World Development Sustainability 4 (2024) 100147

Contents lists available at ScienceDirect

World Development Sustainability

journal homepage: www.elsevier.com/locate/wds

Observations on status and trends of agricultural extension and inequality in Uganda

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ARTICLE INFO

Keywords:
Uganda
Agricultural extension
Inequality
Rural development

ABSTRACT

The global pandemic has accentuated inequalities, with vulnerable populations in developing countries fairing worst. In rural sub-Saharan Africa, restrictions on mobility to limit the spread of COVID-19 negatively impacted access to extension services and inputs by farmers. In response, countries deployed digital technologies to meet some of these challenges in the context of existing income, gender and spatial inequalities and historic declines in funding for public extension. Focusing on Uganda, which had one of the longest and strictest lockdowns, the paper used panel datasets of farmers from 2005 to 2019/2020 and found persistent socio-economic and gender inequalities in access to extension. Data from rapid rural surveys from 2020 to 2021 and a review of recent literature suggest these inequalities increased during the pandemic. The paper then builds on the structure and reforms of the current extension system to assess the potential of the digital services and their added value given the inequalities observed. The paper finds that the ability of government-led, inclusive, digital extension services is limited unless investments in extension are increased. In light of long-term declines in funding for extension, future research should focus on the effectiveness of policies to encourage private sector-led digital extension efforts to strengthen the pro-poor nature of agricultural growth.

1. Introduction

The COVID-19 pandemic accentuated inequality across the globe [1]. Income inequality, for example, was predicted to increase for emerging markets and developing countries, impacting the most vulnerable the hardest [2]. In a sub-Saharan African context, the most vulnerable include women relying on the agricultural sector for their main income source. There is broad agreement in the literature that rural inequality is extensive in developing countries [3] and that government extension services are not setup to explicitly reduce rural inequality. Policies to limit the spread of COVID-19 through restrictions on mobility and direct contact could have further reduced that ability of extension to reach the rural poor. The potential to use ICT (information and communication technology) to provide agricultural information to rural areas offers one avenue to overcome these challenges. To date, no research has investigated the different roles that income, gender, and space play in shaping unevenness in supply of and access to agricultural extension.

The objective for this paper is to investigate the potential of the government agricultural extension services in Uganda to support inclusive growth in the agricultural sector post-pandemic. The paper first offers a synthesis of the literature on inequality as it relates to agricultural development in general and agricultural extension in particular. Second, the discussions of the impact of inequalities are grounded by a case study of Uganda, which draws upon the most extensive panel-series of data available for sub-Saharan Africa using the World Bank's Living Standards Measurement Study—Integrated Surveys on Agriculture (LSMS-ISA) dataset [4]. The dataset contains panel household data from 2005 to 2019/20 using seven waves of data collection. Inter-household trends in Ugandan agriculture are analyzed to identify patterns pre-pandemic. Third, the review of pre-COVID-19 trends is supplemented with results from a high-frequency survey administered after March 2020 [5]. Fourth, based on findings from the Ugandan experience, the paper concludes by discussing the potential for more inclusive extension services using ICT.

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https://doi.org/10.1016/j.wds.2024.100147
Received 17 November 2022; Received in revised form 21 March 2024; Accepted 12 April 2024
Available online 12 April 2024

2. Materials and methods

The literature review in Section 3. relied on a review of existing literature with a focus on peer-reviewed journal articles to build an up-to-date understanding of the status and trends of extension and inequalities. The literature review search was conducted using George Washington University's access to PubMed/Medline and Web of Science Core Collection. In order to capture most recent effects from the pandemic, relevant gray literature was included. To map the grey literature, searches were run in Google Scholar and Google Search to ensure no preliminary studies from these two major databases were missed. Searches were undertaken between October 2020 to April 2022, with follow-up searches repeated in January 2024.

For the quantitative analysis in Section 4., data from the World Bank's Living Standards Measurement Study—Integrated Surveys on Agriculture (LSMS-ISA) dataset [4] allow tracking of how many households received extension advice from 2005 to 2019/20. These data have been used to investigate the relationship between extension advice and technology adoption and risk exposure by smallholder farmers [6], agricultural productivity and household welfare [7], and consumption inequality and agricultural productivity [8]. Of the Ugandan households with data captured since 2005, around 1000 households were consistently tracked across the years (see Table 1), allowing the setup as panel data.

