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Indigenous and research-based adaptation strategies of smallholder women rice farmers to climate variability in the Northern Region of Ghana

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Abstract
This study investigated the indigenous and research-based strategies of smallholder women rice farmers in adapting to climate variability. Specifically, the study explored women rice farmers' adoption of climate variability related adaptation strategies using descriptive statistics; ranked farmers' perceived effectiveness of indigenous and research-based adaptation strategies to climate variability using descriptive statistics and Friedman's Test; and finally, identified and ranked challenges to adopting the adaptation strategies using charts and the Kendall's Coefficient of Concordance. Questionnaires were administered to 260 randomly sampled women rice farmers in two districts in the Northern region of Ghana. This was complemented with key informant interviews with the staff of Ministry of Food and Agriculture and some community leaders. The results revealed that farmers perceived crop related practices (mixed cropping and indigenous varieties) to be the most effective indigenous adaptation strategies while improved variety strategies (high yielding, early maturing and drought resistant varieties) are the perceived most effective research-based adaptation strategies. The most pressing challenges constraining farmers adopting of both indigenous and research-based adaptation strategies are inaccessibility of tractor/bullock services, inadequate funds and inaccessibility and high cost of farm inputs. The study therefore recommends that women rice farmers should form groups and through Ministry of Food and Agriculture and other agricultural-based NGOs be assisted to acquire mini tractors. Also, rice seeds (indigenous and hybrid varieties) should be subsidized by the Government and made accessible to farmers through community agricultural extension officials.

Keywords
Adaptation strategies, climate variability, Friedman Test, Kendall's Concordance Coefficient, smallholder women rice farmers.

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1. Introduction

Agriculture is often adversely affected by the erratic rainfall patterns with the perennial variability in rainfall resulting in droughts, flood and bushfires in the Northern Region of Ghana [1]. The results are often a decline in the moisture level of soil leading to decreasing agricultural productivity and farmers' income [2]. The perennial occurrence of floods, droughts and bushfires in Northern Ghana heightens farmers' struggles for food every year especially between the periods of March and July [3].

The national average yield of rice has remained low at 2.5 tones/hectare/year [4] and was reported in 2013 to be 2.2 tones/hectare/year by the Crop Research Institute, Savannah Agricultural Research Institute, and International Food Policy Research Institute. Although Ghana has the potential of achieving 6-8 tons/hectare/year, the survey attributed the low yield to climate variability and low adoption of climate related adaptation strategies by smallholder farmers [4]. The highest rice producing region in Ghana is the Northern Region, which produces about 37 percent of the national rice output [5].

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There exist numerous technologies for women rice farmers in the Northern Region to adopt in their bid to adapt to climate variability. These innovations/technologies are mostly being developed by Ghanaian Universities and other governmental and non-governmental research institutions in collaboration with donors and other international research institutions [12]. However, these technologies do not seem to be carefully documented in the Ghanaian adaptation literature. The technical and economic prospects of these innovations have not also been fully explored by farmers due to low awareness levels which have resulted in low adoption [13]. Generally, the agricultural activities of female farmers lack the needed resources vis-à-vis their male compatriots. This difference shrinks efficient agricultural investments by female farmers which constrains their investments aimed at enhancing resilience to climate variability [14]. In Northern Region, just as in many parts of Northern Ghana, relative to male farmers, female farmers have less ownership and access to land including other supporting production resources [15, 16, 17]. Yet, females constitute about 50.4 per cent of the region's population [7]. This is partly due to the cultural practices in the region.

Rice production is likely to reduce due to climate variability [18]. This undesirable effect of climate variability worsens the plight of the poor, vulnerable and marginalized groups, who are mostly women and children [18]. Targeting female farmers among other factors is vital in stimulating the adoption of newly introduced climate-related technology [13]. The focus of this research, therefore, was to solicit from smallholder women rice farmers in the West Mamprusi District and the Savelugu/Nanton Municipality, how they adapt to the current climatic conditions and what factors hinder their ability to adopt the available climate variability adaptation strategies. The questions to which this research sought to find answers to were: 1. What are the indigenous and research-based adaptation strategies of smallholder women rice farmers to climate variability? 2. Are there differences in farmers' perceived effectiveness of adaptation strategies to climate variability? And 3. Are there differences in the ranking of challenges to adoption of climate variability adaptation strategies among smallholder women rice farmers?

1.1 Literature Review

Adaptation to climate variability is the adjustment in human or natural systems in response to actual or anticipated climatic stimuli or their effects, which lessens damage or exploits beneficial prospects. These may include both on- and off-farm activities. The main aim of adaptation is to minimise the negative effects of unavoidable climate variability through actions targeted at the vulnerable system. Adaptation could also involve taking measures to seize new opportunities brought about by climate variability [19]. Adaptation of farmers can be planned or spontaneous (autonomous); public or private; and reactive or proactive (anticipatory) adaptations [20], [21], [22]. Whereas Proactive adaptation is when a system is amended long before experiencing the effects of climate variability, reactive adaptation is when a system amends

at the onset of experiencing the effects of climate variability. Adaptation is spontaneous when it is as a result of changes in the natural ecological systems and changes in the markets or welfare of human systems rather than by the conscious efforts of an individual. On the other hand, planned adaptation is the result of a deliberate policy resolution based on a changed or anticipated change in conditions which needs to be restored to a desirable state [21], [23]. In this study, adaptation refers to how smallholder women rice farmers are either adjusting their practices or putting measures in place to adapt to climate variability. This can either be self-improvised mechanisms by the farmers (i.e. indigenous adaptation strategies) or recommendations backed by research from governmental and non-governmental organisations (i.e. research-based adaptation strategies).

Indigenous Adaptation Strategies include all the measures and practices innovated by the farmers themselves. These could either be the creativity of recent or past generations [24]. This study perceives indigenous adaptation strategies to mean all the traditional climate-related adaptation practices emanating either from farmers of current generations, or those passed onto farmers from previous generations. The indigenous adaptation strategies include the use of indigenous varieties, mixed cropping, loosing of soil, creating bunds or drainage channels, use of manure, cultivating short season crops, homestead gardening, migration, increasing planting space, changing timing of farm operation, crop diversification, regular or early weeding, prayers and timing of rain ([24, 25, 13, 26, 27, 28, and 29]). This study classified the indigenous adaptation strategies into four main categories based on how they are related and practised in the study area: crop related, soil related, cultural practices related and other indigenous related strategies. On the other hand, research-based adaptation strategies include soil and water conservation measures such as conservation agriculture to retain soil moisture [30]; modify planting times and change to crop varieties resistant to heat and drought [31]; new cultivars [32]; changes in the farm portfolio of crops and livestock [33]; and shift to non-farm livelihood sources [34].

