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Climate Shocks, Adaptation, and Well-Being in Ghana

A MIXED METHODS STUDY

Nkechi S. Owoo

Abstract

The research paper adopts a mixed methods approach to understanding climate shock and consequences in the Ghanaian context. The nationally representative Ghana Living Standards Household Survey (GLSS) is merged with district-level geocoded information on climate events to quantitatively explore associations between climate shocks and farm inputs demand. Results show commercial purchases of inputs as a potential coping strategy among agricultural households. The remainder of the paper uses qualitative methods to better understand other adaptation strategies. Interviews with women shine more light on their housework adjustments and implications for leisure. Adaptation is, however, not a universal response to climate change and disaster events. Despite observed mental health associations, the paper highlights the role of religion in passive dispositions when it is believed that disaster events are divine and do not merit an adaptation response. The study improves understanding of individuals' adaptation, and non-adaptation, responses to climate shocks in Ghana.

KEYWORDS
climate change fatalism, farm input demand, gender roles, mental health, mixed methods, Ghana

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Climate Shocks, Adaptation, and Well-Being in Ghana: A Mixed Methods Study

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The survey dataset analysed during the current study are available from the website of the Ghana Statistical Service: https://www2.statsghana.gov.gh/nada/index.php/catalog/97/study-description. The data on climate shocks is available from the Geocoded Disasters (GDIS) dataset from the International Disasters Database (EM-DAT).

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1. Introduction

The growing body of research on climate change has focused understandably on adaptation responses to climate change among farmers (Khanal and Mishra, 2017; Abbass et al., 2022). In Ghana, agriculture is predominantly smallholder, traditional and rain-fed. Climate variability and shocks therefore pose severe risks and threats to farmers livelihoods and food security (Asare-Nuamah and Mandaza, 2020; Cooper et al., 2008; Devereux, 2007). Recent research indeed points to the adverse effects of climate change on farming yields in Ghana (Asare-Nuamah, 2021; Jagermeyr et al., 2021; Atanga and Tankpa, 2021; Tetteh et al., 2022), and the adoption of farming technologies is therefore a necessary adaptation response to climate shocks to mitigate lower yields.

Another branch of research on climate change adaptation explores women's coping strategies as it relates to gender roles and their domestic work. Not much is known about how women cope with climate change, particularly in developing country contexts, despite their higher vulnerability. In Pakistan, women coped by reducing their frequencies of buying clothes, and bought less expensive foods, among others (Batool et al., 2018); in Kenya, women diversified their activities, withdrew labour from male enterprises, among others, as a means of coping (Rao, 2019); in Iran, the use of credit facilities and loans was the dominant strategy (Moayedi and Hayati, 2023). Women already shoulder almost three times more domestic work in Ghana, compared to men (Owoo et al., 2022) and the effects of climate shocks have the potential to increase this. With the exception of work by Glazebrook (2011) in Northeast Ghana, few studies have explored how climate change contributes to women's hardships and domestic work burdens in Ghana.

While existing research suggests that farm households adapt to minimise risks of food losses and insecurity, and women adopt strategies in response to disaster events, adaptation is not a universal response to disaster and climate shocks. Underlying religious and cultural beliefs play an important role in individuals' decisions to adapt, or not to adapt, to climate events. While research on the role of religion on climate change policies and adaptation is new and growing, no attempt has been made to understand the role of religion on climate change adaptation in the Ghanaian setting despite over 98% of the population reporting some religious affiliation (GSS, 2021). This is a serious oversight for a couple of reasons. First, if the population has strong religious beliefs that climate change is God-sent and outside of their control, then coping/adaptation responses are likely to be weaker and less urgent (Hulme, 2015; Schwadel and Johnson, 2017). Additionally, if the population believes that climate change and disaster events reflect the end of the world and an imminent afterlife, there may be a lower perception of climate change risk (Hope and Jones, 2014). Therefore, these two factors—lower perceived risks, and lower motivations to invest in preparedness—are implicated in effects of religiosity on climate adaptation. Sharma et al. (2021) uses a cross-section of 75 countries and find that a country's propensity to adopt climate change policies is negatively influenced by the average strength of religiosity within the population. They further add that these results are irrespective of religious affiliation.

Nonetheless, the effects of climate change are undeniable. While existing research focuses predominantly on physical health impacts (Trtanj et al., 2016; Lawrance et al., 2021), some considerable climate-related health consequences are on mental aspects (Page & Howard, 2010; IPCC, 2022). While most of the research that has been conducted on the linkages between climate change and mental health has been conducted in Europe, North America, and Australia, several of the areas that are currently most vulnerable to climate change are in low- and middle-income settings, with fewer adaptive mechanisms. In Ethiopia, Cooper et al. (2019) showed that water insecurity resulting from flooding contributed to anxiety and fatigue among pastoralists. Gibson et al. (2020) also found that a high proportion of participants in Tuvalu in the Pacific Region were experiencing significant psychological distress as a result of their experience of climate change effects. Merely hearing information about devastating effects of climate change also increased their stress levels. In Ghana, Acharibasam and Weniga (2018) found that climate change contributed to a rise in use of counterproductive emotional regulation strategies among farmers in Northern Ghana, which likely increased predispositions to mental disorders in the future. Dziwornu and Kugbey (2015) explored mental health problems and coping strategies among 400 flood victims and non- victims in the Eastern Region of the country, and using t-tests, found significant differences in mental health outcomes between flood victims and non-victims. In this paper, potential channels of effect are explored in advancing our knowledge of how climate shocks affect mental health in Ghana.

The following specific questions are asked:

1. What is the relationship between climate shocks and input demand (through commercial purchases) in Ghana?
    a. What other strategies are adopted by farmers to cope better with shocks?
2. How do women in Ghana cope with climate change?
3. What is the role of religion in climate adaptation strategies?
4. What are the potential channels through which climate shocks affect mental health in Ghana?

Using a mixed methods approach, the main results may be summarized as follows. Adaptation is not a universal response to climate shocks, and while a lot of studies are geared towards building adaptive capacity of households, particularly in developing country settings, more recognition should be given to cultural and religious factors that may significantly mitigate responses. In this paper, agricultural households adapted by increasing their input demand when disaster events occur, and women adapted by changing their domestic work hours and reducing their sleep durations. In other cases, religious individuals, believing that disaster events are divine and should not necessitate responses, adopted more passive dispositions. The effects of climate change are however undeniable, and using a mixed-methods approach, the research indicates that heat stress, loss of employment opportunities and forced migration are important channels through which climate shocks affected the mental health and wellbeing of Ghanaians.

The rest of the paper is organized as follows: Section II presents information on the datasets used in the analyses, as well as the analyses techniques employed. Section III presents the results from the quantitative and qualitative analyses and discusses the research findings. Section 4 concludes and provides some policy applications from this research.

2. Materials and methods

2.1 Quantitative data

The most recent round of the Ghana Living Standards Survey (GLSS VII), collected in 2016/17, is used in the analyses. Previous rounds of the survey were conducted in 1987/88, 1988/89, 1991/92, 1998/99, 2005/06, and 2012/13. This repeated cross-sectional dataset collects information on household demographics, household expenses, education, health, economic activities, migration, housing, agriculture, prices of food, pharmaceuticals, and non-food items, and community facilities. Data is available for over 14,000 households and more than 60,000 individuals. The analysis is restricted to 5,666 households that are involved in crop production, the dominant subsector in Ghana's agricultural sector. The sample is further reduced to 5,275 households as a result of missing information of education on some household members. Finally, missing information on community-level variables such as access to passable roads and permanent community markets further reduced the sample to 4,674 observations.

