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The architecture of players in Ghana's digitalising agriculture

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The Southern Centre for Inequality Studies (SCIS) is the first research institute of its kind in the global South. It draws on the intellectual resources of the University of the Witwatersrand and partner institutions in South Africa and beyond, to host an interdisciplinary research and policy project focused on understanding and addressing inequality in the global South.

The Future of Work(ers) Research Project explores how digital technologies are reshaping the world of work and the impact of these changes on inequality. It conceives of the development and application of digital technologies as a contested terrain. It is particularly interested in how collectives of workers are shaping which digital technologies are developed, how and to what end; and the economic and social policies that have been leveraged in response.

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Abstract:

Digital technology is hailed as the appropriate solution for facilitating the deployment of solutions to poor farmers in Ghana in face of the state's inability to provide the required extension personnel. The influx of digital platforms into Ghana has brought in several operators whose connections and what they portend for Ghanaian farmers are under investigation. Using the food regimes approach we explore how digital technologies have been introduced into Ghana's agricultural landscape. Our interest was the developing discourses used to legitimate the transition of agricultural digitalisation from a public good critical for ending rural poverty to a commodity for which farmers assume full costs. Our data was drawn from individual and group interviews with digital players in Ghana's capital city. We obtained additional data from secondary sources including websites and research publications. We contend that the high proliferation of agritechs in Ghana in the face of state withdrawal locks them into the international digital ecosystems riding on the social enterprise discourse to sanitise the exploitation of Ghanaian farmers. In the face of the complex interconnectedness of digital players, there is an urgent need for sharper conceptual tools to move analysis to the conceptualisation of development alternatives to ensure the beneficial impact of digital technologies for poor farmers in countries such as Ghana.

Key words: digital agriculture, Ghana, food regimes, agricultural extension services.

Introduction

Contextually, agriculture remains critical to Ghana's economic growth, the sustenance of its population, and the main source of income for its rural households (Ghana Statistical Service, 2018). About 33% of the total workforce in Ghana and nearly 63% of rural workers make their living in the sector (GSS, 2021). Most Ghanaian farmers are peasants, often with farm sizes ranging from one acre[1] to five hectares (Jayne et al., 2016). In recent years, however, Ghana has experienced a decline in agricultural activities and a further reduction in agricultural employment owing to a decrease in the rural population (Diao et al., 2019). Ghana's food production remains a problem as the agricultural sector is characterised by low farm productivity and a high incidence of rural poverty. Several reasons have been advanced for Ghana's problems in the agricultural sector, with some tracing their roots to colonial policies and the failure of post-independence development projects to reverse the structure of colonial incorporation (Britwum, 2022; Dwyer & Zeiling, 2012; Konings, 1981). Others blame endemic challenges plaguing the sector on incommensurate population growth, outdated technology, and over-dependence on rain-fed farming (Gyimah-Boadi, 1989; Hansen, 1989). Adverse conditions such as low literacy, limited access to productive resources (especially land, financing and markets), poor infrastructure, declining soil fertility, erratic rainfall, drought and the prevalence of pests and diseases have also been blamed (Ghana Statistical Service, 2020). But perhaps the most devastating impact has been traced to the structural adjustment policies of the 1980s and 1990s, which resulted in the massive privatisation of state support systems along the entire value chain for agricultural production in Ghana (SAPRIN, 2004).

Ghana's agricultural sector has undergone substantial changes induced partly by broad national and agricultural policies, which are also shaped by global trends. For some, nominal gains derived from such interventions over the years suggest the potential for economic growth and employment opportunities held by Ghana's agricultural sector. For others, however, the causal factors are heightened by the limitations in agricultural extension service delivery, which constrain efforts to engage multiple interdependent actors to improve farmers' access to agriculture services (Munthali et al., 2018: 64). This, coupled with the inadequacy of agricultural extension agents in effectively carrying out their mandate, leaves several farmers underserved.[2] Improving agricultural production is predicted to lie in the deployment of digital technology to facilitate the emergence of pluralistic extension systems in Africa. Trendov et al. (2019) state that "digital innovations and technologies may be part of

[1] An acre is 0.405 hectares.
[2] The ratio of agricultural extension agents in Ghana has always been low, and until 2017 it stood at one agricultural extension agent to 1900 farmers. Recruitment carried out in that year reduced the ratio to 1:706.

the solution…" for "…more productive, efficient, sustainable, inclusive, transparent and resilient food systems (Trendov et al., 2019: 1). A position shared by international organisations such as the World Bank and the Food and Agriculture Organisation (FAO) suggests promoting practices and policies to draw in many agricultural service delivery actors.

Government's interventions, mainly the provision of infrastructure and a regulatory framework, intensified in 2005 when the Ghana National Telecom Policy was launched. This, together with the reduction in the cost of data bundles, widened the coverage of mobile network operators and increased the number of subscribers (Owusu, Yankson & Frimpong, 2018). In 2016, the Accra Digital Centre was inaugurated to facilitate digital platform start-ups among young persons. The Digital Ghana Agenda initiative was also introduced in 2018 by the National Communications Authority to ensure nationwide internet connectivity. According to Trendov et al. (2019), such interventions enable or provide minimum conditions for deploying digital technology at a national level. Owusu et al. (2018) noted that these have contributed to the growth of digital agripreneurs in Ghana (Owusu, Yankson & Frimpong, 2018). The Ghanaian government's initiatives are driven fundamentally by the dominant neoliberal approach, which shifts all public service provisioning to the market for profit. The policies, developed under the notion that this is the most efficient model for delivering services, are designed to allow many actors to deliver agricultural services to farmers. Taking advantage of that dispensation, there has been an influx of digital platform operators into delivering services in the agriculture sector, with several mobile-enabled information delivery models (Atanga, 2020; Owusu et al., 2018).

