3 Leveraging Spatial Technology for Agricultural Intensification to Address Hunger in Ghana

Prince Kwame Odame
and Ebenezer Nana Kwaku Boateng

Abstract

YouthMappers are using open geospatial tools in support of initiatives seeking to achieve SGD 2 Zero Hunger and SDG 1 No Poverty in Northern Ghana. Students and researchers designed survey questions and a field data collection workflow using simple but cost-effective technology to catalogue a database of farmers, properly demarcate farm sizes, and give farmers, in particular impoverished women, the opportunity to project farm yields and increase the efficiency of their output.

Keywords

Hunger · Agriculture · Spatial analysis · Fieldwork · Ghana · Poverty

1 Intersections of Food, Agriculture, Hunger, and Poverty

Access to food is critical to human survival, and in this case, food security only exists when all people have both economic and physical access to sufficient, nutritious, and safe food that does not only meet one's dietary needs but also offer options to meet their food preference (Ministry of Food and Agriculture 2007; Quaye 2008). In view of the aforementioned, poor food security is not only manifested in the failure of a country's agricultural sector to produce sufficient food but also witnessed in terms of an individual's failure to ensure access to sufficient food at the household level (Clover 2010). Indeed, food security has been cemented in the second goal of the Sustainable Development Goal (SDG), which aims at ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture. To the United Nations, this goal can be achieved through increased productivity and incomes of small-scale farmers, particularly through the provision of financial aid, farm inputs,

P. K. Odame (✉)
University of Education, Winneba, Winneba, Ghana
e-mail: pkwameodame@uew.edu.gh

E. N. K. Boateng
University of Cape Coast, Cape Coast, Ghana
e-mail: ebenezer.boateng@stu.ucc.edu.gh

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knowledge, and necessary agricultural practices needed for sustainable food production.

Measures to ensure we stay on track in achieving the SDGs 1 and 2 must be put in place, as the attainment of these goals contributes to the achievement of other SDGs given a positive relationship between good nutrition and one's ability to attain positive outcomes in health, education, and economics (Tandoh-offin 2019). Another reason to ensure we reconsider the need to address food security to achieve SDG 2 is the recent rise in malnutrition and stunted growth in Northern Ghana where 33% of undernourished children under 5 years are considered to be stunted. Compared to global rates, Ghana's stunt rate is 12% higher than the reported 21.3% by the United Nations. Aside from Ghana, the prevalence of malnutrition has particularly affected many countries in the Global South, particularly South America and most countries on the African and Asian continent. In terms of global ratio, the number of children found to be undernourished was estimated to have reached 821 million and that translates to one malnourished child out of every 9 (UNICEF 2018).

In Ghana, over 41% of the economically active population aged 15 years and older are into agriculture, and this statistic is even higher for the three northern regions even though these regions still record the highest rate of child malnutrition (Ghana Statistical Service 2012). Being rural oriented, Hjelm and Dasori (2012) further noted that farming is the chief source of livelihood with about 80% of all households in the Northern Regions in it. Despite the contribution of agriculture to people's livelihood, Ghana's Ministry of Food and Agriculture (2013) stipulates that farmland in Ghana is mostly smallholder farms with most farm sizes being less than 2 hectares, hence the difficulty of engaging in commercial or sustainable food production.

While Ghana's agricultural sector is largely considered to be dominated by smallholder farmers, the Ministry of Food and Agriculture (2007) ranks Ghana as one of the few African countries to attain some level of parity on food security but also cautioned that this revelation was just momentarily as further assessment on a regional basis indicates acute food insecurity in some part of the country, especially the three Northern Regions. Reasons for this caution include the fluctuations in the output of food production due to heavy reliance on rain, poor infrastructure, and use of traditional farming tools and practices. Unfortunately, data on a wide range of agricultural activities in Ghana is near absent, hence the inability of government agencies to make concrete projections or reveal the true state of Ghana's food security. Of course, investment in research by the state has always been a challenge given the stiff competition from other critical sectors of the economy. Even if such data exist, they may only reflect aggregates and be obsolete, and in-depth details may not even be available from the state (Ministry of Food and Agriculture 2007).

The need for data in the agricultural sector, in recent years, has gained attention due to its capacity to propel new knowledge, improve practices, and also improve the effectiveness of governments' policies in increasing food production. The relevance of data in the agricultural sector is seen at every stage of the food value chain where data on farms, farmers, and final consumers is always gathered for various interventions and projects. In fact, the importance of data cannot be withheld as accessibility to it becomes the game-changer in the agricultural sector, hence the need for its openness.

