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Smallholder Farmer Resilience as a Pillar of Climate-Smart Agriculture: A Review

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Cover Page Footnote

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RESEARCH ARTICLE

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ABSTRACT: *This systematic review synthesizes and assesses scientific literature publications (n=42), to identify and depict the focus of climate change adaptations and resilience research on smallholder farmers in the savannah ecological zone (SAZ). We found substantive studies providing evidence of climate impacts, with adverse consequences on both human and environmental systems. Adaptive actions are being employed to manage the changing conditions as response to climate impacts. Notably, most research efforts are currently restricted to impacts on adaptation, food security, and vulnerability, with a very rare focus on climate resilience and the effects of adaptive actions. Hence, the possible maladaptation outcomes, which affect the sustainability of both human and environmental systems, are not adequately known. The current research focus is found contrary to evidence showing the paradigm shift of approaches to toward climate resilience and the call to incorporate efforts into sustainable development framework (climate-smart agriculture). Also established is the lack of methodological coherence required for standardizing evidence to meaningfully inform policies and interventions. Therefore, this review and argues for more climate resilience research that ensures context specificity, robust indicator selection, and incorporation of indigenous knowledge into methodological frameworks that ensure effective assessment.*

Keywords
climate resilience; climate-smart; smallholder; maladaptation

I. INTRODUCTION

The Intergovernmental Panel on Climate Change [IPCC] (2018) identified different options of adaptations that can reduce the effects of climate change while producing maladaptive outcomes on human and ecological systems. Maladaptation is defined as an adaptive action that increases the propensity of greenhouse gasses, vulnerability among certain social groups, and limit future adaptive options directly or indirectly (Barnett & O'neill, 2010). According to the Food and Agriculture Organization [FAO] (2013, 2017) and IPCC (2018), adaptations without considering possible maladaptation outcomes could result in distressing effects on socio-economic, food security, ecosystems, and the health of smallholder farmers. Scaling up appropriate options that lessen maladaptation effects on humans and the ecosystem provides several positive synergies to smallholder climate resilience and sustainable development (Campbell et al., 2014). Appropriate adaptations would ensure food and water availability, reduce climate impacts, improve health, ecosystem services, and reduce poverty and inequality (FAO, 2013).

FAO (2013, 2017) has argued that the best approach to achieving the desired synergies to smallholder climate resilience, food security and sustainable development is through climate-smart agriculture (CSA). This is because CSA has the potential to increase sustainable productivity, reduce agriculture's greenhouse gas emissions, and increase carbon sequestration (Notenbaert et at., 2016). Hence, efforts to cut emission and enhance climate resilience while meeting the growing food, income and feed demand have been premised on CSA. Thus, CSA would ensure productivity; sustainably increase farmed yield and incomes, resilience; ensure building of resilience and adaptation to climate impacts and mitigate; reduce and or remove greenhouse gas emissions, if possible.

Since 2005, clarification and incorporation of climate change, disaster, and environmental risks reduction into the popular goals of sustainable development (SDGs) have intensified (Gallopín, 2006; Füssel, 2007; Plummer & Armitage, 2007). This effort reinforces the need for lesser maladaptive options among smallholders to contribute toward achieving sustainable development goals (SDGs 11&13). Therefore, promoting investment and research toward identifying maladaptation outcomes and means of mitigation serve as a key enabling condition to prioritizing appropriate adaptations. To achieve this would require vigorous conceptual and methodological consistency needed to explicitly identify possible maladaptive outcomes among farmers to help inform policies and interventions (Brenkert & Malone, 2005). According to Crane et al. (2017), an important contribution of research would also include clarifying what precisely vulnerability and adaptations are and their interrelated drivers. Research needs to also identify consistent ways of assessing vulnerability and adaptations and provide tools for tracking possible changes. This would enable the methods to be tested in multiple sites and aid cross evidence evaluation to better situate scientific inputs to policymaking

