this section we provide recommendation base on the findings of the study. First, we provide recommendations for those who wants to develop useful digital software for usage by actors in the agricultural sector or more specifically socio-technical innovation in the tractor rental services in Ghana. Next, we provide recommendations for addressing problems in the field of tractor service delivery other than the development of app. Then we end with recommendations for further studies.

For software enthusiasts interested in developing digital agricultural software for use in within tractor rental services in Ghana, it is essential for them to gain a deep understanding of the local and traditional practices of the involved actors especially that of local farmers. Additionally, a comprehensive diagnosis of existing challenges within the local tractor rental network, from various perspectives, is necessary. These insights should then be integrated into the development of the platform. We suggest that developers engage external experts to facilitate a multistakeholder forum involving the human actors to be engaged on their platform. This forum can serve as a platform for generating holistic, multi-perspective solutions to issues, with a specific focus on trust-building among actors and the integration of local farming practices as well as other organisational practices into the platform. Aside the above, it is imperative to address other challenges in the field of tractor service delivery that are a prerequisite for the functioning of their platform. Investing in the acquisition of more tractors is fundamental for any tractor rental platform to operate effectively and efficiently. Without an adequate number of tractors, the supply cannot meet the demand for services, particularly during the planting season. This is therefore the number one prerequisite to be met by any platform. It is also essential to conduct awareness campaigns, especially in the operational areas, to demystify the functionality of the software/platform for end-users. The process of innovation adoption is essentially information seeking and hence this will be a beneficial practice.

Developers may find it beneficial to establish decentralised mechanisation services, with a specific focus on designated municipalities and the provision of in-person offices. This approach can concentrate the limited available tractors to an area, effectively meeting the needs

of that region/area. The presence of an office also allows for direct interaction with end-users, especially farmers, fostering a higher level of trust in the system. Lastly, to ensure the success of such software platforms, we recommend that the government create a conducive environment, such as providing network coverage in rural communities.

On the other hand, we recommend that governments and other interested agencies/institutions to explore alternative solutions to the challenges in the tractor rental network to complement whatever developers may do or preferably focus on these alternative solutions. Building upon the findings of this thesis, we propose that the government, through municipal authorities, employ the use of social-organisational institutions such as farmer-based organisations and women farmers associations to facilitate organised access to tractor rental services. This approach allows farmers, both small-scale and large-scale, to collaborate and aggregate their demands, enabling services to be provided in bulk.

For future research endeavours, we recommend adopting a mixed-method approach encompassing both quantitative and qualitative data. This comprehensive approach should encompass all areas in which this platform operates. Additionally, it should quantitively examine farmer demographics and how they intersect with the qualitative findings above.

8.3 Limitations of the study

While this study has contributed valuable insights within its specific context, it is important to acknowledge its limitations. The observation and findings presented here are rooted in a particular setting (Trotro tractor in Nkoransa South Municipality), hence caution should be exercised when attempting to generalise them to a broader population. However, it is worth noting that the processes elucidated in this study may hold relevance in similar contexts, although further research is warranted to confirm their applicability on a larger scale. This study, despite its focused scope, unveils important processes that may resonate beyond the confines of the examined area, potentially offering valuable insights for comparable settings.

8.4 Reflection on Research

This explorative study is one of the first to look at matchmaker platforms in Ghana. The thesis started with the general research question. How have matchmaker platforms changed the process of accessing tractors in Ghana? With it original aim of investigating how the use of the Trotro tractor app have helped farmers and other end users to bridge to barriers to accessing mechanisation in Ghana especially the gender barriers. Guiding question and other materials were there developed along answering this research question. However, one month into data collection in Ghana, I discovered that the Trotro tractor app which was the central focus of my thesis then was never used by farmers or any end user. However, the app formed part of a broader network of actors that still sort of linked farmers to tractor owners. Hence, I had to refocus my study on the platform and change my general research question as well as adjust my thesis proposal on the field. The new focus went the general research question of this thesis; ***What are the features of the matchmaker platform and what constraints affect its use?*** The good thing was that I want to the field being guided by the fact that the study was explorative and hence things cold change. I however, had anticipated that these modifications would have

been made earlier on in the data collection process, rather than midway through it. However, these changes presented me with several valuable learning opportunities, which I will explain in detail below. One positive aspect of these changes was that my theoretical framework did not need to be altered to accommodate my new research focus. I would say one of the best decisions I made in this thesis journey was my choice of theoretical framework. It offered me the best lens through which this study could be conducted. See reflection on theoretical framework below.

