

Is the right going wrong? Analysing digital platformization, data extractivism and surveillance practices in smallholder farming in Ghana

Rebecca Sarku ^a and Matthew Ayamga ^{b,c}

^aSustainability Research Institute, University of Leeds, Leeds, UK; ^bBusiness Management and Organization Chair Group, Wageningen University and Research, Wageningen, The Netherlands; ^cInformation Technology Chair Group, Wageningen University and Research, Wageningen, The Netherlands

ABSTRACT

The development of digital platforms is seen as a tool to promote inclusion and foster collective action, particularly for smallholder farmers in the Global South. However, the rise of platformization has given large organizations control over these platforms, raising concerns about whether digital innovations are truly benefiting smallholder farmers. This study examines digital platform practices in Ghana's smallholder farming sector, drawing on concepts such as datafication and surveillance capitalism. Evidence suggests that digital platform operators have gained more from these technologies than the farmers they aim to support. Numerous digital technologies – enabled by donor projects, accelerators, and startups – collect extensive data from farmers through GPS, drones, surveys, and mobile apps. These practices risk creating new forms of extractivism and surveillance. The study provides policy recommendations and outlines future research directions to address these challenges.

KEYWORDS

Digital platforms;
smallholder farming sector;
agricultural information;
Ghana

1. Introduction

Digital platforms (DPs) are key to the transformation of agriculture. In the smallholder farming sector, DPs such as open data kits, short message services (SMS), social media platforms, drones, and robotics are used to exchange written, audiovisual, and visual information. DPs are useful for documentation, farming activity registration, and agricultural advisory services (Barber et al., 2016; Bell, 2015; Munthali et al., 2018; Wolfert et al., 2017). They also provide market access or linkages for farm produce (Kim, 2018; Lakemann & Lay, 2019). The potential of DPs to transform smallholder farming in Africa has attracted considerable enthusiasm in public discourse, development policies and investment agendas (Mann & Iazzolino, 2019).

DPs are treated as a crucial growth sector in their own right and are seen as a means to transform the business practices of farmers, small-scale traders and market vendors (Cinnamon, 2020; Mann, 2018). Besides, data generated from DPs are framed around big data for development (MacFeely, 2019). DPs are potential sources of entrepreneurship (Srinivasan & Venkatraman, 2018), empowerment, bringing about economic efficiency, feeding into policy formulation processes or enhancing state accountability (Namyanya et al., 2021). Several public and private DP initiatives have been launched to build trust and inclusivity in smallholder economies in the global south.

CONTACT Rebecca Sarku  r.sarku@leeds.ac.uk  University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, UK
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In Ghana, technological innovations, including DPs, are transforming agriculture and the agrifood systems in many ways – changing farming practices, agroecology, and rural dynamics (Miine et al., 2023). This change involves the shifts from manual farming practices to data-driven and/or semi-autonomous activities (Abdulai et al., 2023a). The smallholder farming sector in Ghana has witnessed the use of digital tools, such as robots, drones, mobile phones, and AI (Ayamga et al., 2021). DPs are used to provide digital agricultural services that enhance farming and related value-chain activities (Aker & Mbiti, 2010). Whether these technologies transform the sector positively is still in question (Abdulai et al., 2023b). Hence, scholarship must explore how DP practices are taking place.

At the onset of digitalization, particularly its emergence in the Global South, including Ghana, it was very much envisaged that DPs would be emancipatory tools, whether for changing agricultural practices, increasing food production, integrating smallholder farmers into the global market, or enhance collective action among farmers (Cieslik et al., 2018; Coggins et al., 2022; Goedde et al., 2021). But now, we live in a time where big corporations have more control, integrating different platforms or even buying out promising start-ups financed by capital markets to create monopolies, which would change the initial narratives of DP developments for agriculture and other sectors (Askanius et al., 2022; Pentzien, 2021). This phenomenon reinforces the idea that neoliberal economics and the tech sector cannot be disentangled, shaping contemporary discussions on digital authoritarianism (Roberts & Oosterom, 2024).

In Ghana, the implication of the emergence of ICTs, including DPs, includes the redefinition of the state's role since state agencies lose their dominant position in information delivery. Also, the state and its agencies depend on the private sector to develop and implement agricultural services. The state's control in the production and dissemination of agricultural services has been reduced due to private sector involvements with the integration of different technologies to provide information for farmers. This has changed state agencies' regulatory mode or style of operation, resulting in the absence of a central governing authority for information (Sarku et al., 2021a). The availability of DPs allows for the flow of information from less traceable and verifiable sources, as information provided by the technologies transcends distances, territories, and borders.

In the context of Ghana, where there are hybrid institutions and limited enforcement of institutions, it is not known whether the practice of using DPs for providing agricultural services constitutes platformization, new forms of datafication, and surveillance capitalism. Despite growing interest and research on the impact of digitalization on agriculture and rural livelihoods, there is a need for further exploration to fill the knowledge gap on the scope of DP practices in the smallholder farming sector in Ghana.

After this introduction, the remainder of the paper is organized as follows: section 2, focuses on a literature review on the transformative potential of digital platforms and the continuities of colonial legacies of datafication, and surveillance capitalism through the practice of platformization. In addition, it presents the theoretical and the conceptual framework guiding the research. Afterwards, the paper presents the research method employed in section 3, followed by the research findings in section 4. The discussion and conclusion are presented in sections 5 and 6, respectively.

2. Literature review

This section reviews the literature on the transformative potentials of digital development and the continuities of colonial legacies of DP developments in Africa, leading to the formulation of the research question. Building further on the literature review, a theoretical and conceptual framework is developed and applied in section 4 for the analysis of DPs in the smallholder farming sector in Ghana.

2.1. The transformative potential of digital platforms in smallholder farming

Digital platforms (DPs) have the potential to be transformative in the smallholder farming sector, particularly in Africa. Scholars have argued that DPs can significantly improve access to information,

establish valuable networks, and reduce transaction costs (Aker et al., 2016; Klerkx et al., 2019). DPs facilitate various agricultural needs, including the supply of inputs, credit services, information verification, and payment transfers (Munthali, 2021; Ximena et al., 2017). DPs open up possibilities for collaborative buyers to ensure market security in lending arrangements (Agyekumhene et al., 2020). They also enhance transparency, broaden market access, strengthen negotiation power, and diversify production for the market (Duncombe, 2018; Jouanjean, 2019). DPs in the digital transformation of smallholder farming goes beyond making radical changes to farming practices (Qureshi, 2023). Advocates argue that DPs create a shared understanding of the market, increasing efficiency throughout the agricultural value chain (Gashaw & Kibret, 2018; Jouanjean, 2019) and integrating smallholder farmers into international trade (Gardner et al., 2019). They enable cost-effective crowdsourcing of information, monitor the agroecological environment, and support new forms of organization through citizen science initiatives (Cieslik et al., 2018). Moreover, DPs reduce information asymmetry, fostering transparency, accountability, trust in partnerships and open innovation (Blumenstock et al., 2016). It is proposed that DPs will gradually increase the visibility of smallholder farming activities to public and private sector actors, leading to better planning, product development, and service provision (Wolfert et al., 2021).

Despite the promotion of DPs as catalysts for development, scholarship often overlooks the specific socioeconomic and historical contexts of smallholder farming and continuity of colonial legacies (Gatti & Visser, 2020; Heeks & Shekhar, 2019), leading to datafication, and surveillance capitalism through digital platform development.

2.2. The continuities of colonial legacies of datafication, and surveillance capitalism through digital platform development

Economies in the Global South, particularly Africa, have assumed that DP development can be replicated along economic development theories, but they have failed to consider the specific socioeconomic and historical context of the sector's emergence and development (Kleibert & Mann, 2020). The reliance on DPs for development mirrors the continuity of colonial legacies, economic development theories, and large-scale infrastructure projects (Graham et al., 2015; Graham & Mann, 2013; Ouma & Adésinà, 2019). DPs in Africa continue to perpetuate colonial legacies through interventionist and extractive practices. Nothias's (2020) work highlights how platforms, under the guise of philanthropy, foster dependencies similar to historical colonial patterns. For instance, Facebook's Free Basics initiative, aimed to create a perceived need for connectivity among impoverished communities, creating dependency on their service where none previously existed (Alter, 2017; Graham, 2016). The example, among other digitalization projects such as biometric identity programs in the global south (Krishna, 2021), underscores how DPs often leverage disadvantaged populations for data extraction, datafication and digital experiments, reflecting a new form of colonialism in the digital age (Zuboff, 2019).

