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Resilient Dryland System

Gendered Analysis of Stakeholder Perceptions of Climate Change, and the Barriers to its Adaptation in Mopti Region in Mali

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Abstract

The current study presents the farmer and community perceptions of the causes and effects of climate change, the barriers to adoption of the resilient practices, and the present level of practices adoption in Mopti region in Mali, paying special attention to the gender of household head and farming systems in the region.

The study results show that the majority of farmers perceive changes in climate in the past 10-20 years and that female-headed household in the region are more vulnerable to climate change. Strategies to adapt to climate change are diversified, but as expected, the proportion of adopting households is lower among the female-headed households than their male counterparts. The most commonly cited constraints to climate resilient practices adoption are low agricultural productivity, declining soil fertility and poor seed quality. However, female headed households have to withstand specific barriers including lack of finances, labor shortages and lack of access to land. Adoption of adaptation technologies was also assessed in various farming systems. The more diversified a farmer's system is, the more climate resilient it is. Farmers' reports that the most important adaptation methods influencing positively crop yield are mixed farming, irrigation, fertilizers and improved seed varieties. Crop yields, livestock units owned and per capita income significantly increase through technology diversification, but no clear relationship was observed with respect to food security indicators.

In summary, the farming systems in the area are diversified but in order to have a more adaptive and resilient system, there is a need to design and implement inclusive locally adapted strategies promoting mixed farming and crop diversification, including use of improved crop varieties and soil fertility management. The lack of labor and finance, and lack of access to land and to adapted livestock breeds is also an important barrier to climate resilient strategies, in particular for female farmers. There is a need to implement innovative and inclusive credit schemes to increase farmers' liquidity and capacity to invest in climate change adaptation. Increased adoption of climate resilient practices can also be enhanced by integrating climate change and agro-meteorological forecasts in the current extension and advisory services. Finally, improving local nutritional skills through enhanced diets could increase climate resilience by augmenting food security.

Gendered Analysis of Stakeholder Perceptions of Climate Change, and the Barriers to its Adaptation in Mopti Region in Mali

Technical Document Produced for the USAID Funded Project on Global Climate Change Program "Disseminating learning agenda on resilient-smart technologies to improve the adaptive capacity of smallholders farmers in Mopti region, Mali"

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Executive Summary

The current study presents farmer and community perceptions of climate change, and the barriers to adoption of climate resilient practices in Mopti region in Mali, paying special attention to gender and farming systems in the region. In particular, the study analyzed perceptions of causes and effects of climate change, adoption of climate resilient practices, and the barriers to adoption of the practices, paying special attention to male and female headed households. The study results show that majority of farmers perceive changes in climate in the past 10-20 years. However, many farmers do not know the actual causes of climate change. The most common changes in climate cited by farmers include stronger and violent winds, increased temperature, poor rainfall pattern and reduced vegetation cover. The study results show that female headed households in the region are more vulnerable to climate change. Both female and male headed farmer households in the region use diverse strategies to adapt to climate change. The most common ones include livestock diversification, crop diversification, mixed farming, use of fertilizers, utilization of weather forecast information in agriculture, and implementation of soil and water conservation measures. The proportion of adopting households is however; lower among the female headed households than their male counterparts. The main barriers to adaptation particularly cited by female farmers are associated with lack of finances, labor shortages and lack of access to land.

A Poisson regression model was used to determine the factors influencing the number of farm-based adaptation methods used by an average farmer to adapt to perceived climate changes. The results show that households headed by males were more likely to use more adaptation practices compared to their female counterparts. Other factors that appear to influence adoption behavior include crop land size, neighborhood effects, participation in non-farm income generation, and perception of the benefits of adaptation practices, land ownership, and farming system where the farmer resides.

The study further examined the relationship between adaptation methods and selected livelihood indictors. The results show that the level of percapita income, crop yields and livestock units owned by a household generally increase with the number of technologies adopted. However, no clear relationship was observed with respect to food security indicators. A yield function was also estimated to determine the effect of the number of adaptation methods on crop yield; the results show that crop yields significantly increase with the number of technologies adopted. With regard to the farming systems, the number of adaptation methods used exhibit positive and significant effect on crop yield in the mixed and dry systems but insignificant in the rice system. The study further examined the individual effects of the various adaptation methods on crop yield, and the results show that irrigation, mixed farming, use of fertilizer, use of improved seed varieties appear to be the most important methods for climate change adaptation.

The findings from this study provide some key lessons for policy makers and institutions engaged in agricultural development in Mopti region. There is need to design and implement inclusive strategies that: promote and encourage mixed farming, crop diversification in both male and female headed households, in order to mitigate rising climate related risks and to improve food security and household incomes; promote and encourage use of improved crop varieties and fertilizers by both male and female headed households; promote and encourage adaptive and improved livestock breeds, and livestock diversification. Measures that increase access to land for both male and female farmers are also important for increasing adoption of climate resilient strategies. There also need to implement innovative and inclusive credit schemes (low-interest credit facilities) to increase liquidity farmers (especially the female farmers who lack collateral), to invest in climate change adaptation. Adoption of climate resilient practices can also be enhanced by integrating climate change in the current extension and advisory services. Finally, the increase of food security could be based on the improvement of nutritional skills and on the implementation of improved recipes taken into consideration existing improved varieties specific qualities and the present availability of local food linked to climate change.

1. Introduction

Climate change remains a major development challenge in developing countries, particularly in the Sub-Saharan economies, including Mali. The majority of the population in these economies reside in the rural areas and derive their livelihoods directly from the agriculture sector. Sustained livelihood improvements in many of the rural communities will require implementation of inclusive interventions that promote adaptation of the agricultural sector. In particular, strategies for effective climate change adaptation and mitigation need to be gender inclusive, targeting both male and female farmers. This is especially important in the Sub-Saharan African countries, where female farmers form the majority of the non-adopters of technologies, yet they contribute at least half of the agricultural labor force in these economies (FAO 2011). However, formulation of robust policy interventions and programs aimed at promoting adaptation strategies for the agricultural sector require a better understanding of how male and female farmers perceive climate change; the adaptation measures used by female and male farmers; their perceived effects of climate change and the barriers to climate adaptation.

This report presents farmer and community perceptions of climate change in Mopti region in Mali with two objectives:

1. To draw lessons from the experience of farmers, community leaders and local organizations in meeting the 'Global Climate Change' (GCC) project's objective of disseminating learning agenda on resilient-smart technologies to improve the adaptive capacity of male and female headed farmer households in the region.
2. To assess the best adaptation practices used by male and female headed farmer households in the region and the barriers to climate change adaptation.

2. Methods and Materials

2.1 Data Types and Sources

This report utilized the baseline survey data collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in 2014 in Mopti region in Mali. The data collection covered three farming systems in the region. These include the rice farming system, the dry cereals farming system and the mixed farming system. The farming systems were categorized according to the main crops grown by the farmers. The dry farming system comprises villages known for producing dry cereal crops (sorghum/millet). These include Diallassagou, Nene, Koro, Dioungani peulh, Dioungani Dogon, Ounouna, Ogotena and Mandougou. The rice farming system comprises rice producing villages including Neima, Sare-Mala and Kolonie. The mixed farming system covers villages known for production of both rice and dry cereals including Kouna, Somadougou, Soufouroulaye and Youre villages.

The survey collected data from individual farmer households, community members (at the village level) and experts working with institutions and non-government organizations in the region. The baseline survey covered a sample of 297 farmer households, 16 NGOs and 11 Focus group discussions (FGDs) from eleven villages.[1] The sample of individual households comprises 13% female and 87% male headed households, a proportional representation of the actual heads of households in the region. The composition of the male and female headed households included in the survey is presented in Table 1. Data were collected using semi-structured questionnaires, which captured relevant variables including the farmer perceptions of climate change, adaptation mechanisms, crop and livestock production in the respective farming systems, and the socio-economic and demographic characteristics of households.

1. After cleaning the data, the final sample stood at 281 farmer households.

Table 1. Composition of female and male headed households (means).		
Variable	Male headed	Female headed
Number of male children below 14 years	3	2
Number of females below 14 years	2	2
Number of males between 14 and 18 years	1	1
Number of male children between 14 and 18 years	1	2
Number of males between 18 and 65 years	3	3
Number of females between 18 and 65 years	2	2
Number of members above 65 years	1	1
Household size	14	13

Focus interviews were also conducted. These consisted of village level semi-structured group discussions moderated by a neutral facilitator in the presence of an observer. The group consisted of the village chief, village counselors, women representatives, youth representatives and any other person involved in decision making. The facilitator uses a questionnaire to collect participant's point of view and harmonize interviews between villages. The moderator creates the best possible conditions so that participants feel comfortable articulating their views and discussing aspects opposing or connecting group members. Group dynamics allow exploring and stimulating different perspectives permitting the direct expression of sometimes-unexpected social, cultural and/or religious beliefs and assessing experiences, needs, expectations and representations issues.

2.2 Data Analysis

The data were analyzed by farming system and gender of the head of the household. Descriptive statistics such as means, standard deviation, frequencies and percentages were computed for the relevant variables. Analysis of variance (ANOVA) with Bonferroni adjustment test was performed to examine the variations in mean values across the three farming systems. Independent samples T-tests were also performed to determine the mean difference between male and female headed households.

In addition, regression models were estimated to analyze farmer climate adaptation behavior and the effects of climate change adaptation on agricultural productivity. In particular, a count model (Poisson) was estimated to analyze the factors that influence the number of adaptation methods used by an average farmer in the region. Furthermore, a yield function was estimated using ordinary least squares (OLS) to determine the effect of adaptation methods on crop productivity.

3. Results and Discussion

3.1 Awareness, Knowledge and Practices to Mitigate the Effects of Climate Change

This section explores questions regarding how farmers and other stakeholders in Mopti region, Mali, actually perceive climate change, vulnerability to climate change, causes and effects of climate change, and what motivates them to adapt to climate change. Understanding how farmers (and other stakeholders in the agriculture sector) perceive climate change is important for designing and implementing programs aimed at promoting robust adaptation strategies for the agricultural sector. Bryan et al., (2009) argue that farmers first perceive that changes in climate are taking place before they may adapt to the changes.

3.1.1 Awareness and Perceptions of Climate Change

3.1.1.1 Individual Farmer Perceptions of Climate Change

Table 2 shows results of farmers' perceptions of climate change in Mopti region. The survey results show that at least half of the farmers interviewed perceive that climate has changed over the past 10-20 years. Stronger and violent winds was the most reported climate event among the interviewed households (cited by 83.3%), followed by increased temperature (by 74%), reduced rainfall (by 56.6%), and reduced vegetation cover (by 52.7%). A similar pattern in perceptions is noted across the three farming systems with 75.9% of farmers in the rice system, 86.4% of farmers in the dry cereals system and 83.1% of farmers in the mixed system reporting stronger and violent winds over the past 10-20 years. Reduced vegetation was the least reported climate change event in all the farming systems (Table 2).

With regard to gender, there are no significant differences in perceptions of climate change between male and female headed households in the different farming systems (Table 3). Male headed households in all the farming systems mainly reported increase in temperature, and stronger and violent winds as the main climate events. The pattern is similar for the female headed households except those from the mixed farming system; here, they perceived reduced vegetation cover and increased temperature as the main climate events.

Table 2. Perceptions of climate change over the past 10-20 years, by farming system.

	All households (n=281)		Rice system (n=58)		Dry cereals system (n=140)		Mixed system (n=83)	
Climate Event	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Wind is stronger and violent	234	83.3	44	75.9	121	86.4	69	83.1
Temperature has increased	210	74.7	39	67.2	106	75.7	65	78.3
Rainfall has reduced	159	56.6	23	39.7	92	65.7	44	53.0
Vegetation cover has reduced	148	52.7	22	37.9	89	63.6	37	44.6

Source: Household survey data

Table 3. Perceptions of climate change over the past 10-20 years, by farming system and gender.

	Rice faming system (n=58)				Dry cereals system (n=140)				Mixed system (n=83)			
	Female headed		Male headed		Female headed		Male headed		Female headed		Male headed	
Temperature	n	%	n	%	n	%	n	%	n	%	n	%
Winds stronger and violent	6	54.5	38	80.9	11	73.3	110	88	8	72.7	61	84.7
Temperature has increased	7	63.6	32	68.1	9	60.0	97	77.6	5	45.5	60	83.3
Rain has reduced	5	45.5	18	38.3	7	46.7	85	68	7	63.6	37	51.4
Vegetation cover has reduced	5	45.5	17	36.2	8	53.3	81	64.8	8	72.7	29	40.3

3.1.1.2 Community Level Perceptions of Climate Change

Table 4 presents the results of the village level survey (focus group discussion) and the NGO survey of expert perceptions of climate change in the region. The village survey data revealed that all the sampled villages have, over the past 20 years, experienced increase in temperature, stronger and violent winds, and declines in surface water due to high temperature, and scarce and poor rainfall distribution. Other important climatic events noted by the community include late start of rain seasons (in seven villages), which are shorter than before (in five villages).[2] These results are further emphasized by the opinions of the experts working with NGOs in the communities, who cited poor rainfall distribution (by 87%) and strong and violent winds as the main changes in climate in the region (Table 4).

3.1.1.3 Perceived Causes and Effects of Climate Change in Mopti Region

Although a majority of farmers are aware that climate has changed, many of them lack a clear understanding of the causes of climate variability. Only 22% of the interviewed farmers perceive that climate change is caused by inadequate rains. Majority of the farmers (61%) did not know the actual cause of climate change, and 15% believed that the changes in climate were due to supernatural powers

Table 4. Changes in climate events perceived at the community and institutional levels.

	Village Survey (n=11)		NGO Survey (n=16)	
Climate Change Event	n	%	n	%
Quantity of rainfall				
Quantity of rainfall received has decreased	8	72.7	n/a	n/a
Quantity of rainfall received varies from time to time	3	27.3	n/a	n/a
Quantity of rainfall received has increased	1	9.1	n/a	n/a
Seasonality of rains				
Rain season is very short	7	63.6	n/a	n/a
Rain season starts late	5	45.5	n/a	n/a
Rain season starts early	2	18.2	n/a	n/a
No change in the season	1	9.1	n/a	n/a
Rainfall distribution				
Rainfall is poorly distributed	11	100.0	14	87.5
Changes in temperature				
Temperature has increased/drought	11	100.0	4	25
Wind speed and force				
Wind is stronger and more violent	11	100.0	10	62.5
Tree population				
Forest cover/tree population has declined	10	90.9	n/a	n/a
Forest cover/tree population has increased	1	9.1	n/a	n/a
Water surface				
Water has reduced (rare cases of floods; ponds have dried up)	11	100.0	n/a	

Source: Village survey and NGO survey, 2014

2. As noted earlier, the survey covered eleven villages across the three farming systems.

(the wrath of gods) (Figure 1). These results generally show that many farmers in the region still lack knowledge and awareness on the causes of climate change. Farmers need to have proper knowledge and understanding of the real causes before they may decide to adapt to climate change. Therefore, institutions and programs promoting adaptation methods in the region need to design communication strategies that create public awareness on this issue.