The existence of climate variability adaptation strategies is no guarantee of successful adaptation in terms of securing basic needs. A similar study on the constraints faced by farmers in Coastal Bangladesh in adapting to environmental degradation and the effects of climate change was conducted using the Problem Confrontation Index (PCI) [35]. The findings revealed that lack of water for irrigation and drinking, land shortage, unpredictable weather conditions, lack of credit, market inaccessibility and a shortage of farm inputs were the major constraints faced by farmers. Also, inadequate funding, lack of information on climate change, poor potential for irrigation, inadequate technical expertise, inadequate labour force, and land inaccessibility were the pressing challenges faced by arable crop farmers in the Owo Local Government Area of Ondo State in Nigeria in adopting agricultural systems, soil conservation methods and other livelihood measures in adapting to climate change [36].

Following the pre-test and focus group discussions conducted in the study area, the prevailing constraints faced by respondents and considered in this study are untimely accessibility of tractor and/or bullock services, inadequate funds, high cost and shortage of farm inputs, lack of information, insufficient labour force/expertise, land shortage, unpredictability of rainfall, market inaccessibility, and socio-cultural and religious factors. In the literature, studies on farmer adaptation to climate change have only identified farmers' strategies of adapting to climate change and the challenges faced by farmers in adopting adaptation strategies. Unlike other studies, this study has added to knowledge by examining farmers' perception on the effectiveness of identified climate variability related strategies. In view of this, the objectives of the study were threefold as follows. First, to explore smallholder women rice farmers' adoption of adaptation strategies (indigenous and researched-based) to climate variability. Second, to rank the perceived effectiveness of adaptation strategies to climate variability. Third, to identify and rank the constraints faced by farmers in adopting climate variability adaptation strategies.

1.2 Conceptual and Theoretical Framework

Natural and human activities cause climate variability which brings about climatic stressors such as floods, droughts and bushfires. To adapt, farmers employ their own improvised measures which have been passed on to them over time as traditional practices to abate the effect of climate variability. However, these indigenous strategies are not sufficient to enable farmers to effectively adapt to the effects of climate variability. The need to rely on innovations developed by research institutions is therefore imperative. The level of adoption of adaptation strategies among farmers depends on the presences and severity of certain constraining factors such as cost, accessibility and technicality of adaptation strategies.

The theory supporting this study is based on the random utility theory as specified by [37] and [38]. If Y_{ia} and Y_{ib} are farmer $i's$ decision on two adaptation choices, which depends on the utilities derived from them and can be represented as U_i^a and U_i^b, then a farmer's choice between the two adaptation strategies depends on which one provides a higher utility. Thus, the assumption is that a farmer prefers and practices the adaptation strategy with the greatest net returns. Farmer i will choose Y_{ia} over Y_{ib} if $U_i^a > U_i^b$; and vice versa [37].

2. Materials and Methods

2.1 Study Area

The study was conducted in the Northern Region of Ghana, precisely in the Savelugu/Nanton Municipality and the West Mamprusi District. The region is in the Guinea Savanna Agro-Ecological Zone and a semi-arid climatic region with its vegetation comprising mainly of grassland areas, interspersed with Guinea and Sudan Savannah Woodland characterised by such drought-resistant trees as the Adansonia (baobab),Vitellaria paradoxa (shea nut), Acacia, Parkia biglobosa (dawadawa),Mangifera indica (mango) and Azadirachta indica (neem) [7]. The average minimum and maximum temperatures of the region are 14^oC at night and 40^oC during the day. The region experiences two seasons: the dry season (November to April) and the wet season (May and October) with an average annual rainfall of 750mm – 1050mm [39]. The region has a land area of 70,384 square kilometres (31% of Ghana's land area) with a population of 2,479461, 10.1% of the national population. The region has a female population of 1,249,574 (50.4%) [7]. The agricultural sector employs 43.06% of the region's female population of 15 years and above [7]. About 14.1 percent of households in the Northern Region are headed by females, which is higher than the national average of 11 percent [7]. Figure 1 presents a map of the study area indicating the location of the selected communities considered for the study.

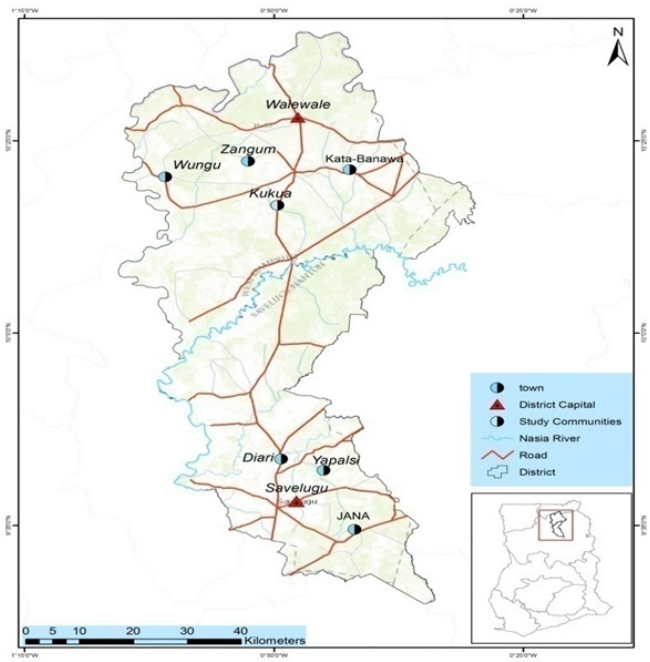

Figure 1. Map of Savelugu/Nanton Municipality and West Mamprusi District Showing Study Communities. **Source:** Department of Geography and Resource Development, University of Ghana, 2016

2.2 Sampling Techniques and Sources of Data

A multi-stage sampling technique was used. The first stage involved the purposive selection of the Northern Region because it is in a guinea savanna ecological zone located in a semi-arid climatic region and is the nation's highest producer of rice. In the second stage, West Mamprusi District and Savelugu/Nanton Municipality were also purposefully chosen among other districts based on their contribution to the region's rice output and also because of the erratic rainfall patterns in these two areas relative to other districts in the region. Based on population and land size, four communities in West Mamprusi District and three communities in the Savelugu/Nanton Municipality were randomly selected. Simple random sampling was used to proportionately select a total of two hundred and sixty (260) smallholder women rice farmers from all the communities. Questionnaires were administered to farmers and focused group discussions were held in all communities to solicit communal views on issues relating to all farmers. Data was collected in March 2016. Table 1 presents the sample size by district and community.

