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FARMER-LED RESEARCH IN THE QUEST FOR CLIMATE RESILIENCE: PROMISING DREAMS BITTER CHALLENGES

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Abstract

Increasing accumulation of ecological, economic and societal challenges characterise Ghana's agricultural systems, raising questions about the resilience of smallholders (who dominate the sector) to shocks and stresses. The question of resilience brings into sharp focus the aerial differentiations and spatial associations observed in the regional contexts within which climate resilience is sought. The conversation around issues of climate resilience has tended to view smallholders as end users of research results as opposed to co-creators of knowledge pertinent to the subject matter. In Ghana, very little literature, if any, exists about farmers leading the process of knowledge generation to improve our understanding of climate resilience, particularly, in light of how smallholders understand it in the context of their farming systems, farmer organizations, services and value chain actions. This paper highlights the unconventional route of farmer-researchers working with and through their colleagues to unravel the contextual realities of climate resilience and to cast the findings thereof to conventional sources to identify points of convergencies, divergences and the nuances therefrom to lay bare the question of "whose reality counts?" in the resilience conundrum. The methodology consisted of a mixed-methods approach explicated through a convergent parallel design. The findings are that, farmers' sensitivity to climate change is high and their adaptive capacity is low, necessitating more support for effective resilience building, not from the lenses of ivory tower theorization models of mainstream science, but in a better appreciation of farmers' articulation of the science of what it takes to build their resilience.

Keywords: Farmer-led research, Vulnerability, Resilience, Transformability, Robustness, Adaptability

Introduction

The evidence from decadal and seasonal timescales suggests that, many areas in Africa are characterized by high degrees of climate variability - this is confirmed by the recent publication of the Intergovernmental Panel on Climate Change [IPCC] (2021), which established that, increases in heavy precipitation that can lead to pluvial floods are projected for most African regions, even as increasing dry climatic impact-drivers [CIDs] (aridity, hydrological, agricultural and ecological droughts, fire weather) are projected in the western part of West Africa. At the local front, increasing accumulation of ecological, economic and societal challenges characterise Ghana's agricultural systems, raising questions about the resilience of smallholders (who dominate the sector) to shocks and stresses. The question of resilience brings into sharp focus the aerial differentiations and spatial

associations that can be observed in the regional contexts within which climate resilience is sought (i.e., vulnerability context). As rightly noted by Meuwissen et al. (2019), resilience issues need to be addressed with a focus on the regional context in which farming systems operate because farms, farmers' organizations, service suppliers and supply chain actors are embedded in local environments and functions of agriculture. This subject is adequately addressed by the most recent climate change vulnerability (CCV) assessment (Environmental Protection Agency [EPA], 2020), which suggested that, there is increasing vulnerability generally, as one moved from the coast into the transition and northern savannahs.

The Upper West Region (UWR) on average, is the most vulnerable in the country with the ten (10) districts with the highest CCV scores located here. The most vulnerable district to climate change in Ghana is Wa East. The second and third most vulnerable regions are the Northern and Upper East (UER) Regions, respectively. In the Northern Region (with Savannah Region inclusive), the Sawla-Tuna-Kalba District on the fringes of Côte d'Ivoire and Burkina Faso had the highest CCV whereas, Garu Tempane on the border to Togo had the highest CCV in the UER. The results reported in the EPA study were partly on account of research in which smallholders were viewed and treated as objects of the subject of climate vulnerability (resilience) as opposed to co-creators of the knowledge on the subject matter.

The conversation around issues of climate resilience has tended to view smallholders as end users of research results as opposed to co-creators of knowledge pertinent to the subject matter. In Ghana, very little literature, if any, exists about farmers leading the process of knowledge generation to improve our understanding of issues around climate resilience, particularly, in light of how smallholders understand it in the context of their farming systems, farmer organizations, services and value chain actions. This study seeks the unconventional route of farmer-researchers working with and through their colleagues to unravel the contextual realities of climate resilience and to cast the findings thereof to conventional sources to identify points of convergencies, divergences and the nuances therein, in order to lay bare, the question of "whose reality counts?" in the resilience conundrum. Support for this line of thinking is confirmed by Gonsalves et al. (2005) tracing back some one and a half decades that established that, while there is growing interest in participatory research and development (PR&D), it remains widely perceived as incompatible with accepted norms and practices in the mainstream research community. This is largely because this approach to research demands a set of knowledge, attitudes and skills that go beyond the typical human and organizational capacities under top-down research and development paradigms. Farmers' capacity for research and experimentation is generally not acknowledged by agricultural researchers and society at large. However, with the growing recognition of the value and usefulness of indigenous knowledge systems, scientists are increasingly aware of farmers' capacity for experimentation resulting in the evolution and adaptation of indigenous knowledge systems in the subject matter of climate resilience.