Moreover, climate change scholars and practitioners have advocated for robust conceptual and methodological consolidation toward assessing and prioritizing appropriate adaptations (see Carpenter et al., 2001; Burton et al., 2002; Cumming et al., 2005; Folke, 2006; Gallopín, 2006;Füssel, 2007; Plummer & Armitage, 2007). They have equally argued for improvements in the methodological coherence and the need for standardizing evidence (see Carpenter et al., 2001; Folke, 2006; Plummer & Armitage, 2007; Christiansen et al., 2018). Crane et al. (2017) indicated that these calls are prerequisite conditions needed to ensure robust and credible measures among climate-related researchers. Hence, adequate efforts toward clarity in offering specific climate-resilient assessment parameters have become paramount to help expose overly unfounded claims, promote cross-case study, and meta-analyses (Christiansen et al., 2018). Similar arguments and advocacy for vigorous methodologies and precision in reporting methods and objectives in climate-resilient research are evident in practitioners' working papers and reports (see Sperling et al., 2008; Sperling & McGuire, 2012; FAO, 2013; IPCC, 2018).

Therefore, this study seeks to provide the evidence needed to help materialized the call for careful examination and reflection upon adaptation choices made by farmers. While several scholarly efforts have evaluated various aspects of smallholder CSA (see Hammond et al., 2017; Neufeldt; et al., 2015; Westermann et al., 2018), gaps still exist in the development of coherent and robust frameworks to effectively evaluate 'resilience building and adaptation to climate change as a pillar of CSA (Kalaugher et al., 2012; Le Bouhellec et al., 2016; Challinor et al., 2018; Jones et al., 2018). Above mentioned studies have also focused on a larger spatial scale that usually results in over-generalization of research findings. Hence, we take a step in this regard to (1) analyze climate change variation in the SAZ at a finer spatial scale, 2) ascertain how climate-resilient frameworks are conceptualized to analyze the CSA options; and 3) proposing an idealized theoretical framework needed for effective resilience assessment. The study used a systematic review method to help achieve the stated objectives.

II. MATERIALS AND METHODS

The Systematic Review method used in this study constitutes a research methodology conceptualized to categorize, evaluate, and infer available evidence in a field with specific research questions (Thomas and Harden, 2008). This method of literature analysis started in the early 1990s among health sciences when researchers adopted it to help systematically analyze data from various Randomized Controlled Trials healthcare interventions (Crane et al., 2017). The method's transparency, accuracy, and replicability made it a unique research technique distinctly from traditional literature analyses (Magarey, 2001). According to Crane et al. (2017), the method generally entails the following phases: exploration; selection of publications; extraction of data from the selected studies; and then analysis of the extracted data. They further indicated that all the phases are executed using processes that embody the ethics of consistency, transparency, steadfastness, and completeness.

We used the vulnerability and resilient assessment approach of Crane et al. (2017), FAO (2013), Ford and Pearce (2010), Cutter et al. (2008), and Jones et al. (2018) to structure the systematic review and guide the analysis of published work to develop an understanding of climate resilience (see Figure 1). This approach conceptualizes climate resilience as the ability of human and environmental systems to thrive with climate variation or risks in retorting or reorganizing such that their essential function, identity, and structure are maintained, while also preserving the ability to adapt, learn, and transform. In this case, resilience is not only considered to be a process, but also embeds adaptation within climate resilience (Tierney and Bruneau, 2007), linked to vulnerability (Cutter et al., 2008), and transformation of socio-economic conditions. This is to ensure context specificity, robust indicator selection, and incorporation of indigenous knowledge (Maxwell et al., 2015; Jones et al., 2018). The review was further refined from FAO (2017) working paper and in-depth CSA sourcebook, and IPCC (2018) report on indicative synergies between mitigation options and sustainable development, which readers can refer to for more detailed information about the concepts.