Table 1. Sample Size Distribution by Communities and Districts

District	Community Name	Number of Respondents Community	District
Savelugu/Nanton	Diare	38	
	Jana	36	110
	Yapalsi	36	
West Mamprusi	Zangum	37	
	Kata-Banawa	38	150
	Kukua	35	
	Wungu	40	
Total Sample Size			260

2.3 Methods of Data Analysis

2.3.1 Adoption of Climate Variability Adaptation Strategies

The indigenous and research-based strategies used by smallholder women rice farmers in adapting to climate-related shocks (mainly bushfires, droughts and floods) were categorised into main groups depending on how they are related. The indigenous climate-related adaptation strategies were broadly categorised into four, namely Crop Related Strategies (CLRS), Soil Related Strategies (SRS), Cultural Practices Related Strategies (CUPRS) and Other Related Indigenous Strategies (OIS) [13]. The research-based adaptation strategies were categorised into five, namely Improved Varieties Strategies (IVB); Soil and Plant Health Strategies (SPHS); Husbandry Strategies (HS); Other Research-based Adaptation Strategies (ORAS) and No Adoption of Research-based Strategy (NRS) for some farmers who reported not adopting any research-based adaptation strategies in response to climate variability [13].

The specific climate-related adaptation strategies under each main category were identified by reviewing literature, conducting focus group discussion at the local community level and also conducting key informant interviews. Respondents were then asked to tick all strategies ever practised in the last five years. Descriptive statistics (percentages) were then employed to analyse farmers' adoption levels of adaptation strategies and presented in the form of tables. The SPSS version 22 was the software used for the analysis.

2.3.2 Effectiveness of Climate Variability Adaptation Strategies based on Farmers' Perception

In the survey, smallholder women rice farmers were asked to separately rank the main categories of indigenous and research-based strategies based on their effectiveness in ensuring adaptation to climate variability. The highest ranked strategy was assigned a numeric value of one. The rankings were then subjected to the Friedman's two-way analysis of variance test without replication by ranks [40]. The Friedman test is a non-parametric statistical test developed by Milton Friedman. Similar to the parametric repeated measures ANOVA, it is used to detect differences in treatments across multiple test attempts. The procedure involves ranking each row (or block) together, then considering the values of ranks by columns [41] and [42].

The Friedman statistic, T is given by equation (1) [42]:

$$T = \frac{12}{bk(k+1)} \sum_i^k = 1R^2 - 3b(k+1) \text{ ..... } (1)$$

Where b is the number of smallholder women rice farmers, k is the number of climate-related strategies; Ri is the rank sum for the ith climate-related strategy.

$T \sim X^2(k=1)$ follows approximately a chi-square distribution with K-1 degrees of freedom.

The decision rule is that if, reject the Ho; otherwise do not reject.

$$Y > X^2_{(k-1,1-\infty)}$$

2.3.3 Identifying and Ranking Constraints to Adoption of Adaptation Strategies

The constraints militating against smallholder women's rice farmers adoption of the available climate variability adaptation strategies were identified from past research works and pretested through focus group discussions and key informant interviews. Nine constraints prevail in the study area and were considered for the study. These constraints were categorized into two: those militating against the choice of indigenous adaptation strategies and those hindering the adoption of research-based adaptation strategies. The constraints were then presented to respondents for ranking from the most pressing constraint to the least pressing one using numeric scales 1, 2, 3....9. The total rank score of each constraint was calculated and the constraint with the least score ranked as the most pressing one while the constraint with the highest score was ranked the least.

The Kendall's Coefficient of Concordance (W) was then used to determine the level or degree of significant agreement among respondents on the rankings of the constraints [40]. The Kendall's coefficient of concordance (W) is a measure of the agreement among several (m) quantitative or semi-quantitative variables that are assessing a set of n objects of interest [43]. In the social sciences, the variables are often people, called judges, assessing different subjects or situations [44]. Given that T = the sum of ranks of each constraint being ranked, the variance of the sum is given by equation (2) [43]:

$$Var_T = \frac{\sum r^2 - (\sum r^2)/n}{n} \text{ .....(2)}$$

And the maximum variance of T is then given by equation (3):

$$\frac{m^2(n^2-1)}{12} \text{ .....(3)}$$

Where, m denotes the number of sets of ranking by the farmers and n denotes the number of specific constraints being ranked. The Kendall's coefficient (W) is therefore given as:

$$W = \frac{[\sum r^2 - (\sum r^2)/n]/n}{m^2(n^2-1)/12} \text{ ..... } (4)$$

Equation (4) is further simplified to the computational formula as:

$$W = \frac{12[\sum r^2 - (\sum r^2)/n]/n}{nm^2(n^2-1)} \text{ .....(5)}$$

The Kendall's coefficient of concordance (W) is a positive value ranging from zero (maximum disagreements among rankers) and one (maximum agreement among rankers). The coefficient of concordance (W) was tested for significance using the F-statistic. This is given by equation (6):

$$F = \frac{[(m-1)w_c}{(1-w_c)} \text{ ..... } (6)$$

The F-statistics has $V_i = \frac{(n-1)-2}{m}$ Degree of freedom for the numerator and

$V_2 = (m-1)[(n-1)-2/m]$ the degree of freedom for the denominator.

Decision rule: If $F_{cal} > F_{cri}$ from Fisher's F-statistics distribution, the null hypothesis is rejected; otherwise, it is not rejected.