Mwema and Birhane (2024) emphasized that the history of undersea cables in Africa is closely linked to capitalism, colonialism, and the trans-Atlantic slave trade. Wanjiru (2020) also argues that digital technologies represent a new form of colonialism, where online experiences are commodified and extracted as capitalist resources. This digital 'scramble for the state' parallels historical colonialism, as it involves exploiting valuable resources, with power concentrated in the hands of a few. The continuity of these colonial legacies is further evident in the institutional and regulatory frameworks established by tech corporations. Nothias (2020) discusses Facebook's shift from public relations campaigns to a strategy focused on civil society engagement and Wi-Fi hotspots, indicative of a deeper entrenchment within local governance structures. This mirrors historical centralized investment in post-colonial states, where policies control practices to attract investment and maintain economic stability (Mann & Iazzolino, 2021). Similarly, DPs implement top-down control over digital markets, justified as a means to increase efficiency and predictability, but often resulting in regulatory capture by private interests (Mazzucato, 2013). This dynamic not only marginalizes

public sector initiatives such as public sector agricultural extension delivery, but also entrenches foreign dominance over local markets, perpetuating the unequal power relations reminiscent of colonial times (Mkandawire & Soludo, 1999).

In response to the trends in digital technology development, digital rights activism in Africa have focused on critical issues like internet shutdowns, government surveillance, and the lack of data privacy frameworks (Donovan & Martin, 2014; Freyburg & Garbe, 2018). Despite the potential for local pushback, African responses have been muted or even less loud, possibly due to the differing political landscapes, tech ecosystems, and dependence on donations (Nothias, 2020; Nyabola, 2018; Oyedemi, 2019). The DP development critique is gaining traction because platforms in Africa often operate with minimal resistance, embedding themselves into platformization, datafication, and surveillance capitalism, reinforcing historical patterns of exploitation and control under the guise of development and connectivity.

It is clear that, even in the formative and piloting stages, the development agenda of DPs aims to serve the interests of private actors, shareholders, and donors (Mazzucato, 2013). The use of DPs in the smallholder sector also reinforces the business and donor-driven regulatory control that was initially established during the adjustment era (Mann, 2018). Mann and Iazzolino (2021) argued that after the failure of neoliberal structural adjustment programs, new institutional economists (NIE) developed digital agricultural infrastructures to enhance markets from the grassroots. This mirrors the economic strategies of the colonial and post-independence eras, where developers justified these initiatives to increase efficiency, attract investment, and make markets more predictable to suppliers and aggregators (Milan, 2020; Morozov, 2013). The notion has led to the development of numerous DPs and innovation centers, mimicking the Silicon Valley phenomenon (Block & Keller, 2011; Mazzucato, 2016; Weiss, 2014), with funding and start-up programs often driven by commercial interests rather than local needs (Mann & Iazzolino, 2021). Donors prefer conditional cash transfer into DP start-up initiatives instead of direct support to governments, as the initiatives allow them to target aid to eligible individuals and use conditionality to encourage certain developmental behaviors (Ouma & Adésinà, 2019) such as quantitative monitoring and evaluation of DP projects through experimental research. The NIE perspective has also led to a substantial amount of research funding driven by the commercial interests of tech firms (Mann, 2018).

The development of DPs for smallholder farming sector occurs in a context of consistent under-investment in state extension and agricultural research and development (Ouma, 2015). There is also a risk that public sector platforms (e.g. E-agricultural platforms) may lack the financial resources and business infrastructures to scale and compete with their private sector counterparts (Mann & Iazzolino, 2019). Moreover, when DP replaced the vacuum left by extension services, they become the sole reference for farmers, pushing the role of public extension services further to the sidelines (Sarku et al., 2021a).

Furthermore, the model of operation of DPs is based on network effects, where different platforms or service providers are integrated into a single proprietary platform, leading to monopolies and entrenched pre-existing inequalities (Bonina et al., 2021). Independent start-ups may enter into locked relationships with larger platforms, such as Google, due to their network power and scaling opportunities (Barwise & Watkins, 2018; Kleibert & Mann, 2020). The big platforms run on 'platform-based superstructures,' creating infrastructural conditions with global validity, while lesser actors (start-up platforms) are, in effect, partially dependent (Askanius et al., 2022; Koskinen et al., 2018; Schwarz, 2017). With a DP practice such as the provision of bundled services through the integration of several platforms, operators can identify and direct creditworthy borrowers toward credit facilities (Carolan, 2018; Mkandawire, 2011; Srinivasan & Burrell, 2015). This could lead to significant differentiation in rural areas, as the most productive farmers may displace less productive ones (Bateman et al., 2019; Steyn, 2016).

The literature review has revealed the continuities of colonial legacies of datafication, and surveillance capitalism through digital platform development in Africa. It indicates that despite the potential benefits associated with DPs, there are many negative implications (Coad et al., 2020). In the

studies conducted in Africa including Ghana, scholars suggest technological deterministic views of DPs to have capabilities that could fill in gaps in government extension service delivery, and also deal with exploitative middlemen in the smallholder value chains. This research argues that these narratives have shaped a discourse that portrays digital platforms as the ultimate solution to integrate smallholder value chain actors into the global trade. Scholarship focusing on smallholder farming in Africa have sang the praises of digital technology development, focusing on social and economic empowerment, inclusivity and emancipatory viewpoints with limited pushback and critical analysis of the negative implications (Nothias, 2020). The current literature on DPs in Ghana's smallholder sector for instance, primarily focuses on evaluating specific platforms, value chain development, and barriers to adoption (Agyekumhene et al., 2018; Ayamga et al., 2021, 2024; Coggins et al., 2022; Johnson, 2018; Munthali et al., 2018; Nyamekye et al., 2019; Sarku et al., 2021b). Albeit, scholarship continue to grow on the negative effects of digital development in other sectors apart from agriculture in Africa (see for instance, Birhane, 2020; Coleman, 2019; Giacomini, 2020; Iazzolino, 2021; Karar, 2019; Mwema & Birhane, 2024; Nothias, 2020; Nyabola, 2018; Oyedemi, 2019). The literature review underscores an area currently understudied in digital development sector.

Given the identified knowledge gap, this study aims to explore digital platforms in the smallholder sector, the practices associated with their use for the delivery of agricultural services, and how these practices lead to platformization, datafication, and surveillance capitalism. This knowledge remains largely under researched in the literature and deserves more attention. The overarching research question that guides the study is: How do practices of digital platforms in the smallholder farming sector in Ghana contribute to platformization, datafication, and surveillance capitalism? The answer to this question involves the identification of DPs and their development, type of agricultural services they provide to smallholder farmers, including the enacted practices (i.e. competence, meaning, and materials). The research will also investigate how DPs integrate various services and processes into a single interface, transform farming activities into quantifiable data leading to nudging of users towards specific services and a close loop. This research will provide knowledge on the 'other side' of digital development for smallholder farming sector and contribute to the broader discourse on the implications of digital technologies in development by examining the practices of DPs and how practices have the potential to lead to datafication, data extraction, and surveillance capitalism.

2.3. Theoretical framework

To understand the implications of digital platforms (DPs) in the smallholder farming sector, this section delves into the theoretical concepts, including practice theory, digital platforms and platformization, datafication, and surveillance capitalism. The concepts provide underpinnings for examining the categories of digital platforms for the smallholder sector, the practices of DPs and how practices result in platformization, datafication and surveillance capitalism.

2.3.1 Practice theory

Practice theory focuses on the routine behaviors within social contexts, emphasising the role of human actions and interactions in shaping societal structures. Digital platforms are developed and expressed through practices. A practice combines *competence* (skills and know-how), *material* (things, infrastructures, objects) and *meaning* (social relevance, experiences attached) that are enacted and reproduced (Shove et al., 2012). Gherardi (2012) indicates a practice comprises a set of activities that form a pattern; however, new meanings and activities are derived from the routine. This theory is integral in understanding how DP operators engage smallholder farmers, how platforms are integrated into their daily routines for resultant changes in their farming practices. Shove et al. (2012) highlight how new technologies and practices can disrupt existing routines and establish new norms within communities. In the context of smallholder farmers, practice theory can help explore how DPs alter and transform traditional methods of provision of agricultural services

and data collection. We apply the definition of practice by Shove et al. (2012) in this study to illustrate materials (i.e. types of DPs), competence (their roles), and meaning (i.e. modes of accessing data). We are also interested in how DPs contribute to practices of platformization, datafication, and surveillance capitalism.

2.3.2 Conceptualising digital platform and platformization

Drawing from Poell et al. (2019), we define digital platform as (re-)programmable digital infrastructures (hardware and software) that facilitate and shape personalized interactions among end-users and information providers, organized through the systematic collection, algorithmic processing, monetization, and circulation of data. Digital platforms share three essential characteristics: they are technologically mediated, allow interaction between two or more sides (e.g. buyers and sellers) and enable the execution of defined tasks (Cusumano et al., 2019; de Reuver et al., 2018; Gawer, 2009). Individuals function as users and data inputs, while some platforms may integrate different functionalities (Schwarz, 2017).