With regard to the impacts of climate change, a majority of the farmers (96%) interviewed indicated that climate change variability affected their farming activities. The perception is most common among households in the mixed farming system (reported by 99%) followed by rice and dry cereals farming systems, respectively. In all the farming systems, more female headed households (compared to those headed by males) indicated that climate change had affected their farming activities (Fig. 2).

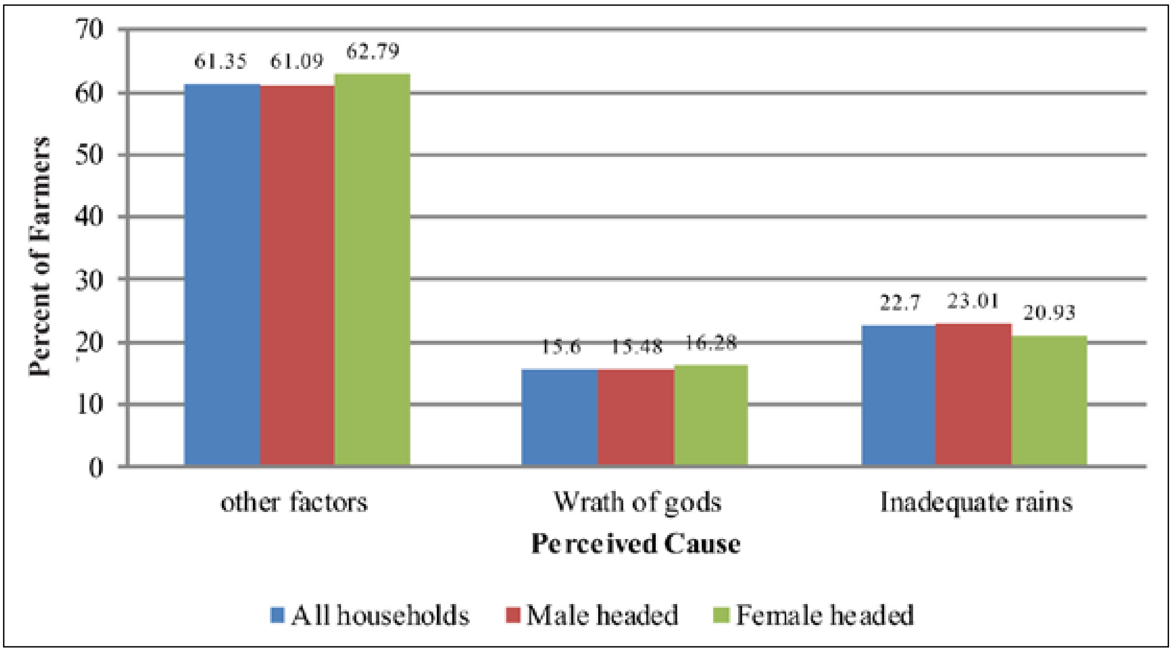

Figure 1. Perceived causes of climate variability, by gender.

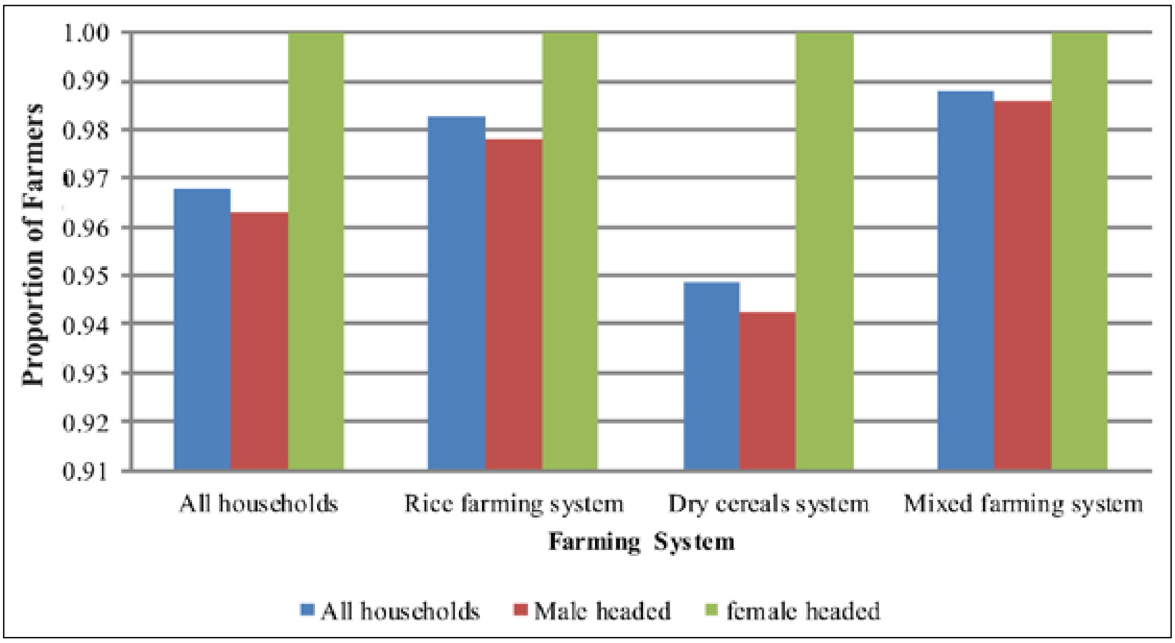

Figure 2. Influence of perceptions of climate variability on farming activities.

Table 5 presents the results of the village and NGO surveys on how the effects of climate change are perceived. At least 10 village focus group discussions indicated that climate change had increased poverty in their community and reduced the purchasing power of households. In the same line, the NGO expert

Table 5. Community level perceptions of the effects of climate change.

Perceived effect	Village survey		NGO survey	
Reduced purchasing power	10	90.9	6	37.5
Food insecurity and malnutrition	5	45.5	13	81.25
Low yields	5	45.5	5	31.25
Losses in livestock	2	18.2	n/a	n/a
Rural-urban migration	1	9.1	n/a	n/a

Source: Village Survey and NGO survey, 2014

interviews revealed that food insecurity and malnutrition had increased in the communities. Other climate change effects reported by the community include: loss of livestock and low agricultural productivity, which were mainly attributed to rampant land degradation caused by extreme weather events such as droughts and floods, aggravated by poor land-use practices as well as increased pest infestations and other weather related pathogens.

Case Study 1. Climate Change is Due to the Wrath of God

Moussa Bouaré is an illiterate, 75-year-old farmer heading a family of 13 persons. His expanded family cultivates rice, sorghum, millet and cowpea. The cropping season activities begin with an animal traction ploughing and the sowing is generally done in June. Moussa's family has four cattle and 15 goats, one horse, and two asses, which are partly fed through seasonal transhumance. In the dry season, the main animal feed is bourgou (Echinochloa stagnina (Retz.) P. Beauv.), a perennial semi-aquatic tropical grass. His family has difficulties accessing food in August and September, before the harvest. However, they eat three meals per day at any time of the year. Most of the cereals, legumes, meat and milk come from their own produce. In addition, they collect wild products and wood for fuel. As a consequence, Moussa states that he has been able to send five children from his family to school, to build infrastructure in his house or farm, to contribute to social events, to pay for health care and to buy more food.

The main constraints he detects to his family's climate resilience are low yields, poor rains, lack of quality seed, poor soils and rainfall distribution. Moussa and his family consider themselves very vulnerable to flood, drought, unpredictability in the onset of the rainy season and strong winds. In addition, he says that he has tried to improve his family's resilience by cropping gardens but this has not worked because their well broke down. Moussa thinks climate change is due to the wrath of God. He explains that climatic vagaries are discussed in the mosque and that Islam suggests that human beings should change their behavior to set things right. He says, "Men do not love each other anymore [as it is demonstrated by] conflicts between villagers, separation of families and illegal deforestation". Moussa says that, besides climate change, he has experienced the wrath of God on various occasions in his life such as in the case of illnesses, death of family members and the birth of an excessive number of daughters while "if they were boys we would have more useful arms".

At being asked what methodologies he would use to overcome climate change assuming that climate change was not caused by the wrath of God but could be managed at the family scale, Moussa declared that he would stop cutting trees of certain species such as *Faederbia albida* and *Balanites Aegiptica*. Also, he said he would use compost to improve soil fertility. Based on this discussion, it could be argued that Moussa is not carrying out measures necessary to be more resilient to climate change. However, this is not the case. On the contrary, Moussa already applies some of the best science-proved technologies. He uses improved seed, compost, mineral fertilizers and pesticides. External inputs are used when a distributor is available, even these inputs are not easily accessible in the area. He also uses fertilizers if he can obtain them from the government although access is very complicated and usage is rare (the fertilizer and pesticide market are at 7 and 10 km from his village respectively). To overcome climate change, he also seeks information about weather forecasts from neighbors and others in the village. In addition, during drought periods, he receives assistance and input from NGOs.

3.1.1.4 Vulnerability to Climate Variability and the Severity Weather Shocks

3.1.1.4.1 Perceived Vulnerability of Households and Communities to Climate Change

Figure 3 presents farmer perceptions of vulnerability to climate change in Mopti region. At least 95% of the interviewed households indicated that they were susceptible to climate variability; a majority of these households were from the dry cereals systems followed by the mixed and rice farming systems, respectively. This result is expected because of the limited agriculture production activities in the dry farming system relative to the rice and the mixed systems. Households engaged in the rice system, for example, may feel less vulnerable to the effects of climate change because they are more food secure and are able to generate incomes from the rice and other agricultural enterprises that may thrive in the system. The results further show that female headed households are more likely to feel vulnerable to climate change than those headed by the males in all the farming systems.

The surveys also collected data about the groups of people perceived by the community to be most vulnerable to the effects of climate change. The results are presented in Table 6 and Figure 4. The households interviewed mainly cited the sick (by 47%), children (by 47%) and the old (by 45%) as the groups in the region that were likely to be most vulnerable to climate change. It is quite surprising, however, to find that only a few households cited women (by 28%) and the disabled (21%) as a vulnerable group to climate change. Nonetheless, the NGO experts interviewed (about 75%) considered the female members of the community one of the most vulnerable groups in the region, alongside children (view held by 81%), and the elderly or the seniors in the community (cited by 56%) (Figure 4). Children and the elderly are vulnerable to climate change mainly because they are physically weak and thus unable to engage in productive work. Similarly, one would expect women in the study area to be vulnerable to

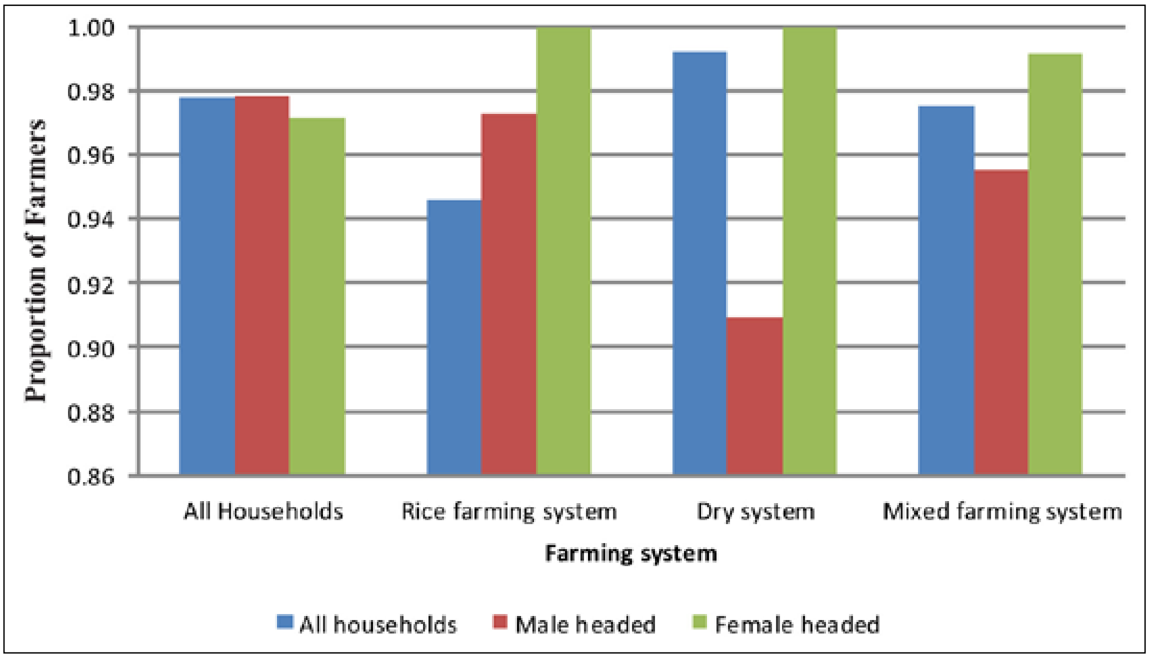

Figure 3. Proportion of households feeling vulnerable to climate change

Table 6. Groups of people vulnerable to climate variability as identified by farmers.						
	Pooled sample		Male headed		Female headed	
Vulnerable group	n	%	n	%	n	%
Sick people	128	47.41	104	43.33	24	64.86
Children	128	47.41	120	50.00	8	21.62
Elderly	124	45.93	115	47.92	9	24.32
Women	78	28.89	57	23.75	2	5.41
Men	60	22.22	58	24.17	2	5.41
Disabled	59	21.85	74	30.83	4	10.81

Source: Individual household survey

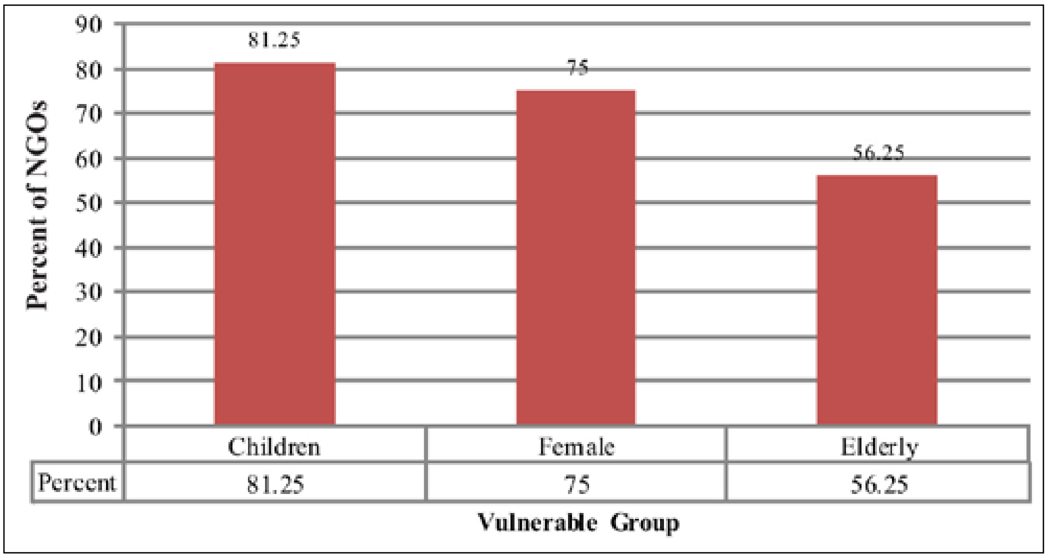

Figure 4. Most vulnerable groups as identified by NGOs

the effects of climate change because many of them have limited access to and control over productive resources, particularly land and liquid capital needed to invest in climate adaptation. Further, many women do not control revenues from agricultural production; as yet non-farm income generating opportunities are scarce in the villages. Development interventions that empower women and those that promote creation of income generation may, thus, be important in climate change adaptation.