2.1 Selection of Literature

The desired articles were identified through a keyword search on ResearchGate, Google Scholar, complete academic search, ScienceDirect and MendeleyFeeds. The search criteria included; 'TITLE: (adaptive capacity) (vulnerability) (resilience) AND TOPIC: (smallholder farmers OR agriculture OR smallholders OR farming OR farmers)" and "Alli title: "vulnerability, adaptive capacity, climate resilience AND smallholder farmers OR farmers OR small-holders OR agriculture OR farming". The search and selection by title, abstract, and conclusion screening for relevance extracted 42 papers from the study area (see Table 1). The individually 42 published studies were then subjected to complete text screening and face interpretability. The rationale for considering interpretability is to help determine whether a particular article was readily interpretable (Crane et al., 2017). As such, a published study was excluded in the analysis if the text explicitly connected theory, operationalizations, and measures for at least a construct used in the primary research question. Also, the articles needed to be focused on SAZ in Ghana in order to be included.

Table 1: Significant and Value Criteria Used in Article Selection and Complete Text Screening

Search Criteria	Rationale
Must be published between 2008-2018	Studies published within this period would be useful to help fully appreciate research response to the call to incorporate climate change (disaster and environmental risks reduction) into the popular goals of sustainable development started in 2005.
Must be in the SAZ in Ghana	Most climate studies on smallholder agriculture in Ghana are focused here, as the zone serves as the most relevant area for designing interventions aimed at fostering climate resiliency. The generality of the characteristics of the zone across Sub-Saharan Africa would help provides a perspective that those working in the sub-region can benefit from.
Must be focused on climate change (e.g. Vulnerability, adaptive capacity, food security, seed security and/or climate resilience) and smallholder farmers	Full reporting of research focused on a combined analysis of these focal areas is necessary to adequately assess the quality of operationalizations toward achieving climate resilience.
Must be readily interpretable	The article explicitly connected theory, methods, and covers at least a concept used in the primary research question needed to assess the quality of operationalizations.

To answer the research questions, the review systematically assessed and synthesized the selected scientific and academic literature publications (n = 42), to identify and characterize the nature of climate change vulnerability, adaptations and resilient research in the SAZ. We used the article stated research objectives, findings, and recommendations as to the bases of characterization. Also, in the analysis, literature gaps are presented to help redirect research efforts in SAZ where applicable.

2.2 Scope

The review focused primarily on SAZ, located in the northern part of Ghana, which is largely characterized by a range of lowland and grassland. The SAZ has a relatively dry climate characterized by a single rainy season that begins in May and ends in October with annual rainfall ranges between 750 mm and 1050 mm (Ghana Statistical Service, 2013). The annual mean temperature ranges between 22.4oC and 33.9oC (Acheampong et al., 2018). The SAZ is characterized by a prolonged dry season between November and March/April. They consist of the Upper East, Upper West, Savannah, North East, and Northern regions out of the 16 administrative regions of Ghana (see **Plate 1**).

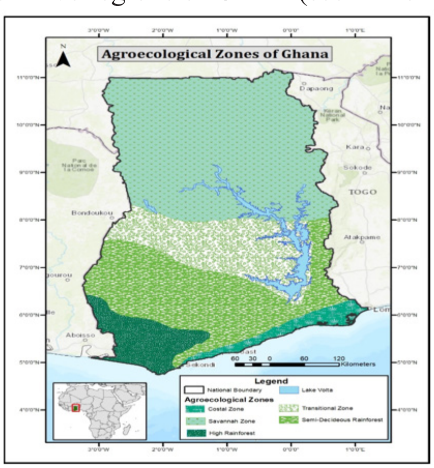

Plate 1: "Map of the Agro-ecological zones of Ghana. Source: Environmental Protection Agency, GIS Unit."