To assess the relationship between access to extension services and socio-economic, gendered, and spatial inequalities, this paper identified data on the key variables of interest from the Ugandan national panel surveys: number of contacts with extension agents, gender of the household head, consumption expenditures, amount of agricultural land owned, and distances to major roads, population centers, and markets. Selection of inequalities were furthermore informed by the theoretical framework on extension proposed by Gautam [9] and built upon by Anderson and Feder [10]. The detailed description of methods and how to obtain the STATA code used are referenced in Appendix S1, with Appendix Supplementary Table 5 describing the definitions and units of both dependent and explanatory variables used. To complement the above analysis with impacts on agricultural extension during the pandemic, additional rapid surveys undertaken in 2020 and 2021 were used [5].

3. Literature review

3.1. Inequality and agricultural development

First, this paper breaks down the literature on inequality as it relates to agricultural development into three dimensions: socio-economic (e.g., per capita income); gender (e.g., intra-household inequality), and spatial inequality (e.g., distance to markets). These dimensions are related to access to agricultural extension in the section following this one.

Table 1
Summary statistics of trends in extension visits.

Year	Number of households	Number of extension visits (average)
2005/06	2294	0.15[a]
2009/10	1632	0.43
2010/11	1840[b]	0.26
2011/12	1837	0.29
2013/14	1224	0.24
2015/16	1137	0.14
2018/19	912	0.10
2019/20	1131	0.22

Source: World Bank 2021, LSMS datasets for Uganda. Each year, a household that had missing data on extension was dropped.

[a] In 2005, the survey did not differentiate or account for alternative sources of extension advice (e.g., large farmers) and hence is expected to underestimate actual advice received.

[b] In 2010/11, the wave mistakenly omitted any households that did not receive extension advice. The 2010/11 dataset was hence appended to record all households that were omitted as not having received any extension advice.

3.1.1. Socio-economic inequality

The pro-poor aspects of agricultural growth are well established [8, 11–13], with the welfare gains being largest for the poorest tenth [14, 15]. Adoption of new innovations to generate growth has long been understood to bring both desirable, undesirable, anticipated and unanticipated consequences [16]. In its early stages, the diffusion of innovations tends to enlarge the wealth gap between early and late adopters, with early adopters often tending to be the wealthier, better educated farmers and those with larger farms (Rogers [16], 288). Three reasons for inequality-increasing diffusion include: windfall profits earned by early adopters (adoption rent); the self-selection of early adopters who are often more actively searching for innovation; and that innovations tend to "trickle" across (within a social stratum) rather than down (between social strata).

One of the most widely discussed research topics on inequality as it relates to agricultural development surrounded the Green Revolution and resultant adoption of capital-intensive agricultural inputs [17–19]. These discussions rather played down the role of extension relative to research, as they primarily focused on access to capital, land and labor. Ruttan [19], for example, highlighted the importance of understanding the institutional environment in assessing impact of agricultural innovations on income inequality. In rural settings marked by highly uneven land ownership, land-saving and labor-using technologies, for example, are expected to "raise the economic return to labor relative to land [and] have the effect of equalizing the income distribution between the landless and the land-owning class" (Ruttan [19], 46). In sub-Saharan Africa, where the Green Revolution largely failed to materialize, current efforts at transformation of the agrarian sector, risk exacerbating inequality where land tenure and ownership is uneven (e.g. see Rwanda; Dawson et al. [20]). Unfortunately, studies focusing on the adoption of improved cultivars, for example, have largely sidestepped looking at inequality and the role of agricultural extension explicitly.

Shocks—such as a global pandemic—may play a crucial role in enhancing inequalities, although evidence remains scarce (Amare et al. [8], 2). Looking at rainfall-related shocks, resource-poor farmers struggle to adopt new technologies, improved agricultural practices, or high-value crops [8,21–23]. In a closed market, improved productivity by wealthier farmers can depress local food prices (to the benefit of poor consumers), but also further reduce the income of non-adopting, poorer farmers [8,24,25]. Given their greater literacy and ownership of smartphones, wealthier farmers would also be expected to more readily access digital extension services that pre-dated or emerged in response to COVID-19 [26,27].