3. Results

3.1 Socio-economic Characteristic of Farmers

The socio-demographic profiles of respondents considered in this research are family labour, farm size, off-farm income, age, farming experience and level of education

of the farmer (Table 2). About 66.2 per cent of sampled respondents reported engaging in at least an off-farm activity with a mean income of GHS132.48. The average farm size of sampled farmers is 1.9 hectares, which is less than the Northern Regional average farm size of 2 hectares. At least every smallholder woman rice farmer has a year of experience in rice farming with an average farming experience of 20.45 years for the sampled farmers. Experience is important in rice farming since farmers are able to understand and apply the appropriate agronomic practices suitable for adapting to climate-related events such as drought, bushfires and floods to reduce their levels of vulnerability. Closely related to farming experience is the age of the farmer. The age of a smallholder woman rice farmer correlates with her understanding of the weather pattern of the locality and how she has been adapting to climate stressors. The average age of sampled farmers for this study is 50.8 years. Majority of sampled respondents (85%) have no formal education. Smallholder women rice farmers' need formal schooling to improve their literacy level and subsequently the ability to read and comprehend concepts especially instructional labels on agricultural inputs and technologies.

Table 2. Descriptive statistics of the socio-demographic profile of respondents

Variable	Minimum	Maximum	Mean	Standard Deviation
Age of Farmer	26	65	50.8	9.28
Farm Size (hectares)	0.11	2.2	1.9	1.07
Annual Off-farm Income	0	1630	632.48	162.91
Farming Experience	1	45	20.45	12.7
№ of Economic Activities	1	6	2.34	0.99

3.2 Adoption of Indigenous and Researched-based Climate Related Adaptation Strategies

Eleven (11) indigenous strategies were identified to be widely practised by smallholder women rice farmers in the Northern Region of Ghana to adapt to climatic stresses. These indigenous practices were categorized into four major groups, namely, crop-related strategies, soil-related strategies, cultural practices related strategies and other indigenous related strategies. The proportion of farmers using each main and specific indigenous adaptation strategy are presented in Tables 3 and 4 respectively.

Table 3. Categories of indigenous adaptation strategies used by smallholder women rice farmers

Main indigenous adaptation strategy category	Frequency	Percentage of sample using strategy (%)
Crop Related Strategies	39	15
Soil Related Strategies	143	55
Cultural Practice Related Strategies	43	16.5
Other Related Strategies	35	13.5
Total	260	100

Mixed cropping and the use of indigenous rice varieties are the specific crops related to indigenous strategies used by smallholder women rice farmers in the Northern Region. Under soil related strategies, four specific indigenous practices were identified and include loosing of the soil surface, creating water bunds and/or drainage channels in their farms and the use of inorganic fertilizer or manure. Loosing of soil is not only the most popular soil related strategies but also the most widely used indigenous adaptation strategies by smallholder women rice farmers in the Northern Region with 87.7 per cent of sampled farmers reported using the strategy. About 75.4 per cent of farmers interviewed reported creating bunds (tie ridging) in their farms to conserve water especially in periods of drought and/or create drainage channels in their farms to prevent flooding in times of floods resulting from high rainfall.

About 38.5 per cent of sampled farmers also reported applying inorganic fertilizer or manure (mostly source from animal droppings) in their farms to enrich soil fertility for high yield. Regular or early weeding, land rotation and prayers are the three specific cultural practices related strategies with 93.5 per cent, 61.9 per cent and 13.4 per cent of respondents using them respectively. Any other indigenous adaptation strategy used by smallholder women rice farmers in the Northern region which cannot be classified into any of the above three main categories of strategies are classified under other related indigenous adaptation strategies as a fourth main category. This research identified early or late planting and timing of rain as the predominant other related indigenous strategies with 82.3 per cent and 73.8 per cent of sampled farmers reported using the two strategies respectively. Overall, most farmers (55%) reported using soil related strategies as means of adapting to climatic stress. About 16.5 per cent, 15 per cent and 13.5 per cent of sampled farmers reported using cultural practice related, crop-related and other related indigenous strategies respectively.

This study identified sixteen (17) predominantly used specific research-based adaptation strategies by smallholder women rice farmers in the Northern Region of Ghana to adapt to climatic stressors. Tables 5 and 6 present the main categories and specific research-based adaptation strategies respectively adopted by smallholder women rice farmers in the Northern Region.

Improved variety strategy is the first main category of research-based adaptation strategies. This consists of three specific adaptation strategies namely high yielding varieties, early maturing varieties and drought/flood resistant varieties. About 68.1 per cent of sampled farmers reported using early maturing rice varieties. Inorganic or chemical fertilizer, compost, herbicides, insecticides and plough back of rice straw after harvest are the five specific strategies comprising the soil and plant health-related main strategy. Approximately 80 percent of sample farmers testified using herbicides on their farms to control weeds; 65.0 percent of farmers interviewed stated using compost, 74.6 percent consented using inorganic fertilizer in their farms to boost soil nutrients for their rice plants,

Table 4. Specific indigenous adaptation strategies used by smallholder women rice farmers

Main Category	Crop Related Strategies	% using strategy	Soil Related Strategies	% using strategy	Cultural Practice Related Strategies	% using strategy	Other Related Strategies	% using strategy
	(1)		(2)		(3)		(4)	
	Mixed Cropping	71.2	Loosing of Soil	87.7	Regular or early weeding	93.5	Early or late planting	82.3
Specific Indigenous Strategies			Creating bunds or drainage channels	75.4				
	Indigenous Variety	67.3	Organic fertilizer	38.5	Land rotation	61.9	Timing of rain	73.8
					Prayers	13.4		

Table 5. Categories of research-based adaptation strategies used by women rice farmers

Main research-based adaptation strategy category	Frequency	Percentage of sample using strategy
Improve Variety Strategies	51	19.6
Soil and Plant Health-related strategies	81	31.2
Husbandry practices strategies	60	23
Other research related strategies	35	13.5
No Adoption of Research-Based Strategy	33	12.7
Total	260	100

58.1 percent spray insecticides on their farms to manage insects, and 35.8 percent of sampled farmers plough back rice straw in their farms after harvesting to decompose and enrich soil fertility for subsequent planting seasons.