This is necessary when viewed against the background that, in recent years, there have been numbers of developments which indicate a positive shift towards incorporating climate resilience into a broader agricultural agenda to ensure that agricultural systems are more productive and less greenhouse gas (GHG) intensive. To this end, resilience issues have found expression in Ghana's current Medium-term Development Policy Framework (MTDPF), the Coordinated Programme of Economic and Social Development Policies [CPESDP] (Government of Ghana, 2017), which is dubbed the *"Agenda for Jobs: Creating Prosperity and Equal Opportunity for All (2018 – 2024)"*. Additionally, some sectoral policies explicitly seek to address issues of adaptive capacity in the quest for resilience. The Food and Agriculture Sector Development Policy (FASDEP II) is the primary document from which the Agriculture Adaptation Strategy is derived. The Investment for Food and Jobs (IFJ) is a second-generation National Agriculture Investment Plan (NAIP) designed to address the challenges identified with the first generation of the NAIPs (i.e., Medium Term Agricultural Sector Investment Plans [METASIP I & II]) developed under the Africa Union's Comprehensive Africa Agricultural Development

Programme (CAADP) framework. The interest of the IFJ is to ensure that Government's strategic focus area of developing climate resilient agriculture and food systems as outlined in the National Climate Change Policy (NCCP) is realized. The National Climate-Smart Agriculture and Food Security Action Plan (2016-2020) was adopted by the Ministry of Food and Agriculture (MoFA) in 2016 to provide additional details on the strategies to align agricultural adaptation issues in the NCCP to the FASDEP II.

There is no doubt that much has been done in the national policy, planning and investment space in support of resilience, but what remains unclear is to what extent these efforts are translating into positive and sustainable outcomes for smallholders – not, from the perspective of academics and researchers' ivory tower research or theorization interests, but from the standpoint of smallholders researching within and through themselves and articulating their findings in ways that enrich the conversation around the subject of climate resilience. We define resilience of a farming system as *"its ability to ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability"* in line with Meuwissen et al. (2019). *Robustness* is the farming system's capacity to withstand stresses and (un)anticipated shocks. *Adaptability* is the capacity to change the composition of inputs, production, marketing and risk management in response to shocks and stresses but without changing the structures and feedback mechanisms of the farming system. *Transformability* is the capacity to significantly change the internal structure and feedback mechanisms of the farming system in response to either severe shocks or enduring stress that make business as usual impossible. Such transformations may also entail changes in the functions of the farming system. These capacities were previously distinguished by Walker et al. (2004), Folke et al. (2010) and Anderies et al. (2013) in the context of social-ecological systems with a focus on the provision of eco-system services. The new thinking espoused by Meuwissen et al. (2019) distinguishes resilience to specific challenges (specified resilience) from a farming system's capacity to deal with the unknown, uncertainty and surprise (general resilience). This conceptualization resonates well with the general outlook of this study and would thus be adopted in the discussion of the main findings of this article.

Methods

Research Design and Sample Size

In line with Creswell and Clark (2017), the overall methodology of this study consisted of a mixed-methods approach explicated through a convergent parallel or concurrent triangulation design. Quantitative methods using basic statistics were used to identify underlying patterns, causal explanations and likely contributing factors; whereas, qualitative methods including participatory multi-stakeholder workshops, interviews and focus group discussions were used to access contextual and experiential knowledge to provide additional nuanced insights on climate resilience from the perspective of farmer-researchers and their colleagues. The study was conducted from 1st May, 2021 to 28th July, 2021 in selected districts of the Upper East, Upper West, Northern and Savannah regions.

Sampling Technique

The study was carried out within the framework of ActionAid Ghana and partners' Northern Ghana Integrated Development Project (NGIDP), as such, the sample size was determined purposively from the target population of the project as presented in Table 2.

Table 1: Target Population and Categories of Respondents

Category of respondents	**# of beneficiaries**
CSOs farmer Networks	525
Farmer Networks and Youth Movements	525
Small holder women farmer groups	12,000
Young farmers, including persons with disabilities	1,500
Total	**14,550**

Source: *ActionAid Ghana, (2020).*

The target sample size was purposively determined to be 1,710 but the actual achieved for the study was 1,702 as detailed in Table 3. In respect of the survey, a target sample of 1,455 respondents (representing 10% of the target project population) against an actual of 1,447 was realized - representing some 0.55% non-response rate. There was no variance between the planned sample of FGD participants (8x2x15=240) against the actual (240); and it was same between the target and actual respondents for the key informant interviews (15 planned against 15 realized).

Table 2: Target Sample Sizes and Actuals

Instruments	Respondents	Target	Per district	Actuals
1) Survey questionnaires	Farmers (women, men, youth & PWDs)	1,455	Women (79) Youth, PWDs, men, (18) =**97**	**1,447**
2) Focus Group Discussions	• 1 Women's group (8) • 1 Mixed group (8)	30	2	**240**
3) Key Informant Interviews	• District Coordinating Director • District Coordinator, NADMO • District Director, Dept of Agric • District Director, Forestry Services Div.	15	**1**	**15**
Total		**1,710**		**1,702**

Source: *Authors, (2021).*

Farmer-researchers collected survey data from a regionally representative sample of respondents as presented in Table 2 (N= 1,455) according to the arrangements of the NGIDP. Data were collected across four regions; Upper East, Upper West, Northern and Savannah regions of Ghana.

