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Traditional and Western knowledge systems used by smallholders: Harnessing synergies for improved household food security in rural Ghana

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ABSTRACT

The discourse on knowledge integration persists in research and development practice. The need for traditional and Western knowledge systems to work together to achieve sustainable agricultural development in Ghana's rural areas has become evermore relevant to achieve household food security in the context of changing climate, declining soil fertility, and labour challenges. The authors examined the role of knowledge integration in shaping the food security outcomes of socially differentiated smallholders' households in Kassena-Nankana Municipal District and the Kassena-Nankana West District in the Upper East Region of Ghana, where food insecurity prevalence is very high. Using mixed methods approach, they found that most low resource endowed households that were unable to combine traditional and Western farming methods were more likely to experience food insecurity than were other households. Farmers with higher resource endowments integrated knowledges from both traditional and Western systems leading to better yield outcomes. However, combining both knowledge systems did not guarantee automatic success due to intervening factors. The authors conclude that different categories of smallholders' resource endowment significantly impacts the smallholders' food security status, and recommend that policy and development programming should promote integration of traditional and Western farming knowledge systems to achieve sustainable food crop production.

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Introduction

Food security is a fundamental aspect of human and social development and has become a key theme in international cooperation to meet the target of the United Nations' Sustainable Development Goal 2 by 2030 (FAO et al. 2022). It is estimated that 2.3 billion people in the world were moderately or severely food insecure in 2021, representing 30% of the global population (FAO et al. 2022). In 2021, the highest prevalence of severe food insecurity was in sub-Saharan Africa, when more than 278 million people were affected by hunger (FAO et al. 2022). The COVID-19 pandemic complicated the food security situation in Africa. The pandemic also highlighted deep fragilities in the agri-food systems, driving further increases in world hunger and severe food insecurity. In 2020, an implied 3.6. million people in Ghana (11.7% of the country's population), were food insecure, and the Upper East Region had the highest prevalence of food insecurity (Government of Ghana et al. 2020). It has been noted that poor agricultural performance is a major cause of food insecurity in northern Ghana, underpinned by two critical drivers: low soil fertility and rainfall variability (Derbile 2010; Ndamani & Watanabe 2016). The history of food security since the 1974 World Food Conference has witnessed several definitions and overlapping paradigm shifts. However, the most influential definition that has become widely accepted is the outcome of the World Food Summit held in 1996, when food security was defined as a situation in which all people at all times have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs

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and food preferences for an active and healthy life (FAO n.d.). The definition establishes the key pillars of food security:

- it deals with the issue of availability of sufficient quantity and quality of food physically present in an area through own production, markets, food aid, or gifts
- it addresses the issue of distribution to ensure that sufficient food for a nutritious diet can be accessed by all
- it covers consumption in the sense that the energy and nutrient needs of the individual are met in order to be active and live a healthy life.

It has often been argued that agricultural growth is particularly effective in reducing hunger, malnutrition, and poverty in sub-Saharan Africa (Fuglie & Rada 2013). Although agricultural productivity has been increasing slowly, it is far below the needs of the continent (Block 2014). Therefore, for the agricultural sector to make any significant contribution to address the food insecurity and meet the needs of the growing population in sub-Saharan Africa, much higher levels of agricultural productivity in a sustainable manner are required. Ghana has a long history of initiatives to improve the agricultural productivity of smallholders[1]. The conventional approach to enhance agricultural production and productivity consists of wholesale transfer of technologies, knowledge systems, and values from the Global North to the Global South. These technologies, values, and knowledge systems are mainly aimed at transforming agriculture in line with market rationalities and neoliberal standards (Ministry of Food and Agriculture 2015), and thus fail to integrate local knowledge systems and values. Consequently, intense investments are made to Westernize agriculture by focusing on mechanization, promotion of monocropping, cash crops, and the use of hybrid seeds, inorganic fertilizers, and agrochemicals.

Traditional agricultural knowledge systems that form the basis for local decision-making and problem-solving strategies for agriculture and natural resources management have received limited consideration among policymakers (Nnadi et al. 2013). That not withstanding, traditional farming practices remain resilient among smallholders in northern Ghana because traditional knowledge systems remain the main driving force in smallholders' decision-making processes regarding land use, food production, learning, and experimentation. Besides, such systems play an important role in maintaining biodiversity and building resilience to adaptation to climate change in order to enhance agricultural productivity (Muthee et al. 2019). The World Bank (1999) argues that traditional knowledge is an integral part of the development process of local communities and a key element of the 'social capital' and main asset of the poor to invest in the struggle for survival, to produce food, to produce shelter, or to achieve control of their own lives. Given the known benefits of Western agricultural knowledge systems and despite years of failure to transfer these systems to African farmers, we argue that an integration of both knowledge systems for harnessing the merits of both is a panacea for African farming challenges. We therefore investigated how farmers are harnessing the synergies between traditional and Western farming practices and technologies to improve household food security and to identify what are the trade-offs and how smallholders rationalize their choices in combining the two forms of agricultural knowledge systems for sustainable agricultural production.

Theoretically, this article is situated within the context where knowledge integration remains a major challenge, undoubtedly due to the tension posed by the binary divide between traditional and Western scientific knowledge (Maweu 2011). Some scholars have resisted knowledge integration on the grounds that the conceptual models and ontologies of traditional knowledge and Western science are sufficiently distinct to make these knowledge systems incommensurable (Cruikshank 2005). Nonetheless, interest in integrating the two knowledge systems is steadily growing along several lines of argument (Agrawal 2002; Aikenhead & Ogawa 2007; Maffi & Woodley 2012). What appears to be missing in the debate is how traditional knowledge and Western scientific knowledge systems can be usefully integrated to ensure smooth diffusion of innovation for sustainable agricultural development in rural areas (Sillitoe 2010; Briggs 2013). Given this research gap, we aim to answer the following question: 'How is the integration of traditional and Western scientific agricultural knowledge and food security outcomes socially differentiated among smallholder households in rural Ghana?' In this regard, the article contributes to the discourse on knowledge integration as a framework to achieve sustainable crop production in order to improve household food security, and it also reveals contextual issues to inform the design of appropriate extension delivery approaches to promote ownership, relevance,

[1]In Ghana, the term 'smallholder' refers to a category of farmers with limited access to land, capital, agricultural inputs, technology, labour, mechanization, and markets, who are more vulnerable to risk than others, and who have landholdings less than 2 ha in size.

and sustainability of agricultural interventions in rural Ghana.