Data on climate shocks was obtained from the Geocoded Disasters (GDIS) dataset from the International Disasters Database (EM-DAT). This contains essential core data on the occurrence and effects of over 22,000 mass disasters in the world from the 1900s to the present day. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. For a disaster to be entered into the database at least one of the following criteria must be fulfilled: Ten (10) or more people reported killed; hundred (100) or more people reported affected; there must have been a declaration of a state of emergency; or a call for international assistance. For Ghana, over 90% of the recorded events are floods, with the remainder being storms. It is expected that farmers in affected districts may respond by increasing adaptive capacities through increased input demand.

2.1.1 Dependent variable

Information on commercial purchase of farming inputs was obtained from the survey question '*Did you spend anything in cash and/or in kind on [input] in the past 12 months' (Yes/ No)*? Affirmative responses were coded as '1', and '0' otherwise. The choice of inputs in this paper (i.e., inorganic fertilizer, herbicides, hired labour) is informed by the existing literature (e.g., Mendelsohn and Wang, 2017; Makate and Makate, 2022).

2.1.2 Main independent variable

The climate shocks variable used in this paper is constructed from the number of natural disasters (mostly flooding) that occurred in various districts in Ghana in the three years preceding, and including, the years of data collection for GLSS VII. A dummy variable of 1 is assigned where the household has experienced a shock within this period. The three-year window is selected to be consistent with Benabderrazik et al. (2022). Information on climate shocks at the district level was combined with district level identifiers in the GLSS VII, making it possible to conduct a micro-level study of the relationship between climate shocks and expenditures on various inputs in different farming households.

2.1.3 Other control variables

Household level factors, farm characteristics as well as geographical and community infrastructure variables are included as controls in the analyses. Descriptive statistics on these are provided in Table 1 below, by rural and urban location.

About a third of households have purchased inorganic fertilizers, while about 60% have purchased herbicides for use on their farms. Half of all households in the analytic sample report hiring labour to assist with work on the farms. The purchase of inorganic fertilizers is statistically higher in rural communities, while the purchase of hired labour is more prevalent in urban farming households.

With respect to their experience of climate shocks, a little under 10% of households have experienced flooding in their districts. Majority of Ghanaians in the sample are Christians (69%); Muslims make up 16% of the analytic sample, while household heads with no religion and Traditionalists make up 7.6% and 8%, respectively. More Christians are in urban, compared to rural areas, while more Traditionalists are found in rural areas.

Three-quarters of all households in the sample are headed by men, and the average age of household heads (male and females) is about 50 years old. With respect to educational attainment, in 36% of households, no household member reports being formally educated. In 39% of households, the highest qualification of a family member is basic education (i.e., BECE, middle school or O level certificate). In 17% of households, the highest qualification of family members is a secondary school or A 'level certificate, while in 8% of households, members have at most a post-secondary school education. Household members in urban households have significantly more educational attainment than their rural counterparts.

With respect to farm characteristics, a farm is, on average, 1.8 acres large, with the largest farm in the analytic sample being almost 11 acres large. Farm sizes tend to be larger in rural, compared to urban households. Households have, on average, almost 2 plots of land each, with no significant differences by rural/urban location.

With respect to household's poverty characteristics, 12% of households are extremely poor, using Ghana's extreme poverty line of about Ghc900 (approx. $60) per year. Nineteen percent of households are poor, and consume less than Ghc1,300 per year (approx. $90). About 70% of households are non-poor. The proportions of poor households are higher in rural, compared to urban households. Households are made up of 5 members, on average, although the largest households are found in rural areas.

About 22% of households in the sample of farming households are based in urban areas, with the larger majority resident in rural areas. This is not surprising as farming activities are predominant in rural communities in Ghana.

With respect to community infrastructure, 41% of households reside in communities where the roads are impassable at certain times of the year. About 21% of households reside in communities with a permanent market. Community characteristics are more favourable in urban areas, where roads are more passable and there is the greater presence of more permanent, fixed markets.

TABLE 1. Descriptive statistics, by rural and urban location

	Full Sample		Rural Sample		Urban Sample		
Study Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**T-Tests**
Dependent Variable: Commercial Inputs							
Purchase of inorganic fertilizer (Yes=1; No=0)	0.337	0.47	0.345	0.48	0.308	0.46	0.07***
Purchase of herbicides (Yes=1; No=0)	0.596	0.49	0.61	0.49	0.545	0.5	0.01
Hiring of off-farm labour (Yes=1; No=0)	0.528	0.5	0.527	0.5	0.53	0.5	−0.03*
Main Independent Variable							
Climate Shocks (Yes=1; No=0)	0.076	0.26	0.071	0.26	0.093	0.29	−0.04***
Controls							
Head- No religion	0.076	0.27	0.080	0.27	0.063	0.24	0.01
Head- Christian religion	0.687	0.46	0.681	0.47	0.706	0.46	−0.07***
Head- Muslim religion	0.157	0.36	0.146	0.35	0.197	0.40	−0.03*
Head- Traditional religion/ other	0.080	0.27	0.093	0.29	0.033	0.18	0.10***
Gender of head (male=1)	0.753	0.43	0.759	0.43	0.734	0.44	0.06***
Age of head	49.503	14.69	49.235	14.76	50.439	14.41	−0.95
Highest education of members: none	0.363	0.48	0.402	0.49	0.228	0.42	0.22***
Highest education of members: basic	0.391	0.49	0.394	0.49	0.38	0.49	−0.06***
Highest education of members: secondary	0.167	0.37	0.148	0.35	0.234	0.42	−0.07***
Highest education of members: post-secondary	0.079	0.27	0.057	0.23	0.158	0.37	−0.09***
Land size (acres)	1.868	0.98	1.908	1.01	1.728	0.85	0.20***
No. of plots owned	1.581	1.15	1.605	1.18	1.498	1.03	0.06
Poverty status: Very poor	0.119	0.32	0.145	0.35	0.027	0.16	0.20***
Poverty status: Poor	0.189	0.39	0.212	0.41	0.112	0.32	0.11***
Poverty status: Non-Poor	0.692	0.46	0.643	0.48	0.86	0.35	−0.31***
Household size	5.11	3.14	5.246	3.2	4.636	2.87	0.79***
Urban location	0.223	0.42	–	–	–	–	–
Roads are impassable (Yes=1; No=0)	0.41	0.49	0.485	0.5	0.15	0.36	0.28***
Permanent community market (Yes=1; No=0)	0.211	0.41	0.079	0.27	0.671	0.47	−0.51***
Region: Western	0.145	0.35	0.153	0.36	0.118	0.32	0.02
Region: Central	0.11	0.31	0.105	0.31	0.128	0.33	−0.080***
Region: Greater Accra	0.017	0.13	0.014	0.12	0.028	0.17	−0.003
Region: Volta	0.093	0.29	0.1	0.3	0.071	0.26	0.001
Region: Eastern	0.127	0.33	0.111	0.31	0.184	0.39	−0.07***
Region: Ashanti	0.165	0.37	0.173	0.38	0.138	0.35	−0.001
Region: Brong Ahafo	0.121	0.33	0.1	0.3	0.193	0.39	−0.10***
Region: Northern	0.117	0.32	0.121	0.33	0.101	0.3	−0.004
Region: Upper East	0.061	0.24	0.068	0.25	0.035	0.18	0.07***
Region: Upper West	0.044	0.21	0.056	0.23	0.004	0.06	0.17***
Observations	4,674		3,976		698		4,674

Note: * p<0.10, ** p<0.05, *** p<0.01.

Source: Author constructions; household weights applied.

Regional controls are also included- 17% of respondents are based in the Ashanti region, followed by 14% in the Western region. About 12% of households are located in the Eastern, Brong Ahafo and Northern regions, each. The fewest farming households are sampled from the Greater Accra region (1.7%), Upper West (4.4%) and Upper East (6.1) regions.

2.2 Qualitative data

The qualitative study employed both purposive and snowball sampling techniques for the selection of its participants. The data collection exercise lasted 2 months from February–March 2023, and participants were sourced from the Ashanti and Northern regions of Ghana.