Following this explanation, platformization arises due to the growing trend where platform operators try to lock in a heterogeneous range of service providers within a standardized interface (Schwarz, 2017). Platformization in this study refers to the penetration of the infrastructures, economic processes, and governance frameworks and the reorganization of cultural practices and imaginations around platforms (Poell et al., 2019). Platformization has emerged mainly due to the 'permissionless innovation' (Gobble, 2015) enabled by free, open, and scalable internet infrastructure (Bonina et al., 2021). This implies that DPs, which initially started as search and social networking platforms, could scale into other forms of markets while also functioning as platforms for other digital innovations (Eriksson et al., 2017; Evans & Gawer, 2016). Automatic data generation can enable novel forms of synergy for those who own and control it. Platformization triggers the (re)organization of practices around platforms, and reciprocally, these practices actively shape the institutional dimensions of a platform. Ultimately, the collaborative activities of both end-users and complementors, coupled with the responses of platform operators to these activities, dictate whether a platform thrives or succumbs. Since this study is interested in examining how practices of DPs result in platformization in smallholder farming sector, this research will examine how DPs are integrated, while also scrutinising the occurrence of datafication and surveillance capitalism.

2.3.3 Conceptualising datafication

The development of data infrastructures is encapsulated in the concept of datafication, referring to the process by which digital platforms transform practices and processes into data that are machine-readable and analysable by digital technologies using data analytics, artificial intelligence (AI), machine learning, and complex algorithms (Williamson, 2018). With the growing prominence of AI models, data is increasingly recognized as a vital resource for advancing social good in development practices (Iazzolino & Stremlau, 2024). The practice extends beyond demographic data volunteered by users to include behavioral meta-data. The continual integration of platform infrastructures, encompassing apps, drones, smartphones, robotics, and other related means, enables the collection of extensive behavioral data. These infrastructures integrate with many devices, allowing platform operators to convert diverse human interactions – rating, chats, payments, conversation, item searches – into data. The data undergoes algorithmic processing and, often with certain constraints, is made accessible to external actors (Mann & Iazzolino, 2019; van Dijck, 2014). Datafication process is also propelled by complementors who actively incorporate platform data into products and services for everyday practices. Insurance companies, for instance, may utilize farmers' income and production outputs in decision-making. Datafication is applied in this study to analyse how DPs transform smallholder farming practices by systematically converting agricultural activities into quantifiable data. This approach helps to explore issues related to data extraction and surveillance capitalism.

2.3.4 Surveillance capitalism

In the context of this study, we operationalized surveillance capitalism as monitoring users' DPs and gathering of vast number of data points about users, with the core purpose of nudging them to patronize services or they lock users in a close loop to patronize services offered on a DP. Surveillance capitalism's practices also include manufacturing prediction products for sale in new behavioral future markets (Srnicek, 2017). Four key features are associated with the logic of surveillance capitalism: (1) the drive towards more and more data extraction and analysis; (2) the development of new contractual forms using computer monitoring and automation; (3) the desire to promise services offered to users of digital platforms; and (4) the use of DPs to carry out continual experiments on users (Zuboff, 2015). While the current use of digital technologies and surveillance could offer valuable insights into how informal settlements impact smallholder farming (e.g., Cinnamon, 2024), this study applies the concept of surveillance capitalism to analyse the implications of platforms, particularly embedding control, nudging practices and surveillance mechanisms.

2.4. Conceptual framework

A conceptual framework is developed based on the selected theories to examine practices of digital platforms for the delivery of agricultural services in Ghana's smallholder farming sector (Figure 1). The arrows in the diagram represent the interactions between these concepts, illustrating how digital platforms drive platformization and datafication, which together enable surveillance capitalism. The conceptual framework uses practice theory to analyse the interplay between competence, material, and meaning in the context of digital platforms and smallholder farming. Figure 1 reflects practices regarding how platform operators use hardware and software to provide agricultural services to farmers. The provision of bundled farm services includes agronomic advice, weather information, market information, insurance and information on input through the integration of several platforms (platformization). Data on subscribers may be generated with or without users' consent through interactions with platforms. Technologies such as data analytics, AI, machine learning, and complex algorithms are used to extract data (data extractivism) on the performance of user interactions on the platforms. The data derived can be used to develop new products for the users (Datafication). The extracted data also enables DP operators to nudge users to opt for new services. In effect, the DPs lock/embed value chain actors (farmers, traders, service providers, traders and third-party partners) into closed-loop systems (Mann & Iazzolino, 2021) by collecting and using data on their aggregated behavior, which could be used for predictions towards providing new services to target groups (surveillance capitalism).

Having this section, the next section describes the research context and method of data collection and coding.

3. Research setting and methods

3.1. The research setting

Agricultural sector in Ghana has undergone several reforms, including the delivery of extension services. The structural changes in the Ghanaian extension delivery system have also included accommodating private extension service providers that mostly provide information with digital platforms (McNamara et al., 2012; Munthali et al., 2018). New actors, including businesses, donors and tech firms are targeting agribusinesses and small-scale farmers (Sarku et al., 2021b). Several factors have enhanced the growth and involvement of both local and foreign private actors in Ghana's smallholder sector. The first is Ghana's development policies, such as the Food and Agricultural Sector Development Policy I & II, Ghana Shared Growth and Development Agenda and the Planting for Food and Jobs program that supports the inclusion of the private sector (Agyekumhene et al., 2018). Secondly, the mobile money digital payment systems launched by MTN Ghana enhance digital payments with technological infrastructures (Adaba & Ayoung, 2017). The country has the second-highest data penetration

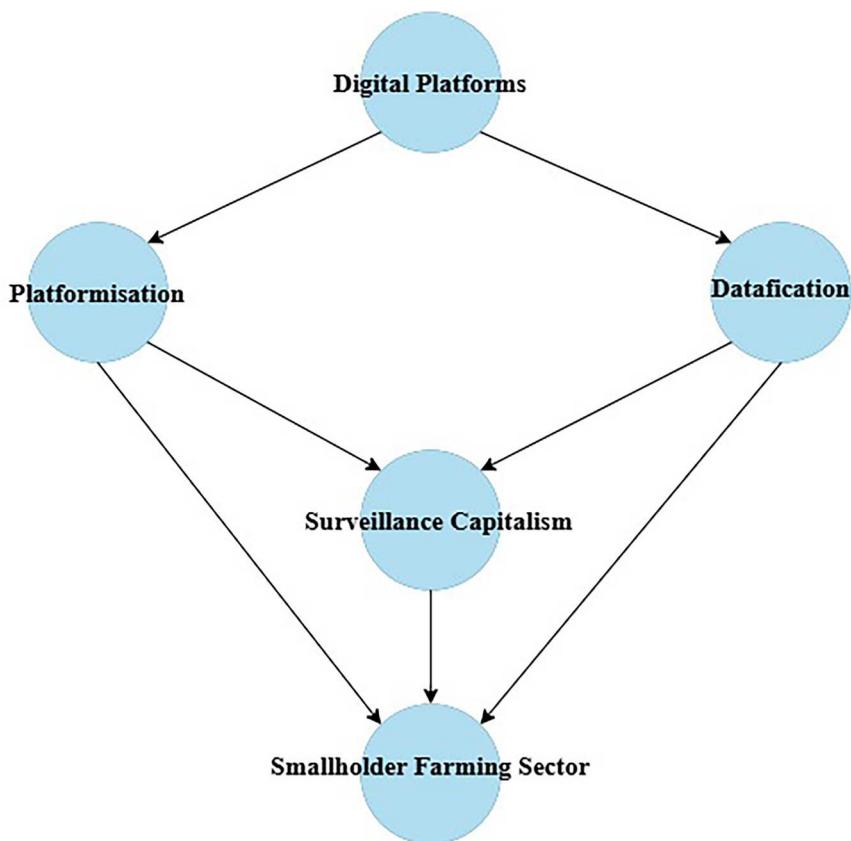


Figure 1. The conceptual framework showing the relationship between DP practices, platformization, datafication, and surveillance capitalism.

rate in sub-Saharan Africa, the fastest-growing mobile money market on the continent and a burgeoning tech start-up scene (Hatt et al., 2020). From the initial single mobile network provider, MTN, the country now has some of Africa's most competitive mobile telephony services (Adaba & Ayoun, 2017). Due to its utility, mobile phones have become the dominant communication platform in Ghana, increasing mobile subscription rates and consequently increasing access to agricultural services (Omondi, 2020). More recently, the Government of Ghana rolled out its digitalization agenda, implementing a national identification ('Ghana Card'), the use of delivery drones for medications, a national digital address system, mobile money interoperability, and an E-Agricultural platform, among other initiatives. The government has stepped up efforts to stimulate market activity and paved way for the rollout of 5G technology (Oxford Business report, 2019).

In 2019, Google opened its first Africa Artificial Intelligence lab in Accra. Recent moves by a big tech company, Twitter (X), to set up its African headquarters in Ghana are remarkable. Although Ghana does not have 'Silicon Valley' compared to other African countries like Nigeria, Kenya and Cameroon, the enabling policy environment, the success of the mobile money initiative and other digital technological initiatives are encouraging the growth of digital hubs, leading to the emergence of numerous AgriTech enterprises. Many organizations use digital innovation hubs (e.g. Accra Digital Center, Ghana Innovation Hub, Kosmos Innovation Centre) to train young entrepreneurs to develop digital platforms. Corporate institutions and donors also invest seed capital into start-up initiatives through digital innovation hubs to provide mentoring, networking, fundraising, and business development support for start-ups.