The structure of the article is as follows. The next section explores the synergy between traditional and Western farming systems for improving household food security. Thereafter, we detail our study approach, encompassing the techniques used for data collection and analysis. Then, we unveil the study findings, and engage in a discourse on the amalgamation of farming knowledge systems and their impact on the food security situation of diverse smallholder households. Our conclusions are presented in the final section.

Traditional knowledge, integration, and food security: a theoretical engagement

Traditional knowledge is considered a strategic resource driving innovations and development. The holders of this knowledge system embrace an indigenous worldview that is holistic. This worldview is based on the perception that the living world is made up of three interrelated worlds: the human world, the natural world, and the spiritual world (Haverkort et al. n.d.). Traditional knowledge is sometimes difficult to distinguish and therefore must be contextualized. For the purpose of this article, the term traditional knowledge has been adopted to represent a body of knowledge held by, constructed by, or acquired by local people over time and transferred from one generation to another (Apraku et al. 2021). This definition highlights special features of traditional knowledge that distinguish it broadly from other knowledge systems. Furthermore, it shows that traditional knowledge is local and deeply rooted in a particular community within a broader cultural tradition (Shaw et al. 2009). In other words, traditional knowledge is tacit or embedded in the practices and experiences of local culture, learned through repetition, and transmitted orally (Muthee et al. 2019). It is constantly changing through mediation and adaptation within some cultural parameter and is closely linked to the survival and subsistence of particular cultural group (Mavhura et al. 2013; Muthee et al. 2019).

Western farming knowledge systems connote the concepts, ideas, values, practices, and technologies that are imparted in the minds of farmers by extension officers, both public and private, who are trained in Western scientific agriculture. The promotion of Western farming knowledge systems has seen changes in African farming systems, technologies, and practices (Kasanga et al. 2019). Currently, smallholders are very much aware of these Western farming practices and technologies but they make conscious decisions to use particular methods that suit their own local circumstances and needs. For example, if a particular piece of farming knowledge works for a farmer and makes economic and sociocultural sense, it will be used, regardless of whether it is drawn from Western or traditional knowledge (Briggs 2013). This demonstrates that farming practices can simultaneously encompass both traditional and Western elements. Raymond et al. (2010) underscores the relevance of an integrated knowledge model and encourages a shift in science from the development of knowledge-integrated products to the development of problem-focused knowledge integration processes. Guye (2014) examined opportunities for integrating local knowledge practices in soil management strategies with Western technology for conserving soil fertility to ensure agricultural sustainability in the Bore District, Guji Zone, in Oromia Region, southern Ethiopia. In his article he argues that differences in wealth, high price of inputs, and insufficient credit retarded efforts in the past to ensure food security. Several studies have shown that decisions by smallholders to adopt agricultural technology are influenced by economic, social, and institutional factors (Akudugu et al. 2012; Mwangi & Kakuiku 2015). Other studies have found that market participation and household wealth are important factors influencing the adoption of Western agricultural technology among smallholders in developing countries (Nazziwa-Nviiri et al. 2017; Baiyegunhi & Hassan 2018). However, the adverse impacts of climate change on African agriculture and livelihoods constitute a development challenge. Yaro (2013) argues that even slow changes in the normal rainfall pattern may seriously affect crop yields. More recently, Apraku et al. (2021) assessed the role of indigenous practices in lessening the impact of climate change in smallholder agriculture, as well as their integration with Western scientific practices among smallholders in Kenya and South Africa. The authors concluded that merging local knowledge and Western science in Africa could help to develop a syncretic agronomic knowledge among local farmers in handling the impacts of climate change. Adopting an integrated approach that combines both traditional and Western farming methods is imperative, not only to improve soil fertility but also to ensure sustainable agricultural intensification (Clay 2018).

Over the years, smallholders in sub-Saharan Africa have developed and adapted time-tested strategies to attain household food security (Derbile 2010; Briggs & Moyo 2012). Some of these strategies include owning multiple holdings, which offer smallholders the opportunity to spread their risks and ensure a constant supply of food. From the perspective of smallholders, food

security can be achieved by growing a wide range of food crops (Briggs & Moyo 2012). Clearly, risk aversion is a key element of crop farming among rural households in northern Ghana, and measures to mitigate declining soil fertility are critical. Animal manure remains the most widely used soil fertility enhancement strategy in crop production in northern Ghana (Derbile 2010). However, there are challenges with the adoption of the practice due to dwindling numbers of cattle and other ruminants. Livestock are considered an important household asset in rural Ghana. Accumulation of livestock allows poor households to invest in farming, diversify their income, and become less poor, which in turn tends to enhance their food and nutritional security. Sekaran et al. (2021) assert that integrated crop-livestock systems could be a key strategy for achieving both food and nutritional security and environmental sustainability.

Given that the two bodies of agricultural knowledge systems are limited in their own ways, the critical consideration for social scientists should be how to integrate Western agro-practices and knowledge with African traditional knowledge systems. The attempts at replacing one with the other is simply flawed, as the African farmer has a history, a sociocultural context, and lives within an economic reality that must necessarily examine incoming knowledges and practices for conformability and acceptance. The synergy we advocate is the selection of good lessons and merging them with established and relevant existing knowledge and practices while abandoning now inappropriate practices.