The Ashanti region is located in the Forest belt in the southern part of the country. About a third of the population is involved in agriculture (Guodaar et al., 2016) and its capital city, Kumasi, is a hub for the buying and selling of agricultural products. Crops commonly produced include maize, cassava, groundnuts and vegetables. The Northern region is located in the Savannah agroecological zone. Majority of the people in the region are involved in agriculture, which is mostly rainfed. Crops typically grown are maize, millet, sorghum, rice, shea nuts and vegetables. Regions in northern Ghana have received significant attention in the literature due income poverty as well as heightened vulnerabilities to climate change (Abdulai et al., 2018, Fagariba et al., 2018, Adu et al., 2018).

To capture heterogeneity in responses, farmers from different age groups, educational backgrounds, residence and gender were considered. In each region, 6 men and 10 women were interviewed. In total, 32 individuals, predominantly small-scale farmers, made up the sample size. Semi-structured interviews were used to elicit information from the participants. Interpreters were used to assist in the collection of the data in localities where the local languages were not spoken by the researcher(s). All interviews were audio recorded with the participant's permission. These recordings were then transcribed and translated verbatim into English from the local language.

Analytic rigor was ensured through comparisons of notes and recordings taken during the interview sessions with respondents. Thematic analysis was used to organize and categorize the data according to patterns and structures that connected the themes (Attride-Stirling, 2001). Thematic analysis was performed by identifying, analysing, and reporting themes across the narratives. An inductive approach was adopted in the development of the qualitative codes where research findings were allowed to emerge from the frequent or dominant themes contained in the data.

The researchers carefully considered all the ethical issues involved in conducting research. Clearance for the study was obtained after going through ethical review by the Ethics Committee for the Humanities, University of Ghana (Approval number- ECH 056/ 22-23). Consent was sought from all participants before proceeding with the study. Anonymity of participants are ensured by using pseudonyms to identify each respondent.

2.3 Methods

The empirical strategy comprised the use of probit regression models to explore connections between climate shocks and the commercial purchase of farming inputs, controlling for a host of farmer and institutional factors, including religious affiliation.

Three specifications of the following regression model is run for the pooled, rural and urban households:

$$PurchasedInputs_h = \alpha Climate\ shocks_h + \beta Location_h + \gamma Controls_h + \epsilon_i \quad (1)$$

$PurchasedInputs_h$ refers to the input demand for inorganic fertilizers, herbicides, hired labour in household *h*. $Climate\ shocks_h$ is a dummy variable with information on whether household *h* experienced a climate shock in their district in the three years leading up to and including the survey period. $Location_h$ refers to whether household *h* resides in an urban (=1) or a rural (=0) household. $Controls_h$ refers to the religious, household, geographic and community controls detailed in Table 1. α, β, γ are a set of parameters to be estimated. The presence of religion in the regression explores its association with climate shocks adaptation. To understand whether there are heterogeneities in adaptations to shock by religious affiliation, an interaction effects technique is adopted:

The model may be presented as follows:

$$PurchasedInputs_h = \alpha Climate\ shocks_h + \vartheta Religion_h + \phi\alpha Climate\ shocks_h * Religion_h + \beta Location_h + \gamma Controls_h + \epsilon_i \quad (2)$$

In all specifications, standard errors are clustered at the district level to account for spatial correlation of climate shocks.

A noted limitation is the "rare event" of climate shocks in the data (i.e., less than 10%). Maximum likelihood estimation is known to suffer from small-sample bias, with a greater degree of bias present when event cases are rare. The use of penalized likelihood reduces the analytical bias from rare events and produces finite, consistent estimates of regression parameters when the maximum likelihood estimates do not even exist because of complete or quasi-complete separation. Results of Firth penalized marginal likelihood estimations are reported as robustness checks in the Appendix Tables A1 and A2.

There are a few other noted limitations. First, for the qualitative survey, the snowball and purposive nature of the data collection process could have led to some bias in responses. Additionally, the selection of respondents was neither random nor representative, and therefore, limits the capacity for inference. Third, despite the use of interpreters, language and cultural barriers could have led to inaccuracies in the translation and the interpretation of some interviews, leading to some loss of information in the analyses.

With respect to the quantitative analyses, the cross-sectional nature of the dataset makes it difficult to control for unobserved time-invariant factors which may bias the results. Based on these limitations, causal claims are not made in the estimation of the effect of climate shocks on adaptation. Results of the quantitative analyses are therefore interpreted with caution, and presented as robust correlations, instead. Results are compared with findings from the qualitative survey to provide a more complete picture.

3. Results and discussion

This section is divided into two and summarizes both quantitative and qualitative results.

3.1 Climate shocks and input demand

Using a probit model specification, with errors clustered at the district level, odds ratios are reported in Table 2, with results disaggregated by rural and urban areas.

It is observed that households that have experienced flooding shocks in their districts are associated with higher odds of purchasing inorganic fertilizers, herbicides and hired labour, although the results are only marginally significant in the last two cases of the pooled sample. Associations are positive, as expected, and marginally significant in rural areas. Among urban households, the occurrence of a shock is associated with an increase in demand for fertilizers, again, an effect which is marginally significant (results from the penalized MLE models show stronger and more significant associations in Appendix Tables A1 and A2). Flooding may lead to greater soil erosion and increase the need for nutrient supplements in the soil. Access to inorganic fertilizers therefore enables farmers to carry out climate-resilient fertilizer application (Murendo and Wollni 2015). The increased odds of investments in herbicides are not surprising given as weeds and other undesirable vegetation often have higher plasticity to changing climate conditions (Verlinden et al., 2014). These results are similar to findings by other researchers that find that farmers increase their input use to mitigate the effects of shocks (Makate and Makate, 2022; Tan et al., 2010; Srivastava et al., 2012; MacCarthy et al., 2017).

TABLE 2. Probit regressions of effects of climate shocks on input purchases

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Shock (Yes=1)	1.398**	1.431*	1.275*	1.352*	1.493*	1.294*	1.804*	1.338	0.911
	(2.00)	(1.84)	(1.69)	(1.81)	(1.80)	(1.65)	(1.74)	(1.56)	(–0.36)
Urban	0.947	0.775**	0.740***	–	–	–	–	–	–
	(–0.45)	(–2.52)	(–2.96)	–	–	–	–	–	–
No religion	0.699**	0.604***	0.984	0.744**	0.580***	1.057	0.470	0.811	0.727
(*Muslim is base*)	(–2.52)	(–3.36)	(–0.15)	(–2.05)	(–3.35)	(0.50)	(–1.64)	(–0.77)	(–1.26)
Christian	0.840*	0.696***	1.096	0.851*	0.657***	1.166*	0.814	0.981	0.774
	(–1.88)	(–2.67)	(1.23)	(–1.68)	(–2.69)	(1.92)	(–0.95)	(–0.10)	(–1.39)
Traditionalist	0.711***	0.659***	0.989	0.749***	0.632***	1.032	0.473**	0.606**	0.647*
	(–3.33)	(–3.10)	(–0.12)	(–2.84)	(–2.95)	(0.32)	(–2.18)	(–1.99)	(–1.66)
Male head	1.275***	1.192***	0.947	1.259***	1.182***	0.930	1.268*	1.228*	1.117
	(4.72)	(3.21)	(–1.06)	(4.01)	(2.64)	(–1.32)	(1.84)	(1.86)	(0.98)
Age head	1.002	0.995	1.020**	1.006	0.996	1.017*	0.977	0.982	1.035
	(0.28)	(–0.55)	(2.42)	(0.66)	(–0.40)	(1.94)	(–0.87)	(–0.82)	(1.44)
Age squared	1.000	1.000	1.000***	1.000	1.000	1.000**	1.000	1.000	1.000
	(–0.78)	(–0.28)	(–2.67)	(–1.10)	(–0.39)	(–2.22)	(0.62)	(0.53)	(–1.32)
Basic	1.042	1.030	1.144**	1.027	1.004	1.122*	1.164	1.356**	1.174
(base: None)	(0.71)	(0.51)	(2.36)	(0.42)	(0.06)	(1.92)	(1.10)	(2.14)	(1.01)
Secondary	1.095	1.072	1.206***	1.077	1.047	1.206***	1.278	1.342*	1.138
	(1.38)	(1.12)	(2.91)	(1.04)	(0.66)	(2.81)	(1.39)	(1.78)	(0.81)
Post-secondary	1.022	0.977	1.265**	0.992	0.922	1.285**	1.213	1.312	1.188
	(0.20)	(–0.23)	(2.36)	(–0.07)	(–0.67)	(2.02)	(0.94)	(1.34)	(1.03)
Land size (log)	1.162***	1.231***	1.272***	1.136**	1.247***	1.276***	1.344***	1.112	1.239***
	(3.11)	(5.62)	(5.60)	(2.53)	(5.10)	(5.03)	(3.12)	(1.55)	(2.80)
# Plots	1.066**	1.126***	1.129***	1.061*	1.129***	1.127***	1.116	1.121	1.156**
	(2.02)	(3.68)	(4.22)	(1.70)	(3.53)	(3.97)	(1.47)	(1.53)	(1.99)
Poor	0.768***	0.911	0.739***	0.758***	0.912	0.737***	0.769	0.829	0.743*
	(–3.24)	(–1.23)	(–5.22)	(–3.24)	(–1.12)	(–4.99)	(–1.62)	(–1.09)	(–1.96)