The third main adaptation strategy category is husbandry practices strategies and consists of five specific strategies namely harrowing, creating earth bunds, planting during recommended periods, dibbling and timely harvest of crops. About 75.0 per cent of samples farmers reported constructing earth bunds in their farms as conservative agricultural practice to adapt to climatic stress. About 80.0 per cent, 62.3 per cent and 63.5 per cent of farmers interviewed reported planting during recommended periods by agricultural extension officers, harrowing their farmland after ploughing, and harvesting their food products at the appropriate time respectively. About 88.5 per cent of sampled farmers reported using dibbling rather than broadcasting rice seeds on their farms. Dibbing reduces seed wastage and ensures right spacing.

Four dominant other related research-based adaptation strategies practised by smallholder women rice farmers in the Northern Region have been identified. These strategies are planting of trees, irrigation, reduced farm size and establishing fire belts. Almost 71 per cent of sampled farmers testified establishing fire belts around their rice farms to prevent the farms from being guttered by wildfires. Almost 52 per cent of farmers interviewed reported reducing their farm size due to climate stressors. It was revealed during the focus group discussions that women rice farmers deliberately reduce their farm size to ensure effective management and utilization of farm inputs as a way of adapting to climate variability. About 36.2 per cent of farmers consented to plant trees in their farms as a strategy to adapt to climatic stressors. Tree planting replaces the vegetative cover. Though there exist few water bodies in the region, 22.3 of interviewed farmers reported engaging in irrigation especially during the off-rainy season. In all, 31.2 per cent of farmers interviewed considered the use of soil and plant health-related strategies, 23.0 per cent uses recommended agricultural practices, 19.6 per cent of sampled farmers reported using improved variety strategies, while 13.5 per cent reported using other related research-based adaptation strategies. About 12.7 per cent of sampled farmers reported not adopting any research-based adaptation strategy.

Table 6. Specific research-based adaptation strategies used by smallholder women rice farmers

Main Category	Improve Variety Strategies (1)	% of sample using strategy	Soil and Plant Health-related strategies (2)	% of sample using strategy	Husbandry strategies (3)	Sample % using strategy	Other research related strategies (4)	% of sample using strategy
	High Yielding Variety	66.9	Inorganic fertilizer	74.6	Harrowing	62.3	Planting of trees	36.2
Specific Research-based Strategies	Early maturing variety	68.1	Compost	65	Earth bunds	75	Irrigation	22.3
	Drought tolerant variety	61.5	Herbicides	79.6	Planting during recommended periods	80	Reduced farm size	51.9
			Insecticides	58.1	Timely harvest	63.5	Fire belt establishment	70.8
			Plough back of rice straw after harvest after harvest	35.8	Dibbling	88.5		

3.3 Perceived Effectiveness of Farmers' Strategies in Adapting to Climate Variability

The main indigenous adaptation strategies namely crop related strategies, soil-related strategies, cultural practices related strategies and other indigenous related strategies were ranked by smallholder women rice farmers from the most effective (1) to the least effective (4) in ensuring high yield and food security in spite of climatic stresses. The total rank scores for all the four categories were ascertained with their mean rank scores and the strategy with the least mean rank score (or least total score) was seen as the most effective strategy (Table 7).

The perceived most effective indigenous adaptation strategy to climatic stresses based on the subjective rankings of smallholder women rice farmers was soil related strategies in both districts and also for the pooled sample. Results of the Friedman's two-way analysis of variance statistic without replication by ranks showed that there are significant differences on the perceived effectiveness of the four main categories of indigenous adaptation strategies to adapting to climatic stresses as ranked by smallholder women rice farmers. The chi-square values for both districts and the pooled sample were found significant at 1 per cent as shown in Table 7. These results also imply that there are significant differences in the effectiveness of indigenous adaptation strategies as ranked by smallholder women rice farmers in the Northern region.

The total and mean rank scores for the main research-based adaptation strategies as ranked by women rice farmers are presented in Table 6. In the pooled sample data, the perceived two most effective research-based adaptation strategies from the rankings of smallholder women rice farmers have improved variety and soil and plant health-related strategies with mean ranks of 1.87 and 2.13 respectively (Table 8).

The results of the Friedman's test showed that there are significant differences on the effectiveness of the five main categories of research-based adaptation strategies' to adapting to climatic stressors as ranked by smallholder women rice farmers. The chi square values for both districts and the pooled sample were found to be asymptotically significant at one percent, implying that there are significant differences in the effectiveness of research-based adaptation strategies as ranked by smallholder women rice farmers in the Northern region.

Table 7. Ranking of indigenous adaptation strategies

Adaptation Strategy	Savelugu/Nanton		West Mamprusi		Pooled Sample	
	Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank
Soil Related Strategies	1.86	1^{st}	1.67	1^{st}	1.75	1^{st}
Cultural Practices Related Strategies	2.43	2^{nd}	2.28	2^{nd}	2.34	2^{nd}
Other Indigenous Related Strategies	2.99	3^{rd}	2.9	3^{rd}	2.94	3^{rd}
Crop Related Strategies	2.73	4^{th}	3.14	4^{th}	2.97	$4th$
Friedman's Test Statistics						
N	110		150		260	
Chi-Square	46.767		117.456		155.102	
df	3		3		3	
Asymptotic. Sig.	0.000		0.000		0.000	

Table 8. Ranking of research-based adaptation strategies

Adaptation Strategy	Savelugu/Nanton		West Mamprusi		Pooled Sample	
	Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank
Improve variety strategies	1.8	1^{st}	1.91	1^{st}	1.87	1^{st}
Soil and plant health-related strategies	2.05	2^{nd}	2.18	2^{nd}	2.13	2^{nd}
Husbandry related practices	2.69	3^{rd}	2.59	3^{rd}	2.64	3^{rd}
Other research-based related strategies	3.45	4^{th}	3.32	4^{th}	3.38	4^{th}
No adoption strategy	5	5^{th}	745	5^{th}	4.98	5^{th}
Friedman's Test Statistics:						
N	110	150				260
Chi-Square	291.299	360.153				650.099
df	4	4				4
Asymptotic. Sig.	0	0				0

3.4 Constraints to Adoption of Adaptation Strategies

3.4.1 Constraints to the Choice of Indigenous Adaptation Strategies by Respondents

The results revealed that all nine constraints were faced by farmers in their choice of indigenous adaptation strategies. Approximately 91 per cent of women rice farmers indicated that inadequate fund was the main challenge in their choice of indigenous adaptation strategies. Also, over 70 per cent of farmers reported that lack of irrigation potential, shortage of farm inputs, lack of skills and untimely accessibility of tractor services constrained their adoption of indigenous adaptation strategies (Figure 2). Few women rice farmers deemed land shortage as a constraint to adapting to climate variability because the majority of the respondents were married and easily have access to farmland from their husbands.