3.1.1.4.2 Perceived Degree of Vulnerability to Climate Variability

In this report, the degree of household vulnerability to climatic change and variability was measured using weather shock indexes. The indexes were constructed following Diiro and Sam (2015) for each of the weather events reported by the households. These included flood, drought, strong winds and change in onset of rainfall and other shocks. An index for an individual weather event was derived as the sum of the scores corresponding to frequency of the event, severity of the event, degree of effect of the shock and the degree of difficulty to the household due to the event. Each of these indicators had a maximum score of 4 – corresponding to the worst case scenario of the event. The average index was constructed by summing up the scores of the five climate events, normalized by 60 – the maximum aggregate score of all the events reported. The indexes take values from 0 to 1, corresponding to favorable weather and severe weather conditions, respectively. Table 7 reports the constructed vulnerability index for the different weather events. Analysis of variance and the Bonferroni test were performed to determine the differences in the mean indexes among the three farming systems.

Table 7. Mean Vulnerability Index by farming system in Mopti region.

Weather shock index	All households	Farming system				
		Rice system	Dry system	Mixed system	F-Statistic	P-value
Index for change in Rain pattern	0.73 (0.24)	0.73[a] (0.20)	0.70[a] (0.27)	0.77[a] (0.19)	1.77	0.17
Index for drought	0.72 (0.30)	0.77[a] (0.22)	0.68[a] (0.30)	0.74[a] (0.33)	1.68	0.19
Index for violent winds	0.64 (0.26)	0.57[a] (0.19)	0.64[ab] (0.30)	0.69[b] (0.21)	3.70	0.03
Index for flood	0.53 (0.34)	0.56[ab] (0.23)	0.46[a] (0.36)	0.61[b] (0.36)	4.34	0.01
Index for other Shocks	0.17 (0.30)	0.40[a] (0.35)	0.06[b] (0.20)	0.22[c] (0.33)	16.31	0.00
Index for all shocks combined	0.49 (0.14)	0.48[a] (0.11)	0.46[a] (0.14)	0.56[b] (0.15)	15.64	0.00

Note: standard deviation in parentheses, common superscripts in rows indicate equal mean values

The results show that the three farming systems are significantly different from each other with respect to the various weather shock indexes, except shocks associated with rain and drought. For example, the mean index for all shocks is significantly higher in the mixed farming system (0.56) than for the rest of the farming systems; but there is no significant difference between the rice farming system and the dry cereals farming system. This result suggests that households residing in the mixed farming system are, on average, more vulnerable to climate change than those in the other systems.

In terms of individual weather shocks in the farming systems, the results show that the severity of floods is comparable between the rice and the mixed farming systems. However, the mixed farming system is significantly more vulnerable to floods than the dry cereals system, which is in turn significantly less vulnerable than the rice system. Furthermore, severity of wind violence is comparable between the rice system and the dry cereals system, and between the dry cereals system and the mixed system but significantly lower in the rice system than the mixed system. The results also show differences among the three farming systems with respect to other shocks – with the rice system registering a higher degree of vulnerability followed by mixed and the dry cereals systems, respectively.[3]

Table 8 presents the mean weather shock indexes by gender in the three farming systems. The index for all shocks is higher among female headed households than male headed households in the rice system, but comparable in the rest of the farming systems. These results generally show that female headed households in Mopti region are very vulnerable to weather events. This is further emphasized later in the document in the section that discusses socio-economic factors that are likely to contribute to high vulnerability to climate change.

3.2 Adaptation to Climate Change in Mopti Region

Adaptation to climate change has recently received significant attention from both researchers and policymakers, mainly focusing on how to increase the capacity of communities, regions and countries to respond to a range of possible impacts of climate change (eg, Antwi-Agyei et al. 2013; Bryan et al. 2009; Boyd et al. 2013; Dasgupta and Baschieri 2010; Kithia 2011; Mary and Majule 2009). This section explores the strategies used by households in Mopti region to adapt to the effects of climate change. It also identifies the interventions and strategies institutions are implementing to help reduce the specific impact of climate change in the region. This information will be important for the formulation of effective policies and interventions for climate adaptation in the region.

3. The survey questionnaires did not list the types of shocks that fall under the category "other shocks".

Table 8. Mean Vulnerability Index, by farming system and gender in Mopti region.						
	Male farmers		Female farmers			
Farming system	Mean	Std. Dev.	Mean	Std. Dev.	T-statistic	P-Value
Rice system						
Index for change in rain pattern	0.71	0.21	0.83	0.16	1.68	0.098
Index for drought	0.74	0.23	0.88	0.14	1.56	0.128
Index for violent/strong winds	0.55	0.18	0.65	0.23	1.51	0.137
Index for flood	0.51	0.21	0.72	0.25	2.39	0.022
Index for other shocks	0.44	0.35	0.22	0.30	-1.29	0.209
Index for all shocks combined	0.46	0.09	0.55	0.14	2.54	0.014
Dry cereals system						
Index for change in rain pattern	0.68	0.30	0.70	0.30	-0.28	0.781
Index for drought	0.44	0.35	0.62	0.40	0.21	0.831
Index for violent/strong winds	0.71	0.28	0.69	0.26	-1.43	0.156
Index for flood	0.57	0.14	0.55	0.19	1.68	0.096
Index for other shocks	0.65	0.31	0.53	0.27	-0.92	0.363
Index for all shocks combined	0.06	0.21	0.00	0.00	0.93	0.354
Mixed system						
Index for change in rain pattern	0.76	0.19	0.89	0.17	2.01	0.048
Index for drought	0.74	0.34	0.76	0.32	0.14	0.889
Index for violent/strong winds	0.70	0.21	0.64	0.22	-0.84	0.405
Index for flood	0.62	0.36	0.53	0.36	-0.79	0.430
Index for other shocks	0.23	0.33	0.14	0.34	-0.61	0.544
Index for all shocks combined	0.46	0.14	0.49	0.14	-0.40	0.687

3.2.1 Climate Change Adaptation Methods used by Farmers

To assess farmer adaptation behavior to climate change, this study examines the rates of adoption of farm based methods and non-farm methods, comparing the behavior of farmer households in the three farming systems, and between male and female headed households in the region. The farm methods include soil and water conservation, fertilizer application, crop diversification, livestock diversification and tree planting, whereas the non-farm strategies include utilization of weather forecasts, information and participation in non-farm income generating activities. As a crude measure of the rate at which an adaptation method is adopted, the study computed the percentage of farmers using at least one of the measures that fall under that category or method. Table 9 presents the proportion of adopters of the various adaptation methods. Analysis of variance and the Bonferroni test were performed to determine the differences in the mean indexes among the three farming systems. The results generally show that a substantial proportion of farmers in Mopti region used various methods to mitigate the perceived effects of climate change. For the whole sample, the most common farm based adaptation strategies include livestock diversification (reported by 95%), crop diversification (by 92%), mixed farming (by 86%), use of fertilizers (by 77%), utilization of weather forecast information (by 70%) and implementation of soil and water conservation measures (by 53%). Other notable adaptation methods reported by the surveyed households include transhumance (by 37%) and planting drought tolerant crop varieties (by 32%). Only 7% of the farmers participated in non-farm income generating activities. These results are in line with the findings reported in literature that biodiversity management, through growing a combination of crops and crop varieties, rearing a combination of livestock, practicing mixed farming, is an important component of farmers' climate change adaptation strategies (Bryan et al. 2013; De Wit 2006; Laube et al. 2012).

Adaptation method (1=yes, 0=no)	All households	Rice system	Dry system	Mixed system	F-statistic	P-value
Diversify livestock enterprise	0.95 (0.22)	0.88a (0.33)	0.95ab (0.22)	1.00b (0.00)	5.40	0.005
Diversify crop enterprises	0.92 (0.27)	0.93a (0.26)	0.89a (0.31)	0.95a (0.22)	1.28	0.279
Practice mixed farming	0.86 (0.35)	0.72a (0.45)	0.86b (0.35)	0.96c (0.19)	8.64	0.000
Use fertilizers	0.77 (0.42)	0.57a (0.50)	0.79b (0.41)	0.88c (0.33)	10.07	0.000
Utilize weather forecast in agriculture	0.70 (0.46)	0.81a (0.40)	0.54b (0.50)	0.90a (0.30)	20.76	0.000
Soil & water conservation	0.53 (0.50)	0.29a (0.46)	0.52b (0.50)	0.72c (0.45)	13.88	0.000
Transhumance	0.37 (0.48)	0.5a (0.50)	0.21b (0.41)	0.51a (0.50)	17.14	0.000
Use of drought tolerant varieties	0.32 (0.47)	0.28a (0.45)	0.21a (0.41)	0.53b (0.50)	13.30	0.000
Irrigation of crop fields	0.16 (0.37)	0.05a (0.22)	0.09ab (0.28)	0.37c (0.49)	21.88	0.0000
Use of pesticides	0.05 (0.21)	0.02a (0.13)	0.07a (0.26)	0.02a (0.15)	2.03	0.134
Engage in non-farm income activities	0.07 (0.26)	0.05a (0.22)	0.08a (0.27)	0.07a (0.26)	0.22	0.801

Table 9. Adaptation methods used by the farmers (mean proportions) by farming system.

Note: Standard Deviation in Parentheses; common superscripts in rows indicate equal mean values

Similarly, findings from past studies conducted in Sub-Saharan Africa show that farmers generally understand and use weather forecasts in planning agricultural activities (Oxfam 2013) to minimize the adverse effects of weather extremes. Most farmer households in the study region access formal forecast information through the media, especially radios. Farmers also use their indigenous and agro-ecological knowledge, based on past experience, to forecast the weather. Thus, increasing farmer access to timely and accurate forecast information on weather extremes such as drought, extreme temperatures and severe winds may be an important strategy for effective climate change mitigation and adaptation in the agriculture sector (Mude et al. 2009).

The results show significant variations across the farming systems with respect to adoption of most of adaptation methods, except crop diversification and pesticide application. For example, the proportion of farmers using improved seed was significantly higher in the mixed farming system (by 53%) relative to the rice system (28%) and dry cereals system (only 21%). It is important to emphasize that the rate of adoption of improved seed is still low particularly in the rice and the dry cereals farming systems, and it hampers realization of sustainable livelihood impacts of improved agricultural technologies.[4]

Low adoption of improved varieties in the rice and dry cereals systems can be attributed to rampant floods and long dry spells which discourage investment in costly varieties, among others factors. A detailed discussion of the barriers to adoption of improved seed in the region follows in a later section.

Further, at least half of the farmer households interviewed in the respective farming systems used fertilizers in crop production. The proportion of fertilizer users was highest in the dry cereals system and lowest in the rice system. Similarly, a substantial proportion of livestock farmers diversified their livestock enterprise (ie, kept more than one type of livestock). Livestock diversification was significantly lower in the rice system than the mixed and the dry cereals systems. The results also show variations in the farmers' utilization of weather forecast information in agriculture across the farming systems. For example,

4. Improved varieties have a wide range of superior traits such as drought tolerance and early maturation, which can reduce farmers' exposure to the risk of extreme weather events. Adoption of improved seed varieties (and traits) does not only generate productivity gains to farmers, but also confers greater flexibility to climate change adaptation.

only 53% of the farmers in the dry cereals system said that they utilized weather forecast information compared to 88% and 90% of the farmers in the rice and mixed farming systems, respectively. Low utilization of weather forecast information in the dry cereals farming system may be due to limited access to forecast information.

The results further show significantly lower proportion of farmers practicing transhumance and irrigation in the dry cereals system compared to the other two systems. The low adoption of irrigation methods could be attributed to lack of water for irrigation, lack of funds to invest in wells that need to be deep and thus costly (especially in the dry areas), and lack of technical knowledge on low cost and effective methods of irrigation.

Adoption of soil and water conservation practices was most common in the mixed systems (72% adopters) and the dry cereals system (52% adopters). Only 29% of the farmers used soil and water conservation in the rice system.

Table 10 presents the details of the level of adoption of the various adaptation methods among the male and the female headed households in the three farming systems. The results generally show comparable levels of adoption between the two farmer categories except for a few adaptation methods. For example a significantly large proportion of male headed households diversified their crop and livestock enterprises, relative to their female headed counterparts. No gender differentials in adoption are noted in the dry cereals system. However, male headed households in the mixed system dominate their female headed counterparts with respect to use of fertilizers and transhumance. Many of these methods including crop diversification and livestock diversification require substantial amount of resources especially land, capital and labor; which are often a limiting factor of production for female farmers. In addition, cultural norms restrict women's movements, which could explain the low level of transhumance practiced by females than males.