TABLE 2. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Household size	1.027***	1.016*	0.995	1.031***	1.020**	1.002	1.007	0.988	0.959*
	(2.79)	(1.78)	(−0.59)	(3.02)	(2.07)	(0.27)	(0.25)	(−0.66)	(−1.95)
Impassable road	0.959	0.974	1.006	1.012	0.921	1.038	0.445***	1.497**	0.758*
	(−0.47)	(−0.27)	(0.07)	(0.12)	(−0.80)	(0.43)	(−3.38)	(2.24)	(−1.65)
Market	0.973	1.087	1.472***	0.963	0.957	1.640***	1.173	1.378	1.140
	(−0.22)	(0.76)	(3.21)	(−0.24)	(−0.33)	(3.15)	(0.83)	(1.55)	(0.81)
Western	0.536***	1.043	0.712**	0.556***	1.133	0.771	0.342**	0.569	0.484**
(base: Northern)	(−3.74)	(0.17)	(−2.30)	(−3.16)	(0.47)	(−1.60)	(−2.45)	(−1.37)	(−2.24)
Central	0.495***	0.942	0.991	0.502***	0.950	1.060	0.344**	0.761	0.642
	(−3.34)	(−0.22)	(−0.06)	(−2.83)	(−0.16)	(0.35)	(−2.52)	(−0.91)	(−1.24)
Greater Accra	1.525	0.667	0.761	1.990*	0.715	0.813	0.310**	0.442*	0.568
	(1.16)	(−0.90)	(−0.80)	(1.71)	(−0.64)	(−0.51)	(−2.29)	(−1.76)	(−1.22)
Volta	0.616**	1.860***	1.644***	0.572***	1.925***	1.926***	0.677	1.559	0.657
	(−2.45)	(2.87)	(3.20)	(−2.79)	(2.60)	(3.89)	(−0.76)	(1.40)	(−1.14)
Eastern	0.392***	1.056	0.850	0.377***	1.151	0.899	0.309***	0.659	0.565*
	(−5.06)	(0.22)	(−1.06)	(−4.64)	(0.48)	(−0.58)	(−2.59)	(−1.34)	(−1.66)
Ashanti	0.491***	0.829	0.942	0.510***	0.840	0.986	0.264***	0.773	0.707
	(−3.49)	(−0.74)	(−0.35)	(−2.99)	(−0.62)	(−0.07)	(−2.76)	(−0.60)	(−0.86)
Brong Ahafo	0.745	1.474	1.432**	0.845	1.518	1.507**	0.330**	1.137	0.983
	(−1.24)	(1.62)	(2.38)	(−0.66)	(1.52)	(2.29)	(−2.43)	(0.37)	(−0.05)
Upper East	2.320***	0.654	1.506**	2.323***	0.684	1.716***	2.063	0.488**	0.478**
	(3.37)	(−1.61)	(2.50)	(3.38)	(−1.33)	(3.01)	(1.36)	(−2.00)	(−2.09)
Upper West	1.012	0.478***	0.587***	1.049	0.488**	0.625***	0.455**	0.847	0.422***
	(0.08)	(−2.66)	(−3.44)	(0.27)	(−2.44)	(−2.85)	(−2.14)	(−0.75)	(−3.30)
N	4674	4674	4674	3976	3976	3976	698	698	698

Notes: Odds ratios reported; t statistics in parentheses: * p<0.10, ** p<0.05, *** p<0.01; Errors clustered at district level.

Results are also supported by the qualitative survey where farmers responded that they experienced increased inputs costs as a result of climate change:

> *...we also use fertilizers because the climate change has also affected the soils fertility, so we do all these one to improve the crops that's why am saying that the cost is high*. Educated male, 38 years, Northern region.
>
> *At first,.... we do not even use fertilizer on the crops but today....if they don't apply fertilizer it won't germinate*. Uneducated woman, 63 years, Ashanti region.

Climate change also increased expenditures on hired labour. In Ghana, farmers hire labour on a daily basis and where temperatures are too high to allow farm work to continue, they experience high costs:

> *There are also days that you take them (hired labourers) to your farm just to weed and because of the scorching nature of the sun, they are not able to put up their best because they are afraid to be in the scorching sun for so long. So, it is affecting the cost of labour and that goes on to affect our crop output*- Educated male, 38 years, Northern region.

Other results from the quantitative regression analyses are worth discussing- Using Muslim household heads as the base category, it is observed that Christian household heads are associated with lower odds of purchasing fertilizers and herbicides, particularly in rural areas. Traditionalists in both rural and urban areas are associated with lower odds of purchasing fertilizers, herbicides and farm labour.

Urban farming households are generally associated with lower odds of purchasing fertilizers and herbicides, compared to rural households. This is not surprising since farming activity is concentrated in rural areas. Male-headed households have greater adaptability and are associated with higher odds of fertilizer and herbicide input purchases, compared to female headed households. Lawson et al. (2020) also find that Ghanaian women farmers are less likely to adopt these sorts of inputs for use on their farms. This is because men usually have more control over essential production resources, compared to women, by virtue of existing social and cultural norms (Omonona et al., 2006). Older household heads have higher odds of using hired labour, although the relationship between adaptability and age is non-linear. This finding is consistent with other studies by Mignouna et al. (2011) and Kariyasa and Dewi (2011). Education is particularly important for the adoption of technology, particularly the use of hired labour. Compared to households whose members have no educational qualification, more educated households have increasingly higher odds of purchasing commercial inputs. This is consistent with other literature (Okunlola et al., 2011; Uematsu and Mishra, 2010) as education likely improves the perceptions of farmers to the agro-economic potential of farming inputs, and hence increases their demand.

Farmers with more plots and larger farm sizes have higher odds of investing in inputs like inorganic fertilizers, herbicides and hired labour, controlling for education and household income, again consistent with other work (Lavison, 2013). Poverty is negatively related with investments in commercial inputs. Compared to non-poor households, poor households have lower odds of investing in farm inputs. This is consistent with an observation by a farmer interviewed from the Ashanti region:

> *...the rich ones buy pumping machine for irrigation*. Educated man, 51 years, Ashanti region.

Larger households have higher odds of investing in herbicides and herbicides, but not hired labour for obvious reasons that larger households enjoy a higher capacity to relax labour constraints (Mignouna et al., 2011).