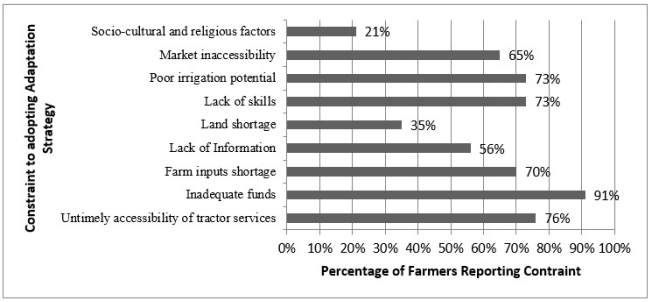

Figure 2. Constraints Militating against the Adoption of Indigenous Adaptation Strategies

Results of ranked constraints by respondents revealed that though there are slight disparities in the order of pressing constraints between the two districts, overall, the five most serious constraints to the choice of indigenous adaptation strategies among smallholder women rice farmers are untimely accessibility of bullock services, inadequate funds, farm inputs shortage, lack of information and inadequate labour (Table 9).

The most pressing constraint hindering the choice of indigenous climate-related adaptation strategies by smallholder women rice farmers in the Northern Region is untimely access to bullock services. Inadequate fund is the second most pressing constraint to choosing an indigenous climate variability adaptation strategy by smallholder women rice farmer in the Northern region of Ghana. Most smallholder women rice farmers are unable to access bullocks to plough their farms at the right time to take advantage of the erratic rains by planting early. About 73 per cent of respondents reported not getting tractors or bullocks to plough their farmlands at the time they need them most.

Shortage of farm inputs is the next important constraint faced by smallholder women rice farmers in the Northern region in choosing indigenous adaptation strate-

Table 9. Ranked constraint faced by respondents in choosing indigenous adaptation strategies

Constraint	Savelugu/Nanton		West Mamprusi		Pooled Data	
	Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank
Untimely accessibility of bullock services	1.9	1^{st}	1.9	2^{nd}	1.9	1^{st}
Inadequate funds	2.24	2^{nd}	1.67	1st	1.91	2^{nd}
Farm inputs shortage	4.35	3^{rd}	3.2	3^{rd}	3.69	3^{rd}
Lack of Information	4.7	4^{th}	5.09	5^{th}	4.93	4^{th}
Insufficient labour force	5.75	6^{th}	4.81	4^{th}	5.21	5^{th}
Land shortage	5.28	5^{th}	5.57	6^{th}	5.45	6^{th}
Unpredictability of rainfall	5.83	7^{th}	6.72	7^{th}	6.34	7^{th}
Market inaccessibility	6.45	8^{th}	7.05	8^{th}	6.8	8^{th}
Sociocultural and religious factors	8.5	9^{th}	8.99	9^{th}	8.78	9^{th}
Kendall's Test Statistics						
N	110		150		260	
Kendall's W^a	0.557		0.79		0.674	
Chi-Square	490.282		947.619		1402.665	
df	8		8		8	
Asymptotic. Significance.	0		0		0	

gies in response to climate-related events. About 33 per cent of respondents complained about not accessing the indigenous high yielding and drought resistant rice varieties in their communities. The fourth constraint to the choice of indigenous adaptation strategies by smallholder women rice farmers in the Northern region is lack of information. The fifth-ranked constraint to the choice of an indigenous adaptation strategy by smallholder women rice farmers is insufficient labour necessary to implement a given indigenous adaptation strategy.

The main source of labour for smallholder women rice farmers in the Northern region is family labour with about 85 per cent of respondents relying on family labour for their farming activities. Consequently, the smallholder women rice farmers are less able to use such indigenous adaptation strategies as regular weeding, ridging, creating drainage channels, and loosing of soil. The research revealed that about 66 per cent of respondents supplements family labour with hired labour in their farming activities. The Kendall's Concordance Coefficient was used to test for the level of agreements of the rankings by smallholder women rice farmers. The results of Kendall's Test showed that the Chi-Square for the pooled sample (x2=1402.665) was significant at 1 per cent with Kendall's concordance coefficient of 0.675 (Table 9). This means that there is a significant 67 per cent agreement among smallholder women rice farmers on the ranking of constraints to the choice of indigenous climate-related adaptation strategies.

3.5 Constraints to Adopting Research-based Adaptation Strategies

All farmers were faced by at least one of the nine constraints in adopting the research-based strategies in adapting to climate variability. The empirical results indicate that about 95 percent, 90 percent and 82 percent of women rice farmers are faced with the challenge of inadequate funds, untimely accessibility of tractor services and poor irrigation potential in adopting research-based adaptation strategies. Figure 3 depicts the prevalence of constraints among women farmers in adopting research-based adaptation strategies.

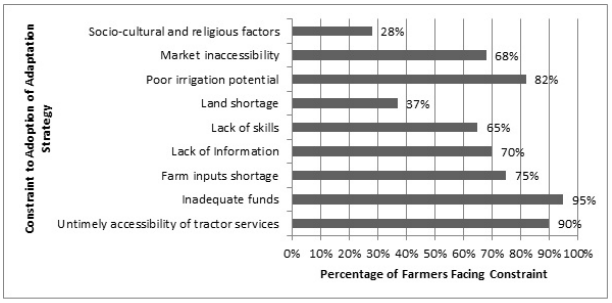

Figure 3. Constraints Faced by Farmers in Adopting Research-Based Adaptation Strategies

Respondents ranking of factors constraining the adopting of research-based adaptation strategies indicate that untimely accessibility of tractor services, inadequate funds, inaccessibility and high cost of farm inputs, and lack of information and inadequate farmer expertise or skills are the five most pressing constraints to the adoption of research-based adaptation strategies among smallholder women rice farmers (Table 10).