Data Collection Instruments and Analytical Framework

A standardized questionnaire developed through three steps of regional level participatory workshops involving a cross-section of NGIDP target beneficiaries (farmer-researchers) as listed in Table 2 was used for the survey. The first round of regional engagements entailed individual regional workshops with farmer-researchers to agree on the core issues to be investigated within the context of resilience as defined by Meuwissen et al. (2019). To this end, the ultimate aim was to build the substance around the analytical framework of the research as follows:

- Resilience of what? → ***Farming Systems***
- Resilience to what? → ***Challenges***
- Resilience for what purpose? → ***Functions***
- What resilience capacities? → ***Robustness, Adaptability and Transformability***
- What enhances Resilience? → ***Diversity, Openness, Tightness of feedbacks, System reserves, Modularity.***

Having reached consensus at this preliminary level, the second round of regional workshops focused on translating the issues identified into questions appropriate to the skill level and knowledge of farmer-researchers and their colleagues (formulated in a style suitable for the target group). A cross-section of farmer researchers carried out this exercise checking for the logical flow of questions in the thematic areas identified; consistency; repetition (weeding out duplication of questions); and ensuring the precision of questions and response options. The process was repeated for other data collection tools such as FGD and Key Informant Interview (KII) guides.

The final stage of regional level workshops consisted in building the capacity of farmer-researchers in the use of the Kobo-collect data collection application tool and a pre-test of the data collection instruments to sharpen their focus and responsiveness for the intended assignment.

Results

The results are discussed under the key questions of the analytical framework that informed the research. However, the demographics of the study population are presented first to set the context upon which the results are premised.

Demographic Characteristics of Respondents

The variables of interest in this research were sex, age, educational attainment, disability and livelihoods as summarized in Table 1. Majority of

respondents were female and accounted for 8 out of every 10 farmer respondents. The age bracket of 18-35 (44.8%) dominated the list of respondents with majority (66.4%) being non-literate in formal educational terms. Persons with disability accounted for 6% of respondents. The dominant livelihood cluster was crop farming, suggesting that responses to majority of the research issues on resilience are attributable to this livelihood subsector.

Table 3: Demographic Characteristics of Respondents

Variable (N=1,447)	Frequency	Percentage
Sex		
Female	1,205	83.0
Male	242	17.0
Age group		
<18	24	1.7
18-35	648	44.8
36-45	509	35.2
46-60	234	16.1
>60	32	2.2
Educational attainment		
None	960	66.4
Non-formal	73	5
Basic	254	17.6
Secondary	119	8.2
Tertiary	40	2.8
Respondents with Disabilities (PWDs)		
Yes	87	6
No	1,358	94
Livelihood Sources (multiple response)		
Crop farming	1,007	69.6
Trading	342	23.6
Agro-based farming	289	20
Livestock keeping	274	19
Agro-processing	207	14
Poultry keeping	184	12.7
Charcoal production	176	12
Casual labour	155	10.7
Salaried workers	98	6.8
Artisanship	71	4.9
Fishing	68	4.7
Bee keeping	38	2.6

Source: *Field Survey (2021)*

Resilience of what? → Farming Systems

The findings in answer to the question of resilience of what? focuses on characterizing the farming systems in which the respondents operate, and this brought to the fore, issues of farming system actors and context actors. Table 4 presents summaries of the predominance of farming systems in the study districts. The results of the multiple responses indicate that majority (48.1%) of farmers were into *mixed cropping*. The next predominant system accounting for 35.4% of the responses was *mixed farming* (crops+livestock+poultry). While the *sole cropping* system (14.1%) was relatively less dominant, *agroforestry* emerged as the least dominant farming system representing some paltry 2.1% of responses. Farmer researchers were then facilitated to interpret the implications of the results of the survey on the resilience of their farming systems.

At the aggregate level, farmer researchers noted that the distribution of the farming systems indicates broadly that, there is good measure of resilience in the study regions. This is premised on the

interpretation that; the farming systems of mixed cropping and mixed farming inherently, are resilience-seeking. These, they intimated, were systems that had the capacity to cushion smallholders against shocks and stresses of all kinds. However, the negligible presence of agroforestry systems (2.1%) suggests there could be significant challenges with mitigation; because, the carbon fixing impact of agroforestry systems are well known as they have the capacity to improve landscapes by acting as carbon sinks. Similarly, the sole cropping farming system with its attendant effects on biodiversity and high incidence of agrochemical use, is compensated for by the fact that, not many farmers (14.1%) in the project regions practiced it. It was pointed out that, sole cropping is usually characterized by a high level of vulnerability as it is largely practiced under rain-fed conditions which makes it highly susceptible to risk of crop failure during times of poor rainfall/drought (duration and distribution) or adverse conditions such as pest infestation or diseases. In the context of general scarcity of irrigation systems, sole cropping under rain-fed conditions is replete with relatively high degrees of uncertainty. The situation is compounded by the near absence of climate information services which could better assist them manage risk and improve their adaptive capacity through forward-looking decision making around appropriate weather index or crop insurance packages.

Further examination of the most dominant farming systems according to aerial differentiation and spatial associations revealed that, mixed cropping was most dominant in the Northern Region [NR] (62.2%), whereas mixed farming had greater expression in the Upper East Region [UER] (49%). Farmer researchers' submissions on these aerial differences revolved around a complex of valid arguments based on their time and place experiences.