Community infrastructure like fixed markets is also important for climate shocks adaptability in the sample. The presence of a permanent market in the community increased the odds of using hired labour. Regional differences are also observed. Compared to the Northern region, all regions had lower odds of fertilizer purchases, with the exception of the Upper East region, which had higher odds. Households in Central, Greater Accra, Ashanti, Upper East and Upper West regions have lower odds of investing in herbicides, compared to households in the Northern region, while households in the Volta and Brong Ahafo regions had higher odds. Compared to the Northern region, the odds of investing in hired labour is higher in the Volta, Brong Ahafo and Upper East regions, but lower in the Western and Upper West regions.

3.2 Other coping strategies

From the qualitative interviews conducted, in addition to greater input demand, a number of other strategies were adopted to cope with climate change and increase farmers' adaptive capacities. These include income diversification, water management schemes, bushfire prevention, as well as changes in planting times and other soil conservation methods.

3.2.1 Income diversification

One strategy was to rear livestock alongside crop production so that these could be sold in the event of crop failures.

> *I try to get livestocks so if I don't get enough yields, I can sell to take care of my family*- Uneducated man, 53 years, Northern region.
>
> *I don't rely on the farm produce, but I also rear livestock*- Educated woman, 31 years, Northern region.

Others opted to have multiple businesses as a cushion for the failure of one of the crops, while others sold excess produce from their farms so that the income could be used to provide some security:

> *I have so many businesses not only shea butter. I am also into groundnut paste.... I try as much as possible to own plenty businesses, so I don't rely on one income.* -Educated female, 54 years, N/R
>
> *For my family, at first, I couldn't afford their school fees but now anytime I bring food stuffs to the house we reserve some to sell.* -Uneducated male, 35 years, N/R

3.2.2 Water management schemes

To protect their farms from drought and dry conditions when the rains delayed or did not fall in the expected quantities, farmers used walls, blocks and sandbags to retain water on their farms:

> *In my farm when we plant rice, we build wall around the farm so anytime it rains the water will remain in there unlike the maize which does not like plenty water-* Educated woman, 50 years, Northern region.
>
> *I get empty fertilizer sacks and fill with sand to surround the farm to keep water inside-* Uneducated woman, 35 years, Northern region.
>
> *We use blocks to block the riverbank for the water to stay in the farm, so it produces more-* Educated girl, 15 years, Northern region.

There are other strategies adopted to retain water during drought conditions. These range from digging wells and boreholes to obtaining pumping machines for irrigation:

> *If it's not raining it affects farming, so we create a well and the water is used to water the crops-* Educated girl, 15 years, Northern region.
>
> *For drought and floods I use the bonding so that when it rains I have water in the farm I don't allow the water to run all over my farm, when there is too much water in the farm I try to create an outlet so that part of the water will go out so that my farm don't get flooded so the bonding serves two purposes, it serves flooding, and then drought-* Educated man, 38 years, Northern region.

3.2.3 Bush fire prevention methods

Climate change makes bush fires more likely (Oldenborgh et al., 2021), and these are a serious concern, particularly for farms in the Northern Region, where conditions are particularly hot and dry. Coping strategies adopted range from weeding a certain radius around the farm (Addaney et al., 2021), to planting trees, as well as transporting all harvested produce away from farms or covering with fresh and damp leaves to prevent them from being consumed in the event of an outbreak.

> *For the farm I plant some trees around the farm to prevent bush fires*- Educated male, 20 years, Northern region.
>
> *….for bush fires I weed the weeds to prevent bush fires*- Uneducated woman, 35 years, Northern region.
>
> *To avoid any fire outbreak, I take all my harvest to the house since no one can tell when it will rain or not. Sometimes I leave them on the farm and cover with fresh leaves so even if there is fire it won't burn my harvest*. Uneducated man, 80 years, Northern region.
>
> *We got someone to do fire bands around the farm and then we tried to clear around about 4 Acres all around the farm to avoid any fires that may come in*- Educated man, 52 years, Northern region.

3.2.4 Soil management techniques

Since rain patterns and quantities have become more unpredictable, farmers respond by changing the times that they plant from past practices and also practicing mixed cropping and crop rotation:

> *From the farm for instance, we used to farm early June, but we have shifted to end of June. Also, part of May there is harmattan which can cause bush fire, so I have shifted it from early to late June*- Uneducated man, 52 years, Northern region.
>
> *So, within the year if we realize it won't (rain) early we delay in planting so it will rain for us to plant*. Uneducated woman, 42 years, Ashanti region.

Findings on various coping strategies observed are consistent with other studies on Ghana. Benabderrazik et al. (2022) found that tomato farmers in the Ashanti and Upper East regions of Ghana changed the timing of planting, engaged in crop diversification as well as water harvesting activities in response to climate shocks. In the Eastern region of Ghana, Addaney et al. (2021) interviewed 50 smallholder female farmers and found that adaptation strategies adopted typically involved adopting mixed cropping to overcome climatic shocks. Limantol et al. (2016) also used data on households in Upper East region to show that farmers responded to temperature and precipitation extremes by planting different crop varieties.

3.3 Role of religious factors in coping strategies adopted

It is important to have a good understanding of farmers' perceptions about the origin of climate change because it likely affects adaptation strategies. The evidence on the linkages between religion and climate adaptation is presented in Table 3, using interactions between climate shocks and religious affiliations of household heads. While Christians who have not experienced shocks are associated with higher likelihoods of purchasing farm labour, the additional effect of experiencing

a shock is associated with a lower likelihood of purchasing hired farm labour. This effect is observed particularly among rural households. A potential explanation for this is that where it is held that disaster events are God-determined, then there is likely to be less inclination to take an active role in adaptation, as well as environmental action. Results from the qualitative analyses are presented below.

While some interviewees believed that climate change is indeed related with human activity:

> *So, I think what has caused all these to happen is we, humankind. Ok, so we are not taking care of the environment in a way that we should do so because at a point in time, like, burning of some things were banished… we were told to put a stop to it. Industries polluting the air and all those things. I think all the pollution that happens cause a change in the climate.* Educated man, 24 years, Ashanti region.

More respondents appeared resigned as they believed that observed changes are divine:

> *For me I can't argue with God. If God says it should rain it will rain… You cannot water that huge farmland unless God cause it to rain …No, no, no, there is nothing I can do about it!* Uneducated woman, 80 years, Ashanti region.
>
> *How can humans do this? It is God, it is all God at work, it gets to a time that he changes the weather patterns.* Educated male, 51 years, Ashanti region.
>
> *It is the plan of God. When he says it should rain today it will. If not, we can't argue with him*. Educated man, 64 years, Ashanti region.