III. RESULTS AND DISCUSSIONS

3.1 Evolution of the Concept of Climate Resiliency

The conceptualization and the operationalization of efforts toward fostering climate resilience have evolved over two decades. Despite its challenges coupled with the relatively slower pace in adoption, the realization of its role in balancing environmental risks and resource scarcities with the pursuit of human well-being and social equity has gained momentum in recent times (DFID, 2001). Particularly, its incorporation in the sustainable development approach toward disaster and environmental risk reduction (Cutter et al., 2008; FAO, 2013). Accordingly, the approach of SDG was first given reflection by the Brundtland World Commission on Environment and Development (1987). The report linked environmental efforts with poverty alleviation and helped prepare the stage for prioritizing essential needs. It, however, acknowledged the impacts of current lifestyle and technology on the environment's ability to achieve present and future needs.

In 1992, half a decade after the Brundtland Commission followed the earth summit organized in Brazil Rio de Janeiro, hosted by United Nations. The UN's Discussion on Environment and Development provided tangible expression to the SDGs and made it further operational by elaborating on how to integrate economic, environmental, and social efforts. After further clarification of the approach by the "Earth Summit", international efforts became parallel toward building frameworks for disaster and environmental risk reduction. The parallel efforts elucidated International Decade for Natural Disaster Reduction in 1990 along with this approach. According to Cutter et al. (2008), the need to ensure environmental risk prevention and the essence of social vulnerability reduction supplanted the engineered-oriented thinking that dominated previously. This set a paradigm shift from the usual mapping of vulnerable areas and/or vulnerability reduction (engineered-based thinking) approach toward disaster and environmental risks reduction to a new approach that included human dimensions of risk reduction.

After this call followed the 2000 Millennium Declaration and the accompanying SDGs. The SDGs provided 18 aims measured using forty-eight indicators which served as benchmarks for signatory countries to assess their all-development efforts. Therefore, creating consciousness on the vital link between poverty and natural disasters reduction. Cutter et al. (2008) stated that the conference clarified and incorporated disaster and environmental risks reduction in the popular framework of SDGs by identifying both the essence and means of building resilient communities by

'(1) complementing disaster prevention efforts with mitigation, preparedness, and vulnerability reduction into SDGs and local plans;

(2) enhancing local institutions and strategies for building resilience; and

(3) including risk reduction into the proposal and implementation of emergency readiness, response, repossession, and revitalization efforts in affected society.'

The Green Economy Report by UNEP and the Sustainable Development Goal 13 have also argued and provided a roadmap for incorporating efforts toward mitigating climate impacts into the sustainable development approach. An example is the first target of SDG 13 aimed at strengthening the adaptive capacity needed to foster local level resilience to climate impacts. According to FAO (2013), these new efforts will be best manifested in CSA which will sustainably increase productivity, reduces/removes greenhouse gas emissions, and achieve global food security while reducing environmental risks and ecological scarcities. Specifically, because the strategies of climate-smart agriculture include adaptation by risk management, fostering resilience of the environmental systems and the transformation of the human systems (such as the political, social, and economic factors).

It would be unrealistic and overwhelmingly impracticable to replicate resilience as used in the disaster risk reduction arena without necessarily applying it to fit the context of climate change. Primarily because the exposure and sensitivity of climate impacts unlike those experienced in the context of disaster are relatively global, invisible, intangible and slower in pace (Cutter et al., 2008). These result in confounding issues of temporal variability, scale-less, and ambiguity in the unit of analysis. In addition, unlike disaster impacts that are localized and event-specific, climate impacts are more complex, interactive and global in perspective (Altieri et al., 2015; Antwi-Agyei et al., 2018; IPCC, 2014, 2018). Also, climate impacts can transcend over boundaries and as well interact with non-climatic factors to exacerbate the vulnerability of the smallholder (Thornton et al., 2014). these characteristics are indicative of the need to pursuit resilience as a holistic process and not an outcome as viewed in the disaster context.