We believe there is a need to understand interconnectedness amongst digital agriculture players and what this means for the structural context of Ghana's incorporation into the international political economy of agriculture. The questions arising are: What is hastening digital acceptance in Ghana's agriculture landscape? And how are locally emerging digital players positioned in the evolving digital agriculture space in Ghana? The latter question leads us to explore the relationships between local and international digital players and the interplay amongst the many players in Ghana's agricultural sector. This paper is organised into five sections. A conceptual frame for discussing the findings follows this contextualising introduction. The third section presents methodological issues. In the fourth section, key findings are organised around themes such as the profile of agritech firms in Ghana, their operational framework, and the interrelationships among the various players. We note how they operate to initiate, convert and finally institutionalise agritech from non-profit ventures to full market-oriented organisations. The fifth section concludes the findings.

Conceptualising players in digital agriculture

Digital technologies have penetrated all agricultural activities at the pre-production, production and post-production phases, including irrigation, planting, application of chemicals, harvesting and data gathering on soil types, weather conditions, farmer profiles, service delivery to farmers and consumers and monitoring consumer behaviour (Fielke et al., 2019; Klerkx et al., 2019; Tsan et al., 2019). Generally, digital agriculture is seen as the solution to feeding the world's growing population by reducing input-associated costs and increasing productivity (Fielke et al., 2019; Trendov et al., 2019). It is also argued that digital agriculture can enhance knowledge exchange and learning through omnipresent data (Baumüller, 2017). Other potential benefits of digital agriculture include improving the welfare of farm animals (Yates, 2017) and minimising the environmental impact of farming practices (Balafoutis et al., 2017). Digital agriculture is also said to assist farmers to market their produce, effectively plan farming activities to mitigate the adverse impact of climate change, manage the delicate balance of soil nutrition and moisture, cope with pests and diseases, and ease constraints on agriculture resources, especially labour and credit. Such observations have led several authors to conclude that digital agriculture is a potential game-changer in agricultural transformation (Klerkx et al., 2019; Tsan et al., 2019), with some even hailing the dawn of a new agrarian transformation powered by digital technologies.

Still, others argue against the widespread belief in the beneficial impact of digital agriculture, explaining that such positions make abstractions of the social, political and economic relations that shape access and use. They point to the national and international political-economic interests underlying production relations which determine the direction and application of the associated services and products of digital agriculture (Munthali et al., 2018). Hierarchical relations among players in digital agriculture have been established. For instance, Kwet (2019) insists that monopolising digital technology by big multinationals, particularly from the USA, is a reinvention of colonialism of the global South. Such technological hegemony is said to have an economic basis accompanied by an ideological support base. Therefore, the aggressive push to digitalise agricultural tasks and services is viewed as part of the deepening incorporation of farmers into the international capitalist production system and as a necessity for the resilient dynamism of capitalism (Xing & Hersh, 2006).

Examining the ethics of data capture and the use of personal data, some have expressed concern about the international domination of the sector (Atanga, 2020). This view is also shared by Fraser (2019), who calls it data colonialism and argues that it is the foundation of contemporary capitalist accumulation. Through this lens, then,

new technologies – turning farmers' data into desirable agronomic products – are not to be treated as mere products introduced for consumer progress but carefully engineered goods embedded with values and power relations that create what Kwet (2019) calls technological hegemony. Such hegemony is characterised by monopoly power over the aggregation, capitalisation and colonisation of farmers' data. An additional concern is the displacement of local products and knowledge systems in peasant and subsistence agriculture (Klerkx et al., 2019; Kwet, 2019). Given this, Reis et al. (2020) highlight the need for critical debate on the so-called benefits of the digitalisation agenda to understand further how digitalisation is changing existing business models and affecting almost every sector of the global economy.

The wide range of digital technologies in agriculture makes it necessary to clarify two main concepts: digitisation, which refers to the transformation of analogue information into digital data, and digitalisation, the process of adopting computer technologies to support agriculture activities. Birner et al. (2021) advance the notion of embodied and disembodied innovations in agricultural economics by categorising agricultural digitalisation as embodied and disembodied. The embodied covers precision farm technologies used for crop and animal production. The disembodied includes software applications used to undertake farm management tasks by farmers or to link farmers with organisations that provide agriculture-related services. Disembodied applications include farm advisory applications, farm management information systems and digital platforms connecting farmers to production value-chain actors. Our focus here is agricultural digitalisation involving disembodied technologies operating to bring agricultural services to all actors in the agricultural value chain.

Literature on digital agriculture focuses on adoption and impact levels, with some covering the economics and management of digital agricultural production systems and value chains (Fraser, 2019). Some have been curious about its distributive impact on emerging power relations, patterns of inequality, the conditions of the agricultural labour force and the ethical issues related to ownership and control over agriculture data and technologies (Birneret al., 2021; Hackfort, 2021). Noting the potential impact of digitally assisted labour control technologies such as surveillance, studies have sought to understand the conditions and distribution of agricultural labour, the adequacy or otherwise of skills composition and emerging patterns of resistance and their potential to counter corporate capital's power (Hackfort, 2021). Those that have focused on the organisations supplying digital technology have attempted to unravel their incentives to provide digital technology for different categories of farmers, especially low-income farmers in the global South.

The current shape and character of global digital ecosystems bring to the fore the importance of political economy discourses derived from a Marxist analysis of commodification and surplus value extraction. Political economy is useful for unpacking how capitalism operates to determine the players in the digital-agriculture landscape and the nature of the relationships between and among the various players (Johnston, 1988). Analytical framing of agrarian studies, grounded in critical inquiry, provides another perspective for explaining the current nature of agricultural digitalisation in developing countries like Ghana. Here we mention those that link development policies and politics to the nature and direction of the changed and changing agrarian landscape. Cohen et al. (1979) and Roberts (1982), provide some guidance in their categorisation of the colonial African labour force to explain how pre-colonial agricultural production was drafted into the economies of capitalist European.