TABLE 3. Probit regressions of effects of climate shocks on input purchases, with religion interactions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Shock (Yes=1)	1.465	1.100	1.683***	1.343	1.059	1.803***	1.524	1.185	0.751
	(1.64)	(0.33)	(3.27)	(1.36)	(0.15)	(3.64)	(1.15)	(0.54)	(–0.80)
Urban	0.945	0.781**	0.734***	–	–	–	–	–	–
	(–0.47)	(–2.42)	(–3.07)	–	–	–	–	–	–
No religion	0.745**	0.574***	1.002	0.784*	0.562***	1.086	0.481	0.701	0.637*
(Muslim is base)	(–2.21)	(–3.40)	(0.02)	(–1.85)	(–3.27)	(0.69)	(–1.46)	(–1.25)	(–1.69)
Christian	0.848*	0.671***	1.147*	0.852	0.634***	1.222**	0.774	0.963	0.738
	(–1.66)	(–2.77)	(1.80)	(–1.57)	(–2.79)	(2.45)	(–1.12)	(–0.19)	(–1.56)
Traditionalist	0.709***	0.630***	1.054	0.740***	0.607***	1.092	0.431**	0.586**	0.642
	(–2.99)	(–3.13)	(0.59)	(–2.62)	(–3.01)	(0.93)	(–2.24)	(–1.96)	(–1.50)
Shock*no religion	0.609	1.612	0.904	0.668	1.435	0.801	0.694	1.000	2.814
	(–0.88)	(1.61)	(–0.37)	(–0.69)	(1.09)	(–0.78)	(–0.51)	(.)	(1.63)
Shock*Christian	0.967	1.436	0.654**	1.046	1.633	0.612**	1.508	1.052	1.426
	(–0.13)	(1.31)	(–2.44)	(0.19)	(1.25)	(–2.46)	(0.70)	(0.12)	(1.05)
Shock*Traditionalist	1.019	1.460	0.636	1.083	1.546	0.639	2.236*	1.006	1.000
	(0.08)	(1.24)	(–1.58)	(0.37)	(1.02)	(–1.47)	(1.67)	(0.02)	(.)
Male head	1.274***	1.194***	0.946	1.259***	1.183***	0.929	1.272*	1.228*	1.107
	(4.72)	(3.22)	(–1.10)	(4.01)	(2.64)	(–1.35)	(1.86)	(1.84)	(0.90)
Age head	1.002	0.995	1.020**	1.006	0.997	1.016*	0.978	0.983	1.036
	(0.29)	(–0.47)	(2.33)	(0.68)	(–0.33)	(1.86)	(–0.83)	(–0.80)	(1.49)
Age squared	1.000	1.000	1.000***	1.000	1.000	1.000**	1.000	1.000	1.000
	(–0.78)	(–0.34)	(–2.59)	(–1.11)	(–0.44)	(–2.16)	(0.58)	(0.53)	(–1.36)
Basic	1.042	1.035	1.138**	1.028	1.006	1.120*	1.177	1.348**	1.182
(base: None)	(0.70)	(0.58)	(2.27)	(0.42)	(0.09)	(1.88)	(1.18)	(2.10)	(1.08)
Secondary	1.094	1.078	1.198***	1.078	1.051	1.200***	1.280	1.357*	1.166
	(1.37)	(1.21)	(2.83)	(1.05)	(0.72)	(2.78)	(1.37)	(1.85)	(0.99)
Post-secondary	1.020	0.984	1.254**	0.991	0.927	1.279**	1.229	1.315	1.226
	(0.19)	(–0.16)	(2.28)	(–0.08)	(–0.63)	(1.99)	(0.98)	(1.36)	(1.25)
Land size (log)	1.163***	1.230***	1.273***	1.137**	1.246***	1.276***	1.351***	1.100	1.227***
	(3.13)	(5.55)	(5.60)	(2.54)	(5.07)	(5.03)	(3.17)	(1.38)	(2.67)

TABLE 3. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
# Plots	1.067**	1.127***	1.127***	1.062*	1.131***	1.125***	1.114	1.125	1.157**
	(2.03)	(3.70)	(4.07)	(1.72)	(3.56)	(3.78)	(1.44)	(1.57)	(2.00)
Poor	0.766***	0.914	0.736***	0.756***	0.914	0.734***	0.780	0.832	0.749*
	(−3.25)	(−1.17)	(−5.34)	(−3.25)	(−1.09)	(−5.06)	(−1.54)	(−1.02)	(−1.86)
Household size	1.027***	1.015	0.996	1.031***	1.019**	1.004	1.004	0.988	0.960*
	(2.80)	(1.61)	(−0.42)	(3.01)	(1.98)	(0.41)	(0.15)	(−0.64)	(−1.84)
Impassable road	0.957	0.970	1.013	1.008	0.914	1.048	0.444***	1.496**	0.760
	(−0.50)	(−0.31)	(0.16)	(0.09)	(−0.86)	(0.55)	(−3.36)	(2.20)	(−1.60)
Market	0.974	1.085	1.476***	0.962	0.956	1.643***	1.183	1.378	1.145
	(−0.21)	(0.75)	(3.23)	(−0.25)	(−0.34)	(3.16)	(0.86)	(1.57)	(0.83)
Western	0.531***	1.027	0.732**	0.549***	1.117	0.786	0.326**	0.529	0.440**
(base: Northern)	(−3.77)	(0.10)	(−2.06)	(−3.21)	(0.40)	(−1.44)	(−2.45)	(−1.47)	(−2.45)
Central	0.491***	0.924	1.023	0.495***	0.930	1.089	0.332**	0.728	0.603
	(−3.41)	(−0.28)	(0.14)	(−2.88)	(−0.22)	(0.50)	(−2.53)	(−1.06)	(−1.36)
Greater Accra	1.511	0.641	0.809	1.961*	0.696	0.840	0.241**	0.448	0.465
	(1.11)	(−0.97)	(−0.62)	(1.66)	(−0.68)	(−0.43)	(−2.06)	(−1.63)	(−1.55)
Volta	0.612**	1.830***	1.692***	0.565***	1.893**	1.967***	0.632	1.520	0.609
	(−2.53)	(2.68)	(3.36)	(−2.84)	(2.45)	(3.98)	(−0.88)	(1.26)	(−1.26)
Eastern	0.390***	1.043	0.868	0.373***	1.140	0.910	0.300***	0.633	0.535*
	(−5.11)	(0.17)	(−0.92)	(−4.68)	(0.44)	(−0.51)	(−2.61)	(−1.46)	(−1.76)
Ashanti	0.486***	0.819	0.964	0.503***	0.830	1.003	0.254***	0.741	0.667
	(−3.55)	(−0.77)	(−0.21)	(−3.05)	(−0.65)	(0.01)	(−2.78)	(−0.70)	(−0.98)
Brong Ahafo	0.738	1.453	1.469**	0.834	1.501	1.532**	0.314**	1.095	0.927
	(−1.28)	(1.52)	(2.51)	(−0.72)	(1.45)	(2.36)	(−2.48)	(0.27)	(−0.22)
Upper East	2.322***	0.643	1.540***	2.317***	0.673	1.749***	1.978	0.466**	0.439**
	(3.36)	(−1.64)	(2.62)	(3.35)	(−1.36)	(3.10)	(1.25)	(−2.09)	(−2.17)
Upper West	1.010	0.468***	0.605***	1.041	0.477**	0.642***	0.424**	0.792	0.379***
	(0.06)	(−2.70)	(−3.22)	(0.23)	(−2.48)	(−2.66)	(−2.14)	(−1.02)	(−3.13)
N	4674	4674	4674	3976	3976	3976	698	694	696

Notes: Odds ratios reported; t statistics in parentheses: * p<0.10, ** p<0.05, *** p<0.01; Errors clustered at district level.

3.4 Implications of climate change for women's domestic work burdens

In Ghana, women are culturally responsible for domestic work and childcare responsibilities within the household, as is the case in many other settings (Forste and Fox, 2012; Cerrato and Cifre, 2018). Climate change has exacerbated these burdens in numerous ways including increased time sourcing for fuel and water. Consistent with research noting the disproportionate effects that women face as a result of climate change (Ayeb-Karlsson, 2020; Sorensen et al., 2018; UN Women, 2021; DCAF, 2022), this study found effects in the same direction. Women reported reduced sleep periods so that they could begin their household responsibilities earlier:

> *I wake up very early to set fire and prepare food for the family. If it starts to wind before I set the fire, it will cause bush fire*. Uneducated woman, 40 years, Northern region.
>
> *For the harmattan the wind starts at 10 am so anytime I want to use firewood I wake up very early in order to avoid any fire outbreak*. Uneducated woman, 50 years, Northern region.
>
> *I wake up very early to process the Shea butter since the harmattan gets windy around 9 to 10 am*. Educated woman, 20 years, Northern region.
>
> *Anytime the sun will shine I get up early to do everything early (to avoid discomfort of working later in the day with the higher temperatures). For the harmattan too anytime I'm about to cook I keep the coal pot at one corner, so the wind doesn't worry*. Educated woman, 22 years, Northern region.