Open data in this regard refers to all data sources that are accessible and shareable and can be used by anyone. It has been proven to be beneficial to ensuring sustainable agriculture for smallholder rural communities mostly in developing countries. When reliable and accessible to farmers, open data can influence food security by offering famers the ability to make precise projections on farming output, battle climate change, promote higher food production, and improve access to markets. In fact, open data can also generate sector changes to provide innovations to benefit all (Lohento et al. 2017; Musker and Schaap 2018).

Despite the numerous benefits attached to open data, Jellema et al. (2015) identify the African continent to be the least inclined to open data due to limited internet access, limited funding for research or data creation, and scarce mediators who play a vital role between accessing open data and use of that data. Fortunately, Ghana has made a bold step in signing up to the Open Government Data initiative in 2014, which establishes Ghana's clear indication to harness the benefits of open data in all sectors of the economy including the agricultural sector.

Under the auspices of the USAID, the International Institute of Tropical Agriculture (IITA) engaged the University of Cape Coast YouthMappers chapter to facilitate a farmer profiling project as a way to examine the efficacy of various farming technologies that were introduced to small-scale farmers in the three Northern Regions of Ghana. Aside from the expectations of improving the output of smallholder farmers, these interventions also aimed at improving the living conditions and economic prospects of these farmers given an observed positive relationship between asset accumulation and poverty alleviation.

2 YouthMappers and the International Institute of Tropical Agriculture

From its inception in 1967, the International Institute for Tropical Agriculture (IITA) has positioned itself as a research-for-development (R4D) organization that focuses on providing tailor-made solutions to end poverty, hunger, and the destruction of natural resources across the African subregion. To achieve this, the IITA engages various national and international agencies like Ghana's Ministry of Agriculture and other allied agencies to enhance food security, improve livelihood, preserve natural resources, and increase employment. On the back of the aforementioned, the IITA is funded and constitutes one of the 15 research labs under Consultative Group on International Agricultural Research (CGIAR).

As a research lab, the IITA has executed over 70% of the CGIAR's programs in sub-Saharan Africa and also hopes to lift about 11.5 million young people from poverty through an intensive program to rejuvenate 7.5 million hectares of farmland by 2020 (Consultative Group on International Agricultural Research 2020). Unfortunately, the evidence to evaluate the IITA's ability to deliver on this audacious goal is not available to the researcher. Among the key thematic areas that border on the IITA's activity are biotechnology and genetic improvement, natural resource management, social science, and agribusiness as well as plant production and plant health. It must be noted that each thematic area is limited to a section of the African continent and keenly related to the agricultural needs of the identified subregion.

With its footprint in 30 countries in Africa, the focus of activities in West Africa is crop improvement and biotechnology, and this centers on the improvement of crops like roots, tubers, and bananas. Fortunately, the identified crops are mostly found in the three Northern Regions of Ghana, hence the IITA interest in introducing various farm technologies to farmers in the identified communities. At present, the IITA Ghana office has an administrative facility and a demonstrational lab in all the three Northern Regions, and it is in these labs that farmers receive first-hand orientation of modern farming technologies. On the whole, the IITA is represented in 12 West African countries and has also undertaken projects that offer additional support like mechanization, agribusiness, and capacity development. On the other hand, Sudan is the only country in Northern Africa with an IITA office despite efforts to champion policies for agribusiness, nutrition, and health.

Aside from focusing on farmers' needs, the IITA also initiates programs to end poverty by addressing the increasing rate of unemployed youth in sub-Saharan Africa. By this, the IITA establishes a Youth Agripreneurs program as a conduit to create job opportunities by encouraging the youth to consider the agricultural value

chain as a viable livelihood option. Such programs are executed with various business incubation programs that offer the needed environment and resources for various brainstorming activities.

3 First Engagements and a Research Method Design

The search for an outfit with the needed experience and dedication to undertake a farmer profiling project necessitated the collaboration between UCC YouthMappers and IITA. To most of our mappers, news of this potential collaboration was like winning a lottery since it did not only validate our efforts but also offered an opportunity to solve real-world problems. Additionally, location of the study site also added up to the euphoria, especially when most of our mappers appeared to originate from the South or middle belt of Ghana. We could see the smiles and excitement on their faces as everyone appeared to show interest in this project. Unfortunately, logistical constraints and project requirements did not permit us to engage over 80 mappers on campus for this project.