Table 11 presents the number of adaptation methods used by an average household in the three farming systems in Mopti region. The results show that households used multiple strategies for adapting to the impacts of climate variability and change. For the whole sample, most of the households used five technologies (by 28%); and a substantial number of farmers used six and seven practices – as reported by 22% and 18% of the farmer households interviewed, respectively.

The results further show variations in the number of methods used across the farming systems. For example, a large number of farmers in the rice system used between five and six adaptation methods, as reported by 25% and 29%, respectively. Most farmers in the dry cereals system used between four and six methods whereas majority of their counterparts in the mixed farming system used eight methods (33%).

With regard to gender, the results show that most male and female headed households used five methods (Figure 5). However, the proportion of farmers using five technologies is larger among female headed households (32%) than the males (28%).

Case Study 2. More Investments are Needed for Adaptation

Soleymane Tangara lives in the village of Youre. He is 55 years old, and is part of a family comprising eight men and seven women that farms six hectares of rice, three of millet, one of sorghum, and half hectare of cowpea, peanut and other local crops. With this, he declares to have revenues for approximately USD 1,500 per year, mostly from rice. He reports considerable problems linked to climate change including low yields, lack of quality seed and poor soil fertility. Irregular rains and high temperatures together with strong winds have also become a constraint to increased production.

Table 10. Climate adaptation methods used by the farmers, by gender (mean proportions).

	Male headed households		Female headed households			
Rice system	Mean	Std. dev.	Mean	Std. dev.	T-statistic	P-value
Soil and water conservation	0.3	0.46	0.27	0.47	-0.16	0.872
Fertilizer application	0.62	0.49	0.36	0.5	-1.53	0.131
Livestock diversification	0.96	0.2	0.82	0.4	-1.65	0.104
Utilization of weather information in agriculture	0.85	0.36	0.64	0.5	-1.65	0.106
Mixed farming	0.79	0.41	0.45	0.52	-2.28	0.026
Use of drought tolerant varieties	0.3	0.46	0.18	0.4	-0.77	0.447
Use of pesticides	0.02	0.15	0	0	-0.48	0.633
Crop diversification	0.94	0.25	0.64	0.5	-2.89	0.005
Transhumance	0.6	0.5	0.36	0.5	-1.39	0.169
Non-farm income diversification	0.06	0.25	0	0	-0.85	0.398
Dry cereals system						
Soil and water conservation	0.54	0.5	0.4	0.51	-0.99	0.323
Fertilizer application	0.79	0.41	0.73	0.46	-0.52	0.604
Mixed farming	0.85	0.36	0.93	0.26	0.89	0.376
Use of drought tolerant varieties	0.22	0.42	0.13	0.35	-0.80	0.422
Use of pesticides	0.08	0.27	0	0	-1.13	0.259
Utilization of weather information in agriculture	0.54	0.5	0.6	0.51	0.47	0.641
Livestock diversification	0.9	0.31	0.87	0.35	-0.34	0.731
Crop diversification	0.94	0.23	1.00	0	0.94	0.351
Transhumance	0.22	0.41	0.13	0.35	-0.74	0.459
Non-farm income diversification	0.07	0.26	0.13	0.35	0.83	0.408
Mixed system						
Soil and water conservation	0.74	0.44	0.64	0.5	-0.68	0.497
Fertilizer application	0.9	0.3	0.73	0.47	-1.67	0.098
Mixed farming	0.96	0.2	1.00	0	0.68	0.496
Use of drought tolerant varieties	0.56	0.5	0.36	0.5	-1.18	0.240
Use of pesticides	0.03	0.17	0	0	-0.55	0.581
Utilization of weather information in agriculture	0.89	0.32	1.00	0	1.16	0.250
Livestock diversification	0.94	0.23	1.00	0	0.79	0.429
Crop diversification	1.00	0	1.00	0	-	-
Transhumance	0.54	0.5	0.27	0.47	-1.67	0.099
Non-farm income diversification	0.08	0.28	0	0	-0.99	0.326

Table 11. Number of practices used, by farming system.

Number of	All households		Rice system		Dry system		Mixed system	
adaptation methods	n	%	n	%	n	%	n	%
0	1	0.36	1	1.72	-	-	-	-
2	1	0.36	1	1.72	-	-	-	-
3	15	5.34	7	12.07	7	5	1	1.2
4	38	13.52	8	13.79	29	20.71	1	1.2
5	81	28.83	15	25.86	47	33.57	19	22.89
6	62	22.06	17	29.31	31	22.14	14	16.87
7	53	18.86	6	10.34	19	13.57	28	33.73
8	28	9.96	3	5.17	7	5	18	21.69
9	2	0.71	-	-	-	-	2	2.41

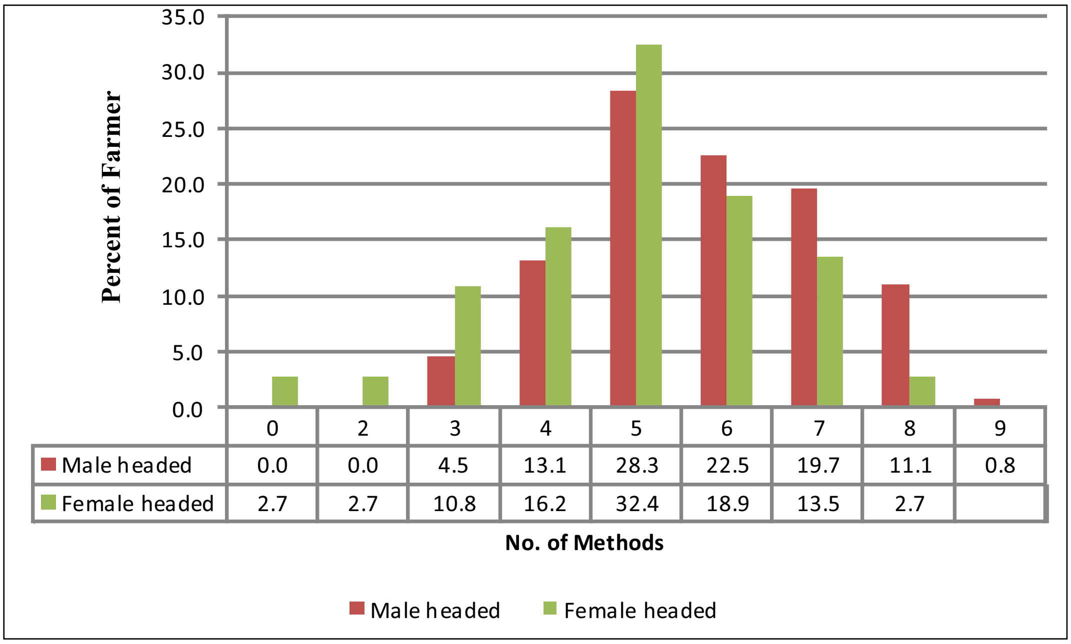

Figure 5. Number of adaptation methods used, by gender.

However, during the last five years his family has been able to invest in farm improvements. They have built a small well and bought a pump. Also, they bought a Cart and few Oxen. They have bought fertilizers and a machine to distribute pesticide. They have also hired some temporary labor: up to ten people work in the farm during the season. They have two children in school, one boy and one girl. All these investments are being made thanks to the effort of five family members that have been working in the fields. Other members are either too old or too young to work full time.

In spite of all these investments, various issues are present. The extent of labor involved is reducing the family's capacity to undertake soil and water conservation technologies. Also, investments are constrained because climate change is reducing their income level. In fact, to be able to cope with climate vagaries, the family is forced to buy cereals for subsistence, as well as feed and fodder for the animals. Soleymane says that money is also needed for "women activities". Cooking and raising small animals for milk production are exclusively done by women and they sum up to $150 per year, he reports.

Soleymane realizes that more investments are necessary to improve climate resilience. For example, he understands that rice would need much more labor during the cropping season. Also, he knows very well that compost and fertilization could improve the yield in his fields. He doesn't have sufficient money to buy the appropriate quantity of pesticides at the right time or to invest more in labor. He also thinks he would need more equipment to reduce workload. Soleymane is very knowledgeable about new technologies that he has come across in the past. His family has also diversified their cropping system. However, they are limited by insufficient access to labor, equipment, fertilizers and pesticides. Lack of capital is reducing their capacity to adapt their farm to climate change and to overcome poverty.

3.2.1.1 Soil and Water Conservation Measures used by Farmers

Table 12 reports the various soil and water conservation (SWC) measures used by the households, comparing the three farming systems in the region. Although more than half of the farmers implemented at least one soil and water management technology, the rate of adoption of the individual measures is generally low. Zai was the most common soil and water conservation measure used by the households – as reported by 43% of the whole sample of farmer households; the likelihood of adoption of any of the other SWC measures is less than 25% (Table 12). The low uptake of SWC measures may hamper farmer households from achieving sustainable resilience to climate change. Literature suggests that SWC measures are the most critical entry points for improving land resource resilience and productivity (eg, Bryan et al. 2009). SWC measures maintain long term productivity and ecosystem functions (land, water, biodiversity); and increase productivity (quality, quantity and diversity) of goods and services (including safe and healthy food).

The results further show significant variations in adoption of most of the SWC measures in the farming systems; except vegetative barriers, ridges (courbes de niveau) and wells. The results also show more adopters of the SWC measures in the mixed farming system compared to the rice and dry cereals system. For example about 69% of farmers residing in the mixed farming system used zai compared to only 34% and 32% of those residing in the dry cereals and rice farming systems, respectively. About 35% of farmers in the mixed system used art ponds relative to only 16% of the users in the dry cereals system.

Table 13 shows the proportion of male and female headed farmer households using the different SWC measures in Mopti region. As can be discerned from the table, there are no gender differences in adoption of the soil and water conservation measures in the region. However, the proportion of female adopters of SWC measures is slightly higher than male adopters, except for zai.

Case Study 3. The Use of Zai Increases Food Security

Mama Djongo, a farmer belonging to the village Alley Daga, considers that the best climate resilient practice he uses is the zai pit. Since trees are sown in holes, Mama says “tree holes preserve rainfall water and accumulate wind sediments”. He experimented with such a zai for annual farm crops and declared that “productivity and yield increased as the pit accumulated runoff water”. The revenues generated through the zai have increased income and allowed his family to buy more equipment. Mama thinks the technology “increases his family climate resilience and food security” and gives a higher income at the end of the season.

Table 12. Water and soil conservation measures used, by farming system

SWC measure (1=used, 0=No)	All households	Rice system	Dry system	Mixed system	F-value	P-value
Zai	0.42 (0.49)	0.24^{a} (0.43)	0.34^{a} (0.48)	0.69^{b} (0.47)	19.88	0.0000
Art ponds	0.23 (0.42)	0.22^{ab} (0.42)	0.16^{a} (0.37)	0.35^{b} (0.48)	5.64	0.0040
Vegetative barriers	0.23 (0.42)	0.22^{a} (0.42)	0.20^{a} (0.40)	0.30^{a} (0.46)	1.51	0.2231
Courbes de niveau (ridges)	0.23 (0.42)	0.22^{a} (0.42)	0.19^{a} (0.40)	0.30^{a} (0.46)	1.73	0.1786
Wells	0.23 (0.42)	0.22^{a} (0.42)	0.19^{a} (0.39)	0.30^{a} (0.46)	1.99	0.1393
Stony bund	0.21 (0.41)	0.24^{a} (0.43)	0.14^{a} (0.34)	0.33^{b} (0.47)	5.93	0.0030
Dams and dykes	0.20 (0.40)	0.24^{a} (0.43)	0.13^{a} (0.34)	0.30^{b} (0.46)	5.28	0.0056
Ravine creusée	0.20 (0.40)	0.22^{a} (0.42)	0.14^{a} (0.34)	0.29^{b} (0.46)	4.06	0.0183

Note: Standard deviations in parentheses; Common superscripts in rows indicate equal mean values

Table 13. Water and soil conservation measures used, by gender.

SWC measure	Male headed (n=244)	Female headed (n=37)	T- statistic	P-value
Zai	0.43 (0.50)	0.35 (0.48)	-0.95	0.34
Artificial ponds	0.23 (0.42)	0.24 (0.43)	0.24	0.81
Vegetative barriers	0.23 (0.42)	0.27 (0.45)	0.54	0.54
Courbes de niveau (ridges)	0.23 (0.42)	0.24 (0.43)	0.18	0.18
Wells	0.23 (0.42)	0.24 (0.43)	1.08	0.28
Irrigated fields	0.22 (0.41)	0.30 (0.46)	-1.46	0.15
Stony bund	0.21 (0.41)	0.24 (0.43)	0.47	0.63
Dams and dykes	0.20 (0.40)	0.24 (0.43)	0.65	0.51
Use of improved land preparation techniques	0.22 (0.41)	0.14 (0.35)	-1.14	0.25
Ravine creusée	0.19 (0.40)	0.24 (0.43)	0.72	0.47

Note: Standard Deviations in parentheses

However, Mama also depicts various detrimental aspects linked to zai cropping. First of all, he generally prepares the zai in November and only puts it to use the following May. The long time between the operations “increases the risk of zai erosion”. In addition, zai preparation is very costly, and the family uses revenue from rice production for this project. Finally, the technique is also labor-consuming.

3.2.1.3 Soil fertility management practices: fertilizers to tackle climate change in agriculture

Fertilizers, whether organic or inorganic, constitute key ingredients for food security because they provide crops with the necessary nutrients to produce food for the human population and livestock. Fertilizer use can thus play a key role in mitigating climate change.[4] Table 14 presents the proportion of farmers using the two types of fertilizers (organic and mineral fertilizers) in the three farming systems in Mopti region. Considering the whole sample, a majority of farmers (66%) used organic fertilizers compared to 49% who applied mineral fertilizers; and about 39% used both organic and mineral fertilizers. The results further show significant variations in fertilizer adoption across the farming systems. In particular, adoption rates are generally higher in the mixed farming system relative to the rice and dry cereals farming systems. For example, 71% of the farmers in the mixed system used organic fertilizers compared to only 31% and 44% of users in the rice and dry cereals systems, respectively. Further, about 43% of the farmer households in the rice system compared to 72% in the mixed system and the 73% in the dry cereals system.[5]

The results further show gender differences in the level of adoption of fertilizers, with male headed households dominating their female counterparts. About 69% of the male headed households used organic manure compared to the 51% of the adopting female headed households. Similarly, a significantly high proportion of households headed by males (about 52%) used mineral fertilizers compared to only 35% of adopters among female headed households (Table 15).