3.1.2. Gender inequality

The concept of "time-poverty" in agriculture is well established, with women facing double burdens from both productive and reproductive labor in their households. Lyon et al. [28] also identify a third burden of organizational labor for women (e.g., in coffee cooperatives). Kabeer [29] argues that gender inequalities manifest at their intersections where the most acute forms of poverty and marginalization are located. One illustrative example is that of women and girls from the poorest caste, who have also lower levels of education and suffer higher levels of violence [29]. Women are more disadvantaged in accessing and adopting agricultural technologies [30,31]. Women have also been more severely impacted by COVID-19 from increased (including domestic violence, food insecurity, and job losses; Béné et al. [32]), and may face greater exposure than men to climate-change risks [33].

Social networks, useful for learning of new technologies, are also less accessible to women [34]. Women's lack of ownership of land and limited size of their landholdings further limit their ability to experiment and adopt new technologies [26]. The limited landholding also reduces their visibility as farmers to extension services [35], with them being less likely to be chosen as lead farmers for demonstrations (e.g., Duffy et al. [36] for Malawi).

In order to assess the potential of digital extension, insights on intra-household dynamics are needed on access to and use of smartphones. Anecdotal evidence suggests that, if given the opportunity, women are as likely as men to engage with agricultural extension messaging provided through smartphones (e.g., Mittal [37] for audio messages in India). With campaigns launched during the global pandemic that temporarily spurred the gendered adoption of digital tools through project-based financing, it is important to monitor what happens beyond the initial adoption of such tools at the intrahousehold level (e.g., [38, 39]), including benefits gained and costs shared [40].

3.1.3. Spatial inequality

Geographical location and distance to users of ag products and inputs matter in agricultural development. The reach of markets into regions that are distant from cities, particularly regions that have poor transportation and communication infrastructure, is limited. This makes modern inputs at farms expensive [41] and the prices of crops or livestock products low [42], which can leave large areas of the countryside impoverished. Distance and poor infrastructure also lead to incomplete information about technology and prices and this slows down the adoption of improved agricultural technologies even in environments where inputs, credit and insurance are available to address barriers to adoption [43].

Geographical proximity (e.g., neighbors) also plays a crucial role supporting farmers' learning through their social networks to update their knowledge and beliefs about agricultural technologies [44]. The learning effects might be less determined by absolute distance (i.e., geographical closeness) but rather by relative distance (i.e., kinship and other groups) fostered through social capital. Beaman and Dillon [45] find that information diffusion declines with social distance. Especially for more knowledge-intensive adoption (e.g., learning through digital extension) to take place, kinship groups are crucial as their members put greater care into explaining more complex technologies [44,46,47].

At the country level, spatial inequality accentuates local inequalities, accounting for around one-third of economic inequality observed, however, the main explanatory factors of economic inequality are not geographic properties, but rather differences in infrastructure [48]. Provisioning or accessing quality extension services is compromised by remoteness due to lack of transportation options as well as limited access to electricity or cellphones. The expected global convergence between lagging and leading areas due to the rapid spread of modern information and communication technologies [49,50] may not succeed in reducing these rural-urban inequalities.

3.2. Relationship between agricultural extension and inequality

Few case studies exist that have sought to account for the role of traditional agricultural extension in income inequality per se [51,52]. Traditional, top-down extension approaches aiming to transfer new crops or varieties are limited in their adaptability to novel contexts, hindering the adoption of new technology amongst farmers [53]. As adoption itself is a slow process often focused on learning by doing and experimentation [54], a lack of adaptability of the technology might increase inequalities as the technologies were possibly developed with wealthier, more experienced farmers in mind.

A lack of adaptability need not lead to greater inequality, as shown in African case studies. Adoption of groundnuts in Uganda reduced both the depth and severity of poverty (Kassie et al. [55], 1792; with poorer and more educated farmers benefitting most) and adoption of high-yielding varieties of rice and maize reduced poverty without increasing inequality [56,57].

The nature of the diffusion of rival or non-rival goods can have important effects on the potential for extension to increase or decrease inequality [45]. Adoption of non-rival goods, such as sustainable land management practices that are labor- and knowledge-intensive necessitate more in-depth engagement with public extension services than adoption of rival goods, such as synthetic fertilizer, that are capital-intensive [44,58]. Given the lower capital barriers to adoption, it is expected that extension services focusing on the diffusion of knowledge (a non-rival good) would reduce socio-economic inequalities. With extension officers' limited time and resources, it is likely that the majority focus on more capital-intensive interventions (e.g., new crop varieties) that require less contextual or in-depth knowledge sharing. As a result, sustainable intensification practices (e.g., Push-Pull) lack support from an adequate extension system in East Africa [59].