3.2 Definitions Conceptualizing Climate Resilience

In the context of disaster risk reduction, resilience is viewed as a system's ability to tolerate disturbance and re-form into an effective operational system again (Cutter et al., 2008, p. 2). Or the degree of the persistence of a system and its capacity to absorb change and shocks, while still sustaining the same relationships between its population (Holling, 1973, p. 14). These definitions viewed resilience as an outcome as it is typical in a disaster context. However, resilience is much considered as a process in the context of climate change. Choptiany et al. (2016) defined it to be the resistance of a system to climate-related shocks and stresses involving its ability to survive, recover from, and even thrive in changing climatic conditions. Also in climate context, resilience entails adaptive actions that ensure sustainable development at all scales and systems transformation by mitigation and adaptation (IPCC, 2018). According to FAO (2013), resilience is the propensity of human and environmental systems to thrive with extreme climate variations or shocks by retorting or reorganizing to maintain its essential function, identity, and structure, along with maintaining the capacity of adapting, learning, and transforming.

The new perspective of climate resilience is to be a process that embeds adaptation capacity within climate resilience (Tierney and Bruneau, 2007) which is linked to vulnerability and human systems transformation (Cutter et al., 2008). This is much appreciated when vulnerability is defined as a 'function of who and what is at risk and sensitivity of the degree to which the system can be damaged (Cutter et al., 2008). Adaptation is defined as short-term measures or strategies (Coping) and longer-term strategies (mitigation) that are needed to effectively respond to evolving conditions that have or not previously been experienced (Twomlow et al., 2008). As such, transformation is considered essential in ensuring climate resilience is focused on changing the existing unfavorable systems; economic, social injustices and power imbalances. See Crane et al. (2017) for further and detailed analysis of the conceptualization of climate vulnerability and adaptation (adaptation by risks management) using systematic review analysis.

This review focused primarily on the application and conceptualization of resilience as a borrowed practice from disaster risk reduction into climate change. That is viewing adaptations as the means of mitigating or minimizing climate risks while ensuring the sustainability of environmental systems and human systems, including the transformation of unfavorable socio-economic systems. The application and conceptualization of climate resilience is illustrated in **Figure 1** below.

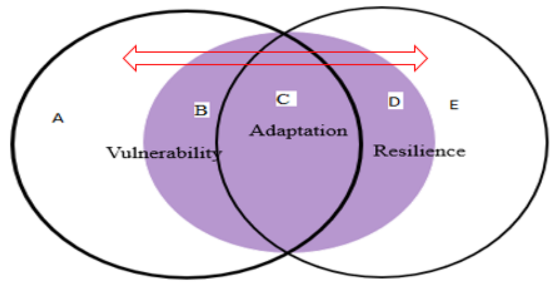

Figure 1: Idealized Theoretical Framework of the Conceptual Linkage Among Climate Resilience, Vulnerability, and Adaption. Authors' Construct, 2019.

From Figure 1, **Region 'A'** represents smallholder farmers who are exposed and/or sensitive to climate change impacts yet, have no adaptive capacity to survive, recover from, and thrive in changing climatic conditions. **Region 'B'** represents smallholder farmers who are exposed and/or sensitive to climate change impacts and have some amount of adaptive capacity but not enough to survive, recover from, and thrive in changing climatic conditions. **Region 'C'** represents smallholder farmers who are exposed and/or sensitive to climate change impacts but have adequate and robust adaptive capacity to survive, recover from, and thrive in changing climatic conditions. On the other hand, farmers represented by **Region 'D'** are those who are not exposed and/or not sensitive to climate change impacts, yet without the adaptive capacity needed to survive, recover from, and thrive in changing climatic conditions. **Region 'E'** represents smallholder farmers who are not exposed and/or sensitive to climate change impacts and have no adaptive capacity needed to survive, recover from, and thrive in changing climatic conditions. Thus, in an ideal situation, smallholders with robust CSA should be found in the region **'C'**. Hence, region **'C'** is considered the ideal situation for climate-resilient farmers.