The top five pressing constraints to smallholder women rice farmers' adoption of research-based adaptation strategies are inability to access tractor service at the appropriate time, inadequate funds, inaccessibility and high cost of farm inputs, lack of information, and lack of requisite expertise on the part of women farmers necessary to implement a given research-based adaptation strategy. The results of Kendall's Test showed that the Chi-Square value for the pooled sample (x2=1353.513) was significant at 1 per cent with Kendall's concordance coefficient of 0.651 (Table 10). This means there is a significant 65 per cent agreement among smallholder women rice farmers on the ranking of constraints to the adoption of research-based climate-related adaptation strategies.

Table 10. Ranked constraints faced by women rice farmers in Adopting research-based adaptation strategies

Constraint	Savelugu/Nanton		West Mamprusi		Overall	
	Mean Rank	Rank	Mean Rank	Rank	Mean Rank	Rank
Untimely accessibility of tractor services	1.3	1^{st}	1.45	1^{st}	1.39	1^{st}
Inadequate funds	2.36	2^{nd}	2.28	2^{nd}	2.33	2^{nd}
Inaccessibility and the high cost of farm inputs	4.92	4^{th}	4.03	3^{rd}	4.41	3^{rd}
Lack of Information	4.45	3^{rd}	4.75	4^{th}	4.62	4^{th}
Lack of requisite labour expertise	5.09	5^{th}	5.32	6^{th}	5.24	5^{th}
Market inaccessibility	5.87	6^{th}	5	5^{th}	5.38	6^{th}
Poor irrigation potential	5.97	7^{th}	6.15	7^{th}	6.08	7^{th}
Land shortage	6.6	8^{th}	7.08	8^{th}	6.89	8^{th}
Sociocultural and religious factors	8.35	9^{th}	8.9	9^{th}	8.66	9^{th}
Kendall's Test Statistics						
N	110		150		260	
Kendall's W^a	0.605		0.701		0.651	
Chi-Square	531.985		841.353		1353.513	
df	8		8		8	
Asymptotic. Significance.	0		0		0	

4. Discussions

Mixed cropping is the most widely used crop related indigenous strategy among smallholder women rice farmers in the Northern Region. The women rice farmers in this study area reported planting short duration crops such as maize on their rice farms after broadcasting or sawing the rice and before the farms get flooded. Mixed cropping reduces the likelihood of complete crop failure due to the adverse effects of climate variability as different crops require different weather condition for good yields. This is similar to the finding on farmers in South West Nigeria who employed mixed cropping as an adaptation measure to climate change [45]. Also, most farmers in Bangladesh cultivated short duration crops in their rice fields as a climate change adaptation strategy [35].

Smallholder women rice farmers have also identified some traditional rice varieties such as 'mandie' which they deem have high yields in their localities in spite of the erratic nature of the rains and unpredictable temperatures. Loosing of the soil ensures water peculation into the soil and fastens seeds germination. Bund creation (tie ridging) is also widely practised among smallholder women rice farmers as an adaptation strategy to climate variability. The use of contour ridges as a strategy to control soil erosion for better root penetration and soil moisture conservation is common among farmers in the Manyoni District of Tanzania [46]. The use of manure, though is not popular among smallholder women rice farmers, is seen to be an effective strategy for improving soil fertility. This is not different from the findings that farmers in Manyoni District of Tanzania improved soil organic matter by allowing livestock to graze on farmlands after harvesting [46]. Focus group discussion responses revealed that the low usage of manure is due to unavailability of means of transportation to convey animals dropping to farm sites. Regular or early weeding as practised by farmers minimises unnecessary competition between the rice crop and other unwanted plants in the farm for soil nutrients. Land rotation, on the other hand, allows a farmland some fallow period to regain its fertility after it has been continually cultivated for a long time. Farmers indicated during the focus group discussions that the prevalence of drought as a result of a prolonged period without rain and the occurrence of floods due to erratic rains can be explained in the spiritual realm as curses befallen on society as a result of provocation of the gods. Therefore, farmers have to pacify the gods through sacrifice and prayers to unravel such calamity. This confirms an earlier finding that households in the Chiredzi District of Zimbabwe adapted to climate change and variability through prayers and religious festivals [47]. Women farmers early or late planting and timing of rain as other indigenous climate variability adaptation strategies confirm an early report which revealed that most farmers in South West

Nigeria resorted to early or late planting as the main strategy to adapt to climate change [45].

Women farmers' adoption of early maturing rice varieties such as Gesmi (matures 85 days after planting), NERICA 1 and 2; high yielding varieties such as Gbewa rice, NERICA 4; and drought/flood resistant rice varieties such as AGRA rice (matures 120 days after planting) and Digang (matures 110 days after planting) were considerably high. The high adoption level of improved variety by farmers in this study is above the 7.7 per cent of farmers in Ekiti State, Nigeria who adopted improved varieties in adapting to climate change [48]. The reason for the high adoption could be attributed to the high education of farmers by both governmental and non-governmental organisations in the region. On the other hand, the high adoption of inorganic fertilizer and herbicides among women rice farmers in the Northern region could be the results of the Government of Ghana subsidy on fertilizer and other seeds. This finding is congruent with the strategies of farmers in Kamenyanga and Kintinku in Manyoni District of Tanzania who either buried or burnt crop residues to replenish soil fertility [46].