Table 14. Types of fertilizer used and adoption levels, by farming system

Fertilizer type used	All households	Rice system	Dry system	Mixed system	F-value	P-value
Use of organic manure	0.495 (0.501)	0.310 a (0.467)	0.443a (0.499)	0.711c (0.456)	13.52	0.0000
Use of mineral fertilizer	0.665 (0.473)	0.431a (0.500)	0.721b (0.450)	0.735b (0.444)	9.56	0.0001
Use of both mineral fertilizer and organic manure	0.391 (0.489)	0.172a (0.381)	0.379b (0.487)	0.566c (0.499)	12.06	0.0001

Note: Standard Deviations in parentheses; Common superscripts in rows indicate equal mean values

Table 15. Fertilizer use, by gender

	Male headed households		Female headed households			
Fertilizer type used	Mean	Std. dev	Mean	Std. dev	T-statistic	P-value
Use of organic manure	0.69	0.46	0.51	0.51	-2.544	0.012
Use of mineral fertilizer	0.52	0.50	0.35	0.48	-2.085	0.038
Use of both fertilizer and organic manure	0.41	0.49	0.24	0.43	-1.989	0.047

4. It is estimated that over 89% of agriculture’s future greenhouse gas mitigation potential is based on soil carbon sequestration (Smith et al. 2007).
5. Please note that the intensity of fertilizer application is not captured in this report due to lack of adequate data.

The observed large number of users of organic manure relative to the mineral fertilizer may be explained by two reasons. The first one is that the high cost associated with mineral fertilizers may hinder many resource poor farmers in the region from using the input. Secondly, organic fertilizers are not only cheaper but are also easily available to the farmers. It is however important to note that, although organic manure and crop residues may be easily available and are affordable alternative sources of soil nutrients, they are labor intensive and do not have adequate nutrient levels (Morris et al. 2007). For instance, a farmer needs to apply about 6-10 MT of manure per hectare to generate the adequate amount of nitrogen and phosphorous (Abdoulaye and Sanders 2005). In this case, supplementing with mineral fertilizers is important to avoid nutrient mining and soil degradation, and may thus be a key strategy for climate adaptation in Mopti region.

Case Study 4. Women for Soil Fertility Management

Mata Kamian lives in Soufourolaye and is 58 years old. She is responsible for a family of 11 people. Her family crops rice, sorghum, cowpea and peanuts for a total revenue of $800 per year. In addition, her family has four beefs, two sheep and four goats. With an average revenue that is well below the poverty line, Mata's family does not have any children at school. However, they manage to have three meals, even if the months of April and September are often food scarce. In this situation, it is no surprise that Mata receives support: local NGOs often provide her with inputs for the cropping season.

Climate change is affecting the family strongly, mainly through repeated droughts and floods. The household's productivity is decreased by strong winds and late-starting rainfall. Insufficient family labor and lack of equipment are also constraints. She hires two temporary laborers over the course of the season to crop her five hectares of land. Mata's family would like to build water saving infrastructure, but cannot afford to. They also would like to access agro-meteorological information.

Mata uses fertilizers for the cereals she crops, but she doesn't have sufficient budget to access the necessary pesticides for the rice. Mata uses composting and mineral fertilizers jointly to improve soil quality and yield. Mata says, "Even if we use fertilizers, the additional support of composting is required. Earlier I was using fertilizers alone and my production was not much; now with compost it has increased". This practice helps her cope with climate change because "it increases production". To obtain the financial means to prepare compost, she uses revenues from small sales.

She prepares the compost[6] by digging three one-meter deep pits close to each other. The first pit is filled by vegetation and animal residues. After 15 days, the content is removed and placed in the second pit, and the second pit is filled again by vegetation and animal residues. After 15 days, the material is displaced from the second to the third pit, and from the first to the second pit, and so on. To sum up, it takes 45 days and three displacements to produce good quality compost that increases soil fertility and production.

3.3 Constraints to Resilience and Barriers to Adaptation to Climate Change

3.3.1 General Constraints to Resilience

Table 16 presents the main development constraints identified by surveyed households in the region. The most common ones include low agricultural productivity (as reported by 82%); declining soil fertility (by 79%) and poor seed quality (32%). A similar pattern of perception of the constraints is noted across the farming systems, particularly the mixed and the dry cereals systems where majority of the farmers cited low yields and poor soils as the major constraints hampering livelihood improvement.

6. The composting methodology presented in this case study is not supported by ICRISAT. Instead, it exemplifies how in some cases farmers have been trained in methodologies that doesn't take into consideration labor requirements and doesn't maximize labor efficiency. High quality composting preparation doesn't necessarily require displacement of composted material between pits.

With regard to gender, both male and female headed households identified poor yields, declining soil fertility and inadequate rainfall as the main constraints to resilience (Figure 6).

Table 16. Constraints to resilience, by farming system

Constraint	All households		Rice system		Dry system		Mixed system	
	N	%	n	%	n	%	n	%
Low yields	230	81.9	46	79.3	114	81.4	67	80.7
Poor soils	222	79.0	33	56.9	120	85.7	66	79.5
Inadequate rainfall	210	74.7	43	74.1	112	80.0	52	62.7
Poor rainfall distribution	116	41.3	36	62.1	64	45.7	16	19.3
Poor seed quality	91	32.4	26	44.8	50	35.7	14	16.9

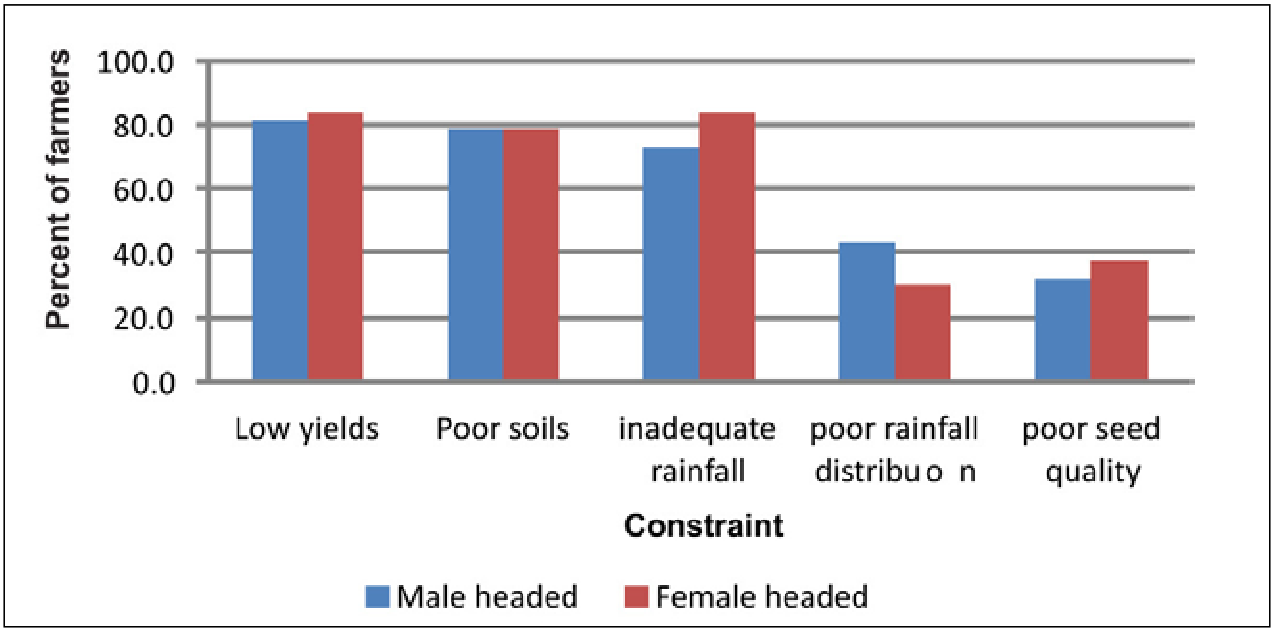

Figure 6. Development constraints, by gender.

The survey of experts working with NGOs also revealed that drought and poor soils are one of the main constraints in the region (Table 17). Other important constraints identified include lack of access to improved seeds/planting materials, lack of equipment, limited access to land, labor constraints due to migration (eg, to gold mines), floods, lack of liquid capital, lack of technical knowledge, illiteracy and lack of collective action.

3.3.2 Barriers to adoption soil and water conservation, by farming system and gender

Table 18 presents the main barriers to adoption of water and soil conservation (SWC) methods in Mopti region. The constraints noted by farmers were diverse; the most popular ones included lack of finances (cited by 29.5%) and limited labor (28%). Soil and water conservation measures are labor intensive and many of them may also require substantial amounts of capital investment. Many farmer households are resource poor and may not afford to purchase these technologies. In addition, the opportunity cost of time investment in some of the labor intensive SWC measures appears to be quite high for both youth and adults. As a results many people in the region, especially youth, migrate to urban areas and gold mines where the returns are more certain than in farming, thus reducing labor supply to the agricultural sector. Other constraints noted by farmers include limited land rights since most of the land in the region is communally owned; and agro-ecological factors including soil attributes, water attributes. These barriers were more markedly noted by farmers in the mixed farming system.

Table 17. Constraints identified by NGOs.		
Constraint	Number of NGOs	Percent of NGOs
Drought/poor rain distribution	13	81.25
Poor soils	9	56.25
Lack of seed	4	25
Lack equipment	4	25
Land pressure/deforestation	3	18.75
Labor constraints because of migration to gold mines	3	18.75
Floods	2	12.5
Lack of financial resources	2	12.5
Illiteracy	1	6.25
Lack of technical knowledge	1	6.25
Lack of collective action in the villages	1	6.25
Land pressure and lack of cohesion	1	6.25

Table 18. Barriers to adoption of SWC measures, by farming system.

	All households		Rice system		Dry system		Mixed system	
Barrier	n	%	n	%	n	%	n	%
Lack of financial capital	83	29.5	11	26.8	50	35.7	50	60.2
Labor constraints	79	28.1	11	26.8	38	27.1	38	45.8
Hydraulic characteristics	35	12.5	3	7.3	25	17.9	25	30.1
Plant characteristics	30	10.7	4	9.8	21	15.0	21	25.3
Land tenure	14	5.0	1	2.4	10	7.1	10	12.0
Soil characteristics	11	3.9	-	-	9	6.4	9	10.8
Official regulations	3	1.1	1	2.4	2	1.4	2	2.4

With regard to gender of the household head, comparable proportions of male and female headed households cited financial and labor constraints as the main barriers to use SWC practices (Figure 7).

Case Study 5. Labor Intensity Reduces Potential Use of Improved Practices

Lack of labor can be a strong constraint to climate change adaptation. Amadou Baby Kamian is an example of a knowledgeable farmer who is eager to implement new technologies but the lack of family labor constrains his ambitions. He has a farm of six hectares and a family of six people, of which he is the only person who can effectively work. Amadou would like to widely implement the zai pit and he has just learned the advantages of composting. On the zai pit, Amadou says, “In our zone, rainfall is rare and scarce, so the zai allows us to enrich the soil and save moisture. Also, with the zai, after the first rainfall in the beginning of May, we can start sowing because there is moisture.” About composting, he says, “I had heard about composting but never practiced it. Now I have the knowhow, I can do it: It is tenable but requires more labor.”

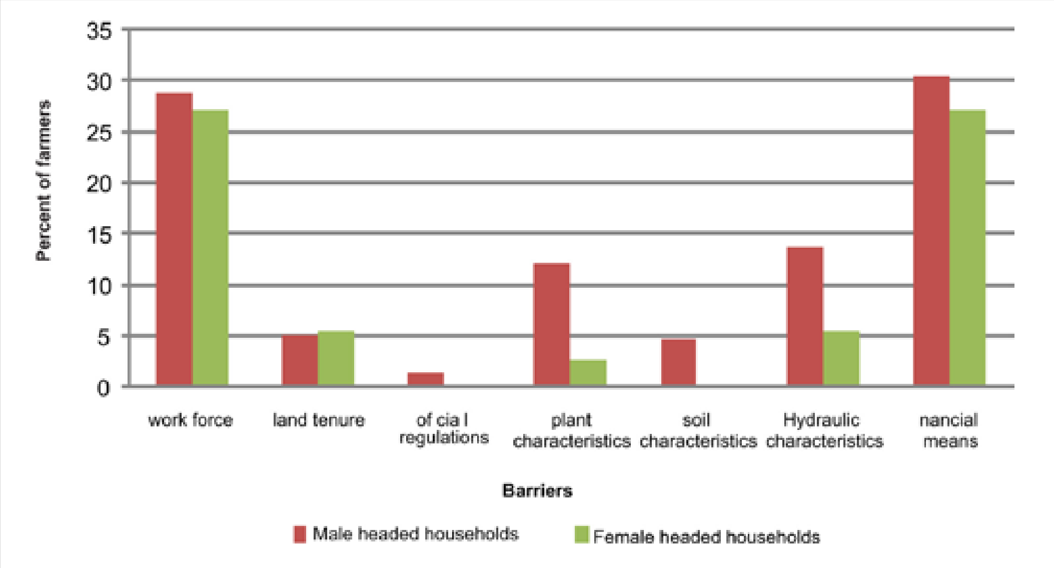

Figure 7. Main barriers to adoption of Water and Soil Conservation practices.

3.3.3 Barriers to Livestock Diversification, by Farming System and Gender

Diversification within the livestock subsector is one of the major strategies used by farmers in Mopti region to adapt to climate change. Farmers however noted several constraints that hamper livestock diversification (Table 19). The main barriers cited are associated with poverty (by 25%), lack of livestock pasture (by 22%) and inadequate feeds (by 14%). The relative significance of these barriers is quite comparable across the farming system. It is also important to note that majority of the respondents reported that many other barriers hamper diversification; although they did not specify them[7].

3.3.4 Barriers to adoption of drought tolerant planting materials/seed, by farming system and gender

Modern farm technologies such as improved varieties provide farmers with the opportunity to increase productivity, and enable them to adapt to climate change. However, many farmers in Mopti region do not use improved varieties. This is mainly because it is expensive (as reported by 10% of non-user farmers), and not easily available to them (by 9.8%) (Table 20). Most farmers thus resort to using their own saved seeds or alternatively purchase such seeds from the local markets, which are likely to be of poor quality. Several studies on adoption have also reported that many farmers in the Sub-Saharan Africa want to use improved technologies but lack liquid capital to purchase them; and they have limited access to credit as well (Bryan 2009; Langyintuo et al. 2010).