As the acting advisor, the choice of who to select for this project became a headache given the diversity and entrenched commitment of our chapter members. To select 5 mappers for this project, the selection criteria focused on students who required more than a year to complete their program. This was needed to ensure a smooth propagation of knowledge and lessons acquired from the project. The pool of eligible students was still around 30 students, and each mapper was poised to make the cut. Finally, a ballot was cast, and the 5 members of this project include Kwame Odame, Ebenezer Boateng, Daniel Osei Acheampong, Confidence Kpodo, and Sabina Abuga.

Typically, a bus ride from Cape Coast to Tamale is about 15 hours, but the IITA was inclined to sponsor our flights from Accra to Tamale and that trip took less than an hour. In fact, that was a relief to us since it spared us long sitting hours. In our first meeting with staff and officials of the IITA, the chief scientist for the program mentioned that their decision to collaborate with us was heavily based on reports of our activities and their observation of our enthusiasm using open data and tools to address real-world issues. Here, we took the chance to inform our hosts of our intention to utilize open data platforms, namely, Kobo Toolbox, OSMtracker, and Java OpenStreetMap editor (JOSM). The choice of these platforms was informed by the numerous advantages that come with the use of open data and extensive experience gained from the use of these platforms in previous projects.

Guided by the objectives of IITA, our first engagement began with a demonstration of Kobo Toolbox, which was the primary data collection platform for the project (as seen in Fig. 3.1). For most of the staff of IITA, open data tools, like Kobo Toolbox, were a new phenomenon, and to make the interaction more practical, the survey questions were used in developing the research instrument since it offered the advantage of learning this tool and familiarizing ourselves with the research instrument.

The target group for this project comprised small-scale farmers under the Africa RISING program. Small-scale farmers in this regard refers to farmers with not more than 3 acres of land and grow crops for basic subsistence since their yearly output could only cater to their family needs. This includes farmers in Tingoli, Duko, Tibali, and Cheyohi of the Northern Region; Goli, Goriyiri, Zanko, and Guo in the Upper West Region; and Gia, Bonia, Nyangua, and Samboligo in the Upper East Region (map of study area is shown in Fig. 3.2). While selecting 4 farming communities in the aforementioned regions, the entire data collection exercise lasted for 10 days covering 216 farmers. It must be noted that the Africa RISING program offers support for farmers of both sexes, and though the study captured data from both sexes, emphasis was also placed on examining the efficacy of farming technologies on women's livelihood since asset acquisition is deemed critical to people's ability to escape poverty (Fig. 3.3).

Fig. 3.1 A training session on the main platform of the project, Kobo Toolbox is given in the laboratory

Fig. 3.2 A field practical session with demonstration of Kobo Toolbox launches the project in the study area

While employing Kobo Toolbox as the primary platform for data collection, the survey instrument was further divided into different themes, which reflect different focus areas for this project. Aside from the farmers' biodata, other themes on the instrument ranged from farmers' previous practices, which formed the basis to compare the efficacy of IITA's intervention on farmers crop yield and livelihood. Other themes include financial literacy and alternative support livelihood programs for farmers.

Having completed an engagement with a respondent (farmer), OSMtracker was employed to demarcate the boundary of their farm. This was deemed critical since most farmers did not have an objective boundary of their farmland,

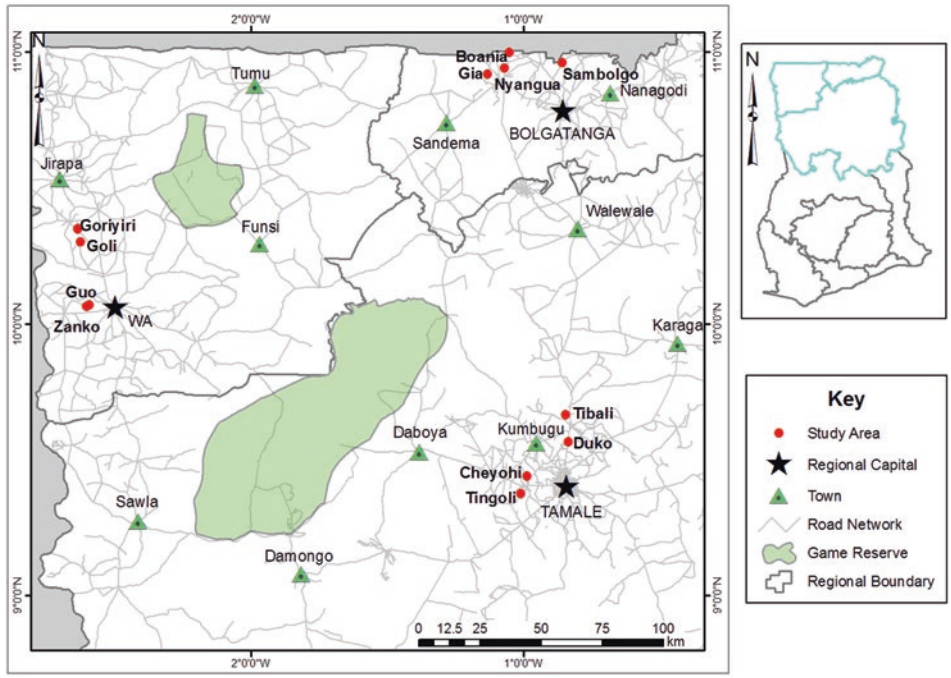

Fig. 3.3 Study areas in Northern Ghana are shown. (Credit: UCC YouthMappers)