Current extension efforts are hence expected to be biased towards the diffusion of rival goods and wealthier farmers that are more likely adopters of technologies [60], increasing socio-economic inequalities. Limited access to extension services matters, as shown in studies finding lower adoption of one such rival good, improved crop varieties (Takahashi et al. [44], 32).

Studies focusing on inequality as it relates to agricultural extension, capture uneven gendered access to extension (with women in sub-Saharan Africa around twice less likely to be visited by an extension officer; Meinzen-Dick et al. [61]). The persistent prevalence of male extension officers translates into less effective learning by women as evidence show women learn better from female extension officers [26, 62–64]. Social groupings, such as popular farmer clubs in Malawi, are mostly male-dominated at the leadership level, controlling participation and information sharing [36]. Extension services often fail to account for gender dynamics [65]. They are not designed to address these unequal power relationships (i.e., time poverty, limited mobilities or educational attainments) through more demand-led, gender-sensitive services [66]. Data assessing gender and intra-household dynamics systematically, however, continue to be rare or non-existent (e.g., Meinzen-Dick et al. [61]; Lecoutere et al. [39] for Uganda).

The factors that lead to spatial income inequalities also affect the ability of extension services to provide services to farmers. At the local level, extension officers are often hampered in reaching more remote regions due to limited government budgets for travel and poor transportation infrastructure. Similarly, women farmers are more limited in their ability to attend demonstrations or courses further from their homes [61]. As a result, information asymmetries persist, with farmers failing to have access to extension officers leading to lower adoption of new technologies [67–69].

Different approaches to extension show some promise at increasing inclusiveness: farmer field schools' objectives include reducing gender inequality by working with specific community groups that include minorities ([70,71], 4). Female membership in field schools in Kenya, Uganda and Tanzania approximates 50 percent [72]. Peer-to-peer learning—fostered, for example, through farmer field schools—has been shown to be effective especially for less experienced farmers [73].

3.3. Inequality and agricultural extension in Uganda

The agricultural sector continues to play a large role in the Ugandan economy: with 75 percent of the population living in rural areas, the sector accounts for 24 percent of GDP and employs around 65 percent of labor [6,74]. Extension efforts are crucial: after a period of failed modernization under the National Agricultural Advisory Services Projects in the form of public-private partnerships, extension services since 2014 have been in the domain of the army under the Operation Wealth Creation (OWC) program [26]. Given their logistical forte, provisioning shifted from agricultural information to inputs with resultant increases in budgetary outlays. This restructuring also skewed funding from technology generation under the National Agricultural Research

Organization (NARO) towards input provisioning under OWC [75]. Extension coverage remained poor (with hiring of extension officers delayed under OWC; Nakazi et al. [75]), with only 10 percent of farmers having received at least one visit by an extension officer [76]. While the government's National Agricultural Research System (NARS) generates agricultural technologies and management practices of relevance to farmers, adoption of these agricultural technologies is still lagging [7].

3.3.1. Socio-economic inequality

Traditionally, rural poverty in Uganda is defined by a lack of land, livestock or off-farm income [77]. In addition to these three indicators, Ugandan smallholder farmers are increasingly vulnerable to climate shocks, with greater volatility in production reducing household consumption [8]. Reductions in consumption are more significant for poorer households, increasing inequality [8]. Variation in wealth, including land, livestock and total assets, was the largest contributor explaining consumption inequalities [8], which corroborates earlier findings by Anderson and McKay [78] that around 50 percent of consumption inequalities in sub-Saharan Africa can be explained by differences in land and asset ownership. Poorer households in Uganda and those dependent on labor for income also appear to have experienced more food insecurities and income losses due to COVID-19 [79].

In Uganda, adopters of purchased inputs (e.g., pesticides, fertilizers and seeds of improved cultivars) are notably younger and better educated. They are, furthermore, wealthier (spending on average 32 percent more on household consumption than non-adopters), and around twice as likely to be classified as non-poor (Mukasa [6], 5). Information asymmetries play an important role, with farmers frequently making decisions with incomplete information [23,80]. Other factors associated with Ugandan farmers' adoption of new technology include market access, household assets, human capital and farm size [23].

Additional government support for extension has been noted as a key factor when trying to increase the adoption of agricultural technologies amongst poorer Ugandan farmers (e.g., in the case of groundnuts, Kassie et al. [55]). Access to non-farm income (including remittances) in rural Uganda further explains increased adoption of improved maize seeds, as it allows farmers to overcome credit constraints [81].