The finding of this study that soil related strategy is the most effective indigenous adaptation strategy is contrary to a report that soil related strategies are the least effective in securing crops yield in Northern Ghana [13]. This means that smallholder women rice farmers agree to the effectiveness of dibbling, loosing of soil, creating bund or drainage channels in their farms and the use of manure in securing high yield as a means of adapting to climatic stresses than any other indigenous strategy. This could be explained by the fact that since the rainfall pattern is erratic and unpredictable, creating bunds to conserve the little water from the few rains or creating drainage channels to avoid flooding as a result of heavy rainfalls and loosing of the soil could be a better means of ensuring the wetness of soil suitable for rice growth than planting early or late, timing the rainfall pattern and weeding regularly. Also, applying inorganic fertilizer on rice farms and dibbling before sowing are surer ways to minimize the impact of climatic stressors than engaging in the land rotation, mixed cropping and sowing indigenous varieties. The least effective category of indigenous strategies was found to be crop related strategies comprising of mixed cropping and the use of indigenous rice varieties. This explains why the majority of smallholder women rice farmers (55%) use soil related strategies while the minority (15%) use crop related strategies. The findings showed that high yielding, early maturing and drought/flood-tolerant varieties are perceived by farmers to be the most effective strategies in adapting to climatic stresses while the use of inorganic fertilizer, compost, herbicides, insecticides and plough back of rice straw after harvest are the second most effective category of research-based adaptation strategies to climate-related events. The idea of not adopting any research-based adaptation strategies was the worst or least option for smallholder women rice farmers' adaptation to climate stresses. In a focus group discussion, it was noted that though improved rice varieties are effective adaptation strategies to climate variability, its' adoption among farmers (19.6%) is not as high as expected due to the inaccessibility and high cost of such varieties. This deviates from an earlier finding by [35] who revealed that irrigation was a preferred strategy than drought tolerant and short duration crop varieties among farmers in Bangladesh for effective adaptation to climate change. This could be attributed to differences in spatial and regional as well as the cost of adaptation strategy.

Most farmers also complained of lack of credit as one of the major challenges to adopting climate change adaptation strategies. Unfortunately, few women farmers were able to borrow money from friends and relatives to support their farming activities. Lack of funds and inadequate farming inputs were identified as pressing constraint to farmers' adoption of climate-related adaptation strategies among farmers in Owo Local Government area of Ondo state in Nigeria [35]. The main source of information on indigenous climate-related adaptation strategies to smallholder women rice farmers is farm-to-farmer extension contacts, especially with highly experienced farmers. Given that some farmers reported not receiving any extension service from their colleagues for the past twelve months makes such farmers ignorant of some indigenous adaptation strategies. This has been identified as one of the pressing constraints to the adaptation of smallholder farmers to the risk of drought incidences in the Chivi District in Zimbabwe [47]. Women farmers who rely on hire labour for their farming activities can sometimes be denied of access to labour because hired labour is not a reliable labour source since most farmers who are often hired are usually busy working on their farms at the time that smallholder women rice farmers need their labour in their farms.

Access to tractor or bullocks for ploughing is also a serious challenge faced by women rice farmers. When rain sets in, the number of farmers wanting to plough their farms far exceeds the number of tractors available. The situation is worst for female farmers as their male counterparts must be served first. The results revealed that about 73 per cent of respondents reported not getting tractors or bullocks to plough their farmlands at the time rain sets in. Most research-based adaption strategies such as inorganic fertilizer, agrochemicals, improved varieties and irrigation involve cost which most women farmers are not able to afford. Unfortunately, formal credit institutions which could assist farmers in financing their farming activities are limited to about 90 per cent of respondents reporting not receiving any credit

facility from any formal credit organisation. This finding confirms the lack of funds to be a major constraint in the adoption of irrigation practices among farmers in the Northern Savannah zone of Ghana [49]. Most smallholder rice farmers (33%) complained about not accessing the high yielding and drought resistant rice varieties, inorganic fertilizer and agrochemicals in their communities. Others also just could not afford to purchase such vital farm inputs due to high prices. High cost and inaccessibility of seeds and fertilizer have been reported to be among the important constraints to its adoption by smallholder farmers in Chivi District of Zimbabwe [47]. The main source of information on research-based climate-related adaptation strategies to smallholder women rice farmers is formal agricultural extension contacts, especially with highly experienced farmers. However, approximately 39 per cent of respondents reported not receiving any extension service from agricultural extension officers and other formal institutions for the past twelve months making them ignorant of some research-based adaptation strategies. This is consistent with the findings of [50]. Some adaptation technologies are quite laborious and require some level of technical skills and knowledge by farmers for effective executions. The main source of such skills to smallholder women rice farmers in the Northern region is education. Undoubtedly, 78.5 per cent of sampled farmers have never been to school and thus cannot read common instructional labels on farm inputs for effective utilization. Also, lack of skills on the part of farmers was identified to be the major hindrance to the adoption of irrigation technologies among farmers in Northern Ghana is a serious challenge to adopting climate change-related adaptation strategies [49, 51].

5. Conclusions and Recommendations

The indigenous adaptation strategies used by women rice farmers are soil related strategies, cultural practices related strategies, crop-related strategies and other indigenous related strategies; and the research-based adaptation strategies also include improved variety strategies, soil and plant health-related strategies, recommended agricultural practices and other research-based related strategies. Also, whereas soil related strategies (loosing of soil, creating bunds or drainage channels, and organic fertilizer) are perceived to be the most effective indigenous adaptation strategy; improved variety strategies (high yielding varieties, early maturing varieties and drought/flood resistant varieties) are perceived to be the most effective research-based adaptation strategies.

Finally, the major constraints militating against the adoption of indigenous and research-based adaptation strategies among smallholder women rice farmers are untimely access to bullock and tractor services, inadequate funds, shortage and high cost of farm inputs, and lack of relevant information. This study provides the following recommendations. First, it is imperative that the agricultural extension officials of the Ministry of Food and Agriculture should intensify engagements with smallholder women rice farmers by educating them on effective agronomic practices while encouraging farmer-to-farmer extension services to promote the adoption of research-based adaptation strategies to complement indigenous adaptation strategies. Second, smallholder women rice farmers in the various communities of the region should also form groups and through MoFA and other agriculture-based NGOs (e.g. Market for Development - MADE) be connected to the appropriate credit sources, and skill upgrading opportunities on modern agronomic practices to enable them to minimize their vulnerability to climate variability. In this respect, smallholder women rice farmers should use their groups as collateral to acquire mini tractors on hire purchase basis since they lack individual purchasing power. Finally, the Micro-Credit Unit of the District Assemblies and Non-governmental institutions should provide credits in the form of farm inputs especially improved rice seeds varieties and inorganic fertilizer to enable farmers to effectively adapt to climate variability. In line with this recommendation, women should be given priority in the on-going input credit scheme of the planting for food and job social policy of the government.

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