Study districts and methodology

Study districts

The study was conducted in Kassena-Nankana Municipal District and Kassena-Nankana West District of the Upper East Region, Ghana. Over the years, the Upper East Region has been noted as having the highest prevalence of food insecurity in Ghana (Government of Ghana et al. 2020). The Upper East Region is in the north-eastern Ghana and shares a boundary with Burkina Faso in the north and Togo to the east. Originally, Kassena Nankana District was created as a district assembly in 1988 and was later split into two districts in February 2007. The Kassena Nankana Municipal Assembly was elevated to municipal status in June 2012. The Kassena-Nankana Municipal District has a total land area of 767 km^2, and in 2021 it had a population of 99,895, comprised of 48,658 males and 51,237 females (Ghana Statistical Service 2021). The Kassena-Nankana West District covers a total land area of 812 km^2, and in 2021 it had a total population of 90,735, comprised of 43,909 males and 46,826 females (Ghana Statistical Service 2021). The two districts are coterminous and are within the Guinea Savannah agro-ecological zone. The vegetation is a degenerated guinea savannah type, consisting of a fire-swept grassland of varying heights occurring between deciduous trees, which mostly have economic and social value (Yaro 2006). Agriculture is the dominant economic activity in the study districts and the main crops cultivated in the districts are cereals (millet, sorghum, and maize), legumes (cowpea (black-eyed pea), groundnut, soybean, Bambara bean, and pigeon pea) and vegetables (roselle, okra, pepper). Also, farmers own livestock (cattle, donkeys, pigs, goats, and sheep) and poultry (chicken, guinea fowl, ducks), depending on their level of resource endowment.

Methods

We used a mixed method approach to collect and analyse data. This approach was deemed relevant and appropriate because of both the need to maximize empirical power and effectiveness, and the need to provide comprehensive perspectives of the phenomenon under consideration in order to enrich understanding (Yin 2014). Eight study communities – Punyoro, Vunania, Saboro, Mirigu, Bonia, Gingabnia, Doba, and Kajolo – were purposely selected based on geographical differences of the Kassena-Nankana Municipal District and Kassena-Nankana West District in terms of communities that had reached their land frontier and those that still had virgin lands available for expansion or at minimum, sufficient fallow lands. These criteria are underscored by Boserup's assertion that reduced fallow and access to virgin lands trigger intensification process and stimulate technology adoption (Boserup n.d.).

The first phase of qualitative data collection commenced, with the support of extension officers, by arranging focus group discussions with farmers at the community level. A total of eight focus groups were constituted (i.e. one per community) with a maximum of 12 participants per group, mainly household heads. We facilitated the discussions in the native languages (Kasem or Nankam) and used a thematic focus group guide to explore issues related to traditional and Western farming systems in smallholdings, how socially differentiated smallholders integrated both farming knowledge systems, and how integration of the knowledge systems influenced the household food security outcomes of the differentiated smallholders.

The outputs from the focus group discussions informed the design of the survey instrument for the second phase.

The second phase was primarily a survey based on the variables identified from the first phase and from the literature. It took the form of pre-coded structured questionnaires administered face-to-face with members of 122 sampled households that had been randomly selected. The questionnaire was structured into five sections, respectively to capture personal information of participants, to cover household information, to capture data on farm size, types of farmland, cropping system, and farming practices and technologies, to focus on the combining of traditional and Western farming systems, and to look at household food sources, periods of hunger, reasons for food shortages, and coping strategies.

The third phase of the study was mainly qualitative and employed in-depth interviews to collect data from key informants to provide deeper insights and understanding of the different farming practices and technologies, as well as drivers for integrating the two forms of farming practices and technologies, and the rationale for informants' decisions. Using holding size as the main filter (Chamberlin 2008), smallholders were classified into three categories: high resource endowed, medium resource endowed, and low resource endowed, locally respectively referred to as *vale-didera*, *achea*,[2] and *vale-nabona* among Kasem-speaking communities. Six in-depth interviews were conducted in Nankam, Kasem, or English separately with six individual smallholders, two from each of the three categories of smallholders (i.e. 2 high resource endowed, 2 low resource endowed, and 2 medium resource endowed). The survey data were analysed using the Statistical Package for the Social Sciences (SPSS) version 20.0 for Microsoft Windows, to provide frequency tables, percentages, and simple cross-tabulation. The qualitative data from the focus group discussions and interviews were transcribed, coded, and analysed using Clark & Braun's five-phase framework for qualitative thematic analysis (Clark & Braun 2013). Based on the survey sample, the key sociodemographic characteristics of the 122 survey participants are summarized in Table 1.

Table 1. Sociodemographic characteristics of the study participants, 2019

Characteristic	Frequency	Percentage
Sex		
Male	69	84
Female	53	65
Age (years)		
31–40	32	39
41–50	22	27
51–60	30	37
61–70	22	27
71 or older	16	20
Educational level		
No formal education	64	78
Primary/Junior High School	42	51
Middle/O Level	4	5
A Level/Senior High School	6	7
College/Polytechnic/University	6	7
Marital status		
Married	78	95
Single	4	5
Widowed	32	39
Divorced	1	1
Separated	6	7

Results

In this section, we first examine how the two forms of agricultural knowledge systems are integrated by the three categories of farmland farmed by smallholders before presenting an analysis of their food security outcomes in relation to different levels of integration of Western and traditional farming methods.

Integration of traditional and Western scientific farming practices

Traditional agricultural farming practices refer to farming practices that are native to smallholders in rural areas. We focused on elements such as the smallholders' knowledge and practices related to soil fertility management, cropping systems, seed systems, and adaptations to rainfall variability. The dominant features (measured in percentages) of traditional farming practices among agrarian smallholder households in the studied communities are shown in Table 2. The results suggest that traditional farming practices predominantly took place on farmland used for mixed farming.[3]

The dominant features of Western scientific farming practices in the two study districts are shown in Table 3. The results show a pattern with these forms of farming practices predominantly on lowland and bush farms.

In terms of the integration of the two forms of agricultural knowledge systems, the majority of the study participants (72%) combined both traditional and Western scientific farming practices/technologies at different levels (Table 4). With respect to how socially differentiated smallholder households combined the two forms of knowledge systems, the results show that the majority (88%) of high resource endowed

[2]In Nankam-speaking communities
[3]In the studied districts, mixed farming was done on land close to homesteads and involved the cultivation of food crops for household subsistence.