This effect on women's domestic work was observed among Northern women, but not among women in the Ashanti region. Part of this is attributable to differences in cooking fuels used by women in the two regions- while women from the Northern region commonly used coal pots and firewood, their counterparts in the Ashanti region often used LPG gas stoves, which are less likely to cause fires from exposed flames. To avoid higher temperatures later in the day, which would increase discomfort from their strenuous activities, women reported coping by reducing sleep hours and beginning domestic work earlier. This reduced sleep has noted implications for their physical and mental wellbeing (Mussida and Patimo, 2021).

Despite their being directly affected, many women reported having no participation in decisions-making about climate change and environmental actions within their communities. One woman puts it as follows:

> *No, I am not part of anything. I don't know of it because I am a woman that is why I am not involved in any decision making*. Educated woman, 28 years, Northern region.

Often, the final decision lay with the community ruler:

> *In this land everything is for the chief so cutting down of trees is decided by the chief.* Uneducated women, 40 years, Northern region.

3.5 Climate change and mental health

There is evidence of poorer mental health outcomes as a result of climate change shocks from surveyed farmers. These are through increased socioeconomic disruptions associated with unemployment and forced migrations, as well as consistent with the heat aggression hypotheses (Liu et al., 2021; Zhang et al., 2020) where high temperatures trigger stress responses:

> *When the sun is hot and I'm at work I easily get angry.* Educated male, 23 years, Ashanti region.

Continued poor harvests and lost yields also triggered feelings of hopelessness among affected respondents:

> *Yes, because when you work, and it doesn't go well you don't even feel happy…* Uneducated female, 42 years, Ashanti region.

In some cases, it led to the abandonment of farming activities altogether, and therefore a loss of livelihood.

> *He claims now he feels reluctant to go into the farming business again, he's thinking of having a job change, ok. So, I will say that's the effect, that is how it has affected his life because now he no more wants to go into farming… he's unemployed now.* Educated male, 24 years, Ashanti region (*speaking about brother*).

Another effect of climate change may be observed in the migration of family members, with implications for human and social capital.

> *I have a cousin who located from the village to southern Ghana because he was within this dry seasons. What he used to do is dry season gardening but the water body around which he was doing that has almost dried up and it's not able to support dry season garden anymore in the village. So currently he is down south working in people's cocoa garden so when the rains come back, he comes home to continue his farming*- Educated male, 38 years, Northern region.

This migration coping strategy was not reported by any interviewed farmers from the Ashanti region, however, consistent with findings by Benabderrazik et al. (2022).

4. Concluding remarks

This paper explores the experiences and coping/ adaptation strategies of small-scale farmers in Ghana. The objectives were four-fold: 1) Explore the relationship between climate shocks and input demand and other farm strategies in Ghana and examine location and religion heterogeneities; 2) Explore the role of religion in climate change coping/adaptation strategies; 3) Examine how climate change affects women in their culturally prescribed roles within the household; 4) examine potential channels that explain the climate-mental health nexus.

Interesting results were found using a combination of secondary quantitative data and primary qualitative information. First, climate shocks are associated with increased input demand, particularly in rural areas where agricultural activities are concentrated. Second, farmers adopted a variety of other strategies such as income diversification and soil/water management to cope with the effects of climate change. Third, it was found that religious factors play a role in coping strategies and highlights the point that adaptation to climate change is not a universal response. Although some respondents responded that the effects of climate change are man-made, other religious fatalists believed climate change to be sanctioned by God and were therefore less likely to take adaptative measures. Fourth, climate change increased pressures from women's domestic work within their households. Women typically reduced sleep times to begin domestic work earlier when it was cooler and less windy. Finally, potential connections were made between climate change and mental health through channels including heat stress, unemployment, and forced migration.

A number of policy applications can be drawn from these findings. *First*, there needs to be continued access to critical farm inputs in both rural and urban communities in order to maximise adaptive capacities to climate shocks. The Ministry of Food and Agriculture should continue to promote the use of organic fertilizers through the establishment of organic fertilizer plants in all the 16 regions across the country, as well as increasing the quota for organic fertilizer supply in the Government's flagship programme- Planting for Food and Jobs. The network of agro dealers should also be expanded equitably across the country. While agro dealers may prefer to operate in more urban areas as a result of higher associated purchasing power and lower transportation costs, they may not reach the poorest and remotest communities. To this end, 'lead farmers' or emerging commercial farmers can also be encouraged to sell inputs to replace the activities of agro dealers that may be located further away from the production points. Support for more intense activities of agro dealers in rural and more remote communities can be provided through start-up capital, training, and investment in equipment.

Second, there should also be the development of more efficient community infrastructure such as roads to increase households' investments in commercial inputs, and by extension, their adaptability to climate events. The study showed that passable roads are important determinant of climate adaptability in both rural and urban communities. Rural communities however tend to

have significantly more impassable roads, with implications for input access, compared to urban counterparts.

Third, women's viewpoints to address climate change need to be recognized and incorporated into community action plans to ensure equal rights and equal participation. In the qualitative study, women were underrepresented in the decision-making processes despite their being more affected. The Ministry of Gender needs to work closely with the Environmental Protection Agency (responsible for developing the National Adaptation Plan) to ensure that gender considerations are properly integrated. Additionally, efforts to provide clean and affordable cooking options for women in Northern Ghana would be helpful as these are likely to reduce domestic work burdens, which have implications for health and wellbeing.

Finally, religion is also often cited as one of the many limitations to climate change adaptation. Although evidence is preliminary at this point, it suggests some role for churches and religious groups in efforts to raise awareness about climate change and discourage fatalism, where it exists, in order to increase more adaptative behaviours, particularly in small towns and rural villages where agriculture is concentrated.

Issues of social identity and adaptation responses explored in this paper are interesting and worth greater in-depth examination; the paper provides suggestive material to motivate further work in these areas.

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Appendix

TABLE A1. Firths MLE regressions of effects of climate shocks on input purchases

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Shock (Yes=1)	1.732***	1.822***	1.474***	1.646***	1.980***	1.511***	2.490**	1.614	0.861
	(4.09)	(4.03)	(2.93)	(3.34)	(3.98)	(2.80)	(2.52)	(1.37)	(–0.45)
Urban	0.910	0.661***	0.621***	–	–	–	–	–	–
	(–0.82)	(–3.85)	(–4.50)	–	–	–	–	–	–
No religion	0.558***	0.428***	0.968	0.621***	0.397***	1.083	0.280***	0.719	0.626
(Muslim is base)	(–3.77)	(–5.66)	(–0.22)	(–2.87)	(–5.66)	(0.50)	(–2.71)	(–0.82)	(–1.16)
Christian	0.757***	0.538***	1.158	0.773**	0.488***	1.279**	0.741	0.952	0.688
	(–2.97)	(–6.43)	(1.57)	(–2.54)	(–6.84)	(2.41)	(–1.06)	(–0.19)	(–1.43)
Traditionalist	0.573***	0.494***	0.977	0.626***	0.458***	1.046	0.321**	0.458*	0.521
	(–4.75)	(–5.91)	(–0.20)	(–3.80)	(–6.14)	(0.37)	(–2.29)	(–1.85)	(–1.56)
Male head	1.497***	1.325***	0.910	1.469***	1.303***	0.882	1.485	1.381	1.182
	(4.39)	(3.38)	(–1.14)	(3.83)	(2.87)	(–1.38)	(1.62)	(1.62)	(0.84)
Age head	1.004	0.992	1.033***	1.010	0.994	1.028**	0.960	0.973	1.056
	(0.29)	(–0.62)	(2.59)	(0.67)	(–0.43)	(2.02)	(–0.96)	(–0.74)	(1.49)
Age squared	1.000	1.000	1.000***	1.000	1.000	1.000**	1.000	1.000	1.000
	(–0.78)	(–0.40)	(–2.75)	(–1.11)	(–0.54)	(–2.26)	(0.69)	(0.49)	(–1.41)
Basic	1.071	1.051	1.245***	1.047	1.011	1.208**	1.236	1.611**	1.286
(base: None)	(0.83)	(0.63)	(2.83)	(0.51)	(0.12)	(2.25)	(0.81)	(2.19)	(1.16)
Secondary	1.154	1.117	1.362***	1.125	1.071	1.369***	1.451	1.595*	1.228
	(1.40)	(1.11)	(3.18)	(1.06)	(0.62)	(2.92)	(1.27)	(1.85)	(0.82)
Post-secondary	1.035	0.954	1.481***	0.989	0.867	1.517**	1.341	1.569	1.327
	(0.23)	(–0.33)	(2.83)	(–0.06)	(–0.85)	(2.53)	(0.88)	(1.56)	(0.98)