hence their difficulty in projecting crop yield and estimating the value of their lands. At the time of the data collection, tree stumps, footpaths, stones, wooden pegs, and soil mounds were among some of the local tools that were used to separate one farmland from another. While correcting this anomaly, android phones with OSMtracker were offered to farmers while they walked round their farmlands. Figure 3.5 portrays an accompanied walk with a farmer who used OSMtracker to map the boundaries of his land.

The data collected from the field was readily available for analysis since the team relied on Kobo Toolbox. Before data analysis, data cleaning was first executed by downloading the project data in SPSS file format. This was done to eliminate or correct incomplete entries and ensure consistency in output. After the data cleaning, IBM SPSS version 21 was used for the analysis. The first analysis focused on the demographic characteristics of the respondents, while the rest of the analysis centered on the objective of the study, which employed both descriptive and inferential statistical tools to make sense of the data.

Having cited the use of the aforementioned open-source platforms, none of these 12 communities appeared to be on any map, and in this regard, the team resorted to OpenStreetMap (OSM) as a way to increase the visibility of these farming communities to the world. This situation resulted in the use of Java OpenStreetMap editor (JOSM) and OSMand, which were employed to remotely map and collect field data, respectively. The full extent of this mapping exercise is still available on OpenStreetMap and can be downloaded for any geospatial activity (Figs. 3.4, 3.5, 3.6, and 3.7).

4 Challenges from the Field

In carrying out this project, the following constraints were encountered: While all but one project member resided in Southern Ghana, a major challenge encountered in the field was language barrier. This was an issue as the major languages spoken in Southern Ghana differed significantly from the dialects spoken in the northern part. In fact, almost all of the local farmers could not

Fig. 3.4 The author speaks with male farming elders in one of the study communities

Fig. 3.5 UCC YouthMappers interact with a famer for field mapping of farm boundaries

speak or read English or any local languages spoken by the UCC YouthMappers team. To remedy this situation, the team engaged the services of translators who were familiar with the local terrain. One challenge envisaged here was the tendency of these translators to properly offer the needed service, and to this view, the team offered suitable incentives and also took time to rehearse the survey a number of times. Upon obtaining satisfactory feedback from the translators, we proceeded to the field.

The high temperatures associated with dry and dusty winds from the Sahara Desert were dominant in this area, and unlike the south, the air in the north felt thinner and warmer in the day. With desert winds, daytime temperatures were as high as 35°. This saw most team members developing cracked lips, dried nostrils, and blisters on their feet as a result of wearing boots for longer hours in the scorching heat. While enduring these conditions, both the IITA staff and the local farmers seemed fine as they went about their duties

Fig. 3.6 Female farmers gather with the mapping volunteers during a break in training

Fig. 3.7 YouthMappers accompany a farmer along a walk to deploy OSMtracker to map the boundaries of his land

without any constraints. To shield ourselves from the effect of the weather, we resorted to the use of local remedies like the shea butter, which offered a great deal of relief and insulated our lips and nostrils from the harsh weather.

The bad nature of roads and long routes to farms also posed some challenges to us. Though the team members lodged in the respective regional capitals, which had relatively good roads, the roads leading to the various farming

communities were not as good as the ones encountered in the regional capitals. In some cases, the team had to endure long travelling hours, which made trips very exhausting and unpleasant. Aside from the long distance to the communities, the use of OSMtracker to map farmlands also came with some discomfort. This was typically so as most farmers lived far from their farmlands. When the team asked the farmers to estimate the distance to their farms, common responses included "the farm is not far" or "the farm is just here." Unfortunately, "just here" was found to be about a 45-minute walk from the community, and due to exhaustion, team members had to resort to a motorbike. Even with the motorbike, a team member endured about a three-and-a-half-hour ride to complete mapping of all farmlands in a community. All of these completed on a day when temperatures were between 30 and 35 °C.