Table 19. Barriers to livestock diversification, by farming system.

	All households		Rice system		Dry system		Mixed system	
Constraint	N	%	n	%	n	%	N	%
Lack of financial means	71	25.3	7	12.1	35	25.0	17	20.5
Absence of prairie/pasture	62	22.1	11	19.0	36	25.7	15	18.1
Unavailability of feed	40	14.2	4	6.9	24	17.1	11	13.3
Other factors	281	100.0	51	87.9	140	100.0	35	42.2

7. These may include both technical and economic factors such as lack of information, diseases and pests, land shortages.

With regard to availability of seed to the farmers, a substantial proportion of adopting households also reported that it is quite difficult to get improved seed varieties in the region (Figure 8). In all the farming systems, improved seed is more difficult to acquire for female headed households than their male headed counterparts.

3.3.5 Barriers to Fertilizer Adoption

Lack of access to fertilizers and limited capacity to purchase and use fertilizers are some of the major constraints to fertilizer adoption in the Sub-Saharan Africa identified in literature (Kelly 2006; Morris 2007). In attempt to understand farmer access to fertilizers in the study area/region, the survey asked farmers on how they judged fertilizer availability and supply in their villages. The results are presented in Figure 9 and Table 21. At least half of the households interviewed indicated that fertilizers were not easily available. Indeed, only 42% of adopting household reported that they had a fertilizer seller in their village, and the distance to the nearest sources outside the village is 10km (Table 21). With regard to gender, lack of access to fertilizers was more pronounced among female headed households relative to their male counterparts (Figure 9). The pattern is similar across the farming systems.

Table 20. Reasons for not using improved seed, by cropping system.

	All households		Rice system		Dry system		Mixed system	
Reason	n	%	n	%	n	%	n	%
Cannot afford to buy	19	10.3	-	-	2	2.0	11	37.9
Varieties are not available	18	9.8	12	29.3	2	2.0	8	27.5
Other factors	22	12.0	9	22.0	2	2.0	11	37.9

Table 21. Source of fertilizer and seed in Mopti region.

Variable	Pooled (n-170)		Male (n=160)		Female (n=10)		T-statistic	P-value
Presence of fertilizer source in the village (1=yes)	0.42	0.49	0.44	0.50	0.32	0.47	-1.309	0.192
Distance to fertilizer nearest source (km)	12.95	10.19	12.76	10.31	13.92	9.75	0.519	0.604

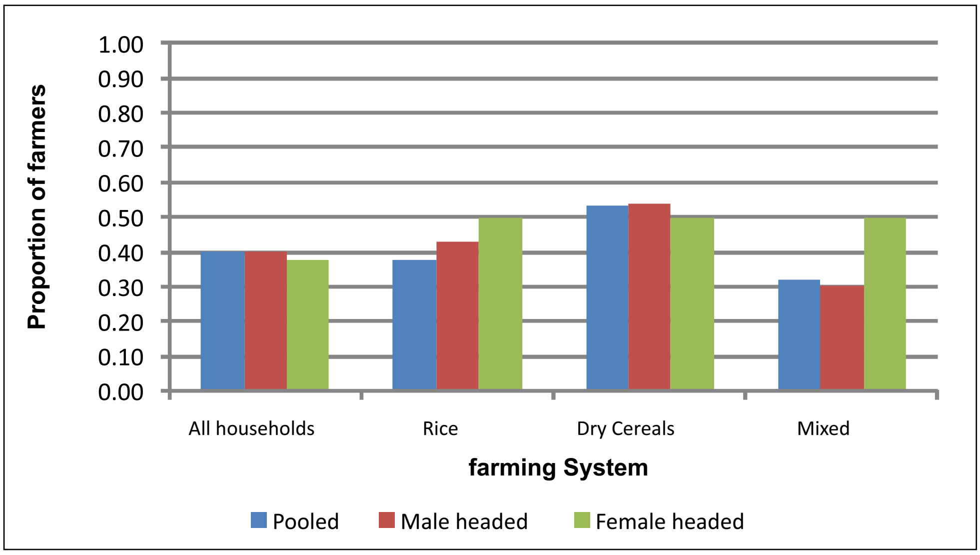

Figure 8. Proportion of adopters reporting unavailability of improved seed, by gender.

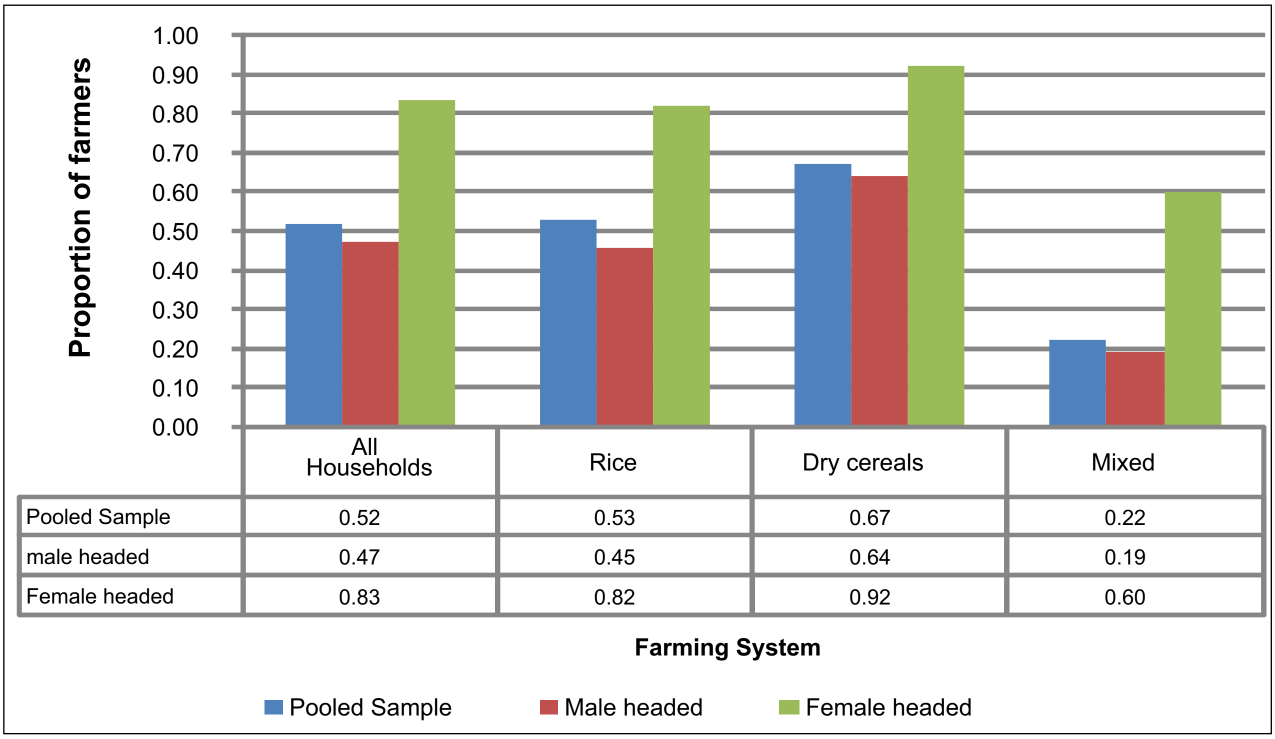

Figure 9. Proportion of farmers reporting lack of access to fertilizers.

Case Study 6. Capacity Development on Soil Fertility Management

Lamina Kamian has been recently trained in composting and micro-dosing for sorghum production through the Farmer Field School. He has also been able to train other fellow farmers in his village. He said he did not know about these methods before but is now convinced enough to adopt them in the future. He now recognizes the value of investing in these climate resilient technologies because “these investments bring us a lot of revenues, and increase foodstuff availability.”

Lamina is head of a household of 13 people (of which nine are women). His family grows rice, millet, sorghum, cowpea, peanut and okra. During the last five years, he has been able to buy a Cart to improve his farm, but he thinks that had it not been for climate change, his farm could have done even better. In the future, he would like to use his revenue to undertake more composting, but also to buy more small equipment to reduce family labor.

3.3.6 Determinants of adoption of farm based adaptation practices in mopti region

This sub section examines the adoption behavior of the sample of farmers, paying special attention to the role of gender. In particular, a count model (a Poisson in our case) was estimated to analyze the socio-economic factors that influence the number of adaptation methods an average farmer in the region can adopt. Separate models were estimated for male and female headed households to determine if the determinants of adoption differ between the two categories of households. The results of regression models are presented in Table 22.

Although separate models were estimated for the determinants of climate change adaptation behavior among male and female headed households, analysis started by estimating a single model for climate change adaptation with gender simply as a dummy variable as is customary. Column 1 of Table 22 presents estimates of the pooled model. The results show that gender of head of a household is significantly associated with the number of climate change adaptation methods adopted by the households in Mopti region. The coefficient on gender is positive, suggesting that households headed by males in this sample

Table 22. Determinants of adoption of farm based adaptation methods.

Variables	(1) All households	(2) Male headed households	(3) Female Headed households
Gender of household head (1=Male, 0=Female)	0.118**	n/a	n/a
	(0.0519)		
Crop land per capita (ha)	-0.00262**	-0.00348***	0.0522
	(0.00107)	(0.000923)	(0.0329)
Age of household head (years)	-0.000720	-0.000471	-0.00124
	(0.00121)	(0.00112)	(0.00531)
Household size (no. of persons)	0.00662	0.00529	-0.0227
	(0.00426)	(0.00427)	(0.0197)
Number of adult members in the household	-0.00124	-0.000139	0.0324
	(0.00602)	(0.00619)	(0.0262)
Household head has some formal education	-0.0316	-0.0604	0.0105
	(0.0486)	(0.0489)	(0.182)
Tropical livestock units owned	0.00316**	0.00286**	0.0382
	(0.00127)	(0.00117)	(0.0234)
Per capita value of crop output (CFA)	3.18e-08***	2.73e-08**	1.46e-08
	(1.09e-08)	(1.22e-08)	(3.32e-08)
Farmer seeks advice from peers (1=Yes, 0=No)	0.161***	0.168***	0.389
	(0.0430)	(0.0471)	(0.258)
Farmer interested in land management (1=Yes, 0=No)	-0.0462	-0.0312	-0.231
	(0.0325)	(0.0352)	(0.241)
Perception that adaptation methods are beneficial	0.0810**	0.0815**	-0.0856
	(0.0372)	(0.0412)	(0.152)
Farmer uses weather forecast information in agriculture (1=Yes, 0=No)	-0.0340	-0.0503	-0.0101
	(0.0345)	(0.0350)	(0.114)
Farmer participates in non-farm activities (1=Yes, 0=No)	-0.0941**	-0.0817*	-0.229
	(0.0442)	(0.0471)	(0.232)
Household owns land (1=Yes, 0=No)	0.0583*	0.0504*	0.0533
	(0.0321)	(0.0303)	(0.0957)
Distance to an input supply shop (km)	0.000110	4.29e-05	-0.00177
	(0.00178)	(0.00189)	(0.00840)
Household ever received assistance after drought spell	0.0146	0.0558*	-0.360***
	(0.0315)	(0.0326)	(0.121)
Farming system (1=dry cereals system)	0.0200	-0.0274	0.411**
	(0.0510)	(0.0505)	(0.189)
Farming system (1=mixed system)	0.115*	0.0472	0.481**
	(0.0619)	(0.0617)	(0.200)
Constant	1.329***	1.482***	1.195***
	(0.0977)	(0.0908)	(0.282)
Observations	276	239	37

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

are likely to use more adaptation practices compared to their female counterparts. The regression results also show that climate change adaptation behavior is significantly influenced by crop land size, neighborhood effects, participation in non-farm income generation, and perception of the benefits of adaptation practices, land ownership and residence in the mixed farming system.

The results of the pooled model discussed above do not show if the determinants of adaptation behavior differ between male and female headed households. Drivers may be different between the two farmer categories for a number of reasons. For instance, there is evidence that female headed households in developing countries such as Mali are, on average, financially constrained (eg, Seeben 2011) compared to male headed households and thus have limited capacity to invest in purchased technologies. Furthermore, some cultural restrictions exist that may limit female interaction with development workers (especially male agents), further limited women's access to information, which hampers adoption of technologies.

Columns 2 and 3 of Table 22 display the coefficient estimates and standard errors for male and female headed households. As shown in the table, the determinants of adoption are different for male and female headed households. In particular, the coefficients on crop land owned, peer influence, perceptions on the benefits of adaptation, participation in the non-farm sector, land ownership and tropical livestock units owned by the household are significant in the model for male headed households but not in their female headed counterparts. In addition, a significant and a negative effect of aid received after a drought spell is observed in the model for female headed household but the effect is positive in model for their male headed counterparts. The results also show that females residing in the mixed farming systems use more adaptation methods compared to their counterparts in the other farming systems. It is not clear why most of the coefficients are not significant in the model for female headed households. A possible explanation could be the smaller size of the sample of female headed households relative to that of their male counterparts.

3.4 Climate Change Resilience of Households in Mopti Region

This study analyzed household resilience to climate change by examining the relationship between methods used by farmers to adapt to climate change and selected household livelihood indictors. The study considered five indicators; crop yield, per capita crop revenue, tropical livestock units owned by the households, number of meals and food supply diversity. Crop yield was computed as the quantity of crops harvested divided by the total crop acreage. Per capita crop revenue was computed by dividing crop revenue earned by the number of people in the household. Tropical livestock units (TLUs) were computed following the procedure by Jahnke et al. (1982). Food supply diversity was computed following the guidelines by the Food and Agriculture Organization (FAO 2013). The index was derived as a count of seven food categories consumed by a household – including cereals (sorghum, millet, rice, wheat or other grains); root tubers such as potatoes, yams, cassava, taro or other tubers; fruit and vegetable; legumes; animal proteins such as meat, fish, egg; dairy products including milk, yogurt or other dairy products; and other products such as those sourced from the wild.

3.4.1 Comparison of Mean Values of Livelihood Indicators with the Number of Adaptation Methods

We plot the mean values of the selected indictors against the number of technologies adopted by a household. The results are presented in Figures 10a to 10c. As shown in the figures, the average per capita income, crop yields and livestock units owned by a household generally increase with the number of technologies adopted.