TABLE A1. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Land size (log)	1.288***	1.432***	1.503***	1.240***	1.472***	1.513***	1.624***	1.179	1.404***
	(6.19)	(7.91)	(9.54)	(4.95)	(7.67)	(8.88)	(3.82)	(1.46)	(3.01)
# Plots	1.108***	1.212***	1.219***	1.100***	1.215***	1.214***	1.221**	1.194*	1.266**
	(3.43)	(5.60)	(6.25)	(2.98)	(5.25)	(5.76)	(2.04)	(1.80)	(2.39)
Poor	0.647***	0.855**	0.619***	0.636***	0.858*	0.615***	0.671	0.741	0.635*
	(–5.26)	(–1.97)	(–6.27)	(–5.17)	(–1.80)	(–5.96)	(–1.42)	(–1.21)	(–1.85)
Household size	1.045***	1.025**	0.991	1.052***	1.033**	1.003	1.007	0.980	0.936**
	(3.62)	(2.05)	(–0.79)	(3.86)	(2.39)	(0.24)	(0.18)	(–0.61)	(–2.01)
Impassable road	0.921	0.958	1.012	1.004	0.873*	1.065	0.259***	1.872**	0.647*
	(–1.08)	(–0.59)	(0.16)	(0.04)	(–1.74)	(0.83)	(–4.21)	(2.52)	(–1.80)
Market	0.947	1.147	1.871***	0.935	0.930	2.234***	1.292	1.651***	1.220
	(–0.50)	(1.34)	(6.12)	(–0.51)	(–0.57)	(6.26)	(1.14)	(2.64)	(1.07)
Regional controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	4674	4674	4674	3976	3976	3976	698	698	698

Notes: Odds ratios reported; t statistics in parentheses: * p<0.10, ** p<0.05, *** p<0.01.

TABLE A2. Firths regressions of effects of climate shocks on input purchases, with religion interactions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Shock (Yes=1)	1.882***	1.168	2.348***	1.623*	1.105	2.644***	1.785	1.353	0.638
	(2.86)	(0.64)	(3.96)	(1.88)	(0.33)	(3.78)	(1.16)	(0.64)	(–0.99)
Urban	0.905	0.671***	0.612***	–	–	–	–	–	–
	(–0.86)	(–3.72)	(–4.62)	–	–	–	–	–	–
No religion	0.627***	0.397***	0.999	0.685**	0.382***	1.132	0.287**	0.574	0.509
(Muslim is base)	(–2.84)	(–5.87)	(–0.01)	(–2.15)	(–5.66)	(0.73)	(–2.48)	(–1.29)	(–1.56)
Christian	0.770***	0.510***	1.249**	0.775**	0.465***	1.383***	0.676	0.931	0.637
	(–2.68)	(–6.75)	(2.27)	(–2.43)	(–7.11)	(3.04)	(–1.33)	(–0.26)	(–1.62)
Traditionalist	0.572***	0.463***	1.088	0.615***	0.434***	1.151	0.267**	0.442*	0.512
	(–4.42)	(–6.09)	(0.69)	(–3.66)	(–6.25)	(1.08)	(–2.48)	(–1.82)	(–1.52)
Shock*no religion	0.426*	2.136	0.836	0.497	1.717	0.683	0.876	8.754	4.338
	(–1.92)	(1.46)	(–0.40)	(–1.45)	(0.96)	(–0.77)	(–0.11)	(1.35)	(1.30)
Shock*Christian	0.950	1.801*	0.492***	1.101	2.216**	0.439***	2.001	1.022	1.691
	(–0.18)	(1.92)	(–2.64)	(0.30)	(2.12)	(–2.64)	(0.99)	(0.03)	(0.83)
Shock*Traditionalist	1.002	1.814	0.468**	1.117	1.970	0.468**	4.061	0.965	0.544
	(0.01)	(1.60)	(–2.39)	(0.31)	(1.62)	(–2.18)	(0.97)	(–0.03)	(–0.37)
Male head	1.495***	1.328***	0.908	1.468***	1.305***	0.881	1.501*	1.382	1.165
	(4.37)	(3.40)	(–1.16)	(3.82)	(2.88)	(–1.39)	(1.66)	(1.62)	(0.77)
Age head	1.004	0.993	1.032**	1.010	0.995	1.027*	0.963	0.974	1.058
	(0.30)	(–0.56)	(2.47)	(0.70)	(–0.39)	(1.94)	(–0.90)	(–0.72)	(1.55)
Age squared	1.000	1.000	1.000***	1.000	1.000	1.000**	1.000	1.000	0.999
	(–0.78)	(–0.45)	(–2.67)	(–1.13)	(–0.57)	(–2.20)	(0.63)	(0.48)	(–1.46)
Basic	1.071	1.057	1.235***	1.047	1.011	1.205**	1.265	1.592**	1.296
(base: None)	(0.82)	(0.70)	(2.73)	(0.51)	(0.13)	(2.22)	(0.90)	(2.13)	(1.20)

TABLE A2. (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour	Fert.	Herb.	Hired Labour
	Pooled Sample			Rural Sample			Urban Sample		
Secondary	1.151	1.124	1.348***	1.126	1.075	1.358***	1.464	1.620*	1.274
	(1.38)	(1.18)	(3.06)	(1.06)	(0.66)	(2.85)	(1.30)	(1.90)	(0.96)
Post-secondary	1.032	0.963	1.462***	0.987	0.871	1.505**	1.371	1.573	1.389
	(0.21)	(−0.26)	(2.73)	(−0.07)	(−0.82)	(2.48)	(0.94)	(1.55)	(1.13)
Land size (log)	1.291***	1.429***	1.506***	1.242***	1.471***	1.515***	1.633***	1.157	1.378***
	(6.23)	(7.85)	(9.55)	(4.97)	(7.66)	(8.88)	(3.84)	(1.29)	(2.84)
# Plots	1.109***	1.213***	1.217***	1.101***	1.218***	1.210***	1.222**	1.203*	1.268**
	(3.47)	(5.62)	(6.19)	(3.03)	(5.31)	(5.66)	(2.04)	(1.87)	(2.40)
Poor	0.643***	0.860*	0.615***	0.633***	0.862*	0.611***	0.698	0.747	0.642*
	(−5.32)	(−1.89)	(−6.34)	(−5.22)	(−1.75)	(−6.02)	(−1.28)	(−1.17)	(−1.80)
Household size	1.046***	1.024*	0.993	1.053***	1.031**	1.005	0.999	0.980	0.937*
	(3.68)	(1.89)	(−0.57)	(3.88)	(2.30)	(0.39)	(−0.01)	(−0.62)	(−1.94)
Impassable road	0.918	0.951	1.025	0.997	0.863*	1.084	0.258***	1.859**	0.649*
	(−1.13)	(−0.68)	(0.35)	(−0.04)	(−1.88)	(1.06)	(−4.23)	(2.48)	(−1.78)
Market	0.949	1.143	1.878***	0.934	0.929	2.241***	1.319	1.646***	1.227
	(−0.48)	(1.30)	(6.14)	(−0.52)	(−0.58)	(6.28)	(1.23)	(2.63)	(1.09)
Regional controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	4674	4674	4674	3976	3976	3976	698	698	698

Notes: Odds ratios reported; t statistics in parentheses: * p<0.10, ** p<0.05, *** p<0.01.