The resulting framework broadly outlines three forms of agricultural production. First is the fully waged labour under plantation agriculture, producing crops for the European industries. The analysis of Cohen et al. and Roberts underscores the observation by Asuming-Brempong et al. (2013) that commercialisation was a key driver of agricultural transformation during the colonial period. Colonial cash crop-export oriented agriculture caused neglect of food crop production (Kansanga, et al., 2018; Assuming-Brempong, Anarfi, Arthur, & Asante, 2013). Accompanied by the acquisition of large tracks of land for commercial farming, many peasant farmers were dispossessed of their land with the ensuing dependence on waged labour on coffee, cocoa, and rubber plantations. The second, peasant cash crop production for European markets, was incorporated into the capitalist political economy through research and development of seeds and chemicals for pest control and other farm tasks. The third was subsistence farming, under which most of the food crops consumed within the colonies were produced (Cohen, Gutkind, & Copans, 1979). The incorporation though less direct, was also connected through so-called improved seeds and fertiliser. The tendency has been to assume that peasant and subsistence farming, which depend on non-waged labour applying rudimentary technology, resist integration into the liberal economy and therefore remains separate from the international capitalist production.

Agrarian and peasant studies have benefitted from the emergence of the food regime thesis, which draws on the Marxist analysis of "use and exchange value [to explore] the capitalist drive to commodify all conditions, activities and means of human existence" (Bernstein, 2016: 628). Lately, the food regime theory has gained currency in studies on digital agriculture. The food regime approach originally deployed to understand the shape of agriculture and its place in the capitalist economy emerged from the seminal work of Friedmann and McMichael (Bernstein, 2016). Even though lamenting the limits of Marxist analysis in terms of its inability to account for the inherent

destructive impact of the capitalist mode of accumulation during the third food regime, it remains a tool for understanding current trends in digital agriculture.

The food regime approach seeks to address three main questions. First is the direction of food production, its location and producers, and the mode of production employed. The second covers the consumers of agricultural products and their consumption patterns. The third revolves around the nature of international relations arising from a specific historical epoch's expressions of ecological and social effects of production and consumption patterns (Bernstein, 2016). The key elements employed to distil different food regimes are their determinants, drivers and consequences. Unpacking these broad areas, Bernstein (2016) states that studies are interested in the international state system and the division of labour as well as patterns of trade. Agricultural industry relations are also of interest, especially the alterations in farm production tasks and their impact on the environment. This leads to dominant forms of capital and their accumulation modes, as well as the emergence and operation of alternative non-state or non-capital social movements and the tensions and contradictions that mark their relations. Finally, of interest are the legitimating discourses that give food regimes their right to operate. Using this approach, three phases of food regimes have been outlined, with the prediction that we are in the process of transitioning to the fourth. The first was the colonial regime, the second was corporate globalisation to the third is the corporate food regime, all of which were characterised by high levels of agricultural industrialisation which is "undermining conditions of human survival" (Bernstein, 2016: 628).

Like Prause et al. (2021), we are attracted to the food regimes framework because it allows an understanding of how digital technologies intrude into agricultural food systems. Their reflections underscore the alterations in power relations among digital agricultural players – "producers, consumers, states and corporate actors' (Prause et al., 2021: 644). Extant literature, however, fails to contend with the players emerging within the digital-agriculture landscape and how their layered interconnectedness plays out under the guise of providing poor farmers with the means to deal with resource constraints. In the analytical framing of the food regimes approach, we find useful tools for unpacking how the relations amongst players facilitate processes for commodifying agricultural extension services in Ghana. In employing this approach, we focus on unravelling the processes of moving peasant and subsistence farmers from being the poor who need support to access a public good to reduce poverty and food insecurity to becoming consumers who are ready and able to deploy the financial wherewithal to procure digital services in numbers that can support the growth of digital platforms founded on market principles.

One tool that we found useful within the food regime approach was the discursive logic that gives food regimes their credibility. The discourse legitimating digital agriculture is its presentation as a "game changer", positioning it as the solution to the many problems of agriculture. For some studies, the answer lies in international or national efforts to deploy digital technologies to solve social and ecological challenges, leading to the call for national and supranational policies to democratise digital technologies. The current framing of the benefits of digital agriculture is an "environmental narrative" that links "sustainability to the application of digital technologies" (Prause et al., 2021: 647). In Ghana, however, although the environmental narrative prevails, narratives of poverty reduction and food security are what gain prominence, leading to a stress on productivity and income. Such framings should underscore the need to present digital services to farmers as a public good. The question is how the poverty reduction and food-security-gain discourses can legitimise the deployment of market principles to offer digital agricultural services in Ghana.

Methodology

The study was conducted mainly in Accra, the capital city of Ghana, where the offices of agritechs are predominantly located. We were guided by an exploratory design because of our desire to gain clarity on the relations amongst the dominant players in Ghana's digital agricultural landscape. Following our choice of the formulative research design, we had to rely on a qualitative research approach to collect information. Our population of interest was comprised of agricultural service providers employing digital platforms to provide multiple agricultural services. These include the government ministry in charge of agriculture and private digital-agriculture business enterprises. We first explored the World Wide Web to profile existing digital players in the disembodied agriculture sector. We then used criterion sampling to select agritechs focused on delivering services to farmers and agents in the agricultural value chain. Our initial selection settled on the Ministry of Food and Agriculture as well as two prominent private agritechs in the country, Esoko and Farmerline. We subsequently used a snowball method, pursuing other players mentioned in the interviews with these three, which led us to Ignitia and the Department of Agricultural Economics and Extension of the University of Cape Coast. Information from the face-to-face interviews with the selected agritechs was supplemented with secondary sources and online data derived from the websites of the following Ghanaian players: AcquahMeyer; AgroCenta; DexAfrica; Genetics, Environment, Management, Socioeconomics (GEMS); and Ziongate Geospatial and Research Services (ZGRS). There was no predetermined sample size in line with such a qualitative approach. Data collection continued till saturation was reached.