3.3.2. Gender inequality

Ugandan women do more work in agriculture than men [82]. Women across East Africa, however, have less access to resources supporting technology adoption, including information and financial services [83,84]. Women, it is argued by some, are also more risk averse [85] and focus on food security over income generation, which influences their adoption of high-yielding varieties [86]. Even where the use of modern inputs (e.g., improved cultivars, fertilizer or pesticides) is arguably overall risk reducing, the larger investment costs are not made by more risk averse farmers in Uganda [6]. These findings indicate a potential challenge in the current provisioning of digital extension services, as the private-sector-led digital extension efforts appear oriented towards capital-intensive technologies. While female farmers in Uganda are less likely to receive access to extension services, these services still are effective in increasing their adoption of new agricultural technologies (e.g., Teklewold et al. [84] for adoption of non-drought and drought-tolerant varieties) especially when combined with relevant complimentary information (e.g., on weather). Investigating a model-farmer extension model that focuses exclusively on female farmers, Pan et al. [87] found a significant increase in the adoption amongst women farmers of knowledge-intensive agricultural practices, such as manure management (9 %), intercropping (6 %) and crop rotation (8 %), with no statistically significant uptake of capital-intensive practices, such as synthetic fertilizer (−2 %), pesticides (−3.5 %), nor improved high yielding cultivars (−3.4 %). Importantly, the adopting female farmers also experienced less asset smoothing (i.e., selling of assets to cope with shocks) and improved their households' food security importantly in the crucial hungry season leading up to the next cropping season's harvest [87].

As women are more likely to be marginalized through traditionally male-focused extension services, strengthening peer-to-peer learning opportunities between women has been found to be effective at increasing productivity in Uganda [44,88]. Cai et al. [89] found that combining traditional extension methods of lectures and demonstrations in Uganda with the use of video not only increased women's knowledge most, but effectively closed the gendered knowledge gap. Previous lessons learned from farmer field schools in East Africa—including their ability to reach women and less literate farmers [72]—are also applicable when evaluating the potential and limitation of digital extension.

As regards land ownership, a 1998 law recognizes women's right to own land, yet gender discriminations persist regarding access to resources or revenue gained from crop sales, with women unaware of their rights [84]. Their joint land holdings—reported frequently by agricultural survey participants—are also not reflected in official ownership documents [90].

3.3.3. Spatial inequalities

In Uganda, spatial inequalities permeate into the political sphere, with the ruling elites from South-Western Uganda overrepresented, compared to the less represented North of the country [91]. These geographical biases are expected to translate into differential investments in infrastructure (e.g., roads) crucial to reduce inequalities in the agricultural sector. Price disparities in input prices were substantial, driven by large transportation costs for more distant, rural farmers [92]. Poverty rates reflected these regional disparities [93], with more remote areas benefitting less from economic growth [94]. Even though improving annually, Uganda scored poorly on indicators of affordability of mobile access [95], indicating that poorer households are less likely to undertake data-intensive mobile operations. Emphasizing the importance of access to social capital, women farmers enrolled in cooperatives are more likely to overcome gender barriers than those lacking such access [96]. As farmer field schools can act as an avenue to reduce these inequalities, it is encouraging that the largest numbers of farmer field schools (n: 113) are informally recorded in the Northern region [97].

3.3.4. ICT and agricultural extension

Uganda is one of the birthplaces of digital extension in Africa, thanks to the pioneering work by Grameen Foundation. Establishing community knowledge workers (CKWs), the Foundation launched already-viable ICT tools more than 10 years ago, including SMS, phone, and web-based [98,99]. Initially deployed via a pilot model that effectively showed increased adoption by farmers of the livestock and agronomic practices disseminated, this agent-based approach was scaled up via donor funding. Challenges to sustain these models include the training of knowledge workers and creating buy-in from farmers to sustain the service after project exit [99].

Moving beyond SMS, phone and web-based tools, videos and smartphone applications have become more prominent. Their effectiveness on increasing adoption is, however, still unknown. For example, the experimental use of videos increased Ugandan farmers' knowledge effectively, but didn't translate into substantial increases in adoption, productivity or profitability [26].