Table 2. Traditional farming practices and types of farrmland, 2019

Traditional farming practice/Technology	Farmland used for mixed farming	%	Lowland farmland	%	Upland (bush) farmland	%
Hand weeding with hoe	122	100	46	38	37	30.6
Animal traction	106	87.6	22	18.2	26	21.5
Own seeds	99	81.8	31	25.6	25	20.7
Stick dibbler/hoe	94	77.7	36	29.8	31	25.6
Animal/compost manure	94	77.7	7	5.79	9	7.44
Mixed cropping	86	71.1	8	6.61	15	12.4
Crop rotation	17	14.1	7	5.79	2	1.65
Zero tillage	1	0.8	1	0.83	0	0
Slash-and-burn	0	0.0	1	0.83	1	0.83

Table 3. Western farming practices and types of farmland in the two study districts, 2019

Western farming practice/Technology	Farmland used for mixed farming	%	Lowland farms	%	Upland (bush) farmland	%
Chemical fertilizer	15	12.4	61	50.4	30	24.8
Herbicides	15	12.4	36	29.8	20	16.5
Monocropping	6	5.0	22	18.2	10	8.3
Certified/hybrid seeds	8	6.6	16	13.2	12	9.9
Ploughing with tractor	7	5.8	30	24.8	28	23.1

Table 4. Smallholder categories and smallholders' knowledge integration, 2019

	Knowledge integration													
	Combined farming systems						Did not combine farming systems							
Smallholder categories	Male	%	Female	%	No.	%	Male	%	Female	%	No.	%	No.	%
High resource endowed	15	57.7	8	30.8	23	88.4	1	3.8	2	7.7	3	11.5	26	21.3
Medium resource endowed	20	47.6	13	31.0	33	78.6	5	12	4	9.5	9	21.4	42	34.4
Low resource endowed	16	29.6	16	29.6	32	59.3	12	22.2	10	18.5	22	40.7	54	44.3
Totals	51	41.8	37	30.3	88	72.1	18	14.8	16	13.1	34	27.9	122	100

households combined high proportions of Western scientific farming methods with traditional methods on their lowland and bush farms, where they cultivated market-oriented food crops. Their farming methods included the use of weedicides, tractor ploughing, chemical fertilizers, monocropping, herbicides, certified seeds, broadcasting of seed and fertilizers, use of sickles to harvest rice, and hand weeding with hoes for crops of groundnuts, vegetables, and maize. Similarly, the results show that majority of medium resource endowed households (c.79%) combined relatively high proportions of Western scientific methods on their lowland and bush farms. The results for low resource endowed households revealed that they combined high proportions of traditional farming methods on their farmland used for mixed farming. These farming methods include: the use of own recycled seeds, hand weeding with hoe, use of animal traction, animal manure, mixed-cropping, crop rotation, use of stick dibbler and minimal use of chemical fertilizers.

Knowledge integration and food security outcomes of different smallholder households

High resource endowed smallholder households

Within the context of the smallholder system, the high resource endowed households were characterized by having less than 1.2 ha farmland on farmland used for mixed farming where traditional food crops were cultivated, such as early millet (*naara*), late millet (*nea*), groundnut, and sorghum. Moreover, households in this category owned an average holding size of 2 ha in lowland and bush, where they cultivated mainly cash crops, such as rice, groundnut, and maize. The main distinguishing feature of high resource endowed households is that they owned livestock/small ruminants (on average 5 cows, 1 donkey, 8 goats, and 6 sheep) and poultry (on average 20 chickens, 15 guinea fowl, and 8 ducks). Also, the high resource endowed households owned other assets such as animal-drawn carts, bicycles, motorcycles, or motorized three-wheeled vehicles. Furthermore, some households in the high resource endowed category were engaged in non-farm activities (petty trading, brewing pito (a type of beer), shea butter processing, and basket weaving) and in formal employment (e.g. security guards, extension officers). As a result, they were able to make modest investments in agricultural inputs and to take advantage of early rains to plough their fields (Yaro 2002). Of the total number of study participants (122), 26 (16 males and 10 females) were in the category high resource endowed, which suggests that such households constituted the smallest cluster in the area.

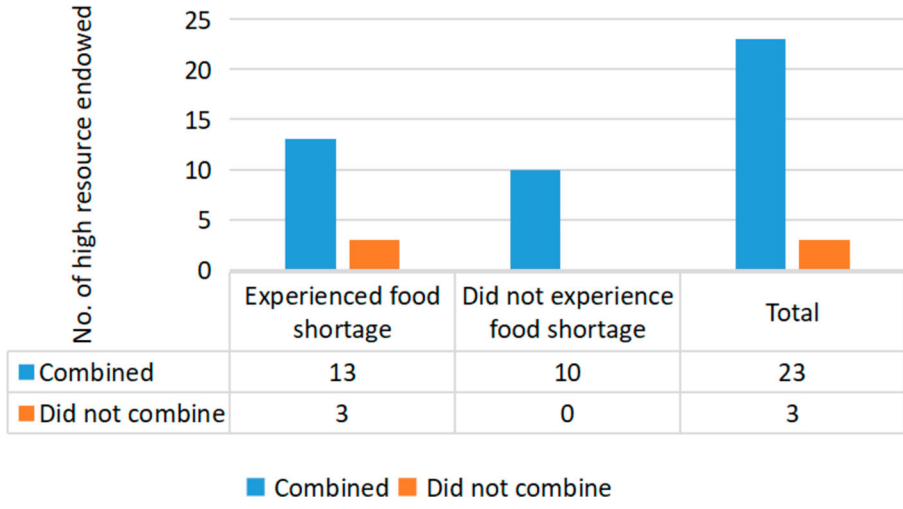


Fig. 1. Knowledge integration and food security outcome for high resource endowed (*vale-didera*) households

The majority of the households in the high resources endowed category combined both traditional and Western farming practices, and about half of them did not experience any food shortages (Fig 1). By contrast all three smallholder households that did not combine farming practices or technologies experienced food shortages (Fig. 1).

Complementing the survey data, the qualitative data provided more nuanced understanding of outcomes the survey presented in Fig. 1. An overview of how a retired educationist, Akanlise (pseudonym) combined traditional and Western farming methods on both his lowland and upland (bush) farmland is provided in Box 1.

Box 1: How Akanlise combined farming practices and his household food security outcomes (Source: in-depth interview, Vunania community, 2019)

Akanlise was a 69-year-old retired educationist, who was married with three children. He owned farmland used for mixed farming (less than 0.4 ha), lowland or valley farmland(0.4 ha), and upland (bush) farmland (1.2 ha), and he combined traditional and Western farming practices on all three types of farmland. In the 2018 farming season, Akanlise harvested 16 bags of rice from his lowland farmland, and 4 bags of groundnuts and 8 bags of maize from his upland farmland.