8.4.1 Choice of Theoretical Framework, Methodology and Their Role in Thesis

The theoretical framework of this thesis was a combination of the Actor-Network Theory and Sumberg's Theory of Constraints to the Adoption of Agricultural Innovations. These two theories provided me with a complementary lens that allowed me to have a holistic understanding of the situation at hand. The ANT gave room to look at the issues being investigated from each actor's perspective giving an inclusive perspective of the platform. I looked at the local network from the angle of all engaged actors in this market. The translation aspect of the theory was the perfect opportunity to look at the evolution of the platform over time which gave a clear understanding of meanings behind the current structure and modus operendi of the platform. What the Sumberg theory added was that, studying the constraints, it opened the horizon to look beyond constraints that were within the control of the actors we identified through ANT but also look at constraints that were beyond the control of these actors and the intersection of these two types of constraints. the only problem we had with the use of these theoretical frameworks is that, whereas we had the opportunity to interview all the human actors identified on the informal/local tractor rental market, we were unable to interview all the human actors that were identified on the Trotro tractor platform. Thus, tractor operators and tractor owners on the platform were not interviewed, this is because we employed a snowball sampling method, with the developers of the platform being our gate keeper. As they were unable to provide us with data of these actors, we could not interview these actors. One could say that is a drawback of the snowball sampling method as there is a potential of balance of the study being affected by the gate keeper.

However, I was aware of this possibility before going to the field. In order to understand the role of those actors, questions about their roles and interest were asked to the developers, and the operators in separate interviews. The responses were compared, and difference were analysis. Follow up interviews were conducted separately with field agents and the developers again to clarify the difference in responses regarding the roles of the tractor operators and tractor owners on Trotro. These findings were also juxtaposed against findings in project documentation therefore triangulating the data on the actors that could not be interviewed.

8.4.2 Answering the General Research Question

The main research question of this thesis was to investigate the features of the matchmaker platform and the constraints that affect its use. I believe that the four specific research questions that I answered in this study helped me to answer the general research question. I defined the features of the platform as its structure, mode of operation, and impact. In terms of the platform's structure (actor-network), I argued that it evolves over time. Therefore,

understanding the history of its evolution can help to clarify the reason behind the actor-network. This led to the second research question, which looked at the evolution of the actor-network of the platform over time. To answer this question, I used the concept of translation in ANT as a lens. *The conclusion was that the platform had undergone several changes that defined and gave meaning to its current structure and mode of operation. Also, the rationale of building a mobile app that was going to be at the center of connecting the various actors did not work out as the mobile app (Trotro tractor app) was not used for that purpose and was used to attract continues funding.*

Regarding the impact, I aimed to understand the changes brought to the process of accessing tractor rental services in Ghana, including the barriers bridged and the ease introduced by the platform. However, I argued that it was not possible to understand whether any change had been introduced without first understanding the long-existing local network that the platform sought to change. Therefore, I first studied the local network in Nkoranza South Municipality, mode of operation, and its constraints. A comparison between these two networks provided insights into the changes introduced. *Based on our analysis, we concluded that the platform did not introduce any durable changes. Yet it is important to note that to some extent, the platform tried to introduce measurability which in itself was good but not align with the local practice of the people. It is important to note that Nkoranza South Municipality is just* one of the areas where Trotro Tractor operated, as stated by its developer. To gain a comprehensive understanding of the broader changes that may have been introduced by Trotro Tractor, it is advisable to look at all the places where the platform worked holistically. However, this task may not be feasible within the scope of an MSC thesis due to time and space constraints.