Table 4: Farming Systems and Percentage Distribution in Project Regions/Districts

District	Mixed cropping only	Sole cropping only	Mixed farming (crops, livestock, poultry)	Agroforestry (tree crops)	Total	Total Percentage
Upper East Region						
Kassena_Nankana_Municipal	44(35%)	0(0%)	81(64%)	1(1%)	126	100%
Bawku_West	77(36%)	33(16%)	88(42%)	14(7%)	212	100%
Builsa_South	60(36%)	35(21%)	68(41%)	3(2%)	166	100%
Nabdam	78(47%)	3(2%)	82(49%)	3(2%)	166	100%
Total (%)	**29.5%**	**9.8%**	**49%**	**3%**		
Upper West Region						
Wa_East	73(75%)	0(0%)	24(25%)	0(0%)	97	100%
Lambusie	17(17%)	6(6%)	77(75%)	2(2%)	102	100%
Lawra	82(45%)	43(23%)	58(32%)	0(0%)	183	100%
Sissala_East	35(40%)	3(3%)	48(55%)	1(1%)	87	100%
Total (%)	**44.3%**	**8%**	**46.8%**	**0.75%**		
Northern Region						
Mion	57(43%)	23(17%)	48(36%)	5(4%)	133	100%
Gushegu	45(49%)	33(36%)	11(12%)	2(2%)	91	100%
Kpandai	90(58%)	34(22%)	28(18%)	4(3%)	156	100%
Tatali_Sanguli	75(49%)	29(19%)	44(29%)	4(3%)	152	100%
Nanumba_South	96(99%)	0(0%)	1(1%)	0(0%)	97	100%
Zabzugu	94(75%)	5(4%)	22(18%)	4(3%)	125	100%
	62.2%	**16.3%**	**19%**	**2.2%**		
Savannah Region						
Central_Gonja	78(44%)	44(25%)	53(30%)	1(1%)	176	100%
Total (%)	**44%**	**25%**	**30%**	**1%**		
Total	**1001**	**291**	**733**	**44**	**2069**	**100%**
Total Percentage	**48.4%**	**14.1%**	**35.4%**	**2.1%**	**100%**	**100%**

Source: *Field Survey (2021)*

The UER has one of the highest population densities (147.2/km²) in Ghana, with the predominant spatial and temporal arrangements within the cropping systems being (a) permanent mixed cropping (48%), practiced around the compound house, consisting of early millet, late millet, sorghum, cowpea and other leafy vegetables, such as tobacco and okra, (b) monoculture of groundnut (29.1%), cultivated together with Bambara bean, cowpea and sometimes late millet, (c) intercrops based on groundnut (7.8%) in lands not suitable for other more demanding crop species (sandy-loamy and gravelly soils), thus there is a trend to cultivate them in bushlands (Callo-Concha et al., 2012); - but these are dwindling speedily due to increasing urbanization. These developments have necessitated a conscious shift to integrate livestock (cattle and small ruminants) and poultry into the production mix to diversify and reduce risk – which is why mixed farming is gaining prominence as a resilience measure. It was argued by farmer researchers and their respondents that, duty bearers need to concentrate efforts at supporting them to minimize risks through; improving irrigation efficiency, encouraging the use of groundwater, promotion of community-based water management systems, introduction of climate tolerant-crop cultivars (improved and certified seed) and weather index or crop insurance services.

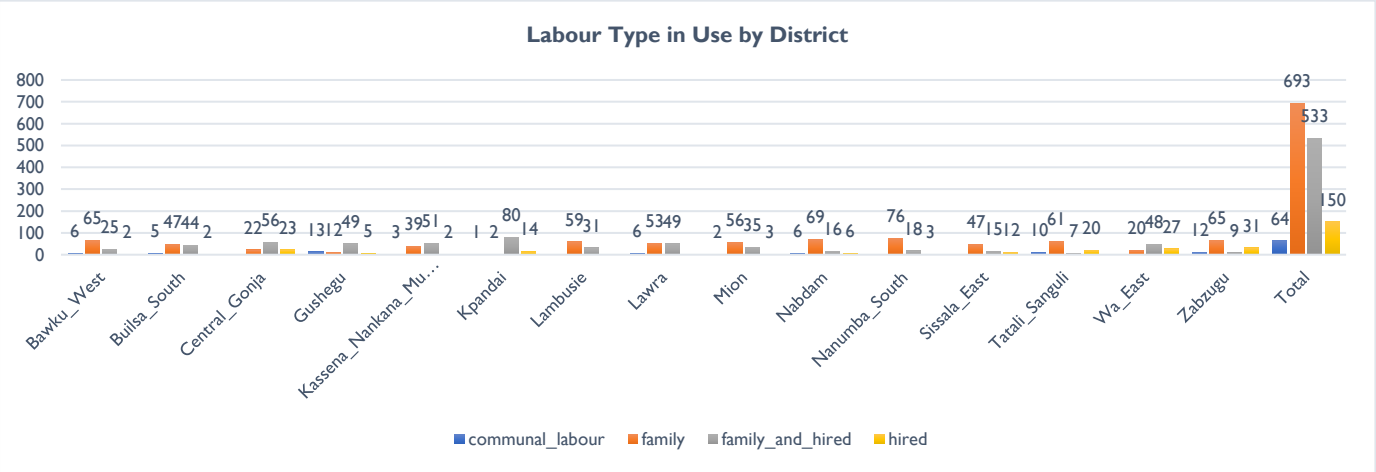
On the contrary, in the NR, population densities are much lower (87.13/km²), the land's carrying capacity is not overstretched and can support mixed cropping under the fallow migratory systems (shifting cultivation) to a greater degree than the UER, although demographic pressure is growing in recent times and fallow periods are reducing. Thus, there has been a transition from fallow-based to a mixture of fallow-based, permanent and other cropping systems, all in an effort to improve resilience to cope with the changing agro-ecology occasioned by the changing climate.