Farmers in each of the regions are expected to be movable from one region to the other as illustrated by the arrow. The mobility from one region to another may be determined by the robustness of the individual adaptive strategies and/or the changing climate conditions. For instance, a smallholder household may be found in region **'C'** at a particular time during a long drought in a community. During the drought the household sells their livestock to meet its livelihood objectives, but as the drought prolongs, the livestock assets deplete which affects the household's ability to meet its livelihood objective. As a result, this household could move from region **'C'** to region **'B'** or region **'A'** over the period (see Haggblade et al., 2010). Similarly, a community that has not experienced flooding could move from region **'E'** to region **'A'** when the community finally experiences perennial flooding that destroys farms and assets (see Antwi-Agyei et al., 2018).

On the other hand, a household without drought-resistant crop varieties could move from region **'A'** to region **'C'** if improved drought-resistant seeds are distributed to those households through seed aid during drought (see Sperling et al., 2008). More importantly, this aspect of the theoretical framework emphasizes the need to view resilience as a process (i.e., preserving the capacity of adapting, evolving, learning and transforming) amidst climate change. Hence, smallholder farmers that are considered climate resilience at a particular period could become less climate-resilient at another period and vice versa.

It must be noted that the adaptation strategies, which determined the region of location of the individual smallholders should be guided by the ability to sustain the human and environmental systems. Consideration of adaptive actions that turn to ensure the transformation of existing unfavorable systems- economic, social injustices and power imbalances among the smallholders is equally important. The assessment process should include self-assessed perceived resilience-related capacities and indicators. As such, while the concept might not fit entirely in practice, it may well serve as a guide to ignite robust and effective climate resilience assessment toward mainstreaming CSA into the sustainable development framework. This will ensure that CSA help in addressing intricate but related issues of climate change and food security while ensuring the sustainability of both the environmental and human systems of the smallholder as proposed by FAO (2016).

3.3 Smallholder Farmers and Climate Resilience Assessment in SAZ

Despite the paradigm shift of local and global approaches to climate change and the need to incorporate climate-smart farming practices into the sustainable development framework. The contrary exists in available climate change literature in SAZ over the past decades (see Figure 2). The research efforts have been overly focused on climate vulnerability and adaptations in isolated case studies to the detriment of climate resilience. Also, there exists little studies on seed security despite the possibility of it being affected by climate change (Madin, 2020). The overly focused research on adaptations as depicted by the graph may not be out of the ordinary though. Primarily because, whereas the global attempt to avert the pace of global warming by cutting emissions of anthropogenic gasses is not exactly racing forward, focusing on adaptations to climate change, for now, seems the only feasible way and is much underway (The Economist, 2015). Nevertheless, the consequences of possible maladaptive outcomes on both the ecological and human systems must not be underestimated under the current global constraint in climate change efforts.