3.2. Research method

We employed a qualitative multi-case study approach to provide a critical analysis of the – (phenomenon) development of DPs in the smallholder farming sector in Ghana, drawing on the concepts of digital platforms, platformization, datafication, and surveillance capitalism. With this approach, we aim to analyse the complexity of the phenomenon (Miles et al., 2018; Yin, 2018). Choosing several case studies (i.e. digital platforms) also fosters contextualized and comprehensive research since it necessitates the gathering of a wide range of data (Hartley, 1994) and permits cross-case comparison to spot growing links between constructs that lead to the production of pertinent insights (Eisenhardt & Graebner, 2007; Flynn et al., 1990). Furthermore, case studies are particularly useful for examining contextual circumstances like the one that underlies our study (Yin, 2003). A qualitative multi-case study approach provided opportunity to analysis the development and practices of different DPs in the smallholder farming sector in Ghana.

To generate data for the research, we analysed information websites, social media channels and policy documents. The aim was to identify and structure digital agriculture, climate, and food services platforms. By so doing, we better understood how different information providers are already active in Ghana. We paid particular attention to the activities and materials that digital platform operators use to provide services. This first step's insights helped structure our search to focus on active digital platforms in the smallholder sector. Identifying active platforms led to scraping of information from the websites and social media using the URLs of pages such as 'Home,' 'Blog,' 'Mission' 'objective,' 'value statement' 'history of establishment' 'Awards,' 'Partners,' 'type of platforms,' 'Services,' 'Funding' and 'Projects.' We also included blogs on the websites of DPs because they provided evidence of partnerships, awards, projects, coverage areas, and how platforms are used to provide services and the associated practices. The approach to data collection is similar to a study conducted by Nothias (2020) on Facebook's Free Basics initiative. We manually drew the information from the website into a Microsoft Excel spreadsheet and Word document format for data analysis.

After collecting data from the websites on pages such as 'Home,' 'Blog,' 'Mission' 'objective,' 'Value Statement' 'history of establishment' 'Awards,' 'Partners,' 'Platforms,' 'Services,' 'Funding' and 'Projects,' we identified a list of initial themes. These themes were related to the research question, covering topics such as specific DPs, modes of accessing data, provision of services, target groups, forms of operations, sources of funding, and skills. The first coding stage followed thematic analysis with Nvivo software, guided by the key concepts: development of platforms, platformization, datafication and surveillance capitalism. We started the data analysis by thoroughly analysing each selected digital platform. The typologies or categories of platforms were derived based on the platform's functions. The analysis shows that each DP operator has one or more platform functions. Based on the functions (services provided), we categorized the platforms into themes such as Fintech, crowdfarming, crop management, etc. With each script derived from a specific platform, we established an understanding of the key DP types and their link with the concepts. These were subsequently cross-checked by looking at the retrieved data again and, on occasion, by referring to the operationalization of the concepts. The thorough coding process allowed for a structured and in-depth data analysis, which will be presented and discussed in the following sections.

4. Findings

4.1. Digital platforms development for smallholder farming in Ghana

The move towards pluralistic agricultural extension delivery where government extension service systems co-exist with the private sector has created opportunity for DP operators in Ghana. DPs development in Ghana is largely initiated by small-medium technological firms (henceforth referred to as DP operators or platform operators). DP operators' strategies in Ghana reflect a broader effort to enhance access to markets and finance. Platforms such as AgroCenta, Esoko, Kwidex, and ANDA,

emphasized connecting farmers with markets and financial resources. The need to improve farmer productivity and income is core in the value propositions of DP operators. Platforms like Ignitia, Farmerline, DigiExt, Esoko among others focus on enhancing productivity and income by providing quality inputs, training, and management tools. The use of digital tools, such as mobile apps, IoT devices, and AI solutions, is a common goal to empower farmers, evident in platforms like Okuafo and Agrilnnova. DPs such as Farmforce and AcquahMeyer Drone Tech highlight objectives like sustainable sourcing and using drones for environmental monitoring. AiScarecrow AgriTech and KaraAgro focuses on specific issues like pest control and early warning systems for crop health. Dent Agrisystems' Aquaponics Hub integrate aquaculture and hydroponics for sustainable food production.

Platform operators in Ghana have identified weak markets and exploitative middlemen as significant barriers to investment and productivity. One DP pointed out the lack of reliable information to enable farmers make decision on when to start sowing seed, source of input and potential markets. The framing is that, the lack of information drives farmers into guesswork, perpetuating cycles of poverty. Hence, a general trend which connects throughout the mission statements of DP operators is the idea of inclusion and transparency. Each DP operator promises to be contributing to specific sustainable development goals (SDGs), mainly, goals 1,2,5,8,9,12,13, and 15. A post by 'Grow For Me' for instant indicates:

We are addressing SDG 1 and 2 by creating wealth and contributing to food stability particularly in the rural communities where mass urban migration is having a detrimental impact on the agricultural food chain, by ridding it of essential labour force particularly during this pandemic.

DPs seem to be independent from government's control, and they provide low-cost mobile application services such as weather information, agronomic advise, insurance, credit services, farm inputs, haulage, and market information. Some DPs have virtual marketplace to facilitate transactions between farmers and buyers, thus eliminating middlemen. While others operate through forums and message boards.

The customer base for DPs are diverse audiences in the agrifood sector, mainly, smallholder farmers. The targeted users also include NGOs, farmer associations, agribusinesses, cooperatives, governments, research institutions, and various other entities, integrating multiple actors within the agricultural ecosystem, aiming to create more extensive, interconnected solutions. Techshelta for instance indicates: *'We provide an efficient and cost-effective online advisory, automation and market linkage service to vegetable greenhouse farmers, aggregators, consumers and input dealers.'*

The platform operators mostly originate from Ghana, with their headquarters' based in Accra. However, they operate in sub-offices in the northern sector of the country due to the presence of donor sponsored climate and agrifood projects. The geographical scope suits their targeted users who are disadvantaged populations mostly located in the hinterlands. Users who are part of donor sponsored projects usually form part of digital experiments initiative, sometimes following randomized control trial approaches. FarmRadio International indicates:

[...] In addition to our main office in Accra on the southern coast, we have a secondary office in Tamale, in the north, where there is more poverty, fewer public services, and greater wet and dry climate extremes.

Platforms like AgroCenta, Farmerline, AcquahMeyer Drone Tech, FarmRadio International, Esoko operate in other African countries, while DPs such as Ignitia, Cowtribe, and Farmforce are foreign owned and have headquarters outside Ghana. Some platforms are start-ups, where operators have presented their concepts and business models in accelerator programs (hackathons), and have won seed grants to scale their ideas. Examples include Farmcap, Complete Farmer, AgroSeal Ghana, Ghalani, Farm Cure, AniTrack. *'AiScarecrow AgriTech is an AgTech Start-up born out of the Kosmos Innovation Center AgricTech Challenge 2019 focused on crop protection. More specifically, we help cereal farmers cut losses to pest birds by 90-95%.'* Some platforms were initially developed as part of donor projects and later transformed into social enterprises. For example, Esoko started as

TradeNet in 2005 with support from the FAO and FoodNet in Uganda. Initially partnering with the United States Agency for International Development (USAID)'s MISTOWA program, it rebranded as Esoko, expanding its tools and services to different countries in Africa with its head office based in Accra. mFarms received funding from the USAID-Agricultural Development and Value Chain Enhancement (ADVANCE) program in collaboration with the Ghana Grains Council. Other platforms also started with their own seed capital, example Farmforce, Farmerline, AgroCenta, RentAFarm, Kwindex, and Grow For Me. SesiTech was established from the commercialization of the output of a research project. Green Afro-Palms for instance mentions at its website that:

We have built GAP up from nothing with no external investment, coupling it with on-ground validation for the adaptation of our business model to enable us capitalise more on the opportunity of the huge deficit of oil palm products in Ghana and Africa.

Platforms have redefined their business models from working solely with projects to include data analysis partnerships including randomized control trials, with different business models concurrently depending on customers' focus. Partnerships with international organizations and investment funds are playing a crucial role in the growth and scalability of DPs. Notable successes include FarmCap winning the 2018 Digital Africa start-up pitch event and the Okuafo Foundation securing a \$600k Zayed Sustainability Prize. Platforms like 'Grow For Me' and Complete Farmer are leveraging investments and collaborations to fund crop production and connect farmers to global markets. Additionally, Agro Innova and Sesi Technologies are enhancing their impact through strategic partnerships. Each DP identified in this research has information on external foreign partners, donors and projects. Beside partnerships, they also receive endorsement by statements such as 'We are Trusted By [...].' An excerpt of funding information by AgroCenta indicates:

AgroCenta raises US\$ 790k of Pre-Series A Working Capital & Development Funding From Shell Foundation, FCDO, AV Ventures and Rabo Foundation to scale its Agri-tech Ecosystem and secure Crop Purchases from smallholder farmers.