Finally, with the IITA staff being our local representatives in the three Northern Regions, the teams also encountered low turnouts in some isolated cases. This stems from late communication to farmers, and in some cases, farmers showed up late although information about the exercise had been received earlier. Also, some farmers had travelled outside the communities to attend to other commitments and were not reached. During moments of low turnout, the team took time to tour the communities since life in Northern Ghana was different from what we knew in the South. This provided the opportunity to learn more about local culture as the team interacted and perfected some phrases in their local dialect. On occasions where farmers had travelled outside the community, necessary transport was provided to get in touch with these farmers though this situation prolonged the time for engagements. For those who could not be reached, attempts were made to reach out to them after the survey period.

5 Findings from Our Work

From the 12 communities engaged, a total of 182 (which translates to an 86% response rate) smallholder farmers were found to be under the Africa RISING program. It is worth mentioning that the number of farmers found in each community was also subject to the population of local farmers in each community and farmers' ability to meet the IITA criteria for inclusion into the Africa RISING program. As seen in Table 3.1, Nyangua in the Upper East had the highest population (12%) for local farmers who were reached for this study. On the other side, Bonia in the Upper East recorded the least number of farmers (2.2%), which may be attributed to the relatively low population in this community.

Table 3.1 Percentage of farmers reached, by community, gender, education level

Variable and category	Percent
Community	
Bonia	2.2
Cheyohi	2.7
Cheyohi No. 2	4.9
Goriyiri	7.7
Zanko	7.7
Guo	7.7
Samboligo	8.2
Gia	8.8
Tingoli	8.8
Duko	9.3
Tibali	9.3
Goli	10.4
Nyangua	12.1
Gender	
Female	48.8
Male	51.6
Level of education	
No education	72.0
Basic education	15.4
Junior high school	5.5
O/A level	2.2

The gender distribution of smallholder farmers revealed that there were 51.6% males and 48.2% females. This shows a relatively low disparity among males and females, although the land tenure system in Northern Ghana is entrusted in the hands of males, which perpetuates a patriarchal dominance and also limits women's access to land for farming or any other purpose. It can be said that IITA's Africa RISING program in Northern Ghana promoted gender equality, which would trickle down to ensuring food security,

thus ensuring equal access to their program for both males and females. In terms of respondents' level of education, 72% had no formal education, and this finding is in a tandem with the Ghana Statistical Service, which stipulates that 44–54% of the people in the North have never been to school before despite a strong belief in the decline of this statistic given government policy to make basic education free. On the back of this, the remaining 28% of respondents appeared to have some level of education, but this does not include any tertiary education.

Obtaining spatial information of farmlands was regarded as important for this study. On that note, all farmlands enrolled in the Africa RISING program were mapped out and presented on a regional basis as seen in Figs. 3.8 (Northern Regions), 3.9 (Upper East), and 3.10 (Upper West). We expected that farmers can use this data to make precise projections about their activities.

6 Assessing Results Relative to Other Interventions

This section presents findings on existing programs enjoyed by smallholder farmers under the Africa RISING program. This was deemed important since it offers a fair assessment of the farming intervention programs, which may also serve as a basis to compare its efficacy on farmers' livelihoods. Having presented a catalogue of interventions to farmers, the results showed that the majority of the farmers practiced the maize leaf stripping technology (52.7%). This was based on the relatively shorter gestation period of maize, being a staple food and always in high demand. On the other hand, cowpea living mulch was identified to be the second most practiced intervention (36.8%). This intervention was practiced since it provides nitrogen for other crops such as maize (Table 3.2).