According to Akanlise, his decision to combine farming practices had helped him to increase his crop yields:

> the use of tractor, chemical fertilizer and hybrid rice seeds combined with the traditional hand weeding with hoe and broadcasting enabled me to harvest more rice although I did not apply the recommended rates of fertilizer. On my upland farmland, for instance, even though I did not apply the recommended rates, combining the fertilizer with animal manure gave me a high yield, which should have been enough to feed the family for the whole year.

Akanlise indicated that he did not experience any food shortages during the 2018/2019 farming season:

> after harvesting my produce from the lowland and upland farmland, I wasn't in a hurry to sell because I was not under any pressure to do so. Two of my children are teachers in Bolga. Also, my wife sells food at the basic school [for primary school education] here, so she is always supportive of the housekeeping needs.

When he was asked why some high resource endowed households experienced food shortages, he gave the following response:

> There are several factors involved. In the first place, the weather plays a critical role. One can apply all the necessary farming technologies but when there is a drought for a certain period beyond measure, yields will be poor and therefore the [high resource endowed households] may not be able to harvest enough to feed themselves. Secondly, some of them have large numbers of family members and therefore may harvest more, but because of the many mouths to be fed, [they] would experience food shortages in the course of the year. Also, if the households have any funerals to perform and do not have livestock to sell to buy food stuff and other things for the funeral, they will have to rely on the harvested food crops to perform the funeral. In that case, the family may run short of food before the next harvest.

The interview with Akanlise revealed how Western farming practices, which were embedded in his deep knowledge of the local ecology, weeding practices, soil characteristics, and manure usage, had ensured a good yield (i.e. neither an optimum yield nor a poor yield). In addition, Akanlise revealed how a diversified livelihood portfolio, involving different family members, was essential to achieve food security. More importantly, his level of education as a retired teacher is relevant for understanding why he chose to combine Western farming practices with local farming knowledge and practices. Also, the social context of food security was apparent (Box 1), as a family could obtain good yields but still not be able to feed themselves all year round if their food supplies were used up during expensive funerals and other celebrations and where they do not have assets such as livestock to sell in order to purchase food. Additionally, it was apparent from the interview that markets were arenas for the exchange of surplus produce, livestock, and other essentials of life.

For Apoab (pseudonym), who was a widow, the dynamics were different from those in Akalise's case (Box 2). Apoab combined traditional and Western farming methods on her different types of farmland and yet she had experienced food shortages during the course of a year.

Box 2: The case of Apoab (Source: in-depth interview, Saboro community, 2019

Apoab, was a 55-year-old widow with six children. She owned small amount of farmland for mixed farming(less than 0.4 ha), valley farmland (0.8 ha) and upland farmland(0.8 ha).
Apoab intimated that she was able to plough her rice field using a tractor and managed weeds with herbicides at the right time to improve crop yields. She was quick to say:

> This season my harvest was good, just like the previous year, so I was able to support my two daughters to go to school. One is in the Community Health School in Bolga and the other is in the Senior High School here.

According to Apoab, although the yields for the season [2018 farming season] were very good, she had experienced shortages of food for about three months before the early millet was harvested. She reported that even though she had run low on food, her household members did not go to bed hungry. When asked why she had a good harvest and yet experienced food shortages for a period of three months, Apoab said:

> [I]t is not always easy for widows who still have young children to take care of. Apart from my two daughters who are in school and their older brother in Kumasi, the remaining three boys are not working, so they have become dependent on me for their daily food. So, if your family is large, you may run short of food. Again, if you have more commitments and expenses to meet due to illness or educational expenses, you have to fall on the food harvested if you don't have anything to sell. Also, some people may decide to fetch some quantity of grain every market day, to sell to get money to do other things or to drink pito. Because you don't see the bottom of the silo, you will eventually come to notice that your grain is almost finished, which will create food shortage for the family.

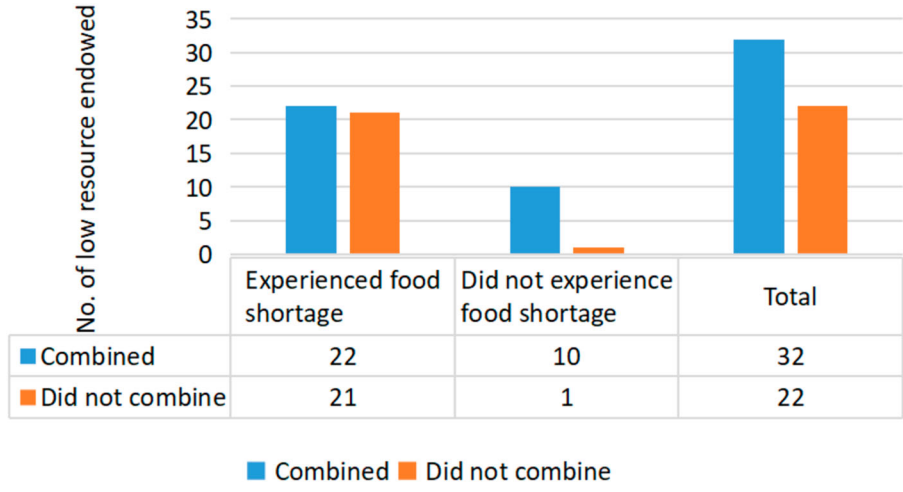
The traditional practice of having different types of farmland with different soil and water conditions (i.e. valley farmland, upland farmland, and land used for mixed farming) that support different crops is infused with Western farming practices that fit with emerging social and biophysical conditions. In dealing with the labour constraints and drudgery of farmland preparation with a sickle, Apoab used herbicides and hired a tractor to do the ploughing. Given the fact that her children were young and in school, in addition to rising labour cost generally, integrating Western farming practices that sped up cultivation was a rational choice and a necessity. Apoab was content with the yields from the farmland, but due to the intervening factors of large household size with a high dependency burden and expenses arising from school and health fees, her food stocks were depleted before the next harvest. She had to sell part of her food stocks to meet the expenditures and the high food needs of her family. The findings therefore suggest that households that are unable to manage the harvest from their own production are more likely to experience food shortage unless they have other sources of income to procure food from the market.