4. Findings on the state of and trends of agricultural extension and inequalities in Uganda

4.1. Quantitative analysis of pre-COVID factors influencing access to extension in Uganda

Setting up the data as panels with repeated observations from the same household unit (see Table 2), each year resulted in lower numbers of extension visits for the same household. The average number of extension visits decreased from a high of 0.43 per household in 2009–2010 to a low of 0.10 in 2018, before recovering to 0.22 in 2019. A

Table 2
Factors that influence access to extension services in Uganda.

Extension services accessed per household	Year only	Year and gender	Year, consumption and gender	Consumption, gender, land owned, distance[f]
Year[a]	−0.0089**	−0.0089**	−0.0102**	
Gender of household head (1 = female)[b]		−0.0504**	−0.0437**	−0.4294
Consumption (in million Ugandan Shilling)[c]			0.158**	2.10*
Distance to Road				0.0050
Distance to Market[g]				0.0067
Total land owned (in acres)[d]				0.0262**
Prob>chi2	0.000	0.000	0.000	0.000[e]
Number of observations	12,007	12,007	11,829	399

Source: World Bank 2021, LSMS datasets for Uganda. Each year, a household that had missing data on extension was dropped. STATA code and definitions of dependent and explanatory variables available in Supplementary Materials.

** $p < 0.01$; * $p < 0.05$.

[a] Multiplied by 365 for ease of interpretation as maximum duration of an extension visit in last 12 months assumed to be one day. Fourth regression dropped Year, as focus was on sum of visits across all years.

[b] From 2005/06 survey.

[c] Average across all years. Not adjusted for inflation. Combination of non-durable consumption (with exception of house payment and healthcare) over 30 days and 4 times the last 7 days' expenditures on household goods.

[d] From 2009/10 survey.

[e] As regression.

[f] Sum of at least one extension visit per year.

[g] Distance to major population center dropped, as the same value as distance to market for half the farming population in our analysis.

one-way analysis of variance revealed that there was a strong statistically significant difference in extension visits across the years. Focusing on less marginalized farmers who have received at least one advice from any extension service in any given year, the decline is similar and significant. The trend is most significant when looking at households that had received at least one advice in any year, and data were available for all eight waves of the survey (see Appendix S3: Supplementary Table 1).

Using the total land owned per household (as of 2009), there is a strong significant relationship between land size and number of extension visits ($p = 0.000$), with the median farming household that received no visit having 2.6 acres, whereas the average farming household with 1 and 2 visits having 4.0 and 5.4 acres, respectively. Running a regression with total visits over all years combined and the land owned in 2009 (see Table 2), amount of land owned was positively associated with extension visits. Using consumption expenditures for each survey year as a measure of income, there is a strong positive relationship between higher income and number of extension visits. This relationship is significant when including year, gender, land owned, and geographical distances (see Table 2 and Appendix S3: Supplementary Table 2).

Integrating the gender of the household head from 2005, running a random-effects GLS regression yields negative trends over time for both year and gender (see Table 2), indicating that female-headed households were less likely to receive extension advice. Focusing on better-off female-headed households that received extension advice, the gendered decline is still significant (see Appendix S3: Supplementary Table 3).

No clear pattern emerges from a visual analysis of the location of households and intensity of extension visits (see Appendix S2: Supplementary Fig. 1). A review of average distance to nearest major road, population center, and markets (see Appendix S2: Supplementary Table 4) shows, surprisingly, that the households with no extension visits are closer to major population centers, but exhibit no other significant difference.

Running random-effects GLS regressions including the above distances in addition to year and the household head's gender, only the proximity to the population center has a significant negative effect on extension visits (see Table 2 and Appendix S2: Supplementary Tables 2 and 3). This effect of distance to the population center holds when running regressions that only include this distance, or when all three distance measures are added together in one single variable. In short, distance appears to matter but fails to be a major determinant of extension visits per the geographical variables available. A possible explanation might be that households that live closer to the population centers might focus on vegetable production that extension officers are perhaps less knowledgeable about. Excluding households identified as urban (n:715), which receive similar amount of extension visits (0.38 versus 0.37 for rural households), however, does not yield any additional explanations of the variance in extension visits observed.

4.2. *Impact of COVID-19 on Ugandan inequality*

The World Bank collected seven rounds of data since June 2020 through high-frequency phone surveys to assess the effects of COVID-19 [5]. The data captured responses from over 2000 households covered in the previous 2019/2020 survey round. Although the surveys excluded questions on agricultural extension, they did capture four relevant trends in inequality:

First, the nearly two-year-long school closures widened educational inequalities with urban, wealthier households better able to take advantage of any (remote) learning or educational activities [100]. Indicative of challenges in digital extension, half of all students stopped learning even as remote lessons were deployed via television, radio and the internet (Blanshe and Latif [101]).