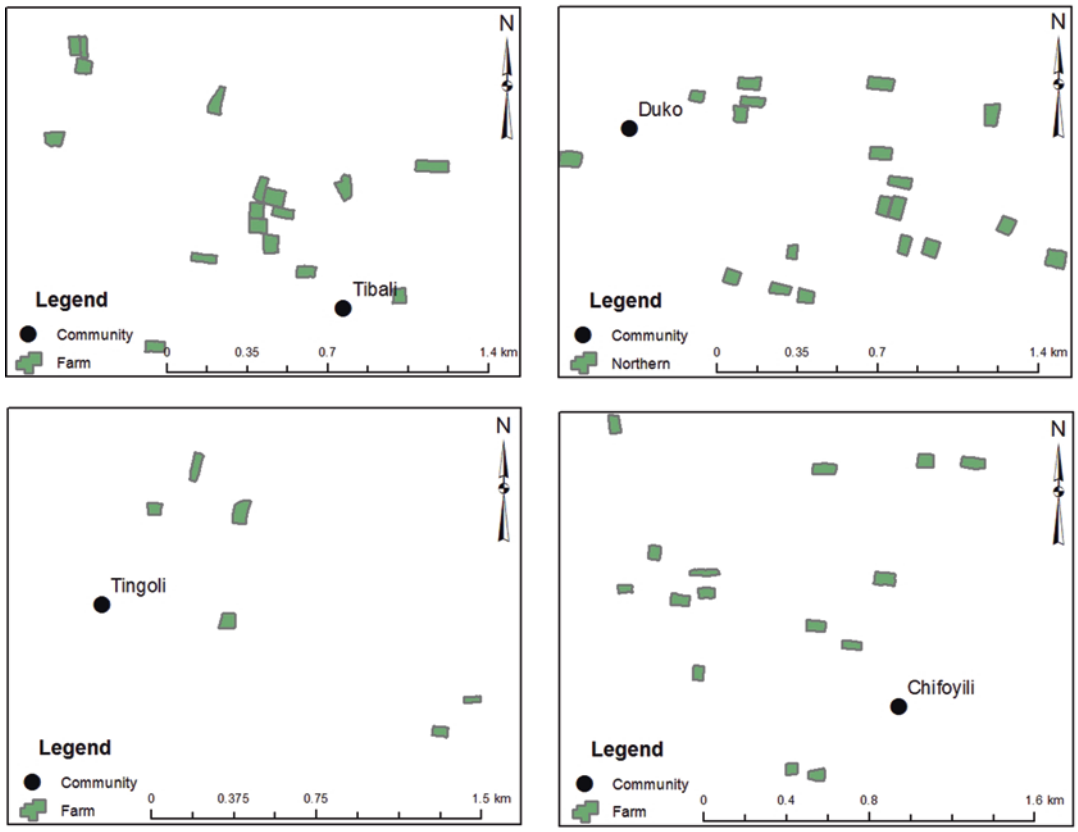

Fig. 3.8 YouthMappers map out farmlands for the communities in the Northern Region during fieldwork in 2019

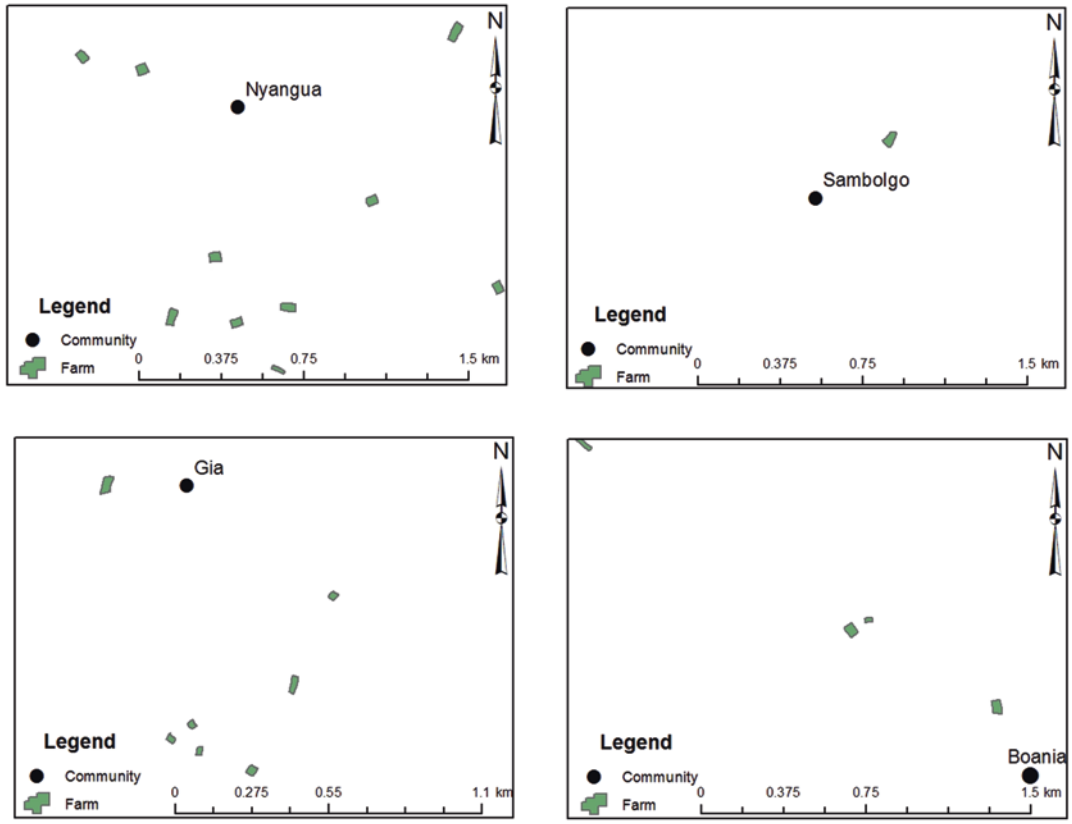

Fig. 3.9 YouthMappers map out farmlands for the communities in the Upper East Region during fieldwork in 2019