On the last specific research question on constraints, it was answered by looking at the factor that hinders actors' ability to exercise their agency on that platform. We categories these constraints into those that are exists because of the actions and Inactions of the actors and those beyond the control of actors thus, external factors acting as constraints. *Several constraints were identified. Some of these constraints existed because of the actions and inactions of actors and we argued that a conscious effort from actors to solve these problems could have addressed them. On the other hand, there were constraints that were beyond the control of actors yet impeded the agency of actors on the platform.*

8.4.3 Personal Reflection and Improvements

In general, I improved my research skills. Coming from a life science background, I had relevant quantitative research experience. Having gained interest in the field of social science, it is undeniable that I needed knowledge, skills, and experience in qualitative research.   This thesis was the second time I conducted a purely qualitative research hence massing relevant skills that will be useful for my career part. The difference between this thesis experience and my first qualitative research which was my research practice internship is that in this thesis I went on the field in person to conduct the interviews whereas in my internship I took all the data online. Specifically, I have gained much experience in conducting interviews on the field. I have learned lessons of how to do it and how not to do it. Though there were some challenges I faced in conducting interviews, I managed to sail through due to contextualized knowledge of

the situation in Ghana, which helped me understand issues better. I learned that studying in a context you have knowledge in can go a long way to help you in executing the project successfully.   I developed the skill for making sure that interviews stayed on the focus topic and not swayed away especially when you meet dominant participants.

Also, this thesis was the first time I had the opportunity to practice the theories of facilitating interactive process after learning these Methods and principles in class. I organized a focus group discussion as part of this thesis with farmers. Though this did not go as planned (hence data not included in thesis), it was a great opportunity to learn how these theories worked in practice.

Throughout the thesis process, I was given the opportunity to take charge of my research, which allowed me to be more innovative and resourceful. Being trusted by my supervisor had a positive impact on my confidence and my ability to deliver quality work. This experience has made me more independent and self-reliant. For instance, while conducting fieldwork, I realised the need to change the focus of my thesis and make relevant modifications. Without hesitation, I took the initiative to make the necessary changes on my own, even before meeting with my supervisor. Overall, I have grown to be more independent, innovative, and resourceful through this experience.

8.4.4 What I will do differently.
Although my thesis journey has been successful overall, there are a few aspects that I would approach differently if I were to do it again. Firstly, I would take the time to better understand the operation of the Trotro Tractor app. This would have saved me a lot of time in the field, as it turned out that the app was not being used by farmers. While in the Netherlands, I did attempt to confirm its functionality with the CEO of the platform, who assured me that it was working. In retrospect, it would have been better to have someone in Ghana download and install the app to check its functionality.

9.0 CONCLUSION

Many studies have been conducted on the access and use of digital agricultural innovations in Ghana, focusing on different aspects of these digital platforms and innovations. However, the matchmaker tractor hires platforms have not been studied holistically since their introduction in the country. There is very little information on their mode of operation, what constitutes them, the impact they have on the tractor rental network, and the challenges they face. This study bridges the gap on the features of these platforms and how they operate in Ghana by focusing on one of these platforms. It further sheds light on how these platforms evolved over time, using the Actor Network Theory and a complementary theory on constraints by Sumberg as a lens for this study. The finding of this study highlights a historical and theoretical appeal for the uber for tractor approach attempting to address the barriers and problems in the tractor hire market in Ghana. However, in practice the Trotor tractor platform have not achieved any durable change in this network with the platform itself facing numerous challenges and not being able to compete with the local tractor rental network. Considering all the challenges/constraints faced by the Trotro tractor platform and their operations in the four years after establishment we conclude that the uber comparison is not a reality for farmers. The platform faced constraints that were caused by actors' action and inactions (endogenous constraints) whereas other constraints were beyond the control of the actors engaged on the platform (exogenous constraints). However, despite the constraints faced by the platform, donors continued investing and providing funding to the platform because they believed the platform was bridging the barriers to mechanisation especially for smallholder farmers.

To address these challenges, we recommend that the developers employ outsiders to organise a multistakeholder forum for the human actors on the platform to find holistic and multi-perspective solutions to issues surrounding trust among these actors. We also recommend developers to engage in awareness creation (on mode of operation) at least in areas they operate. We also recommend the government create a favourable environment for these platforms to thrive for example provision of network coverage in rural communities. For further research, we recommend a mixed method (both quantitative and qualitative) that will holistically look at all areas this platform operated, and qualitatively look at farmer demographics and how they intersect with the above qualitative findings.

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