Second, income from farming was a key source of income during the pandemic, as other income sources (e.g., wage labor) were more negatively impacted [100,102]. Agriculture's share as a source of employment stayed near 60 percent—around 10 percent higher than pre-pandemic—even after employment in the economy had largely recovered [103].

Third, as income losses in agriculture were less than in the non-agriculture sector, the income gap relative to pre-pandemic was less [103]. With losses, however, across the households and sectors, it was poor, rural households that were least able to draw upon loans or savings to cope during the pandemic. Farmers adopted multiple coping strategies, including selling of livestock and reducing consumption during the pandemic, further reducing their ability to withstand future shocks [104].

Fourth, employment and farm income rapidly jumped back near pre-pandemic levels [102]. Overall, COVID-19 increased poverty (from 21.6 percent to 22.5 percent) of both low- and high-income households [105].

4.3. *Impact of COVID-19 on extension*

The pandemic resulted in major restrictions on social mobility, with public transportation closed during the first phase in 2020 [106]. The agricultural sector was partially exempted, as farm-visits were later allowed. In Uganda, confusion around the exemption status resulted in farmers unable to access good-quality seeds during the first planting season after the pandemic started [107,108], with input dealers reporting 40 percent declines in sales [106].

In the initial stages, reduced ability to provide advice to farmers due to restrictions in social mobility has been noted [109]. In one survey, face-to-face interactions with farmers dropped down to 40 percent [110], with extension officers predominantly using phone calls or

WhatsApp [106,110]. As extension shifted from a group-based approach to visits with individual farmers for sake of complying with COVID-19 measures, in-person visits that took place were mainly with wealthier, larger-scale farmers. With farming incomes negatively impacted initially by the pandemic due to the lack of inputs, access to labor and face-to-face extension advice, some farmers pivoted towards home gardening with the government's encouragement to increase their self-sufficiency [109]. Messaging by both governmental and non-governmental actors also moved onto other platforms, including radio [111], as farmers were advised to stay home [112]. Less than 15 percent of extension officers reported using digital applications to respond to farmers' questions [110], although another rapid assessment found the use of less advanced ICTs increased more than 10-fold from their low pre-pandemic levels [106]. Most prominently was the use of WhatsApp to communicate between farmers (who organized themselves in groups) and extension officers. Overall, a lack of funding and training for using ICT by extension workers was noted [110].

The pandemic also sped up adoption of a previously lagging digital voucher system for farmers to obtain subsidized inputs [106]. With farmers' reduced savings from COVID-19, the improved enrollment, however, failed to translate into sustained adoption of non-subsidized inputs. The digital transformation push also accelerated plans to build out a government-owned e-extension system, which includes improved monitoring of service delivery, feedback mechanisms, and knowledge databases. While funding is limited due to ongoing budget cuts, recent USD 200 million funding from the World Bank supporting the development of digital infrastructure is expected to advance the digital transformation across the government [113], with funding approved in 2021 and a financing agreement signed by 2023 [114].

5. Discussion and conclusion

The objective for this paper was to investigate the potential of the government agricultural extension services in Uganda to support inclusive growth in the agricultural sector post-pandemic. Unfortunately, there is little evidence to suggest that the government extension service is likely to do so. There is clear evidence from the global literature that extension services can stimulate agricultural productivity growth [10], but there is equally clear evidence from the literature that extension can increase socio-economic, gender and spatial inequality.

The extension system in Uganda has gone through a number of reforms, but analysis of household data shows that service to farmers has gotten worse, and farmer income and wealth along with gender largely determine how much service a farmer receives. From 2005 to 2019 farm households in Uganda have received significantly fewer visits by extension officers. The reformed extension system run by the army could perhaps be doing a better job than the market at providing inputs and buying farm products, but there is limited empirical evidence to date to support this view. The reforms focus on input supply rather than advisory services which limits its effectiveness in helping farmers improve their agriculture [115]. Our empirical analysis shows that in Uganda wealthier farmers get more access to extension than poor farmers, female-headed farming households are, as expected, less likely to receive advice. Somewhat surprisingly, the distance from markets or from cities does not have a negative impact on extension visits when controlling for other factors.