The primary data collection methods were interviews with key people and group interview sessions using semi-structured guides with pre-scripted open-ended questions. Semi-structured instruments were deemed appropriate because of the inherent flexibility for unpacking emergent themes, allowing for in-depth and contextual explanation through probing. Issues covered in the data collection included the background and events leading to the establishment of the digital platforms and their main functions, funding, governance structure, partners, competitors and operational and policy-related challenges. Both the face-to-face and virtual data collection sessions were undertaken in November 2021. The interviews were conducted in English, recorded by digital audio recorders and augmented with field notes taken during the interactions. The transcripts were subjected to thematic analysis, which refers to identifying themes and deriving associations, explanations and relationships to make meaning. After familiarisation with the transcripts to understand the content and the context of data, codes were generated manually to highlight emerging concepts using open coding. The emerging themes included the types and characteristics of agritechs, their operational framework, the various players and their interconnectedness. Finally, through an inductive process of drawing on existing literature and from the researchers' experiences for reflexive interpretation of the themes, explanations were derived from these themes, as subsequently presented.

Profiling digital players

Digital players: types, characteristics and services

The agrictechs covered in this study dealt mainly with farmers in Ghana. Three had an international operational base in West and East Africa, and one extended beyond Africa to Brazil. Two out of the three which operated internationally – AquahMeyer and Ignitia – were foreign-owned. Our findings show that the first company employing digital means to deliver services to farmers in Ghana was Esoko, established in 2003. In 2005, the Ministry of Food and Agriculture (MoFA) attempted to deploy digitalisation to support its extension services to farmers. Ghana, however, witnessed the proliferation of private agritechs in Ghana from 2010. Thus agritechs in Ghana are relatively young enterprises, with most having been in operation for around ten years. In the first attempt by the state institution MoFA to offer digital services, the ministry was expected to establish 138 Community Information Centres to ease the delivery of agriculture-related information to farmers by connecting them to the Agricultural Network (Agrinet) using the Wide Area Network. The Agrinets linked to agricultural research institutions were sited near market centres and under the management of designated agricultural extension agents. The government was expected to support centres with basic digital communication equipment, such as computers and internet connectivity. A study by Davis and Addom (2010: 431) revealed that forty of these centres were

commissioned and functioned to connect rural communities to the "outside world". When funding ceased, the government's failure to provide the necessary resources and a policy framework for operation collapsed the centres.

A recent attempt by MoFA to offer digitalised agriculture services is its ICT and E-Agriculture Division. The unit assumed part of the extension agents' mandate to deploy technology to bridge Ghana's shortfall in extension agents. This, under the West African Agriculture Productivity Programme (WAAPP), was motivated by the high penetration of mobile phone use, which eased the adoption of internet-based social media platforms. Setting up the necessary infrastructure began in 2015 when some structures of the ministry were renovated to house the e-agriculture unit, and a call centre using an interactive voice response system was set up. At the time of data gathering, out of the three e-agriculture centres located in Accra, Kumasi and Tamale, only the Accra centre was operational, due to financial constraints. The agritech space in Ghana was, therefore, dominated by private providers. One problem agriculture digitalisation is expected to address is bridging the sharp disparities between extension officers and farmers, with MoFA facilitating private participation. We noted earlier the assertion by Osei et al. (2018) about farmers' need for all-year-round information on which to base their choices. Agricultural decision making revolves around tasks before, during and after farming.

Thus, the players performed the traditional tasks of agricultural extension agents, sharing information and support on farming practices, making the disembodied digital forms prominent. Our findings revealed a range of services and products offered by agritechs to farmers in Ghana (Table 1). All players provided information to assist farmers in making informed decisions on major agricultural activities. The information guided decisions before the onset of the farming season about inputs such as crop types and suitable varieties, where they could be obtained, how to transport inputs to farms and tractor services for clearing and ploughing farmland. In the rain-fed agriculture practised in Ghana, reliable predictions about rainfall patterns and quantities are important for short-term-yield crops such as cereals, vegetables and fruits. Information is critical for farmers to make productive decisions about when to plant, where and what to grow and new agronomic practices that help improve productivity. During the farming period, seasonal forecasts on how much rain to expect and when, as well as the rainy season's duration, helped farmers make choices about sowing, transplanting, irrigation and applying agrochemicals and to minimise risks associated with climate change conditions and farm-related diseases and pests. When crops mature, farmers must decide when to harvest, process, and market their produce.

Agritechs offered financial services such as market information and agricultural product pricing in major Ghanaian markets. This service is important to farmers and traders as well. Even though MoFA's Statistics Research

and Information Directorate was collecting market price data, it was for policy-making purposes and not available to farmers in real time. Agritechs also assisted farmers in financing their farming activities, and most – including the University of Cape Coast (UCC), Esoko, Farmerline, and AgroCenta – offered farmers financial literacy skills. Some platform operators connected farmers to financial organisations providing credit to farmers. They were an important source of information on farmer creditworthiness for such financial institutions and non-government organisations (NGOs) supporting farmers with credit. The agritechs gave financial literacy training, while larger agribusinesses had access to strategic and investment advice (Table 1). Farmers were also taught how to apply what was captioned as good agronomic practice (GAP) in farming.

Table 1: Digital products and services on offer in Ghana

Service/ Product	Details	Players
Regulation	Information targeting farmers Accuracy of content Farmer friendly content packaging Cost and quality of inputs	MoFA
Information	Basis for production decision-making Weather forecast Field mapping and profiling Disaster risk diagnoses	MoFA, Ignitia, AquaMeyer, ZGRS, GEMS
	Connecting farmers and service providers	MoFA, Farmerline, Esoko
	Good agronomic practices Field mapping Agrochemical application, Ploughing, planting, harvesting	UCC, Esoko, Farmerline
Financial	Marketing, pricing	MoFA, Esoko
	Strategy and investment	MoFA
	Financial literacy	UCC, Esoko, Farmerline, AgroCenta
	Credit sources	MoFA, Esoko, Farmerline
Farming services	Tractor services	Esoko
	Drone services Applying agrochemicals Analysing soil and water quality	UCC, AcquahMeyer, ZGRS, GEMS
	Technology dissemination	
	Crop counting and yield estimation	
	Input supply Seedlings and agrochemicals	UCC, Esoko, Farmerline
Others	Research and development	UCC, Esoko, Farmerline, AcquahMeyer
	Software development and support	Dex Africa
	Database systems application	Dex Africa
	Global positioning systems (GPS) and mapping systems	Dex Africa
	Geographical information systems (GIS) consulting	UCC, AcquahMeyer, ZGRS, GEMS
	Drone development and training	UCC, AcquahMeyer
	Research and development	UCC, AcquahMeyer

Source: Field data, 2021.