Low resource endowed smallholders

The low resource endowed smallholders were characterized by having less than 0.4 ha farmland used for mixed farming, on which the mainly cultivated traditional food crops such as early millet, late millet, groundnut, and cowpea, as well as leafy vegetables such as okra, roselle, and kenaf. Some of them had 0.8 ha of lowland farmland and cultivated rice and sorghum. The most distinguishing feature of the low resource endowed smallholders is that they rarely owned cattle and had fewer small ruminants (four on average), fewer poultry (six on average), and fewer household assets, such as a bicycle and mobile phone. They were mainly widowers and widows, or they were either divorced or separated from their partners. Yaro (2002) describes such widows and widowers as composed of elderly couples whose children have either died or migrated, or lived a reckless life style (e.g. due to alcoholism). Most households in this category were unable to afford to plough their land and were unable to invest in agricultural inputs, and had limited access to household labour. Of the 122 study participants, 54 (28 males and 26 females) were in the low resource endowed category, which suggests that they were in the majority in the two study districts.

With respect to the food security outcomes of low resource endowed smallholders who combined both farming methods or otherwise, the results are shown in Fig. 2. The fact that this group was already disadvantaged in terms of having limited farmland and low incomes, tended to expose it to food insecurity. Given the socio-economic and physical conditions, the failure to add appropriate Western practices to bolster the group's productivity further exacerbated its food insecurity. The majority of smallholders in the group had a low level of education and were not often prioritized by extension agents, except in the case of special area-based projects.

However, the fact that some low resource endowed smallholders who combined traditional and Western farming systems experienced food shortages while others did not suggests that other issues and intervening factors were involved. Therefore, we explored further to understand the intervening factors. To this end, we examined two low resource endowed smallholder households that combined the two forms of farming methods and how that influenced their food security outcomes. Talaata (pseudonym), a 65-year-old widow with six children and no formal education told us that she integrated traditional and Western farming methods on both her lowland farmland and her farmland used for mixed farming.



	Experienced food shortage	Did not experience food shortage	Total
Combined	22	10	32
Did not combine	21	1	22

Fig. 2. Knowledge integration and food security outcome for low resource endowed (*vale-nabona*) households

She used only low amounts of fertilizers, while embracing mostly traditional methods. Unfortunately, she was unable to embrace the full repertoire of traditional methods necessary to ensure high yields, as such crop and land rotation, manure application, and intensive farming practices (Box 3). Land scarcity and dwindling numbers of cattle and other ruminants pose a challenge to traditional farming practices, which are dependent on the abundance of natural resources in low population density contexts. Dwindling grazing lands and increasing thefts of cattle and other ruminants have reduced the crop-livestock integrated systems needed to make traditional systems viable. Also, being poor excludes farmers from incorporating several Western practices. The choice of one or two Western practices that are known to produce better results when adopted as a package of reinforcing activities does not lead to the desired outcomes.

Box 3: The case of Talaata (Source: in-depth interview, Punyoro community, 2019)

Talaata (pseudonym), a female head of household, cultivated a wide range of food crops on her farmland for compound farming (0.3 ha) and rice on her lowland farmland (0.4 ha). According to her, she used a bullock to plough both types of farmland, used her own […] seeds [collected from her own crops], hand weeded with a hoe, applied minimal quantities of animal manure and fertilizer on the farmland for mixed farming and lowland farmland respectively. She said:

> I don't have the financial strength to buy enough fertilizer to increase my yields. The agricultural officers tell us that we should bury the fertilizer, but I'm not able to do that because it is tedious. Our fathers used animal droppings [as fertilizer], but these days, most of the kraals [animal enclosures] are empty, so it is not easy to collect cow dung. We know that the soils are no longer able to produce enough yields but there is little we can do. We are not able to adopt the white man's farming practices because they are expensive and we are not able to follow our father's practices because of scarcity [of dung].

When asked why some low resource endowed smallholders combined farming practices and yet experience food shortages, Talaata said:

> In my case, for instance, I did not get enough food that we could feed on until the early millet was harvested, so we experienced hunger. Our farmlands are not the same in this community, some have big and others have smaller [amounts of land]. So, you don't expect them to harvest the same. Even with that, it depends on how hard working each person is. If you decide to leave your farmland to be taken over by bush, you should not expect anything good from that land. Also, some farmers don't depend on farming alone. They earn incomes from whatever work or trade that they are involved in. Others have livestock and fowl, which they can easily fall on to buy food.

Talaata reported that her period of food shortage spanned up to six months, and she explained that there were occasions when she had to sleep at night without food. She intimated that her farm size was too small to support her rather large family: 'my children are many, and as [I am] a widow without much support, the small farm is not enough to cater for us [all]'.

The case of Ayeriwuje (pseudonym), presented in Box 4, shows how a low resource endowed smallholder who integrated both traditional and Western farming systems could achieve favourable food security outcomes for their household.

Box 4: The case of Ayeriwuje (Source: in-depth interview, Saboro community, 2019

Ayeriwuje was a 47-year-old male head of household, who was married with three children. He had both farmland for mixed farming (less than 0.3 ha) and upland farmland (c.0.4 ha). He combined both traditional and Western farming practices on the two types of farmland. Ayeriwuje reported that he had not experienced any food shortages. He narrated how he was able to provide adequate food for his household throughout the year:

> I do understand that the fertility of our soils has declined because they are no longer as they used to be during our forefather's time. So, I take steps to maintain or improve the fertility of the soils on my farmland used for mixed farming and on my upland farmland through the use of animal droppings and compost, which I prepare yearly in the animal enclosure (kraal). Before the start of the rains, I carry [the two types of fertilizer] to the farm and then spread them. Additionally, I apply some fertilizer on my upland farmland, which I plough using the tractor. Because of these [methods], I always harvest enough produce from the farm to feed my family until the next farming season, without having to buy or sell my animals to buy food from the market.