The impacts of COVID-19 are likely to have increased inequality in Uganda. The following five factors may well contribute to inequality: First, if wealthier urban population segments are better able to weather the economic impact from COVID-19 in developing countries, any subsequent investments in rural farming properties could increase inequality in agricultural land ownership [116]. These investments could reinforce pre-COVID inequalities in land ownership in Uganda. Second, shifts in remittances (with a 23 percent decline initially observed in sub-Saharan Africa; [117]) and effects on migration due to COVID-19 could have further negatively impacted poorer, rural households by depleting their safety nets and food security. Third, social distancing measures, including the most extreme forms of lockdowns, would have slowed peer learning, which was a key source for less experienced farmers to improve their farm production [73]. Fourth, with the rural poor being less likely to access social safety nets than their wealthier counterparts, COVID-19 may have increased their vulnerability to climate shocks and reduced their likelihood to take risks for adoption of new technology. Fifth, though considerable improvements in mobile infrastructure and accessibility have been achieved over the years, gender and socio-economic inequalities in mobile access and illiteracy have remained high [95].

In principle digital extension could reduce some of these inequities. Uganda is one of East Africa's most innovative digital actors and Ugandan agents reported using ICT for advising farmers. However, without more capacity building, more advanced digital tools are unlikely to reduce inequalities [118]. This trend is accentuated by two additional developments: First, the lost years in schooling are expected to increase illiteracy amongst the next generation of farmers. Second, a 12 % tax on internet use introduced in 2021 [119] will keep more advanced, data-intensive ICT out of the hands of poorer farmers and women [120].

In conclusion, agriculture demonstrated again its importance in providing a more stable income (and food) source to a majority of Ugandans during the global pandemic. Given the potential of agriculture to stimulate pro-poor, inclusive growth, the sector is expected to play a key role in any post-pandemic plan to improve growth and inequality. Government extension in Uganda is unlikely to have a large impact in reducing inequality in rural areas because resources for extension have been declining and the pandemic has strained government's ability to pay for such services. Future shocks and stresses from climate change are to be expected to affect the poor more, especially in rural areas with fewer resources.

Unless investments increase, countries will have to find new, less expensive ways to provide inclusive extension services. Digital extension, using ICT, is one avenue that to date has had a limited impact on reaching the poorest of the poor. NGOs such as Grameen Foundation are working with both public and private actors to develop scalable, more inclusive digital options. To reduce gender inequalities, these tools need to be complemented by face-to-face extension approaches, such as farmer field schools, which include more women farmers, and recruitment and capacity building of more women extension agents. In addition, vulnerabilities in social safety nets exposed during COVID-19 need to be patched, otherwise farmers will be unable to adapt to future challenges. In short, extension efforts that empower women and youth [121] beyond input provisions are needed to ensure that the next rural crisis will not exacerbate inequalities and jeopardize economic growth.

Five avenues for future research were identified. First, an in-depth assessment is needed of how digital extension is being incorporated into the conventional extension service post-COVID, including any use of artificial intelligence [122]. Second, qualitative fieldwork including the use of key informant interviews and focus groups with farmers would yield additional insights about trends in access to digital extension advice from the government and whether such digital advice is useful to them and how it could be improved. Third, this qualitative research could strengthen our understand of how extension could improve its record of reaching the poor, the women, and farmers far from markets and roads as well as socio-political inequalities (i.e., Lwanga-Ntale [123]). Fourth, the qualitative data may identify new variables that could be merged with future World Bank data sets to capture the impact of post-COVID trends on extension. Fifth, as funding gaps continue to plague extension services, a systematic review of private sector extension efforts would be warranted, including a focus on farmers' willingness-to-pay for ICT services [124].

CRediT authorship contribution statement

Samuel T. Ledermann: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Jock R. Anderson:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Carl E. Pray:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgments

The authors would like to thank the two anonymous reviewers for constructive feedback on an earlier manuscript of this paper. This paper is made possible through generous support of the American people provided to the Feed the Future Sustainable Intensification Innovation Lab (SIIL) through the United State Agency for International Development (USAID) Cooperative Agreement AID-OAA-L-14-00006. The contents are the responsibility of the authors and do not necessarily reflect the views of the USAID or the United States government. The authors thank Dr. P. Rwamigisa for advice on an earlier draft.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wds.2024.100147.

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