Resilience to what? → Challenges

The variables of interest in this result area are closely knit to the economic, environmental, social and institutional challenges that impede the ability of farming systems to deliver the desired public and private goods. Farmer researchers were facilitated to distinguish shocks and long-term stresses that affected their resilience in light of three key variables: challenges with labour, crops cultivated and the management of extreme events.

Findings from the farmer-led focus group discussions indicated that, the agricultural practices in the study regions are labour-intensive such that, except for land preparation where farmers use mechanization services, other farm operations such as planting, weed control and harvesting are carried out manually. This is corroborated by results of the farmer-led survey which showed that, *"family labour"* accounted for 48.2% (693) of all farm labour in the study regions; the combination of *"family and hired labour"* accounted for 37% (533); *"hired labour"* made up 10.4% (150) whilst *"communal labour"* accounted for the least (4.4%) as shown in Figure 1.

Figure 1: Distribution of Labour Type by District



Source: *Field Survey (2021)*

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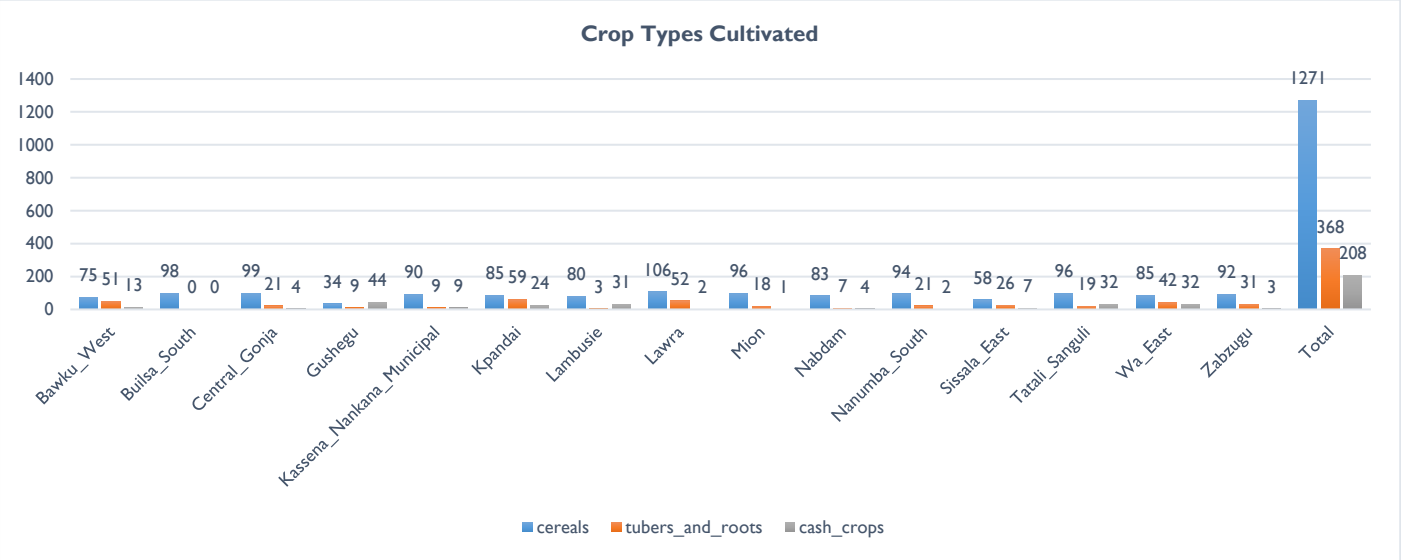
The high percentage of family labour (48.2%) is indicative of good resilience as the absence of hired labour due to prohibitive costs or outbreak of pandemics such as COVID-19 may likely have little impact on labour availability in the study regions.

Results of the survey as shown in Figure 2 indicate that cereals are the dominant crops cultivated with 68.8% (1,271) of the multiple responses of survey participants indicating this to be true. The next significant crops cultivated are tubers and roots (20%), while cash crops make up 11.2% of crops cultivated. It is significant to highlight the fact that, women's inadequate participation in commercial agriculture accounts for the low numbers registered in the survey for cash crop production. Resilience in crop production, is to a significant degree, a function of diversification away from subsistence to commercial production – the 11.2% proportion of the survey sample that is into cash crop production is indicative of high vulnerability. The results suggest that women are not diversifying well enough into the commercial arena to tap into the benefits or leverage the improved markets that are usually associated with commercial agriculture. Only 1 out of every 10 women is into cash crop production and only 2 out of every 10 are producing roots and tubers. Similarly, nearly 7 out of 10 women are into cereal production – making their risk profile in light of rain-fed agriculture very high.