Having identified the existing programs practiced by the farmers, the perspectives of farmers were sought on which of the Africa RISING program they preferred. It was found that the maize leaf stripping (72.41%) seemed to be the obvious choice of most farmers. The reasons for this selection were no different from the ones enumerated above. Aside from maize, cowpea (68.97%) and groundnut (34.48%) also ranked second after maize (Table 3.3).

Having identified farmers' current crop program, the study further sought to identify the farm management practices executed by farmers to increase their crop yield. Maize leaf stripping was the most preferred (42.9%) farm management practice. In simple terms, maize stripping involves the removal of lower leaves from the maize plant at anthesis or post-anthesis. In fact, this is done to increase radiant energy penetration to the understory crop and also boost crop output. When farmers also engage in the rearing of ruminates, the strips from the maize also serve as feed to the animals. Also, other leading management practices include cowpea living mulch (24.7%) and cowpea living mulch, maize leaf stripping (11%) (Table 3.4).

To assess the impact of the program, the yields of the smallholder farmers were measured (refer to Table 3.5). It was observed that there had been a significant increase in the number of smallholder farmers who cultivated maize as other farmers who preferred cultivating other crops changed and aspired to enjoy the numerous benefits associated with maize cultivation. From this data, this appeared to be the presence of female farmers who also considered the short gestation period for maize as an avenue to increase household food supply and sell excess for income. With such surpluses, female farmers may have enough to procure some necessities of life, and this was evident when most women did not own mobile phones, which could cost as low as $5.

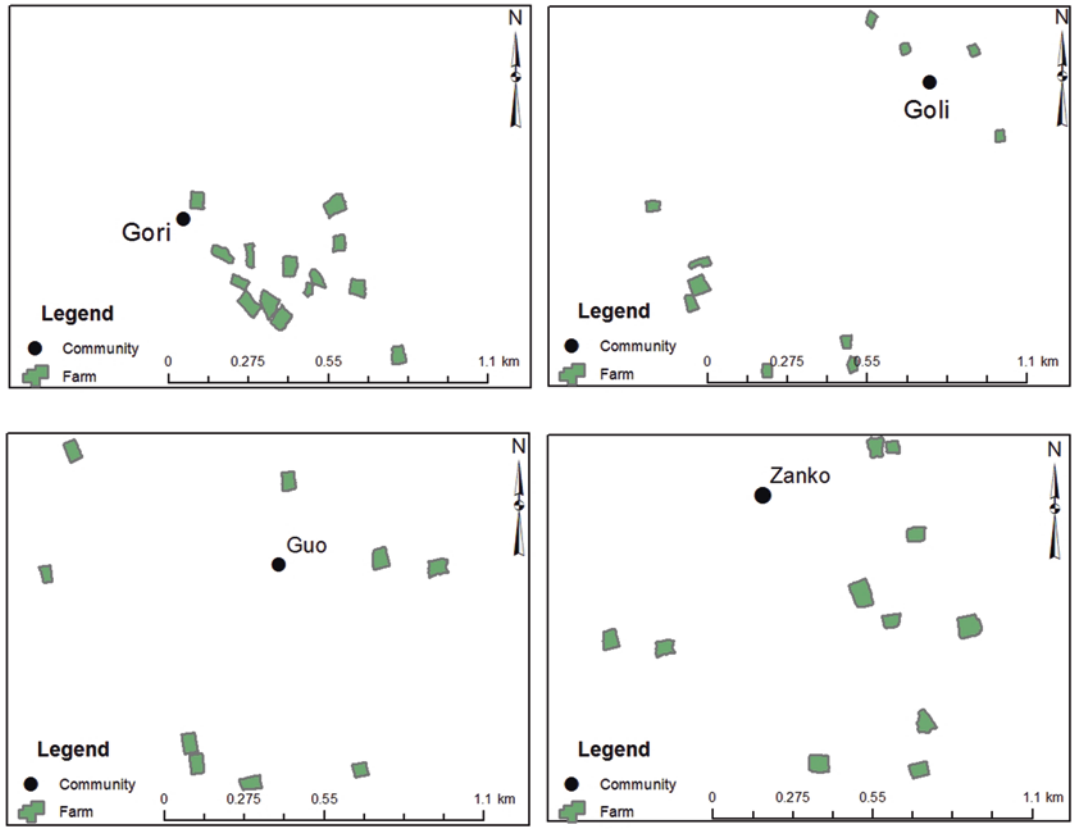

Fig. 3.10 YouthMappers map out farmlands for the communities in the Upper West Region during fieldwork in 2019