With DP operators facing challenges of upscaling their platform to reach large groups of farmers, there is value in using data generated by their systems, to create new innovations. The existence of mobile money systems and mobile network operators like Vodafone, MTN, and Airtel in Ghana have been crucial in transitioning digital payments, business transactions among value chain actors and facilitating the delivery of input and advisory services for farming while minimising the role of middlemen. All it takes is for farmers to register their SIM card with a mobile network operator who is the partner of a DP, building a system that links farmers, marketing agents, agro dealers, and input providers into closed loops around specific value chains.

4.1.1 The enacted practices associated with digital platforms in the smallholder farming sector in Ghana

Many DP focus on digital extension and climate information services as their prime target to support smallholder value chain actors. Findings show fintech platforms provide low-cost private mobile applications to value chain actors. DigiExt utilizes mobile transaction data, farm yield history, and mapping to inform lending decisions and assess risk. Agrocenta's 'LendIt' platform offers digital services, including mobile payments, micro-lending, and pension schemes. The interconnected ecosystem ensures farmers' repayment reliability. Agrocenta's 'AgroPay' platform also extends financial services like crop insurance, while the Mergdata platform owned by Farmerline provides credit for quality inputs and facilitates secure agri-trade transactions. Other platforms, like Farmforce and mFarm, focus on advisory services, marketing, and compliance issues, while Trustee Farm provides data for financial packages. FBSInnova is a Money-In/Money-Out module aiding farmers in budgeting and financial tracking. Platform operators' meaning attach to the practice is to ensure financial inclusion and foster rural development. The materials used in the operation of fintech platforms include mobile transaction data, historical data on farm yield, phones, and mobile money leading

to building competence in financial analysis and risk assessment. The enacted practices associated with fintech platforms are the provision of microcredit, farm mapping, assessing risk through data analysis, and enabling financial transactions. DPs aim to leverage their infrastructure to enhance the bargaining power of individual farmers, enabling them to respond more effectively to price changes and, in turn, strengthen markets from the grassroot.

DPs are also engaged in crowd-farming where platforms use their infrastructure to facilitates consumers/citizens' participation in the ownership of a farm cultivated by a remote farmer. The research identified platforms such as Trustee Farm platform, and FBSInnova DP owned by Agro Innova. Kwidex and Digifarmer adopt a similar model, allowing people to sponsor farms for a share of profits, with Digifarmer provide digital farming insights and quality control. Farmable combines social networking and crowd-farming to link investors to agricultural projects. 'Grow For Me' focuses on agricultural crowdfunding, while SmartFarmer platform promotes cooperative farming. The competence of crowd-farming platforms includes matchmaking between farmers and sponsors. To enact their business model, materials such as online platform, project information, and land availability are applied. The meanings attached to crowd-farming platforms include fundraising, investment, and project support. The research also identified that the enacted practices of the platforms include the inclusion of values chain actors (e.g. aggregators) and the provision of marketplace for buyers. Crowd-farming platforms generate revenue through commissions on funds raised.

DPs also serve as virtual marketplaces enabling direct transactions, market linkages or access to market between farmers and buyers. DigiExt platform employs matchmaking algorithms to connect farmers with export/food processing companies, while Mergdata platform supports agro-input suppliers with market access and post-harvest facilities. CropChain platform owned by AgroCenta manages the agricultural supply chain, incorporating logistics, traceability, and digital trading. Eco-willow Ghana focuses on e-commerce for organic seedlings, while Farmcap facilitates market connections for farmers. TechShelta employs IoT devices to link greenhouse farmers with markets, Trusteefarm offers web-based inter-trading with traceability tools, and ANDA Global utilizes DLT for global market access and financial services. The enacted practices of the platforms include merchandising agricultural commodities, connecting farmers to buyers, providing post-harvest facilities, and offering market information. The competence of the DPs involves market analysis, and supply chain management while the materials applied to enable the provision of services include the use of IoTs, data, and phones. The meanings attached to the operation of virtual marketplaces involve the provision of market access to value chain actors, and information on prices and market standards. In certain instances, the linkages between producers and buyers are facilitated through message boards, allowing users to arrange transactions using mobile money or other digital payment systems. In other cases, DPs incorporated payment technologies into the platforms but allow users to make decisions on the registration process.

Platforms also provide extension services in the form of weather and climate agronomic advisory services. Mainly DPs such as FarmCure, Esoko, AcquahMeyer Drone Tech, Okuafo Artificial Intelligence, Mergdata, Ignitia, KaraAgro AI & Drones among others (see Appendix 1) have competences on precision agriculture, disease identification, and agronomic support. AiScarecrow for instance produces automated scarecrows and agricultural drones. Agrolnnova is a management system for poultry farmers. The materials applied by the identified platforms include IoT devices, drones, AI, soil sensors, real-time data, phones, and radio. The meanings mainly attached to the operation of the platforms involve the need for sustainable farming practices, improved crop yields, and enhanced climate resilience. The enacted practices are pest and disease management with AI, precision agriculture with drones, soil analysis, providing agronomic support through digital platforms, and integrating other value chain actors (e.g. aggregators).

The nexus between experimental research, digital platforms, and agricultural development is evident in projects focused on real-time monitoring, data collection, and predictive analytics. Farmers actively participate in research by sharing data on location, pest incidence, and local weather indicators. DP consider their business models as two- or three-sided platforms,

experimenting through research or donor sponsored initiatives in the agrifood sector while generating revenue from data analysis through partnerships. Platforms include Grameen and FarmRadio International's AgroTech platforms. Other platforms are Platwise, and E-agriculture platform.

Across the country, we have led projects on a range of topics, including climate change, innovative e-extension methods and reducing micronutrient deficiencies using nutrient-rich crops. We have also conducted research on the economic viability of agricultural radio programs, leading to the piloting of our "Green Leaf" sustainable radio program approach.

The competence of experimental platforms includes experimental frameworks on agrifood issues. The materials applied on these platforms include ICTs, DPs, smartphones, and radio for real-time monitoring, and data-driven decision-making. The enacted practices include crowdsourcing environmental data, co-designing platforms, and the use of experimental research frameworks, where different data streams could be shared and integrated to create a more comprehensive view of the agricultural value chain. The experimental nature of these projects emphasizes user-driven approaches, citizen science methods, and multi-stakeholder collaboration, fostering a sense of ownership and trust among farmers.

DPs also provide agrodigital survey services where platforms are used for data collection in survey and development projects. Examples of such platforms include Farmerline's Mergdata platform, ESOKO, mFarm and CropChain. The InnovaSync platform records and manages biometric identification for poultry farmers, farm geolocation, and data for planning and formulation. They manage field surveys and monitor and evaluate community-based projects. The platforms are embedded with GPS, allowing for mapping, profiling, and collecting varied agricultural information. The competence and meaning attached to these platforms include monitoring and evaluation of projects, including project tracking.

There are numerous DPs providing agricultural services for crop farming, including platforms for livestock and aquaculture and fisheries platforms like Lojaanor, a supply chain platform that provides direct access to a profitable market for fisher-folk by short-cutting the long chain and providing cold logistics to avoid post-harvest losses and AkokoMarket operates an eCommerce application for poultry products. Dent Agrisystems, operators of 'Hwesomame' DP are also a mixed platform for crops and aquaculture called Aquaponics (i.e. a technology that integrates aquaculture, hydroponics, renewable energy and IoT for fish and vegetable production). Other DPs that provide services to livestock sector include AiScarecrow, and Anitrack.

There are DPs that have also been designed for transportation management, and access to equipment. For instance, DP such as AgroCenta's Rent tractor platform, and TrotroTractor facilitate farmers' access to tractors. TrotroTractor digitally connects farmers to tractor operators or owners by dialling specific codes – (*714*85#). The platform also allows tractor owners to monitor their equipment's movement and work progress.

4.2. Transformation of digital platform practices into platformization, datafication and surveillance

4.2.1 Platformization in the provision of agricultural information with digital platforms

This section provides an analysis on how platformization is occurring through practices enacted by DPs through integration of technologies to provide services for diverse value chain actors.

Platformization has emerged as a critical concept in understanding the restructuring of various sectors through digital platforms, significantly impacting how services are delivered and consumed. DPs have penetrated infrastructures, economic processes, and governance frameworks, reorganising cultural practices and societal operations around these platforms (Poell et al., 2019). This transformation is evident in smallholder farming in Ghana, where digital platforms (DPs) have revolutionized traditional practices by integrating various services into a unified, standardized interface, thus altering the landscape of agricultural service delivery. DPs, which often began as SMS, call centers and

radio services, have expanded into other markets and domains. As a result, platforms facilitate other forms of digital innovation and enable new forms of market integration and service delivery (Eriksson et al., 2017; Evans & Gawer, 2016). For instance, mFarms, a mobile and web-based platform, exemplifies how platformization integrates various actors and platforms such as three platforms, namely Agribiz, Farmer to Market and m-Xtension, within the agricultural value chain, providing market and management information. Similarly, SmartFarmer leverages the Internet of Things (IoT) to coordinate resources in farming, highlighting the role of platformization in reshaping traditional farming practices through digital means.