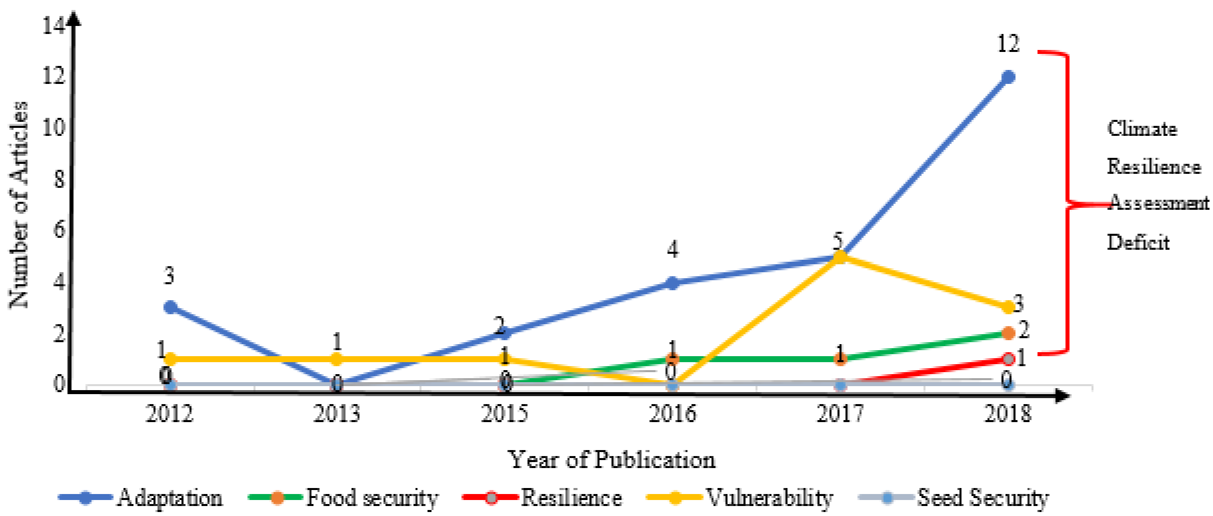

Figure 2: Trend Analysis of Publications Specially Addressing Climate Change Impacts and Smallholder Resilient Over Time. Note: Publications Below 2008 are Not Included.

Similar studies in other areas have shown that some of the adaptation options are unsustainable, lack frameworks for evaluation, and are associated with maladaptation (Loboda, 2014; Ford et al., 2015; Larsson et al., 2016). The IPCC (2018) indicated that adaptations to climate change can also result in maladaptation with the possibility of severe negative effects on sustainable development. For instance, poorly designed or executed adaptive practices among smallholder could result in greater water usage and greenhouse gas emissions, widen gender and social disparity, destabilize health conditions, and deplete natural ecosystems. Likewise, Niang et al. (2014) argued that while the current adaptation efforts in Africa could enhance the resilience of the agricultural system over the short term, those adaptations are found to be insufficient for managing risks of long-term climate change and farming system types.

More so, given the evolving nature of climate impacts, we argue that a mere focus on vulnerability and adaptation in isolation without a holistic climate-resilient assessment will certainly not provide real evidence and lessons required to inform robust practices. Particularly, evidence and lessons are needed to identify and combat maladaptive outcomes. Likewise, Altieri et al. (2015) argued that climate adaptations that improve the resilience of human-agricultural systems are essential but not sufficient conditions to achieve SDGs. Therefore, for smallholders to effectively adapt to climate stresses and ensure sustainability, human system resilience must be met along with ecosystem service resilience. At best, the few efforts that focused on resilience and sustainability have also failed to establish the effects of climate change adaptation actions by way of using site-specific criteria (see **Table 2**). Also, the synergy effects of the autonomous and planned adaptive strategies that foster smallholder's climate resilience is largely unknown in the SAZ as well.

Climate change encompasses intricate interactions and changing possibilities of effects shaped by socio-economic, ecological and political factors. Therefore, a focus on impacts on food security, vulnerability, and adaptation in isolated studies is woefully inadequate to properly provide evidence of the effects of adaptive actions of the farmers on the human and or environmental systems. This is because patterns of risks and potential benefits of the adaptive strategies can shift between human and environmental systems, making the approach of CSA without sustainability dimensions elusive. In a similar argument, IFPRI, (2015) established that smallholders are not a homogeneous group, but rather a diverse set of households living in different types of economies that shape their adaptations and actions toward the environmental systems. Abass et al. (2018) further suggested that the heterogeneity of smallholders causes variation in their vulnerability and adaptation to climate change across social groups. These findings reinforce the need for developing site-specific criteria for assessing adaptation actions. The site-specific criteria would ensure that prioritized adaptation options demonstrate beyond doubt the ability to buffer disturbance while ensuring the sustainability of the local systems. This can be realized when research efforts adopt a holistic climate-resilient assessment such as the one proposed in **Figure 1**.