Table 3.2 Intervention program practiced

Name	Frequency	Percent
Cowpea living mulch	67	36.8
Groundnut spacing	19	10.4
Maize leaf stripping	96	52.7
Total	182	100.0

Table 3.3 Preferred program (among the previous intervention)

Intervention	Frequency	Percentage
Maize leaf stripping	42	72.41
Cowpea living mulch	40	68.97
Fertilizer trials	20	34.48
Groundnut spacing	20	34.48
Strip cropping	20	34.48
Livestock feed improvement & livestock housing	10	17.24
Vegetable maize intercropping	6	12.07
Integrated soil fertility management	9	15.52
Cowpea spraying regime	17	29.31
Nutrition intervention among women	5	8.62
Irrigation	7	12.07
Natural resource management	3	5.17

Table 3.4 Management practices

Variable	Frequency	Percent
No response	3	1.6
Cowpea living mulch	45	24.7
Cowpea living mulch, groundnut spacing	11	6.0
Cowpea living mulch, groundnut spacing, maize leaf stripping	10	5.5
Cowpea living mulch, maize leaf stripping	20	11.0
Fertilizer trials (nitrogen rate on maize), groundnut spacing, maize leaf stripping, livestock feed improvement, & livestock housing	1	.5
Fertilizer trials (nitrogen rate on maize), livestock feed improvement, & livestock housing	1	.5
Groundnut spacing	8	4.4
Groundnut spacing, maize leaf stripping	5	2.7
Maize leaf stripping	78	42.9
Total	182	100.0

Table 3.5 Yield of smallholder farmers, by number of bags

	N	Minimum	Maximum	Mean	Std. deviation
What was your yield last year (maize)?	83	.00	8.00	2.8223	1.59435
What was your yield last year (cowpea)?	73	.0	14.0	2.167	2.4869
What was your yield last two years (maize)?	73	.0	10.0	2.397	1.9947
What was your yield last two years (cowpea)?	72	.0	10.0	1.882	2.2083

Indeed, with the absence of mobile phones, the only way to contact these women was through other family members or friends who owned mobile phones. This situation also posed a challenge for the IITA staff, in making access to information on weather and prevailing market prices of crops a difficult task, and all these further reinforced women's reliance on men.

Fig. 3.11 An elder woman farmer enjoys the training sessions with YouthMappers

7 SDGs and Lessons Learnt

As the world seeks to eradicate hunger (SDG 2) and poverty (SDG 1), organizations and partnerships like YouthMappers and IITA have equally played an active role in providing various support services to smallholder farmers in Northern Ghana. Despite reports of lower farm fields from various research across the country, these interventions from the IITA were found to significantly boost crop yield across the farming seasons. Indeed, the success stories were found to have a greater impact on female farmers since higher farm yields implied some level of economic independence and a general improvement of food security, which influences malnourishment and hunger. It was expected that the IITA would offer more opportunities to increase support for female farmers in Northern Ghana (Figs. 3.11, 3.12, and 3.13).

Engaging YouthMappers students in this project offered us a rare opportunity to explore the breadbasket of our country, its people, and their culture. We gained firsthand account of what it takes to be a farmer, and more importantly, we understood the daily living situations or struggles of female smaller-scale farmers. While this project was limited to selected farmers, and to selected students, the potential to properly demarcate farm size using open tools offers women the opportunity to project farm yields and employ simple but cost-effective technology in making the best of their land. From this project, we appreciate the potential of the Kobo Toolbox in developing a database of all farmers under this program. Our contributions to this data and the findings thus offer a solid backbone to understand the unique needs of female farmers since this will be crucial in improving Ghana's food security and economically empower them, addressing both hunger and poverty through leveraging spatial technologies for agricultural intensification (Figs. 3.14, 3.15, 3.16, and 3.17).

Fig. 3.12 A woman farmer with her child attends the trainings

Fig. 3.13 One of the study communities gathers under tree shade to commemorate trainings with a photo

Fig. 3.14 The author interviews farmer families in Northern Ghana

Fig. 3.15 YouthMappers team members intake and validate data using Kobo Toolbox

Fig. 3.16 Farming families provide critical data for the mapping activities

Fig. 3.17 Women farmers in Ghana especially stand to gain from policies that the data can inform

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