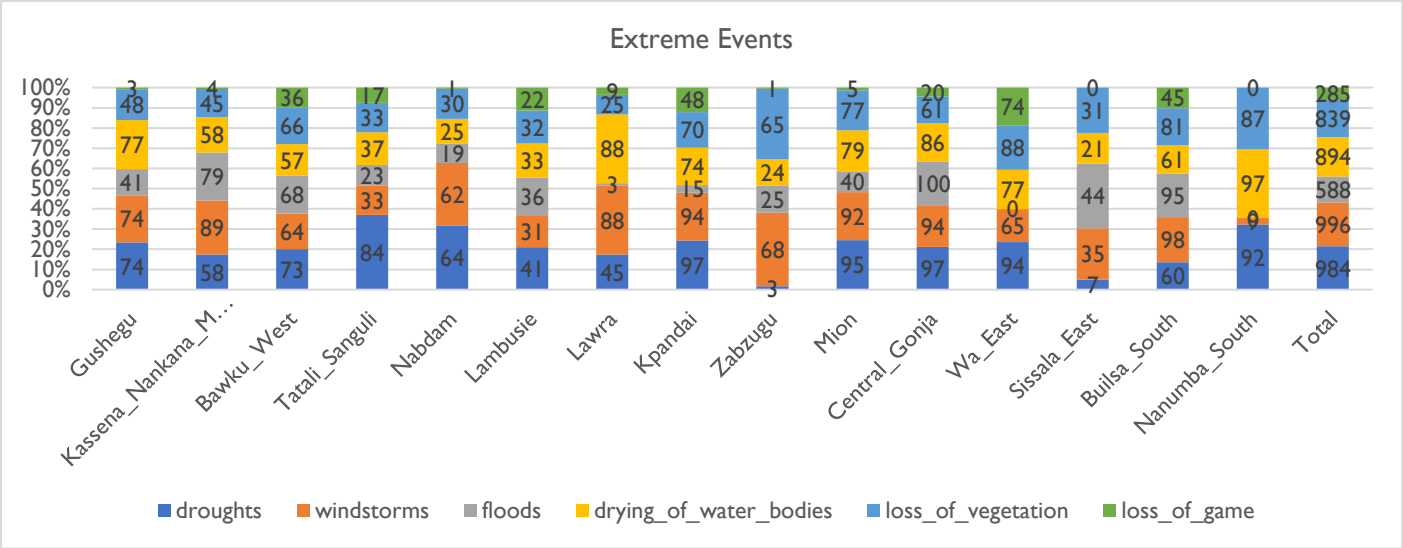
Figure 2: Distribution of Crops Cultivated by District



Source: *Field Survey (2021)*

Finally, the farmer-led research sought to ascertain the perspectives of respondents about the frequency of extreme events on account of the set of variables presented in Figure 3. The results of the multiple responses suggest that, the most widespread extreme climate event is *windstorms*, accounting for 21.7% of the aggregate of multiple responses; this is followed closely by *drought* (21.5%), *drying of water bodies* (19.5%), *loss of vegetation* (18.3%), *floods* (12.8%) and *loss of game* (6.2%) being the least. It would thus appear; the most frequent extreme climate events are mainly ***windstorms*** and ***drought***. Farmer researchers rated their adaptive capacity to deal with these extremes to be very poor as they did not have access to seasonal outlooks, down-scaled to their respective catchments to deal with the consequences of these events. Improving access to climate information services that make the predictability of these events more accurate could go a long way in in addressing these challenges and building their resilience.