One of the key aspects of platformization is its ability to foster new synergies through automatic data generation and analysis. Platforms like KaraAgro AI use high-resolution aerial imagery and AI-driven data analysis to provide precise recommendations for crop management, thereby illustrating how platformization can lead to more efficient and effective agricultural practices. The use of such technologies also exemplifies the platform's role in transforming traditional industries by integrating advanced technologies that were previously inaccessible or underutilized. DigiExt illustrates the essence of platformization by offering a comprehensive ICT-enabled extension service. The platform integrates satellite and drone imagery, weather data, and soil sensors to disseminate timely and relevant production information to smallholder farmers. The platform's blockchain-based supply chain management is applied to ensure transparency and address exploitation by middlemen and stabilising prices. The interface, incorporates local languages and procedures, ensuring that the most technologically averse farmers can benefit from advanced farming techniques. An excerpt of how platforms are integrated for economic and data efficiency states:

Our development process involves real world data collection, pre-processing, processing, careful and accurate data labelling. We use techniques such as Data Augmentation to enhance performance. Our close monitoring, beta testing and fast iteration culture, allows us to generate more real-world data and improve the accuracy and performance of our models.

Moreover, platformization is not just about the technological infrastructure; it also involves reorganising practices around these platforms. As platforms become more integral to various sectors, they begin to shape and are shaped by the practices of their users. For example, Farmerline's Merg-data platform integrates AI and big data analytics to offer personalized support and traceability in the agricultural supply chain. This not only enhances the efficiency of agricultural practices but also creates a feedback loop where the platform's development is influenced by the practices and needs of its users. The collaborative activities between end-users and platform operators thus become central to the platform's success, ensuring its adaptability and relevance in the changing market dynamics. Sesi Technologies are multifaceted ecosystem. Each component, from the Grain-Mate app to the AgroMarket platform and the post-harvest management training, is built with a focus on integrating user-friendly interfaces with robust data protection and management practices. The mobile application architecture collects data such as device IP address, location, and account details to improve user experience. The data is also used for creating and managing user accounts, responding to support requests, and improving the app's functionality. The AgroMarket also requires robust database management and user authentication to ensure secure transactions and accurate matching of buyers and sellers. Integration with external market databases and potential buyer networks is essential for providing accurate market information and facilitating transactions. This involves secure APIs and data synchronization mechanisms.

In the smallholder farming sector, platforms like AgroCenta's CropChain and Complete Farmer's Grower exemplify the dual-edged nature of platformization. AgroCenta's CropChain platform's data-driven architecture tracks and analyses agricultural processes. It also integrates market information and financial services into a single platform. AgroCenta's platform architecture is designed to collect and analyse data at multiple stages of the agricultural process, from farmer registration to the sale of goods. This data-driven approach enables the platform to measure the impact on farmers' incomes and food production, providing valuable insights for continuous improvement. Agrolnnova's

platform entails a suite of technologies, including AkokoMarket and FBS Innova. Complete Farmer's Grower platform integrates satellite data, IoT technologies, and expert agronomic data. The platform's emphasis on data-driven decision-making is evident in its use of proprietary cultivation protocols. These protocols, developed from real-time data, ensures that crops are cultivated to meet market standards, maximising the chances of success for new farmers. TechShelta's platform automation system monitors various greenhouse parameters, sending alerts and allowing farmers to manage their operations remotely.

While these platforms provide valuable services to farmers, they also collect and analyse vast amounts of data at multiple stages of the agricultural process.

4.2.2 Evidence of data extraction

The research analysed for evidence of data extraction possibilities. Findings indicate data extraction with tools like satellite and drone data, biometry equipment, soil sensors, and other data-driven farming practices. We identified that platforms collect various data during registration process, including farmers' bio-data (such as age and gender), income details (both before and after joining the platform), and agricultural information (land size, type of commodity). The collected data are used to create personal profiles for each farmer on the platform. Platforms record and monitor various aspects of livestock farming, such as feed, drugs, birds, egg collection, sales, purchases, and payroll. Data extraction in some DP practices also involved collecting big data from fields (Bronson & Knezevic, 2016), utilizing high-resolution aerial imagery, and deploying drones to detect anomalies that may not be easily visible.

We also identified platforms and the integration of AI, which monitors users with the core purpose of gathering vast numbers of data points about them. The platforms generate valuable intelligence at every phase in the supply chain, from purchasing inputs by growers to delivering certificated shipments to customers. They produce data on education programs, farming standards, crop growth details, quantities, and locations. The approach emphasizes a comprehensive method of data collection across the entire agricultural process. Techniques such as data augmentation are used to enhance performance, including careful and accurate data labeling.

Establishing a digital marketplace employs advanced matchmaking algorithms, which likely involve extracting and analysing data related to agricultural products, market trends, and user preferences. Platforms capture the selling prices of goods, providing a data point that allows measurement of the increase in revenues for farmers. Additionally, the amount of goods offered on the platform measures the increase in food production, indicating a data-driven approach to assessing agricultural productivity. The feedback derived from users is analysed for further performance of algorithms and provision of improved services.

Networking and investment platforms for start-ups connect them with investors. This involves extracting and analysing data related to start-up performance, investment opportunities, and investor networks. Commodity trading technologies describe real-time monitoring of the off-taking process, commodity transactions, product quality, and supply chain logistics.

Some DPs use agents as intermediaries between the digital platform and smallholder farmers, playing crucial roles in collecting and inputting data. This intermediary role highlights the importance of individuals in the data collection process and emphasizes the decentralized nature of data extraction.

4.2.3 Evidences of datafication

Findings on datafication by digital platforms indicate the creation of personal profiles where real-world entities (farmers) are represented and stored as digital data. Blockchain technologies used by DP operators transform the collected data into a digital format, creating a comprehensive profile of each smallholder farmer. This datafication allows for analysis and insights into farmers' preferences, market trends, and transaction patterns.

The introduction of AI-powered assistants and chatbots in the Farmer/customer Helpline enables personalized interactions with customers, tailoring recommendations and solutions. AI relies on data to provide personalized and efficient support to farmers. The emphasis on personalization indicates the use of data to enhance customer satisfaction and streamline processes. Software also transforms traditional record-keeping into a digital format, allowing for efficient data management. The software engages in datafication by converting on-farm activities, geolocation, and biometric data into digital profiles, which is valuable for understanding the characteristics and needs of different farms.

The concept of *'farm records'* in an Excel file format or manually in handwritten form indicates a datafication process where farming activities, resources, and financial transactions are systematically logged for future references. A platform indicates *'good controller for your greenhouse,'* and the subsequent description of an automation system to fulfill the tasks suggests datafication in agriculture. The identified benefits, such as *'Know exactly what's happening in your greenhouse and make data-driven decisions based on facts and not assumptions,'* highlight the shift towards data-driven agricultural decision-making through automation. Also, phrases like *'monitor your rootzone,' 'send alerts when there's a problem'* and *'allow you to manage everything by remote access on any device'* point to the integration of technology to collect and analyse data related to farming. Some organizations have inscriptions such as *'data-driven farming for smallholders.'* An excerpt of datafication states: *'We turn data into tools, which means more vetted acres, more measurable impact on communities, more financial opportunities for farmers, and more clarity for customers.'*

We identified some platforms that claim to provide secure, traceable, and transparent trade processes. The implementation of traceability features implies tracking and recording data related to the entire trade process. There were statements that mentioned that when users use the mobile application, servers automatically record information sent by their devices. This includes details such as IP address, location, device information, operating system details, language preferences, search queries, access times, and dates. The practice indicates an automatic and deliberate process of collecting a variety of data points. Platforms also mentioned scenarios where information may be shared with trusted third parties, affiliates, subsidiaries, and service providers, indicating a level of data sharing and potential data exchange.

Overall, DP practices exhibit clear evidence of data extraction and datafication, aligning with the principles of surveillance capitalism by leveraging data to monitor, assess impact, and optimize services for smallholder farmers in Ghana. These practices align with the broader concept of surveillance capitalism, where data influences user behavior and optimizes service provision on digital platforms.

4.2.4 Evidences of surveillance

The analysis of information about DP suggests evidence of surveillance capitalism highlighting the monitoring of users with the primary goal of influencing their behavior or the core purpose of nudging them to patronize services or locking users in a closed loop to patronize services offered on a platform. Platforms mentioned monitoring the impact of its services by tracking key metrics, such as *'the increase in income'* and the *'reduction in food waste by farmers.'* Monitoring financial metrics, such as farmers' income before and after joining a platform provides insights into the economic impact of the platform on individual farmers, allows the platform to provide real-time market information to farmers, and nudge in decision-making regarding crop sales. The focus on impact metrics aligns with the concept of surveillance capitalism, where data is used to assess the effectiveness of services and influence user behavior. We also identified platforms that track the amount of goods offered on the platform by farmers, enabling the measurement of the increase in food production.