When asked why some farmers combined farming practices and yet experience food shortages, Ayeriwuje responded as follows:

> there are several reasons, some of which are beyond us. The first one is that agricultural officers come around to only teach us Western farming practices and technologies and tell us to use certain types of seeds if we want to increase yields, but these are expensive, so we are not able to adopt them. However, they fail to teach us the ways in which we can improve upon the practices our fathers taught us, which many of us are familiar with. The second one is that households without livestock find it difficult to get these animal droppings to fertilize their farmland and are unable to buy fertilizer, so [they] do not get good harvests to feed their families. Households with bullocks are able to plough early to take advantage of the early rains to get good harvest. Those with goats and sheep are able to sell [them] to buy agro-inputs or food when they run out of stock. Others, too, because of some problems, are not able to manage the little harvest. All these [factors] will cause the individual to not to have enough food available until the following year.

Ayeriwuje's story reveals a good understanding of the declining soil fertility situation in the two study districts, which had inspired him to adopt the use of animal manure, compost, and cropping strategies involving intercropping cereals with legumes to sustain soil health and increase crop production. Intensive agriculture is the answer to sustainable farming for poor farmers with less land than other farmers. The role played by livestock is critical, as farmers are unable to purchase the recommended amount of fertilizers. However, a mixture of animal dung and chemical fertilisers, mixed cropping with leguminous crops, high diversity of crops, and the use of tractors that enable early and quick cultivation can mean that poor farmers have a high possibility of increasing yields and ensuring household food security. The interview with Ayeriwuje identified a major gap in the current extension delivery system, in which the emphasis is on wholesale transfer of Western farming technologies and the neglect of traditional farming technologies and practices that are predominant among smallholder households. Consequently, local farming knowledge and innovations are often not recognized for up-scaling. Furthermore, Ayeriwuje highlighted the significant role of resource endowment as a powerful tool in rural communities to ensure access to timely ploughing to take advantage of early rains.

Medium resource endowed smallholder households

The medium resource endowed households mainly consisted of semi-subsistence smallholders. Members of the focus group discussion in Nankam-speaking communities in both Kassena-Nankana Municipal District and Kassena-Nankana West District described such smallholders as neither rich nor poor, but could provide for their households from their own production up to a point and to complement their food needs from other food sources towards the end of the year. Medium resource endowed households cultivated less than 0.8 ha on farmland for mixed farming and had a mean holding size of 1.3 ha in lowland farmland and upland (bush) farmland. A major feature of this category of households is that they had few resources or endowments to enable them to participate in productive activities, and seasonal migration was seen as a way of reducing pressure on their inadequate holdings (Yaro 2002). As a result, they were able to feed themselves to some extent (i.e. for between seven and nine months per year) but had to purchase food from the market mainly after selling livestock or adopting other household coping mechanisms, such as picking shea nuts, providing labour services, or reducing their food intake to cope when they did not have enough food. The aforementioned practice had implications for households' food and nutrition security, since adults were compelled to eat smaller meals during the initial stages of food shortages, and when the shortages became severe, they went to bed hungry to allow their children to eat. During such periods, it is common to find children cry spontaneously and often hang around their mothers. We found that 42 of 122 survey participants were in medium resource endowed households. The findings presented in Fig. 3 suggest that medium resource endowed households that did not combine farming methods are more likely to experience food shortages than households that combined farming methods. Further analysis of the relationship between knowledge integration and the food security situation of medium resource endowed households did not reveal any significant variations or diversity in the issues we have discussed in the two preceding subsections in relation to the high resource endowed and low resource endowed households.

Discussion

The efforts to improve household food security in northern Ghana are not yielding expected outcomes despite monumental donor and government support (Adu et al. 2018). Over the years, agricultural development policies and interventions have focused extensively on Western scientific farming methods being vigorously promoted by extension officers through government and non-governmental support amidst low adoption and environmental sustainability challenges. Traditional knowledge systems in farming that form the basis for local decision-making and problem solving strategies for agriculture and natural resource management (Muthee et al. 2019) do not find expression in

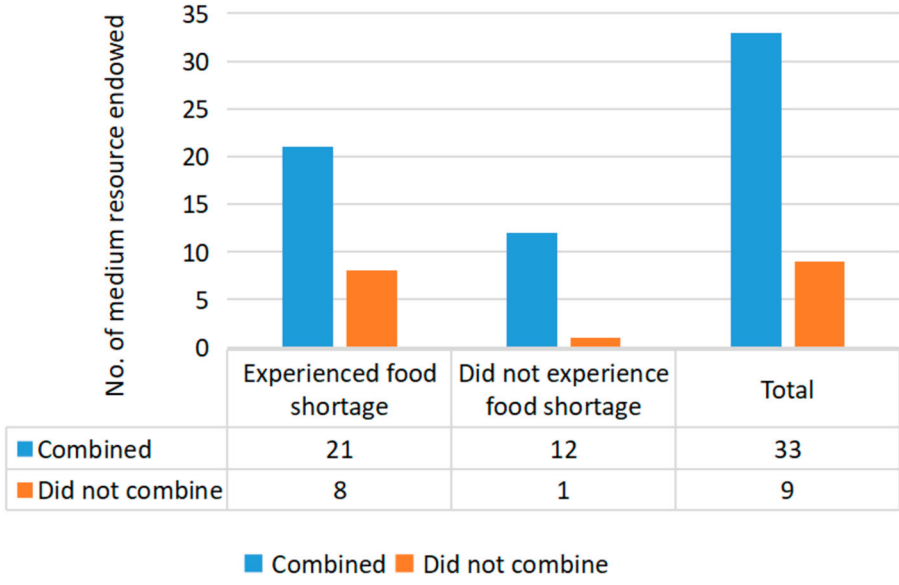


Fig. 3. Knowledge integration and food security outcome for medium resource endowed (*achea*) households

agricultural policies and extension services. Meanwhile, African farmers are generally imbued with years of experience using traditional knowledge and practices acquired from their fathers, and gained through interaction with other people or members of communities (Apraku et al. 2021). Given that smallholders are aware of the existence of both traditional and Western farming methods, and are making conscious decisions and choices about farming systems based on their socio-economic circumstances and biophysical challenges, they could either resort to their traditional farming methods alone or combine them with aspects of Western farming methods in their enterprises.