Figures 11a and 11b present the relationship between the food security indictors and the number of adaptation measures used by a household. The figures show lack of a clear relationship between the two variables. One would have expected to see an increasing relationship between the number of adaptation methods and food security indicators, since a positive relationship was exhibited between farm yield and climate adaptation. The current result may be explained by a number of reasons. It may be that many

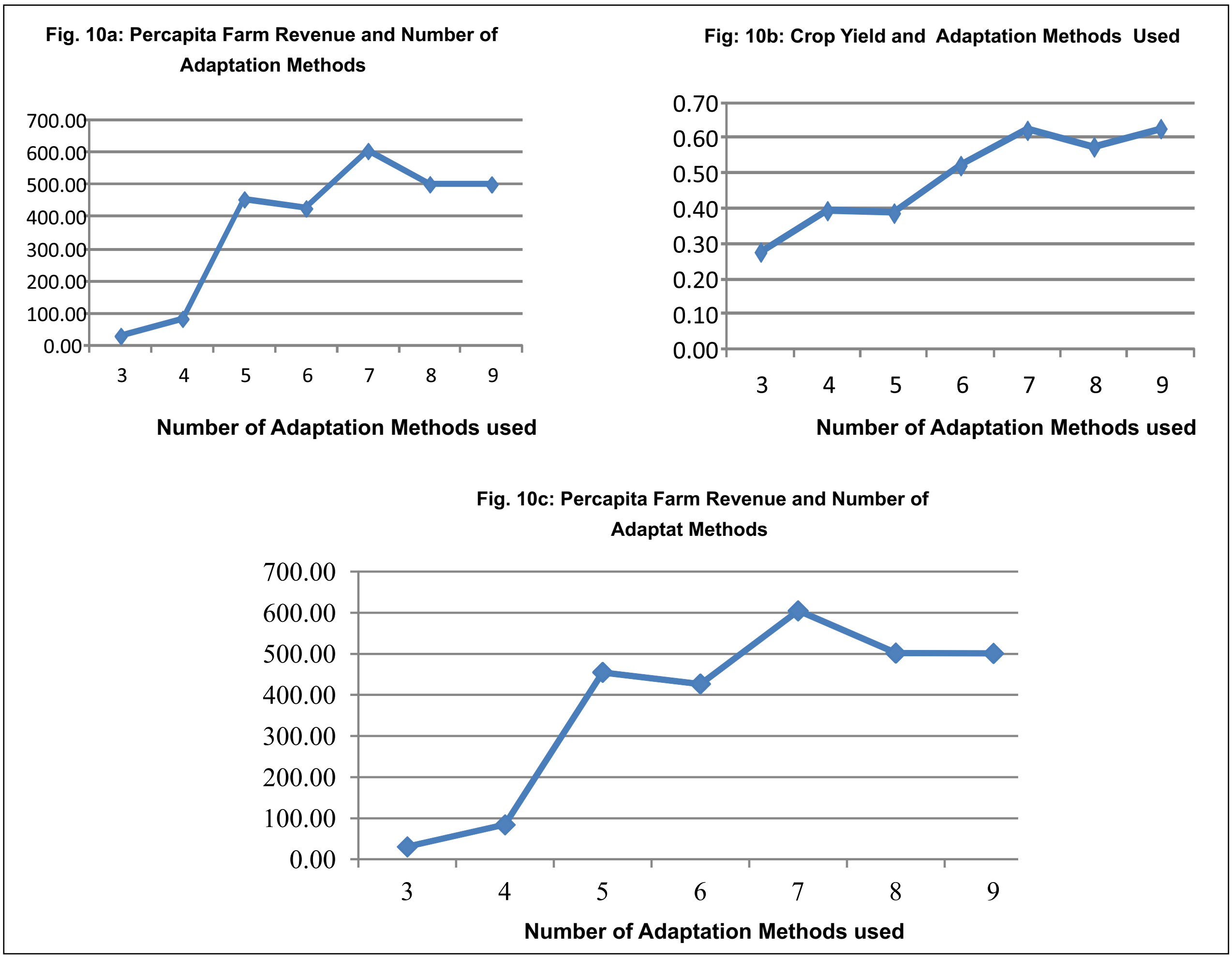

Figure 10. Number of technologies adopted and household income (and crop yield).

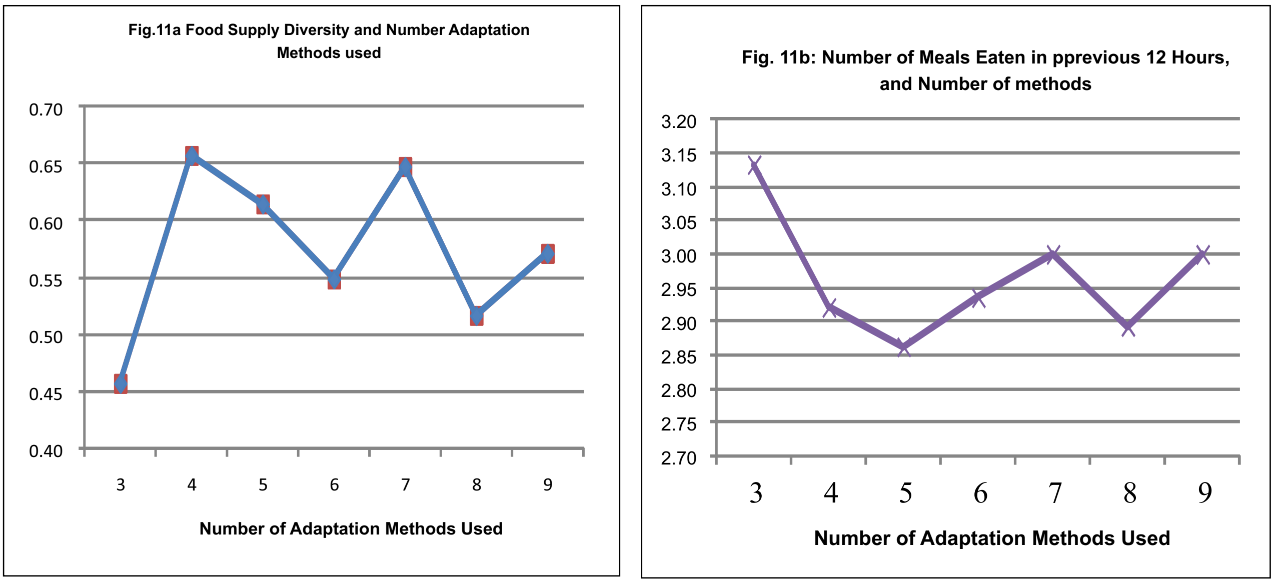

Figure 11. Number of technologies adopted and household food security.

households sell most of the agricultural produce leaving little for home consumption; it may also be that selling households do not necessarily use the revenue from farming to purchase food for consumption. Also, a lack of nutritional skills, appropriate recipes and access to improved cooking stoves could contribute to this result.

Case Study 7. Diversification Has Not Improved Food Security

Aissatou Tembely is a voluntary farmer in a climate change adaptation project. This year she has been trained in sustainable soil fertility management and intercropping and has also adopted it. Her farm's cropping system is quite diversified as she crops millet, peanut, sorghum, okra, cowpea, bissap and sesame. Even before the project training, she was applying the zai pit method and other water saving technologies. She is also able to get some small revenue from selling produce. She says that, over the year, her family has three meal per days. This includes eating fish from the nearby Inner Niger Delta every day, while meat is rarely available. There is a lack of certain vegetables over some periods. At the beginning of the rainy season, some vegetables such as tomato, onion, cauliflower and others are totally unavailable. She says that this year, with the improved methodologies proposed by the project, her production has not improved sufficiently to improve her food habits. For her, eating better would mean "having foodstuffs available and eating whenever you want" and this has not happened as her economic revenues have improved only "a bit".

On the whole, Aissatou does not think her food and nutritional security has changed greatly due to better technologies. It would be interesting to know what would happen over time if Aissatou were involved in a wider activity allowing her to scale up technology adoption.

3.4.3 Effect of Adaptation on Crop Yield in Mopti Region

This subsection presents the results of regression models illustrating the relationship between adaptation methods and crop yields, in the three farming systems in Mopti region. The study analyzed the effect of the number of adaptation methods used, and the individual effect of the respective methods for climate change adaptation. Table 23 reports the model estimates for the effect of number of technologies on yield. Results of the pooled model show a positive and significant relationship between the number of adaptation methods used by a household and crop yields (Table 23, Col. 1). These findings are in line with results presented in the previous subsection showing an increasing relationship between mean yields and the number of technologies adopted (see Figure 10b). Further, the coefficient on the dummy for mixed farming system is positive and significant, suggesting that farmers residing in this farming system realize significantly higher crop yields relative to their counterparts in the rice system.

With regard to the models fitted for the three farming systems, the number of adaptation methods used exhibit positive and significant effect on crop yield in the mixed and dry cereals systems (Table 23, Cols 3 & 4) but insignificant in the rice system (Table 23, Col. 3). Other important determinants of crop yield include participation in non-farm activities, size of crop land, formal education and receipt of aid. In particular, receipt of aid and participation in non-farm income generating activities – all these factors increase yields. However, size of crop area, education of the head of household and the number of adult members in the household decrease yield.

Table 24 presents the model estimates for the individual effects of the various methods of adaptation on yield. The results show that irrigation, mixed farming, use of fertilizer, use of improved seed varieties significantly increase crop yield (Table 24 Col, 1). Fertilizer application exhibited significant effect in the dry cereals system whereas improved seed had significant effect in the mixed farming system. These results suggest that irrigation, mixed farming, use of fertilizers, use of improved seed varieties are the most important methods for climate change adaptation in the region. Thus, programs aiming at increasing resilience of households need to emphasize the adoption of these technologies.

Table 23. Effect of number of adaptation methods used on crop yield in Mopti region.

Variables	(1) All households	(2) Rice system	(3) Dry system	(4) Mixed system
No. of farm adaptation methods	0.0346***	0.0271	0.0228*	0.0992***
	(0.0108)	(0.0213)	(0.0135)	(0.0245)
Weather forecast information	0.0698**	0.0774	0.0411	0.115
	(0.0289)	(0.0527)	(0.0399)	(0.0915)
Ln (crop hectarage)	-0.0605***	-0.0431	-0.0566***	-0.0931***
	(0.0128)	(0.0336)	(0.0155)	(0.0330)
Receipt of aid after drought	0.0898***	0.00863	0.132***	0.0307
	(0.0256)	(0.0669)	(0.0364)	(0.0559)
Age of head of household	-1.67e-05	0.00428*	-0.000183	-0.000898
	(0.000936)	(0.00238)	(0.00117)	(0.00238)
Household head is male	-0.0328	0.0248	-0.0628	-0.0137
	(0.0455)	(0.0730)	(0.0786)	(0.0887)
No. of adult members	-0.00926	-0.00608	-0.000582	-0.0224*
	(0.00577)	(0.0199)	(0.00659)	(0.0118)
Household size	0.00630	0.00252	0.00250	0.0131
	(0.00417)	(0.0131)	(0.00535)	(0.00931)
Household head has some formal education	-0.0805**	-0.0909	-0.0433	-0.338***
	(0.0401)	(0.0846)	(0.0662)	(0.0906)
Weather shock index	0.0274	0.373	0.0370	0.0999
	(0.0892)	(0.279)	(0.101)	(0.183)
Household participates in non-farm work	0.00759	0.438**	-0.0969	0.245**
	(0.0544)	(0.171)	(0.0710)	(0.0945)
Farmer consulted peers on adaptation measures	-0.0217	-0.0626	-0.0261	-0.0753
	(0.0378)	(0.118)	(0.0586)	(0.0640)
Household owns land	-0.0157	-0.0706	-0.00977	-0.00231
	(0.0328)	(0.0748)	(0.0514)	(0.0567)
Farming system (1=Dry system)	0.00437	-	-	-
	(0.0368)	-	-	-
Farming system (1=Mixed system)	0.123**	-	-	-
	(0.0481)	-	-	-
Constant	0.227***	-0.178	0.294**	0.0899
	(0.0816)	(0.211)	(0.120)	(0.204)
R-squared	0.251	0.330	0.195	0.306

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 24. Individual effects of adaptation methods on crop yield in Mopti region.

	(1)	(2)	(3)	(4)
Variables	All households	Rice system	Dry cereals system	Mixed system
Farmer irrigated crop fields	0.0900*	0.0697	0.0952	0.0565
	(0.0533)	(0.296)	(0.0826)	(0.0806)
Farmer practiced soil and water conservation	-0.00372	0.115	-0.0310	0.0532
	(0.0286)	(0.104)	(0.0411)	(0.0855)
Fertilizer application	0.0792*	0.0517	0.0920*	0.139
	(0.0408)	(0.0816)	(0.0536)	(0.107)
Farmer practiced mixed farming	0.111*	0.107	0.0551	0.397
	(0.0584)	(0.131)	(0.0774)	(0.273)
Farmer planted drought tolerant seed	0.0399	0.0253	0.0406	0.120*
	(0.0310)	(0.0888)	(0.0461)	(0.0680)
Transhumance	0.0160	-0.0188	-0.0260	0.0808
	(0.0303)	(0.0668)	(0.0510)	(0.0711)
Household utilized weather forecast information	0.0693**	0.0411	0.0345	0.0720
	(0.0310)	(0.0937)	(0.0367)	(0.0996)
Productivity diversity	0.0250	0.171	-0.0190	0.126
	(0.0562)	(0.151)	(0.0737)	(0.134)
Household participated in non-farm work	-0.00506	0.406**	-0.0854	0.253*
	(0.0559)	(0.159)	(0.0752)	(0.133)
Ln (crop hectarage)	-0.0882***	-0.0469	-0.0877***	-0.124**
	(0.0191)	(0.0567)	(0.0261)	(0.0510)
Household received aid after drought	0.0704***	0.0200	0.112***	0.0233
	(0.0268)	(0.0853)	(0.0398)	(0.0654)
Age of head of household	0.000271	0.00466*	-0.000453	-0.000537
	(0.000912)	(0.00243)	(0.00144)	(0.00261)
Household head is male	-0.0173	-0.00505	-0.0381	-0.0117
	(0.0438)	(0.0998)	(0.0620)	(0.0898)
No. of adult members in household	-0.00713	-0.00778	0.000647	-0.0154
	(0.00604)	(0.0194)	(0.00793)	(0.0190)
Size of household	0.00575	0.00304	0.00285	0.0119
	(0.00426)	(0.0132)	(0.00595)	(0.0126)
Household head has some formal education	-0.0556	-0.0735	-0.0264	-0.300**
	(0.0405)	(0.107)	(0.0608)	(0.122)
Weather shock index	0.0545	0.278	0.0776	0.191
	(0.0932)	(0.382)	(0.135)	(0.276)
Farmer consulted peers on adaptation measures	-0.0459	-0.195	-0.0306	-0.0770

continued

Table 24. Individual effects of adaptation methods on crop yield in Mopti region *continued*.