The requirement to present accurate financial records when applying for loans provides opportunities for surveillance capitalism. Lending platforms rely on data to assess the financial standing

and performance of the farming business. The platforms collect user data to personalize their experience, suggest relevant products or services based on historical records.

Some platforms generate comprehensive data on various aspects of farming, including educational programs, farmer information, crop growth, and supply chain details. The mention of data being *'harvested at every single step'* implies a continuous and extensive monitoring process throughout the value chain. Some platforms involve every agricultural chain stakeholder, indicating a wide-reaching surveillance system encompassing various participants.

The creation of datasets for machine learning experiments and social entrepreneurship suggests a collaborative approach to data sharing but also implies collecting and preparing extensive data about a specific crop, potentially including information on farmers' practices. For instance, the use of dataset for *'in-field crop disease diagnosis and spatial analysis'* implies a geospatial surveillance component, which involves monitoring and analysing the spatial distribution of crop diseases with recommendations for users to patronize certain services provided on the platform.

With the ability of DPs to engage in surveillance capitalism, they also engage in nudging practices to enhance their customer base. For instance, excerpts show such practices are evident as follows:

Earn more by growing cash crops to meet market demand and our buyer specifications. Get expert agronomic and managerial support, access inputs and farm services and receive reliable data to help you farm better.

Another excerpt indicates: *'Easy farming on a click, Trusted farmers and yield assured procedures and Assured farm visibility and regular progress reporting.'*

Nudging also comes into play through the focus of platforms on specific commodity on demand in the global market. In this instance, farmers who are users of the platform are guided automatically to produce specific crops or even varieties for buyers. We identified statements such as: *'A Commodity Trade Finance Platform enabling trade in SoyaBean, Cashew, Cocoa, Coffee, Shea, Barley, Sorghum, Millet, Maize, Sesame, and Fonio.'* The finding implies that farmers may not have the freedom to choose the type of crop that they prefer to cultivate when they subscribe to a DP.

A striking finding is that while DP operators provide information on the traceability and transparency for buyers and investors, there are no information advertised on how smallholder farmers also gain knowledge about the potential investors through the platforms. This observation was made particularly in relation to crowdfarming platforms and fintech platforms. For instance, while a platform mentioned how it incorporates crop insurance, experienced agronomists, and utilizes drone/satellite imagery to create data analytics, to provide leading edge feedback to sponsors and to instill confidence in sponsors, there was no vice versa information to inform farmer about the investors.

[...] Our digital systems allow us to build a better picture of the farms where our cocoa is grown, the farmers who grow it, and their communities, all in real time! As a result, we can better protect the people and places where our cocoa is grown, ensure the authenticity and Rainforest Alliance certification of our beans, measure progress, and quickly identify any potential problems.

In contrast, the information provided to nudge farmers to register with a platform only included: *'reliable funding and input supply,' 'technical and technological support' 'access to weather and agronomic information' and 'guaranteed off-take of produce at harvest.'*

The study also identified platforms that monitor user activities, tracking interactions such as searches, views, and transactions. This monitoring allows the platform to collect data points about users' preferences, behaviors, and trading patterns. Some digital platforms claim that industrial sellers and buyers can conduct the entire trade process on the platform, suggesting comprehensive monitoring of trade activities. This could include tracking product listings, negotiations, agreements, and final transactions.

Findings also show that although the term 'surveillance' may carry negative connotations in some contexts, the platforms identified seem to highlight the systematic and technology-driven monitoring of various aspects of agriculture for the benefit of stakeholders in the supply chain and farmers.

We also found that platforms outline various purposes for processing data, such as creating and managing user accounts, sending administrative information, improving user experience, enforcing terms and conditions, and responding to legal requests. In addition to the findings that surveillance was neutral or even positive in some cases, the information posted by some DPs explicitly mentioned that the collection of personal information from users was willingly submitted. Implying that consents were sort for the collection of personal details. Some platforms also indicate that users were informed about their rights regarding personal data, including the right to withdraw consent, object to processing, access, rectify, restrict processing, and request erasure. This emphasizes user control over their data. Other platforms also mentioned scenarios where information may be shared with trusted third parties.

Furthermore, some platforms also displayed information on the measures taken to secure information, including using controlled, secure environments and safeguards against unauthorized access. A plan of action in the event of a data breach is outlined, including investigation, reporting, and notification to affected individuals. This demonstrates a preparedness for data security incidents. However, platforms reserve the right to modify their privacy policies and commit to notifying users of changes. It is not written where and how data is stored (data management plan) and whether farmers can easily access data.

5. Discussion

In this section, we reflect on key themes that emerged from the results of the practices of DPs.

Platforms do not explicitly mention that they are engaged in surveillance capitalism. However, we identified practices that indicate monitoring and automation, which can be related to surveillance in a broader sense. We identified elements that suggest a form of surveillance or monitoring. For instance, a platform mentioned using a greenhouse controller and automation system that can monitor various aspects of farmers' production. The mention of sending alerts when there's a problem implies continuous monitoring and observation of conditions. The platforms emphasized making '*data-driven decisions based on facts, not assumptions*.' This suggests a systematic collection and analysis of data, indicating a form of surveillance or monitoring to gather information about farmers and their daily practices on the farm. Platforms allow farmers to display their stock, and buyers can see available supplies. This implies a platform where activities are tracked, monitored, and potentially analysed to facilitate market interactions. There is no doubt about the potential impact data collected with DPs and related technologies can have on development (Kim, 2024). However, while the platforms primarily focus on the positive aspects of these technologies, the extensive data collection, monitoring, and interconnectedness also raise concerns related to surveillance.

While the term 'surveillance' may carry negative connotations in some contexts, the platforms identified seem to highlight the systematic and technology-driven monitoring of various aspects of agriculture for the benefit of stakeholders in the supply chain and farmers. Hence, the purpose of surveillance identified in the practices of platforms appears to focus on improving agricultural outcomes and farmers' livelihoods. While these practices aim to enhance on-farm productivity and crop yield through advanced technologies, it's important to note that the term 'surveillance' can be neutral in this context. Surveillance can have positive connotations when used to improve agricultural practices and minimize risks. However, ethical considerations such as data privacy, transparency, and consent should be considered in implementing such surveillance systems. We also identified that surveillance mechanisms are often implemented for security, regulatory compliance, and transparency. However, platform surveillance's nature and extent would depend on policies, practices, and compliance with relevant laws and regulations. Users and stakeholders should be informed about data handling practices and the surveillance measures that are implemented by the platform.

DP usage in farming collects data on crops and related entities that rarely falls under privacy laws and sometimes under competition law since it is non-personal data. The data usually fall under the Free Flow Regulation (e.g. data about chemical components of soil, soil humidity, weather data, emission data, data about the health and growth of crops or animals, and medication data) (Wolfert et al., 2021). Access to free-flow data empowers businesses, research organizations, and national policies to provide better knowledge and enhance innovative activities. However, data generated from farmers can be re-used to build other businesses and services, which will benefit sponsors more than farmers. Consenting to participate in research could mean a transfer of data ownership and rights. Meanwhile, farmers are not readily aware of the negative consequences that this may have, and it is sometimes hard to foresee. Therefore, farmers are at the loose end since they rarely understand the ‘language’ of the project, the value of their local knowledge being used and how to negotiate appropriately. Farmers often do not see these possibilities and are less likely to request or even know where their data will end (McC Campbell et al., 2021a; 2021b). The practices of DPs in Ghana also indicate possibilities of ethical issues. For example, with crowd-farming platforms, there could be a loss of privacy, as crowdfunding campaigns disclose farmers’ personal information to investors, including the location of farms. This may increase the risk of data security breaches and violation of rights to data privacy or access to personal data. Hence, some platforms can be considered data companies despite enabling agricultural production and food supply.

The construction of closed-loop systems through bundled services with several technologies embedded in a platform may result in the accumulation of data about farmers’ location, land size, and other profiles to deliver various services. With such DP practices, we found evidence that platforms can draw data from farmers to redesign new products or outsource to external parties and monitor farmers’ behavior to ensure that it aligns with customers’ needs. Farmers and other actors are nudged towards certain practices or behaviors. The closed-loop system created in the value chain gives platform operators more power over farmers. Some platform practices indicate changing farmers’ decision-making to produce crops in demand by the market. This may affect food security, especially where platforms encourage farmers to cultivate non-traditional food or export-oriented crops.