Agritechs connected farmers to input dealers and service providers. Such information-sharing services, which used to be the traditional responsibility of agricultural extension agents of MoFA, had now been undertaken by digital agriculture players such as AquaMeyer, ESOKO, GEMS, Ignitia, UCC and ZGRS (Table 1). Another set of services outlined in the data gathered was specialised services targeted at larger commercial farmers and service providers. The players involved included DexAfrica, AcquahMeyer, ZGRS and GEMS. These players offered technical services such as GPS mapping and GIS consulting as well as software development and support, in addition to applications for supporting the management of agritech databases. They therefore had a reach beyond farmers to high-earning subscribers. Our fieldwork revealed regulatory facilities designed to protect farmers and offer some semblance of order in the digital agriculture space.

There were several efforts by NGOs, multilateral and bilateral institutions and government to support farmers. Such efforts called for farmer registration, which in the past was a manual process of recording details on paper – a process accompanied by record keeping challenges and constrained by the huge cost of deploying the records for future projects. Thus Esoko and Farmerline's electronic registration of farmers was to facilitate access by the credit providing entities to farmers who had the financial standing to afford farming products. Electronic registration presented an additional advantage: the collection of biometric features such as fingerprints. Having information about farmers, their demographic profile, biometric data, farm size, yield and crop types as well as agronomic information about the land gives some security for financial organisations and agro-product dealers. The data offered by agritechs provided the opportunity to track farmers' creditworthiness. The state project, Planting for Food and Jobs, also cashed in by contracting agritechs to facilitate farmer registration.

Data on farmers was also critical for determining their needs: as agritechs covered in the study explained, the different categories of their beneficiaries or subscribers made it imperative to obtain their profiles to determine the nature of the information to supply. The need to set up a system that was sustainable financially occupied the attention of all the players covered in the data gathering sessions. The strategy was to include all the needs of farmers in one package. Thus, conscious of the fact that farmers' needs were a constellation of requirements that varied according to the phase of the farming season, they developed a system to enable them to:

> … create a digital footprint of the farmer so that the farmer can now go with that data footprint as they transact their various work. So, they want seedlings or if they buy it, there's a footprint to it, if they go to the input dealer to buy any key thing their digital footprints that will be recorded through their transactions and a short printout ... can be taken to a credit institution. The institution can tell, know that you bought maize, you bought seedlings, you bought this input, tractor service. It can also tell your expenditure and when you cultivated the produce, how much produce you harvested and sold it for. So, now the farmer can be assessed based on that position and then can be offered credit to the tune of what will be needed for their production

> and [to] improve their livelihoods. So, that was the birth, through the financial inclusion space during the 2017 era, of Esoko. (Field notes, 2021[3])

The agritechs covered in the study were offering direct services to assist farmers to execute farms tasks. Services on offer included those that used to be delivered by traditional extension support through agricultural extension agents, such as connecting farmers with tractor and drone operators for undertaking intensive and specialised agricultural tasks such as land ploughing, agrochemical application and soil analysis as well as crop yield estimation. Some offered software applications that farmers used to request the services of tractor operators. There were, in addition, several specialised services on offer directly to farmers and other agritechs. The players also served as a channel for the delivery of agriculture inputs. The main strength was data on farmers that facilitated a connection with farmers.

Beneficiaries of digital agricultural services and delivery models

Due to the nature of services on offer, the agritechs targeted different players within the agricultural value chain. Our findings reveal three main beneficiaries of the products and services of the digital service providers covered. They were generally farmers, commercial outlets and non-profit entities such as extension agents, agriculture researchers and policymakers. In fact, most of the service providers targeted all farmers, especially smallholder farmers. Some provided specialised services and were therefore more purposeful in the choice of beneficiaries; these included AcquahMeyer, GEMS, ZGRS and UCC. The others, especially Esoko, Farmerline and MoFA, which operated as generalised digital service providers, had a range of services which extended beyond farmers. The range of beneficiaries shows the penetration of digitalisation throughout the entire agricultural value chain in Ghana. There were, in addition, beneficiaries who were entities that supplied agriculture inputs and services such as seeds, seedlings and agrochemicals. Tractor drivers and drone operators were also additional beneficiaries of the services of the digital-agriculture companies covered in the study. Within the non-profit group of beneficiaries were members of the public who desired information on farmers or farming activities, especially researchers. Field agents also benefited from their services and so did university students of agriculture. The majority of non-profit organisations were NGOs working to support farmers to increase productivity and promote food security.

The agritechs targeted other actors within the agricultural production value chain such as traders, processors, transporters, aggregators and traders supplying fresh products to domestic and international markets. Other beneficiaries were aggregators who supply agricultural products to companies producing fast-moving

[3] Names and designations have been withheld to preserve anonymity.

consumer goods (FMCG). In Ghana, FMCG companies include Unilever, Nestle and The Coca Cola Company. Being heavily dependent on agricultural products, they are anxious to ensure reliable quantities of supplies of the right quality that meet certification rules for export into international markets. Thus crop types and chemicals used were important and to forestall any problems; the companies only bought from farmers who procured and used their agriproducts as well as following their advice on good agricultural practices.

The multiplicity of beneficiaries notwithstanding, there appeared to be a preference for corporate beneficiaries over NGOs. As one agrictech company explained:

> If we can form this business partnership with them, then we are building sustainability because, at the end of the day, these people will either pass on the cost to the farmer or they will absorb it as part of their operational costs. But for an NGO they will just subscribe for the farmers, but every NGO project has an end. Let's say it's a two-year project, so after the two years how do these farmers pay for the service? (Field notes, 2021)

The beneficiaries of agritech services were, in the final analysis, all who required information about agriculture, workers and farmers in Ghana. The services also served as training grounds for students pursuing university-level education in agriculture. They assisted field agents to reach farmers and connected other players to farmers as well.