Table 2: Operationalizations of Climate Resilience Assessment in Savannah Agro-Ecological Zone

Article	Focus and Construct	Critique
Antwi-Agyei et al. (2018)	1. Climatic and non-climatic stressors confronting households (vulnerability)	
	2. Households adaptive strategies to climatic and non-climatic stressors	
	3. Outcomes of coping and adaptation actions (resilience)	
	4. Use of a mixed-method approach involving key informants, focus group discussions and household surveys.	1. Failure to use participant observation method which has the potential of providing insightful information on the possible outcomes of adaptive actions of farmers
	5. Simplistic classification of adaptation outcome	2. Lack of clearly established criteria (base on local ecological and socio-economic characteristics) for assessment of possible outcomes of the adaptive actions
	6. Benefits-Risks analysis largely based on authors inferences and earlier literature justification	3. The inferential analysis is largely based on earlier studies justification. 4. Citations of earlier studies conducted in different ecological and socio-economic settings.

Clearly, from Table 2, the authors' failure to incorporate participant observation does not allow for insightful assessment and appreciation of realistic maladaptation outcomes of the farming practices. Because participant observation has the potential of gaining a close and intimate familiarity with the farmers and their practices through intensive involvement in their cultural environment and local ecological characteristics, over an extended period. This approach could have also helped solicit the inputs and views of the indigenous farmers in developing the criteria for assessing the maladaptation outcomes (see Jones and Tanner, 2015; Maxwell et al., 2015; Jones et al., 2018). Lack of established specific criteria characterized by merely classifying perceived adaptation outcomes based largely on inferences would not be rigorous enough to elucidate the locally justifiable adaptation outcomes. For instance, the authors argued that selling livestock depletes the livestock stock and perpetuates the household's poverty. Which livestock was sold in the study area? Goat, sheep, bull or fowls? What is the market situation for selling these animals in the study area? Giving that these animals have different market prices and that their specific prices differ from one location to the other based on each market situation, this argument without clear criteria leads to ambiguities.

The authors' justification of their inferences with earlier studies, particularly those studies conducted in different agro-ecological zones may not connote the true adaptation outcomes of the study area. Similarly, giving the fact that the socio-economic characteristics (human systems) of the earlier studies differ from the current study area, justification using earlier studies may be too simplistic to fully and or appropriately ascertain the human systems sustainability implications. Also, the time scale of the study (April-July) does not provide enough opportunity for the researchers to fully and adequately appreciate all maladaptation outcomes. This is because evidence showed that the duration of the dry season has increased in the SAZ (Badmos et al., 2018) forcing many household' members to adapt detrimental adaptive actions. Hence, the study period of April to July excludes the opportunity to appreciate the adaptive actions taken in the dry seasons (November to March).

IV. CONCLUSION AND RECOMMENDATIONS

Figure 2 shows that most of the adaptation efforts are already, and currently being taking among farmers in response to observed and projected climate impacts. It would have been expected that adequate research efforts are focused on identifying maladaptation outcomes and means of mitigation to help inform practices and policies. Rather, the research focus has been mainly on adaptive strategies among smallholder farmers toward food security and climate vulnerability. Specifically, most of the studies have been focused on food security, vulnerability, and adaptation, with limited emphasis on assessing climate resilience and the effects of adaptive actions. Besides, there is a lack of methodological coherence required for standardizing evidence to meaningfully inform policies and interventions. There is less-robust climate-resilient frameworks in SAZ to effectively assess farmers resilience.

This review argued for empirical evidence to demonstrate beyond doubt the ability of the adaptive strategies to buffer climate risks while achieving sustainability. To achieve this, it is recommended that researchers utilize indigenous (local) knowledge and stakeholder engagement as well as broader sustainable development frameworks. This would help develop site-specific criteria based on local socio-economic characteristics required for evaluating possible outcomes of the adaptive actions and policies. We propose an ideal guiding framework. Adopting the proposed framework

(Figure 1) would ensure both objective and subjective resilience assessment. This would further ensure effective and more proactive methodology that incorporates collaborative and participatory research engaging scientists and farmers. Given the general characteristics of the SAZ across Sub-Saharan Africa, it is believed that the findings and recommendations would help provide a perspective that other researchers working in African countries can apply.

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