Figure 3: Frequency of Extreme Events by District

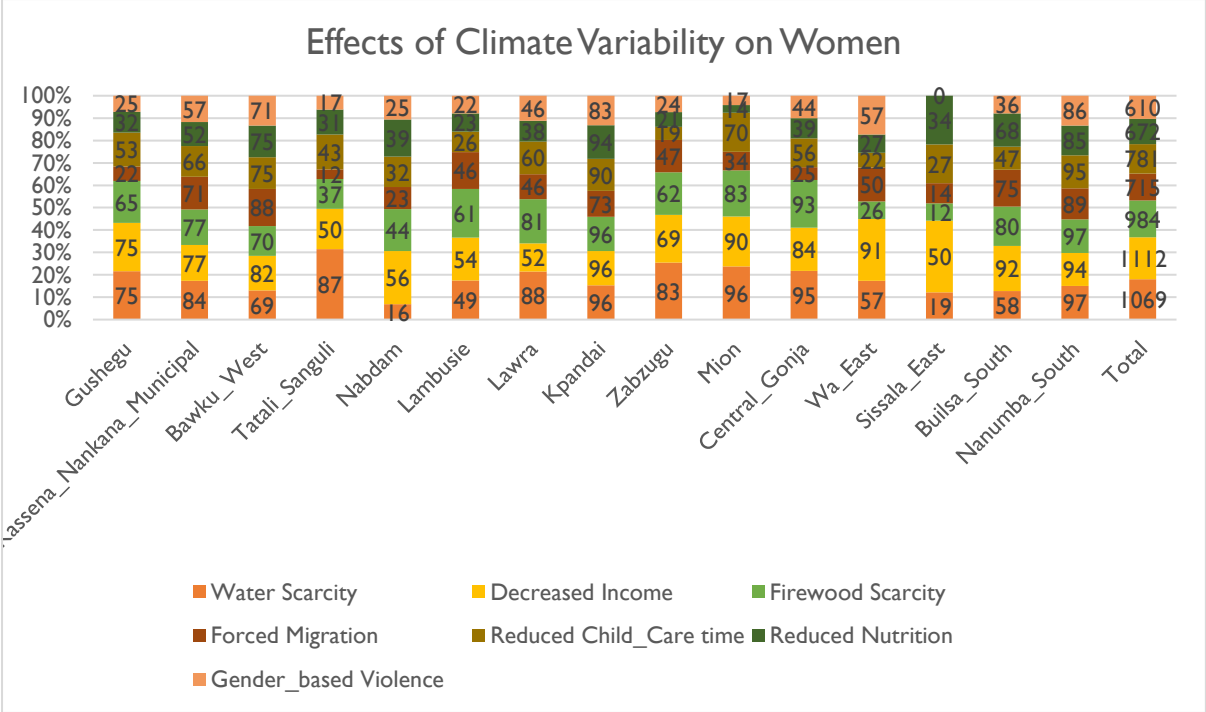


Source: *Field Survey (2021)*

Resilience for what purpose? → Functions

Farmer-researchers were facilitated to examine resilience in light of farming systems' provision of private and public goods. On the private goods front, Farmer-researchers sought to know varied effects of climate variability on women and the implications for their resilience as summarized in Figure 4. The results indicate *"Decreased income"* (18.7%) and *"water scarcity"* (18%) to be the most important effects of variability (from the multiple responses), accounting for a cumulative 36.7% of all the listed effects. The next most significant effects were; *"scarcity of firewood"* (16.6%), *"reduced child care time"* (13.2%), *"forced migration"* (12%) and *"reduced nutrition"* (11.3%). *"Gender-based violence"* emerged as the least (10.2%). It would thus appear that, prioritization of efforts to support women tackle the problem of climate variability and function better, should focus on income generation activities and improved access to sustainable sources of water, although, initiatives to wean their dependence on the natural environment for fuelwood could be reduced through the introduction of energy saving and environmentally friendly technologies.

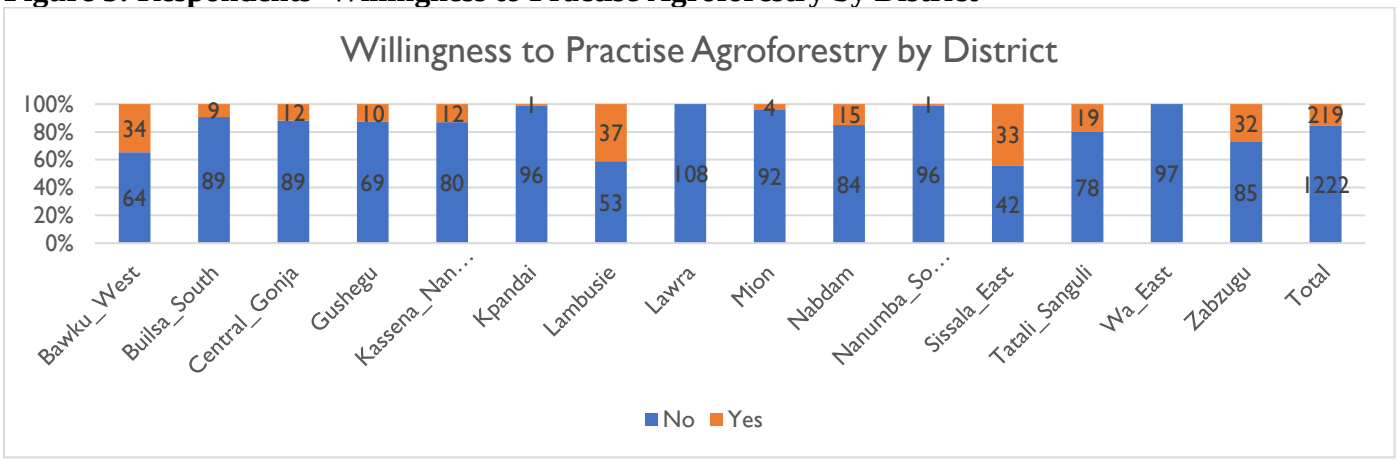
Figure 4: Climate Variability Effect by District



Source: *Field Survey (2021)*

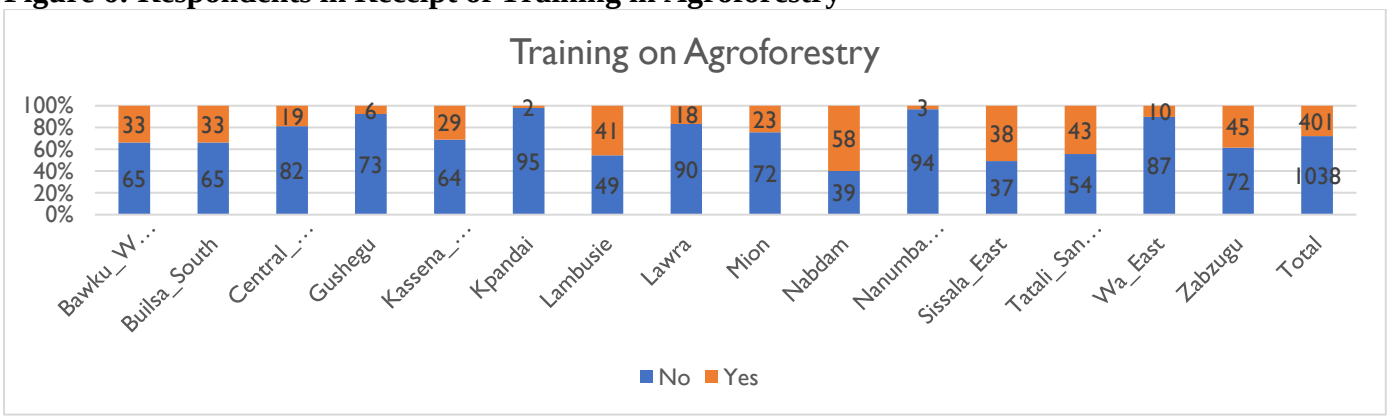
The narrative from the public goods side is that agroforestry is a key topic in the Intended Nationally Determined Contributions (INDCs) of Ghana, whether for mitigation, adaptation or both. In cognizance of these realities, Farmer-researchers sought to know how study participants were into agroforestry and whether some training was received in this regard as presented in Figures 5 and 6 below. The results suggest majority (84.8%) of them were unwilling to practice agroforestry or were not planting trees (as trees were used as the proxy for agroforestry). More than 8 out of every 10 respondents were not into agro-forestry or tree planting. The relatively low interest in agroforestry (i.e., just about 2 out of every 10 farmers are willing to plant trees) is a reflection of long held cultural beliefs and practices hindering the practice. Farmer-researchers acknowledged the myth that when a tree grows to maturity, the one who plants it dies, continues to linger across the study regions and is posing challenges to efforts at nurturing the environment.