The digital channels for delivering services to target beneficiaries were a mix of old and new media. The traditional in-person delivery through agricultural extension agents and what has been termed old media (digital outputs such as radio and television) were very much present. We discovered the operations of private extension officers, often hired by bulk aggregators, to ensure that farmers adhered to agronomy practices that could qualify them for the certification needed for exporting agriculture produce to Western markets. Others were the Alliance for a Green Revolution in Africa, the international non-profit organisation founded by Bill and Melinda Gates, and the Rockefeller foundations for supporting agriculture in Africa.

The emerging or new technologies are those transmitted through mobile phones. These are short message services (SMS), unstructured supplementary service data and interactive voice response systems (IVR), social media platforms and websites. Major players such as MoFA, Esoko, Farmerline and UCC used all existing media to reach farmers. They noted that each mode had its appeal and digitalisation was to fill in gaps in reaching farmers with agriculture services, and not a replacement. Thus interactions between farmers and agricultural extension agents were facilitated by mobile phones, and digital devices also eased connection between farmers and call centres. Farmers with mobile phones received specialised real-time information. Mobile phones enhanced the learning impact of radio programmes when farmers called in to generate discussions. There appeared to be a preference for face-to-face interactions between experts giving farmers advice, followed by specialised services delivered in real

time using digital media. Thus, for the moment, the widespread use of digital media to assist farmers was not considered a harbinger of the demise of agricultural extension agents but rather a tool for facilitating better access to farmers.

Ownership and funding models

We contend that the constellation of players emerging is better understood in terms of the financial arrangements established to facilitate delivery and acceptance of commodified agricultural services rendered to all categories of farmers in Ghana. In all, we discerned three models of funding from our findings, involving an assemblage of players and a delivery of cost in ways that sometimes masked the direct payment of services (Table 2). These were the fully funded services that farmers accessed for free without making payments for them, the second set were subsidised services partly paid for by the state with donor or partner support and the third entailed full cost recovery (Table 2). Apart from state institutions such as MoFA, all others operated on a commercial basis. During the interview sessions, most of the operators insisted that they were social enterprises only out to recoup costs to remain operational and not for profit. Free services were on offer by MoFA through state-owned radio and television programmes, supplemented by agricultural extension agent contact. Other state institutions, such as the Ghana Meteorological Agency, also provided weather forecasts and weather warnings aired by the state broadcaster on radio and television in a programme sponsored by an input dealer, Wienco. State-sponsored institutions such as the Council for Scientific and Industrial Research (CSIR) also shared their research findings for free to support agricultural decision making. Most of the council's research is donor funded.

Table 2: Ownership models and funding mechanisms

Ownership model	Financial Source	Funding mechanism
Public good	State funding	Free information; service provided by state institutions
	Multi- and bilateral funding agencies, international NGOs	Funded projects: funders contract organisations to deliver free services to farmers through digital platforms
Subsidised support	Public-private-partnership	State subsidised projects delivered by private partners or NGOs to farmer
	Farmer-based association	State or donor subsidised projects supported by farmers' membership fees
Private full cost recovery	Individual farmers	Direct payment of fees by farmers through call credit or airtime
	Agri-input companies	Cost of services and information embedded in agriproducts charges
	Commercial output buyers	Cost incorporated in contract farming
	Contract sale	Farmers' subscriptions paid for by profit financial or agriculture business
	Agritechs	Agrictechs relying on others for operational support services for a fee
	Business advertisements on digital platforms	Cost of providing digital services covered by advert of agriproducts

Sarku et al. (2021: 1268) and field data (2021).

Most of the projects initiated by MoFA's e-agriculture unit and other state institutions were donor funded. The World Bank has been one such sponsor. Some of MoFA's projects in agriculture digitalisation with foreign funding were the Community Information Centres established in 2005 and the CSIR's Agricultural Information Centre, funded by the Dutch NGO, the International Institute for Communication and Development. The centre was set up to coordinate activities and faculties of agriculture in Ghanaian universities regarding digital agriculture, serving as a referral hub for 150 researchers and extension officers for information on agriculture. The outcome of this project was a website and database as well as a training facility for researchers and staff. The tendency for activities to halt when funding stops is characteristic of state institutions delivering free agricultural services which, most of the time, were unable to maintain and replace equipment to sustain efficient delivery of e-services. The penetration of mobile phones, however, changed the situation, making them important for overcoming constraints in relation to equipment and infrastructure.

The next mode of funding was the subsidised model, often delivered through donor partnerships with private entities or the state. Farmers carried part of the cost. Sometimes NGOs and public research institutions, especially universities, delivered these interventions. The subsidised model, according to Sarku et. al. (2021), responds to the demands of the current neo-liberal logic which expects that digital services will operate as quasi-public good "with some excludability as users pay … to enable the recovery of cost …" (Sarku et al., 2021: 1265).

In fact, observers such as Osei et. al. (2018) believe that this is the best option for Ghana, which is already pursuing the total liberalisation and commercialisation of farming service provision.

Existing subsidised financing models were state partnerships with private for-profit companies that brought together several players who take up some aspect of providing the resources needed to deliver the service to farmers under the rubric of public-private partnerships (PPP). The collection of players were state institutions such as MoFA, the Ghana Meteorological Agency and CSIR and international agricultural support institutions such as the Consultative Group on International Agriculture Research (CGIAR). Such projects include the WAAPP and the current Planting for Food and Jobs organised by the state. The agritechs provided the platforms for reaching farmers, through either their existing databases or a fresh registration process collecting biodata such as fingerprints. Examples of such models include special projects such as CGIAR's Climate Change, Agric and Food Security, covering rural farmers. Support projects such as these reach farmers through existing private digital agriculture platforms. In the case under discussion, it was Esoko.