Variables	(1)	(2)	(3)	(4)
	All households	Rice system	Dry cereals system	Mixed system
	(0.0464)	(0.250)	(0.0710)	(0.0973)
Household owns land	-0.0227	-0.0951	-0.0104	-0.0382
	(0.0322)	(0.0815)	(0.0505)	(0.0622)
Farming system (1=dry system)	-0.00708	-	-	-
	(0.0414)	-	-	-
Farming system (1=mixed system)	0.0962*	-	-	-
	(0.0539)	-	-	-
Constant	0.233***	-0.199	0.341**	-0.0720
	(0.0832)	(0.243)	(0.149)	(0.284)
Observations	276	56	138	82
R-squared	0.284	0.378	0.240	0.381

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Case Study 8. A Variety of Investments and Technologies to Increase Food Security

Seydou Tolema is the head of a household of 22 people in the village of Korongo. His family has nine boys and ten girls under the age of 15 years, and five of these are attending school. Seydou's farm is well diversified; it includes more than 14 hectares of rice, eight hectares of millet, three hectares of sorghum, one hectare of cowpea and half hectare of sesame and peanut. He has been recently able to acquire four draft cows and two charrettes with the objective of reducing labor and transport time and costs. He has been recently trained as peer to peer trainer in contour boundaries, composting and use of improved varieties. Due to the strong impacts of climate change, he would like to establish contour boundaries and expand zai cropping as well as plant more trees. He is also impressed by the technology of composting that he has recently learned. He says that he was using compost but "but we made it differently." He adds, "I am sure that the compost methodology we learned can reduce labor and we are going to continue with it". He is also willing to expand even further by buying a rice thresher. He says these investments are required to "increase yield and reduce food insecurity".

3.5 Role of Local NGO: Assisting Adaptation to Climate Change

This subsection presents the role of local institutions in shaping adaptation to climate change in Mopti region. Appendix 1 presents a list of some of the organizations supporting the farmers and communities in climate change adaptation. The NGOs strengthen the adaptive capacity of the local communities in the region through various ways: they sensitize communities on climate change and its effects, provide extension and training on climate change adaptation, and promote and support adoption of SWC methods such as improved seed, zai pits, contours and soil erosion bunds as well as tree planting/reforestation. The training strategy is the most sustainable, targeting both men and women. Table 25 shows the number of women trained by the NGOs on climate adaptation in the region.

3.6 Summary, Conclusions and Recommendations

3.6.1 Summary and Conclusions

The present study analyzed stakeholder perceptions of climate change, its causes and effects, adaptation strategies used, and the barriers to adoption of climate resilient practices. The findings from the study show that farmers in the study region are, in general, aware of climate change, and its potential effects on livelihoods. Farmers reported several climatic changes that have occurred over the past 10-20-years including stronger and violent winds, increased temperature, poor rainfall pattern and reduced vegetation cover. In all the farming systems, male headed households mostly perceived increase in temperature and stronger and violent winds. The pattern is quite similar for the female headed households except those residing the mixed farming system, who perceived reduced vegetation cover and increased temperature as the main climate events. A large proportion of farmer households especially those headed by females indicated that climate change had affected their farming activities. Farmers also perceive increased poverty, food insecurity and malnutrition due to climate change in households and communities in the region.

Both male and female headed farmer households in the region use diverse strategies to adapt to climate change. The most common ones include livestock diversification, crop diversification, mixed farming, fertilizer application, utilization of weather forecast information in agriculture, and use of soil and water conservation measures. However, adoption of capital and labor intensive adaptation technologies, especially mineral fertilizers, soil and water conservation practices and pesticides remain low in both male and female headed households. The results generally show comparable adaptation behavior between the households headed by males and those headed by females – except for a few adaptation methods dominated by male farmers. For example, a significantly large proportion of male headed households diversified their crop and livestock enterprises relative to their female headed counterparts. The findings also show variations in adoption of most of adaptation practices among the farming systems, except crop diversification and pesticide application. In particular, most of the adaptation methods are commonly used by farmers residing in the mixed farming system, relative to the rice and the dry cereals systems.

Farmers reported several barriers that hamper adoption of climate resilient practices in the region. The main barriers include lack of financial resources to invest in climate adaptation, limited access to land (especially by female farmers), labor constraints and lack of adequate information. For instance, farmers (especially females) who did not use improved seed and fertilizers cited high cost and limited availability of the inputs as the main barriers to adoption.

We further estimated a poisson model to examine the factors that influence the number of adaptation practices used by a farmer, while paying special attention to the role of gender. The results clearly show that gender plays a significant role in climate change adaptation. In particular, households headed by males were more likely to use more adaptation practices compared to their female headed counterparts. Other factors that appear to influence adaptation include crop land size, neighborhood effects,

Table 25. Number of women and men trained in climate adaptation by local NGOs.

	Completed training		Still training		Adopted a practice	
Village	Males	Females	Males	Females	Males	Females
Nene	40	20	80	40	80	40
Diallassagou	30	10	0	0	10	5
Kuna	60	40	0	0	20	0
Sare-mala	50	50	34	1	59	26
Somadougou	0	0	0	0	0	0
Soufouroulaye	0	0	0	0	0	0
Youre	310	215	30	45	40	50
Dioungani peulh	10	30	35	15	45	40
Ogotena	20	10	0	0	20	10
Ounouna	0	50	0	0	60	60

Source: NGO survey

participation in non-farm income generation, and perception of the benefits of adaptation practices, land ownership and residence in the mixed farming system.

We also estimated a yield function to determine the effect of the adaptation practices on crop yield; the results show that crop yields significantly increase with the number of technologies adopted. With regard to the individual yield effects of the various adaptation practices used by farmers, irrigation, mixed farming, use of fertilizer and use of improved seed varieties appear to be the most important methods for climate change adaptation in the region.

3.6.2 Policy Recommendations

The findings from this study provide some key lessons for policymakers and institutions engaged in agricultural development in Mopti region. Our findings provide very strong arguments for better targeting of climate adaptation practices in the agriculture sector, to respond to climate risk. In particular, the findings call for implementing strategies that: promote and encourage mixed farming; crop diversification; promote and encourage use of improved crop varieties and fertilizers; promote and encourage adaptive and improved livestock breeds, and livestock diversification. There is a need to design and implement innovative credit schemes (low-interest credit facilities) that can increase farmer access to credit in order to make climate-smart farming practices affordable for resource poor farmers, who are the majority. Similarly, promotion of non-farm income generation among women can improve the purchasing power of households, and thus is likely to increase adoption of capital intensive climate adaptation practices among female headed households. Furthermore, implementing measures that guarantee inclusive access to land and land tenure security in the region may stimulate increased climate change adaptation particularly among female farmers. Climate resilience in the region can also be enhanced by increasing farmer access to accurate and timely weather forecast information, as well as increasing public awareness of climate change (causes and effects). In particular, adoption of climate resilient practices can be increased by integrating climate change in agricultural extension and advisory. Increased access to forecast information can be enhanced by designing local systems for information dissemination. An example is sending weather forecast information to farmers and farmer leaders via subsidized periodic phone text messages. This may require facilitating increased access to phone services by both male and female farmers. Finally, food security could also be influenced by lack of appropriate use of available food given the impact of climate change. The improvement of nutritional skills and the use of improved recipes that take into consideration existing improved varieties specific qualities and the present availability of local food linked to climate change might positively influence climate resilience.

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Appendix 1. Some of the NGOs supporting the climate change adaptation in Mopti region

Village code	Organization	Main activity	Climate adaptation measures supported
	AKF	Rural Development, Health, Education	Training of women on techniques of gardening, savings group
Nene	DRA (Direction Regional de l'Agriculture)	Agriculture	Promote use of improved seed, Sensitization
Kuna	ORM (Office Riz Mopti)	Agriculture	-
Sara-mera	ORM (Office Riz Mopti)	Culture of Rice	Development and repair of irrigated perimeters
Somadougou	CRS (Catholique Relief Service)	Agriculture, Education, Society, Humanitarian	Outreach awareness of varieties of millet, sorghum, cowpea through field schools
Somadougou	DRA (Direction Regional de l'Agriculture)	Agriculture (Mentoring producers)	Techniques of adaptation, awareness and supply of improved seed
Soufouroulaye	ORM (Office Riz Mopti)	Culture of rice	Construction of irrigated perimeters, popularization of early maturing varieties, training on production techniques such as organic farming
Youre	DRA (Direction Regional de l'Agriculture	Agriculture	Providing agricultural inputs, seed; training and sensitization on SWC
Dioungani peulh	Djoliba environnement	Controlled environment	Spreading awareness, training on better practices; promotion of reforestation
Dioungani peulh	Poste forestier de Diongani	Support Council	Spreading awareness on climate change and reforestation
Diallassagou	DRA (Direction Regional de l'Agriculture)		Sensitization, promotion of the use of early seeds; support construction of anti erosion bunds
Ogotena	DRA (Direction Regional de l'Agriculture)	Agriculture Diversification	Promote pasture production, mulching in the fields
Ogotena	IFCD (International Fertilizer Development Centre)	Agriculture	Use of micro dosing
Village Ounouna	DRA (Direction Regional de l'Agriculture)	Agriculture	Using early maturing varieties, farmers training, anti erosion bund
Kolonie	ORM (Office Riz Mopti)	Rice Production/Literacy support	Seed supply, training on production and water management of the perimeter

Compost preparation

The following pictures contain different photos for compost preparation in Koro and Bankass.






Community experiential learning for contour boundaries design in Koro village

Intercropping

The following pictures show different photos for intercropping.

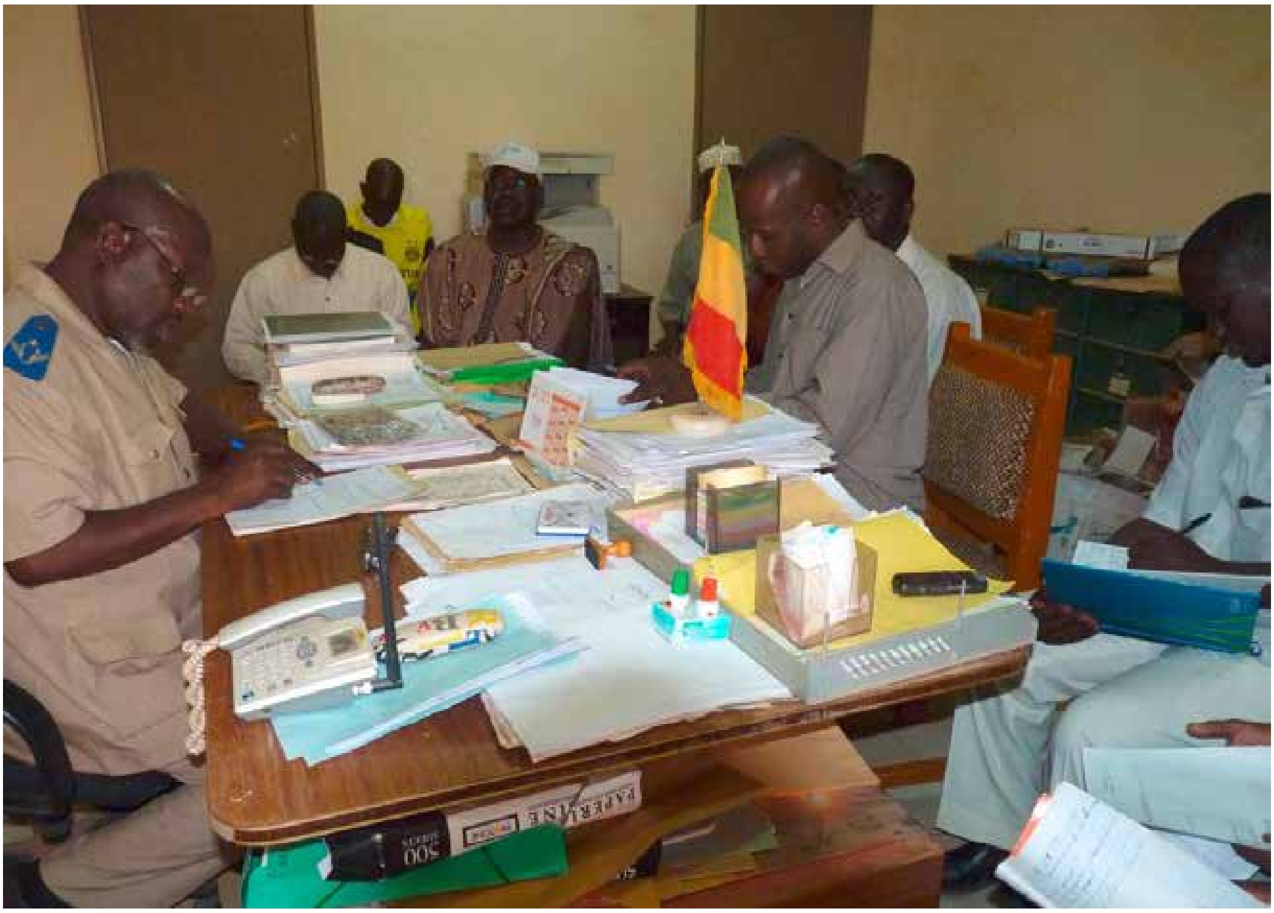
Sorghum intercropping with cowpea in the field of a farmer trained by the project in Somadogo.

Interviews

Some photos done during the interviews to householder done to prepare the present book

Meteo

The photos depict the creation of the Group Local D’action Meteorologiques (GLAM) which will design local level bulletins for farmers and radio transmission every 10 days over the season



Microdose

The following pictures contain different photos for microdosing.

Varieties

Various photos comparing varieties.

Field visit to a Farmer Field School in Alley Daga.

Farmer explaining plastic rain gauge use in Toumboka village.

A women contribute to the design of contour boundaries in Soufourolaye.

Practicing the second microdosing application in a millet field near Koro.

Field visit to an agroforestry food bank managed by the women group in Toroli village.

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