Figure 5: Respondents' Willingness to Practise Agroforestry by District



Source: *Field Survey (2021)*

Figure 6: Respondents in Receipt of Training in Agroforestry



Source: *Field Survey (2021)*

What resilience capacities? → Robustness, Adaptability and Transformability

The results of this question are discussed by distinguishing three resilience capacities (robustness, adaptability and transformability) as espoused by Meuwissen et al. (2019) and noted previously in the introduction to this paper. The farmer-led research on how farming system's capacity to withstand stresses and (un)anticipated shocks revealed mixed farming and mixed cropping as the dominant resilience building anchors. The resilience capacities needed to optimally utilize these farming systems are weakened by limited diversity of low external input sustainable agriculture (LEISA) support, labour constraints, inadequate infrastructure and limited options to access capital (credits for investment) as well as poor markets. Additionally, rainfall variability and nutrient deficiency (N and P) together with unresponsive agricultural policies all culminate in

rather very low adaptive capacity. In order to cope with the uncertainties and risks, farmers are varying planting dates according to onset of the rains and distributing planting over a longer time period (staggered planting). They also use short- and long-cycle improved crop cultivars (e.g., extra early, early and late maturing), intercropping and irrigation. In areas with sufficient availability of land, farmers try to overcome nutrient deficiency through long fallow periods, through clearing virgin land or by increasing manure application as is the case in the NR. Farmers are therefore getting creative and their adaptability is manifest in these processes by which they change the composition of inputs, production, marketing and risk management in response to shocks and stresses as submitted in the foregoing. These developments are also indicative of their level of transformability which they rate very highly.

In sum, it is worthwhile to note that, farmer-researchers view their robustness to be compromised by frame conditions (for which they have little control) but rate their adaptability and transformability highly because these are choice variables for which they have significant measure of control expressed through the response measures, they are deploying to sustain their resilience.

What enhances Resilience? → Assessing resilience-enhancing attributes

Agroforestry constituted the key mitigation variable that was of interest in this study. The results bear out the fact that, while agroforestry has an enormous potential to mitigate climate change - because when integrated with crops on smallholder farms, they create a landscape that acts like a carbon sink; not much is being done in the study regions. Supporting efforts in agroforestry would act as a multiplying factor in improving mitigation. However, the current realities as borne out by the evidence, suggest that, just about 2 out of every 10 farmers are willing to practice agroforestry and there is also a buoyant deficit in respect of existing technical capacities on the subject matter - as only 12.8% of the survey sample that has ever received training in agroforestry is putting it to practice (see Figure 6). As high as 84.8% of the survey sample is unwilling to go into agroforestry.

Conclusion

Overall, the study provides a picture of farmers' resilience situation in four regions of Northern Ghana through the data associated with the selected indices (in the framework to assess the resilience of farming systems) - a unique composite set - at both district and regional levels. As a farmer-led study, it is not a comprehensive study of all the indicators that may be of relevance, but a sufficient study to indicate sector-specific areas and in cross-cutting areas where the study regions are in need and where policies and programmes can be put in place to reduce their agricultural burdens and improve living conditions. At a high level of strategic analysis, the report points to the requirement for actions that will decrease the study regions' vulnerability, as their sensitivity to climate change is high, and their adaptive capacity is low in respect of the support areas they require for effective adaptation and resilience building.

Recommendations

Prioritization of efforts to support women tackle the problem of climate variability should focus on income generation activities and improved access to sustainable sources of water, although, initiatives to wean their dependence on the natural environment for fuelwood could be reduced through the introduction of energy saving and environmentally friendly technologies as well. This would improve their robustness, adaptability and transformability.

The most frequent extreme climate events are mainly windstorms and drought – these represent important points of interventions that need to be prioritised in respect of efforts to reduce climate risk and improve emergency preparedness as part of mitigation efforts and resilience building.

Many taboos around tree planting were also highlighted as significant reasons for the poor state of agroforestry. Development programming in the study regions need to pay attention to these issues to perp up interest in agroforestry and improve mitigation gains.

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