Most of the services delivered by the agritechs involved full cost recovery through different avenues (Table 2). Mobile telecommunication service providers such as Vodafone and MTN Ghana, with facilities for collecting charges at low overhead costs, were useful partners in this funding model. Farmers must subscribe to the network, paying monthly fees from airtime, to receive agricultural information. Another financing model discerned in our findings was derived from aggregators, food processing companies and FMCGs. This model, described in literature as a business to nucleus farmer and outgrower schemes, has farmer beneficiaries in pre-arranged contractual relations with the business entity which supplies agricultural products. They also relied on mobile telecommunication service providers. Direct collection of costs from farmers relied on farmer groups and cooperatives. This approach was often used to reach cash crop producers. Specific examples include Kuapa Kokoo, the African Cashew Initiative and Cocoalink. This approach was used by aggregators supplying international markets. The cost was incorporated in farm inputs such as seedlings and agro chemicals that the companies supplied to their contract farmers. Agricultural input sellers such as Wienco and Yara also lean towards this model, supplying cash and food crop farmers with its agricultural products. Our findings also discerned a business-to-business-to-consumer model, where private service providers were demanding specialised information from an agritech to serve the needs of its customers. This model was used in instances where the information was specialised, such as tropical weather predictions provided by Ignitia to Esoko. An example cited in literature is that between MTN Ghana and

farmers. To facilitate this service, the telecommunication networks supply "simple mobile phones" to deliver digital information to farmers.

The ability and readiness of farmers to pay for digital services has been noted to create two categories of farmers, based on those who believe that the services are a public good and government should carry the full cost, and those ready to pay. Such free services, often delivered through old media such as radio and television sources, are general and do not offer farmer-packaged information. Commodified services are tailored to specific needs of target groups. Literature identifies specific characteristics such as sex, age, farm size and income, as well as membership in farmer-based organisations, literacy and levels of productivity, as factors that shape how farmers view digital information. Farmers who rely on tailored, paid information sources have been noted to be predominantly men (Sarku et al., 2021). Women's sources of agricultural services tend to be generalised, unpaid digital services.

Players and their interrelationships

Our discussions on the range of players partnering Ghanaian agritechs show their connectedness with all institutions associated with agriculture globally. We believe that it is in understanding how they function as non-profit agritechs and transition to private commodity producers that we can appreciate the role of agriculture digitalisation as a tool for incorporating peasant and subsistence production into the international capitalist economy. Examining their role in the commodification of agriculture digitalisation, we grouped the evolving players from our field work into three categories: initiators, converters and institutionalisers. They were a mix of public and state institutions, private corporate entities, non-profit groups, as well as multi- and bilateral agencies. To understand the relations among the players, we categorised them according to their role in the process of delivering disembodied commodified digital agriculture in Ghana. In the process, we tried to outline the discourses underlying the processes accompanying their emergence and how they played a critical role in making digital agricultural service delivery a market commodity.

Initiators

Our discussions so far reveal that agriculture digitalisation was delivered mainly through international actors under the guise of ending poverty. International donors – in Ghanaian euphemism, "development partners" – initiate projects to support marginalised farmers (women, young people, food insecure people) to generate income and access nutritious food all year (Sarku et al., 2021). Emerging from our findings were multi- and bilateral

international development organs, which sometimes buy into continental or regional initiatives of the African Union or the Economic Community of West African States (ECOWAS) to introduce farmers to agriculture digitalisation services and products as a public good. International multilateral development agencies were the FAO and the International Fund for Agricultural Development; bilateral agencies included the United States Agency for International Development (USAID), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Department for International Development. These organisations triggered the emergence of Ghanaian agritechs which we called initiators. The initiators ride on a philanthropic discourse. As explained during our interview sessions with Farmerline, agritechs "… receive support [from international funders] … to experiment with designing AI to support farmers. They title it 'grant' but it is tight on the activities we must do. So those are some of the things … targeted at the operations and the activities we do" (Field notes, 2021). Ignitia also emerged as a philanthropic research project to help poor rural farmers. Based on seemingly benevolent motives, such initiatives bring on board yet more categories of players: capitalist philanthropic organisations such as Mastercard and Bill and Melinda Gates, as well as Rabobank Foundations, private input suppliers such as Yara, the Agricultural Manufacturing Group and DroneHub, and aggregators such as Unilever and individuals such as university-based researchers.

Reflecting on a desk study on the provision of climate information service to farmers in Ghana, Sarku et al. (2021) note that the prevailing governance structure, where international donors initiate digital service provision to farmers, often creates problems of ownership and limits upscaling when the donor-funded phase lapses, raising the question of project sustainability. Being mainly top-down, farmer input is often overlooked and so is the relevance to differences in agro-ecological zones and demographic backgrounds. Agritechs are convinced it is a question of an appreciation of benefits to be derived, and stress the importance of getting farmers to realise the benefits of digital agriculture services for enhancing productivity. Once farmers are convinced, they will pay to access the service. They explain thus: "Farmers see innovation as something they need to experience …. Grants support you to let farmers to have experience [of] the initial service without paying." The strategy is "prepping their minds" to let farmers understand the service or product "and if they see the value of what you are doing for them, then … after the initial stage which was freely paid for by grants, the farmers will be willing to pay for the rest." But the transition needs funding and this is where the next group the convertors enter the scene.

Convertors

Agritechs, once founded, were highly motivated to survive beyond the inception project, and devised strategies to continue to survive as viable entities beyond donor funding. Converting agritechs into sustainable

commercial entities involved collaborative full-cost-recovery services. Successful agritechs were those which could attract further resources to transfer their services onto the open market. This transition is accompanied by an altruistic discourse, to accommodate the commodification of digital services through the:

> … new school of thought that is saying, look, support these social enterprises because these enterprises are led by young people, adopting technologies or using innovative ways of … changing the landscape or tackling very difficult social problems. (Field notes, 2021)

Two things being stressed here were the development of young entrepreneurs, part of the solution to Ghanaian graduate unemployment. Donor organisations sometimes worked through international NGOs and research institutions. Our findings, building on Sarku et al's (2021) earlier efforts, identified the following: the Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance, TechnoServe, World Vision, CARE International, OXFAM, the International Fertilizer Development Centre, the Technical Centre for Agricultural and Rural Cooperation (CTA) and Global Open Data for Agriculture and Nutrition.