Due to literacy or internet connectivity issues, we identified that platforms operate in hybridity through the use of technological infrastructures and field agents as intermediaries to profile information and support advisory services. Field agents primarily serve as social and commercial structures, establishing connections between farmers and the proprietary knowledge integrated into the platform (Meagher, 2018). In this way, platforms transfer mental resources away from people onto technical systems and help restructure agricultural production in ways that benefit capital investors (Isakson, 2014; Kleibert & Mann, 2020). Platforms can become avenues to exploit farmers and labor. The involvement of informal labor (e.g. farmers or field agents) requires critical concern and further research in the agricultural sector in the light of labor regulations. This has become necessary because, unlike their counterparts in the formal sector, who may have negotiation skills and knowledge about data protection, privacy issues, and labor regulations, there are doubts about the kind of contracts formulated especially for farmers. Signing a contract requires knowledge and expertise about what can be done with data, prices of farm products, among other issues. Yet, it is not every farmer who possesses such knowledge. Furthermore, it is not every farmer who can read the terms and conditions before signing an agreement form.

6. Conclusion

This study examined practices of digital platforms in the smallholder farming sector in Ghana. Ultimately, we examined the older modes of production relations such as platformization, datafication and data extractivism. The key findings that emerged from the analyses include:

- DPs perform practices can nudge farmers towards certain behaviors, such as purposely borrowing or cultivating crops for specific markets.

- The practices of monitoring farmers and other value chain actors, from production practices, mobile money transactions, and even the health of crops, provide an avenue for data extraction, surveillance, and accumulation.
- The right to data and knowledge concerning the use of data for DP purposes is also identified since digital literacy issues characterize the smallholder-limited information.

The study's findings set a research agenda that requires empirical research to assess data management, data privacy plans and the collection of personal data from farmers and other value chain actors by DPs. While a recent study examined how providers of digital technologies respond to failure in Ghanaian agriculture sector (Ayamga et al., 2024), further research is required to investigate the extent of data extraction and surveillance of farmers' information and how this might affect trust, adoption and upscale of platforms. Also, there is a need to examine the ownership and control of DPs. Further research should amplify local voices and perspectives, including smallholder farmers, regarding their experiences with DPs.

Finally, the study provides insight into policy strategies for applying digital technologies and the need to look beyond digitalization to consider the potential adverse side effects. There is a need to enforce regulations to protect vulnerable users from fraud, exploitation or economic insecurity. Regulatory bodies should also focus on improving informational and digital literacy at all levels of society.

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ORCID

Rebecca Sarku  <http://orcid.org/0000-0002-2525-5478>

Matthew Ayamga  <http://orcid.org/0000-0002-8654-9533>

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Appendix

Appendix 1: Summary of typologies of DPs and operating organizations

Typologies of DPs	Name of platform	Operating organization	Description
Fintech platforms	Financial Inclusion & Commodity Markets	DigiExt	Grants farmers access to microcredit and the global market
	LendIt	AgroCenta	Builds data for financial institutions to leverage on, and on-lend directly to farmers through mobile money and their QUICK platform
	AgroPay		Facilitate agribusinesses and produce buying companies in making direct payments to farmers through mobile money or bank transfers
	Mergdata	Farmerline	Provides growers access to inputs, training and markets
	mFarm	Image-AD Ghana Limited	Links all stakeholders across the entire agriculture value chain
Crowdfunding/crowd-farming platforms	Farmforce	Farmforce	Enhances visibility to clients
	Digital marketplace & DigiExt commodity trading technology	DigiExt	Applies matchmaking algorithms to pair farmers with customers
	Rent-a-farm platform	Rent-a-farm	Facilitates land arrangement for agribusiness investors and also links buyers to farmers
	FarmCap	FarmCap	Enables individuals to participate in farming by providing funds
	Kwidex	Kwidex	Provides a platform that enables individuals to invest in farming
	Digifarmer platform	Complete farmer	Connects farmers to commodity buyers
	Farmable DP		A farm management platform that helps farmers increase productivity
	Grow For Me	Grow For Me	Enables individuals to fund the production of crops and connect to buyers
	SmartFarmer	Green Afro-Palms	Creates agribusiness driven by entrepreneurship and innovation
	Trustee farm platform	Trustee farm	Connects farmers and consumers globally
Market linkages or digital market	FBSInnova application DP	Agro Innova Ltd	Provides digital innovation for farmers and other value chain actors
	Block chain management web and mobile app	DigiExt	Provide access to microcredit and the global market for farm produce
	DigiExt GPS tracker		
	Mergdata platform	Farmerline	Provide growers with access to quality inputs, training and markets
	CropChain	AgroCenta	A digital food distribution and supply chain platform
	AgroMarket	AgroCenta	Provides farmers with access to markets, information and finance
	e-commerce platforms	Ecowillow Ghana	Address sustainable practices through training of farmers
	Farmcap DP	Farmcap	Enables individuals to sponsor existing or new farms
	AkokoMarket DP	Agro Innova Ltd	Connect farmers to markets through a mobile application
	PlantRite DP	AgroCenta	A sorghum planting initiative
	Internet of Things	TechShelta AgriTech	Builds suites of software and hardware for farming and agribusiness
	AgroSeal platform	AgroSeal Ghana Limited	Offers a platform for commodity sourcing
	Trusteefarm digital market	Trusteefarm Agro Produce Export and Local Sourcing Company	Connects farmers and consumers globally
	DLT enabled platform	ANDA Global Limited	

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Typologies of DPs	Name of platform	Operating organization	Description
Agricultural production and advisory services	FarmerPack	Sesi Technologies	Supports farmers to access the global markets Provide a suite of post-harvest technologies, mechanization services and market access.
	Farm Cure	Farm Cure Ghana Limited	Provides services for pest and disease management
	Okuafo artificial intelligence (AI)	Okuafo foundation AgriTech enterprise	Provides services for pest and disease management
	AcquahMeyer Drone Tech	AcquahMeyer Drone Tech	Provides services for pest and disease management and soil analysis
	CADI AI and KaraAgro	KaraAgro AI	Provides services for pest and disease, water shortage and nutrient management
	AI4Cashew		
	QualiTrace	QualiTrace	Enables farmers and consumers to trace inputs and food sources
	IoT devices	FarmCap AgriTech enterprise	Collects crop, soil, and weather data and shares them with farmers and investors.
	'Hwesomame' DP	Dent Agrisystems	Develops low cost tech products for farmers to grow their crops
	Esoko	Esoko	Provides market data and other information
	Ignitia	Ignitia	Provides weather forecasts and helps farmers and stakeholders across the value chain with information to support decision-making
	IoT devices and online tools	TechShelta	Provide software solutions
	GIS/GPS app	DigiExt	Deliver agricultural extension services
	Mergdata platform	Farmerline	Provides varied agricultural information for farming
	Ghalani App	Ghalani	Provides a mobile and webbased ERP solution for contract farmers
	FBSInnova DP	Agro Innova Ltd	Helps farmers access to Farmer Business School tools and information
	DLT-enabled platform	ANDA Global Limited	Supports farmers in accessing wider global markets with web and mobile platforms and API linkages
	Automated scarecrow devices and sound sensors	AiScarecrow AgriTech	Leverages the use of drones to control pests
	Lojanor DP	Profish AgriTech	Provides logistics and access to the market for fisher-folks
	AniTrack platform	AniTrack	The platform helps farmers identify and track the health status of livestock
Experimental/ research leveraging DPs	Zhulia platform	CowTribe AgriTech	Enables agro-veterinaries to access vaccines, medications, feed, and other supplies directly from distributors and manufacturers
	AgroTech platform	FarmRadio International	A platform that engages farmers to adopt good agricultural practices and connect with new markets
	AgroTech Radio		An advisory digital platform that integrates interactive radio programs to extend the reach of agricultural information
	AgroTech SmartEx		Enables field agents analyse farmers' needs and provide advice, including the procurement of loans
	Plantwise Platform	Plantwise	Helps farmers to predict, prevent, and prepare for plant health threats and reduce crop losses
AgroDigital survey	E-agriculture	Ministry of Food and Agriculture	Provides extension and agronomic practices with varied ICTs
	Farmerline's Mergdata platform	Farmerline	Enable users to create customized surveys to reach target groups

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Typologies of DPs	Name of platform	Operating organization	Description
Agrotech transport	ESOKO	ESOKO	Conducts digitized survey for real-time data submission
	mFarm	mFarm	Provide agronomic and other farm advisory services
	CropChain	AgroCenta	Uses platform to conduct biometric survey
	InnovaSync platform	Agro Innova Ltd	A biometric identification system for poultry farmers
	AgroCenta	AgroCenta	Facilitate the swift access and integration of digital financial services for smallholder farmers and various stakeholders along the value chain in rural communities
	TrotroTractor	Trotro Tractor AgriTech	A platform that connects farmers and tractor operators
Farm input supply	Rent tractors	DigiExt	Offer rental services for merchandize like tractors and drones
	Farm Input and Mechanization	DigiExt	Provide a platform for farmers to order farm inputs
Livestock management	Akokotakra mobile application	Agro Innova Ltd	Livestock farm management