We found that majority of smallholders (72%) across the socially differentiated cohorts combined the two forms of agricultural knowledge systems at different levels on their different types of farmland. This underscores the notion that knowledge integration is akin to traditional African agricultural knowledge systems of exploration and knowing, and constantly changes through adaptation, mediation, creativity, and innovation, as well as through contact with local and external knowledge (Haverkort et al. n.d.). Indeed, smallholders rarely compartmentalize knowledge into such separate forms, but rather develop knowledge as something that is hybridized, mediated, and local (Briggs 2013). Our study revealed that smallholders who adopted sustainable intensification farm management practices, such as hand weeding with a hoe (minimum tillage), manure application, and the use of herbicides, fertilizers, and improved seeds achieved high crop yields. We therefore argue that knowledge integration is akin to and builds on smallholders' systems of learning and experimentation, and thus presents a better framework for harnessing the benefits and complementarities of the two forms of knowledge systems towards achieving sustainable agricultural intensification that is socially inclusive and ecologically sustainable. This argument is consistent with proponents of sustainable intensification who argue that agricultural yields are best increased through a combination of external technical knowledge and local agro-ecological knowledge, which together are more attuned to local contexts and effectively target local needs (Clay 2018). This is underscored by the fact that, in their different ways, both knowledge systems are limited in their abilities to address the threats encountered by smallholders. Instead, sustainable agricultural intensification in a smallholder context would be better served by a system that unifies the two bodies of agricultural knowledge systems (Adenle et al. 2019; Apraku et al. 2021).

With regards to whether agricultural knowledge integration has any influence on the food security outcomes of socially differentiated smallholders, we found that low resource endowed households that did not combine farming methods were more likely to experience food insecurity compared to high resource endowed households. This was because low resource endowed had limited access to different types of farmland, were unable to invest in critical Western farming inputs and to embrace the full repertoire of traditional methods, and were unable to purchase food from the market when food stocks from own farms were depleted. This suggests that resource endowment is critical for knowledge integration and subsequent impacts on household food security outcomes. This finding is consistent with the

findings of other studies undertaken in northern Ghana (Kuivanen et al. 2016; Michalscheck et al. 2018), northern Nigeria (Baiyegunhi & Hassan 2018), and south-western Uganda (Nazziwa-Nviivi et al. 2017). However, the study revealed that even though the high resource endowed households combined both traditional and Western farming methods, over a half of them still experienced food shortages. This calls for a deeper understanding of the intervening factors that define the final outcome.

The most important intervening factors are the effects of climate variability on crops and livestock production, and the depletion of food stocks due to large household sizes and expenditure on education and funerals. Climate change is a major threat to sustainable agricultural production and food systems in sub-Saharan Africa (Yaro 2013; Bawakyillenuo et al. 2016), and it makes farmers vulnerable and worsens existing food insecurity situations. Our study showed that the crop yields of high resource endowed households that experienced food shortages were adversely affected by droughts. This finding supports the results of previous studies that have asserted that climate variability greatly affects subsistence agriculture, resulting in reduction in crop yields and thereby leading to household food insecurity (Yaro 2013; Bawakyillenuo et al. 2016; Sekaran et al. 2021).

Additionally, the sustainability of livestock production is affected by climate change. This means that important household strategic assets such as livestock, which play a key role as an adaptation measure when food stocks are depleted, are severely affected. Dwindling numbers of cattle and other ruminants have had a negative impact on the crop-livestock integrated systems needed to make traditional farming systems viable in order to increase crop yields. Even though households may obtain good yields, depletion of food stocks due to household size and expenditure on funerals and education may exacerbate the deterioration of household food security situations (Obayelu 2012; Lavison 2013). Traditional funeral rites are an important aspect of culture and rituals in rural communities of northern Ghana, in order to usher the dead into the spiritual world. They have become a perpetual sociocultural annual event during which families use the little food they have harvested from the poor soils, such as millet, sorghum, rice, cowpea, Bambara beans, and groundnuts, in addition to livestock such as goats, sheep, guinea fowl, and other fowl to pacify gods and to entertain guests, which in turn depletes households' food stocks and their livestock base. Nyamadi et al. (2015) indicate that households are in deficit after practising traditional funeral rites, which create food insecurity in vulnerable rural communities. This implies that although combining farming methods may contribute to obtaining high crop yields from own farm production, which is essential to obtain adequate food to attain household food security, it will not necessarily guarantee food security because other intervening factors influence household food security outcomes. This finding supports Guye's assertion that the integration of two bodies of knowledge is insufficient to bring about significant changes in food security among peasants in Ethiopia (Guye 2014).

Conclusions

In this article we have shown that high resource endowed households are less likely to experience food insecurity compared to low resource endowed households because the former integrate both traditional and Western farming knowledge systems, which lead to better yield outcomes. Furthermore, we have shown that the high resource endowed households in Kassena-Nankana Municipal District and Kassena-Nankana West District, in the Upper East Region of Ghana, were able to make modest investments in their farming enterprises and to purchase food from the market when their food stocks were depleted. On that basis, we conclude that resource endowment plays a vital role in determining the food security situation of different categories of smallholders by defining the extent to which they can integrate Western and traditional farming practices. This means that the heterogeneity of smallholders calls for targeting and promotion of sustainable intensification methods that are socially inclusive, and for broader social interventions that enable them to access such productivity enhancing knowledge and methods. These findings reaffirm the call for agricultural development interventions to recognize the needs and aspirations of the different categories of smallholders in promoting appropriate farming methods (traditional and Western) that respond adequately to the immediate and strategic needs of socially differentiated smallholders. Agricultural extension delivery that currently focuses mainly on Western farming methods to the neglect of traditional farming methods needs reshaping. Identifying innovative farming practices that integrate both traditional and Western methods is critical to ensure the sustainability of small-scale African farms. This article makes contributes to the ongoing discussion of knowledge integration as a framework for enhancing sustainable agricultural production and bolstering household food security. Moreover, it sheds light on contextual factors that can guide the development of suitable extension delivery strategies, fostering local ownership and long-term sustainability of agricultural initiatives in sub-Saharan Africa.

Disclosure statement

No potential conflict of interest was reported by the authors.

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