The convertors often worked through projects we label carriers, such as ADVANCE II, Smartex, African Cashew Initiative, and Farm Radio International's African Farm Radio Research Initiative (Sarku et al., 2021: 1267-1268). Thus, Esoko's turn into a commercial venture was its participation in the USAID-funded Market Information Systems and Traders Organisations of West Africa (Mistowa). This project, described by Davis and Addom (2010: 431) as "… a community telecentre and special business development unit" covered traders operating along the Ghana, Burkina Faso, Mali, and Niger trade route. The strategy for implementing Mistowa was contingent on the commodification of agriculture digitalisation, based on private sector participation. Esoko, which was tasked to develop the platform to facilitate information delivery to farmers and other users, could only operate as a private for-profit organisation. State sponsored initiatives to support marginalised groups were also carriers; in this case it was youth-targeted planting for food and jobs. It is at this point that the PPP-initiatives operated, asking farmers to pick up subsidised services.

There were, in addition, collaborations with research institutions. In the case of Esoko, the role of York University Centre for Economic Development in Abu Dhabi was critical, as a supporting institution, in Esoko's transition from a Mistowa/Ecamic to (the Eastern Corridor Agro-Market Information Centre) project to a fully fledged private digital agriculture service provider. Funding for the university project allowed them to focus on farmers separately from traders and to convince participating farmers, especially cash crop farmers, of the benefit of real-time information on market prices in bargaining with traders. In the case of UCC, the project was in response

to a call for research funded by the CTA to pilot the use of drones to assist farmers in Ghana; additionally, funding from Mastercard Foundation assisted the university to explore modalities for motivating farmers to pick up costs. The discourse then shifted to social enterprises initiated by young people believing that they were pursuing a social course. As was explained in our interview sessions with the agritechs, an emerging situation is the belief that wealth generation can proceed through efforts to do good deeds. Thus we were told at Farmerline that this new narrative is that:

> … you can make wealth while creating good and it is not possible to create good if you do not have resources. It is very practical. And so, this sort of vehicle or animal [is] called "social enterprise", which has a profit motive, but the concern is with social issues. (Field data, 2021)

This position was shared by Esoko and Ignitia.

Institutionalisers

A hurdle for commercialising agritechs was financial sustainability beyond donor support. An avenue identified was to bring on board all organisations serving farmers to buy into their services and find modalities for collecting fees at a low cost. Platform operators developed products to serve the needs of players beyond farmers and expanded the range of products on offer. Esoko therefore expanded information shared to assist farmers to make production decisions throughout the agricultural cycle. Ignitia, Esoko and Farmerline developed services targeting other agritechs. Connecting with input suppliers, however, was an important avenue. Thus they all took advantage of prevailing developments to leverage conditions for sustainability by ensuring that the platforms served as a space for connecting farmers with products and input providers as well as financial services. Refining their services to reach a wider audience called for dealing with the question of literacy, by replacing the SMS with IVR in local languages. This brought in additional players – mobile network providers. They also enabled the agritechs to collect payments from farmers, who are mostly scattered. Otherwise, low payments made for the services would have been expensive to administer if fees had to be collected in person. The Vodafone Farmers' Club, for example, operated as one such facility.

Conclusion

In this exploratory study, we set out to answer questions around the profile of the digital agriculture players, their interconnectedness, the accompanying power relations and the implications for the future of farmers. We did this relying on the food regime approach to understand underlying discourses that legitimate the commodification agricultural digital service from a public good. Our findings reveal a high incidence of digital penetration into

Ghana's agricultural sector, predominantly the provision of agricultural extension services in the form of disembodied digitalisation, through software applications. Our data showed that the future growth of digital agriculture in the country was promising to be Ghanaian, with a strong international influence, propelled by sponsored initiation projects, albeit obscured in the complex architecture of several levels of partnerships.

As revealed in our analysis, the overall motive of the multiplicity international players was to commodify agricultural services and draw farmers into the profit-making arena of agricultural capital. Thus, the resulting ownership model was a fusion of supposedly altruistic intensions and for profit motive whose survival was contingent on what is considered cost recouping and not profit making. The operational structure of agritechs, was dependent on numerous partners for survival, drawing several external players into Ghana's agricultural digital system. They ranged from private for-profit to not-for-profit with state institutions almost on the margins. The emerging models, consisted of all the ownership modes coming together, to provide specific resources to facilitate a combination of services to farmers. The mix finally served a purpose, to commodify agricultural services and draw farmers into the profit-making arena of agricultural capital.

We found central to the evolving discourses accompanying the deployment of commodified digital agriculture the diminishing role of the state that paved way for other players to emerge in the digital space. The fact that MoFA, the state institution mandated to regulate the agriculture sector and deliver services to farmers, is starved of resources, both financial and human was not seen as the core problem needed attention. The trajectory of discursive legitimation 'social enterprises' suggesting a mix of social, economic and innovative ideals was appealing to young, energetic agrictech service providers. Convinced that their models were inherently altruistic ignored the exploitative relations that were inherent in the emerging models.

Thus far, we see how local Ghanaian players, farmers and the agritechs, are locked into a global digital ecosystem in ways that make them dependent on modern knowledge and inputs. Our conclusion, therefore, is that the penetration of digital solutions into agriculture is also a new means of facilitating this process of the super-exploitation of farmers, irrespective of the mode of production in which they are engaged. In Ghana however, the emerging food regime thesis has been useful in unpacking the discourse driving digital commodification to facilitate the increasing lock-in of Ghanaian peasant farmers in the global agriculture production chain.

As an exploratory study, we have only provided pointers. We would, like however to recommend a research agenda to sharpen the conceptual tools for understanding and tackling the obscurities and complexities of the interconnectedness of players in the African digital agriculture space. The food regime framework was useful

however, we believe the agenda would be incomplete without tools to advance beyond a critique of the mainstream development paradigm to provide transformative alternatives.

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