Journal of Environmental Management 373 (2025) 123838

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Examining the risk mitigation strategies of farm households in Ghana: The role of community water resources

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ARTICLE INFO

Keywords:
Community water resource
Crop diversification
Sharecropping
Committed time
Ghana

ABSTRACT

Agricultural water is indispensable for fostering resilient and sustainable agricultural practices. However, empirical evidence regarding the relationship between community water resources (CWR) and risk mitigation behaviours among farm households remains scant. Utilising nationally-representative household survey data and geospatial information on household locations, we investigate how access to CWR influences crop diversification and sharecropping. By employing instrumental variable techniques and conducting various robustness checks to address potential endogeneity concerns, our results consistently show that communities with access to water resources experience greater crop diversification and reduced sharecropping compared to those with limited access. This effect is particularly pronounced among male-headed, youth-headed, and smallholder farm households in the northern zone. While CWR may not be the sole determinant of crop diversification and sharecropping, it plays a significant role in shaping adaptive strategies amid drought challenges. Moreover, we identify committed time as a critical mechanism through which CWR influences these outcomes. Our findings offer valuable insights for policymakers aiming to allocate resources effectively, especially for vulnerable populations, in enhancing resilience to climate change-induced water scarcity.

1. Introduction

Water for agricultural production accounts for the largest share of global water usage, representing 70% of annual water withdrawals worldwide (World Bank, 2022). The importance of water resources is underscored by Sustainable Development Goal (SDG) 6, which aims to ensure the availability and sustainable management of water and sanitation for all. Member States recognize that water resources sustain economic growth in agriculture, industry, and energy generation, as well as maintaining healthy ecosystems (United Nations, 2018). However, sustainable water availability is threatened by climate change, which impacts rural livelihoods, food security, and poverty, with agriculture being particularly vulnerable (Liu et al., 2022; World Bank, 2022; Gerten et al., 2020; Pastor et al., 2019; United Nations, 2018; Yin et al., 2017).

According to the World Bank, irrigated agriculture covers about 20% of the total cultivated land and contributing around 40% of the total food produced globally (World Bank, 2022). However, demand for agricultural water resources is projected to increase due to population growth, agricultural intensification, industrial production, urbanization, and climate change (United Nations, 2018). Future demands for water across various sectors, especially from regions of low productivity to those with higher productivity, will necessitate reallocation from the agricultural sector, which may impact agriculture given the global rise in food demand.

In Sub-Saharan Africa (SSA), water-induced or environmental migration is partly attributed to water scarcity (Anderson and Silva, 2020; Adaawen et al., 2019). Individuals in communities experiencing severe water scarcity may be forced to migrate to regions with more reliable access to water for agriculture, consumption, and sanitation. Rural households are mostly affected due to their dependence on the agricultural sector for their livelihoods. Reduced water availability can lead to crop failure, loss of livestock, and declining agricultural productivity, prompting farm households to seek alternative livelihoods in

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https://doi.org/10.1016/j.jenvman.2024.123838
Received 15 June 2024; Received in revised form 23 October 2024; Accepted 21 December 2024
Available online 31 December 2024
0301-4797/

urban areas or other regions (Huho and Mugalavai, 2010; Afifi et al., 2012). Additionally, water scarcity may escalate conflicts between different user groups, and the threat of violence or displacement may drive individuals to migrate to safer areas (Huho and Mugalavai, 2010; Afifi et al., 2012).

Past empirical studies have linked irrigation to crop diversification and other welfare outcomes. LaFevor and Pitts (2022) found that irrigation increases crop diversification across low, medium, and high diversity farm regions in Mexico. Similarly, Giordana et al. (2019) indicated that irrigation is linked to increased productivity through complementary inputs, such as seeds and fertilizer, and is associated with improved nutrition, and negatively correlated with poverty. Buisson and Balasubramanya (2019) reported that enhancements in irrigation delivery services expanded the area under cotton and wheat cultivation, while noting that crop diversity depends on extension services, even as water delivery services boost crop intensity. De Sousa et al. (2017), through an extensive literature review, highlighted the significance of irrigation and crop diversification. Pradhan and Ranjan (2016) demonstrated that irrigation access leads to an increase in dry season rice cultivation and other high-value seasonal crops. Burney and Naylor (2012) showed that irrigation promotes the cultivation of fruits and vegetables in semi-arid areas. However, Hazell (1982) and Pinstrup-Andersen and Hazell (1985) observed that irrigation may increase crop diseases and reduce diversity by decreasing demand for traditional varieties. In Ghana, Acheampong et al. (2018) found that small reservoirs help farmers diversify their production activities.

Despite these insights, the influence of access to CWR on sharecropping strategies across heterogenous groups especially in developing country context remains unclear. The issue of water scarcity and migration poses a significant challenge in Ghana, particularly due to the substantial rural migration of youth seeking employment opportunities elsewhere (Ghana Statistical Service, 2023). According to the GSS, rural migration accounts for about 33% of total migration, with the majority of migrants (53%) being females (Ghana Statistical Service, 2023). Common CWR used by rural farm households during the dry season for agricultural production are dams, springs, river/streams, dug-out well, and tube canals. The role of CWR as a risk-reducing strategy and source of empowerment especially for the rural youth has been unexplored, especially where migration and food demand are projected to increase. Despite the acknowledgement of the Government of Ghana regarding the importance of dams in Ghana's agricultural development agenda, the lack of commitment and poor monitoring raises questions about whether water availability encourages risk-reducing behaviours among smallholder farmers in Ghana. This question emphasizes the importance of examining water resources not only as a source of livelihood but also as a risk-reducing strategy and source of empowerment, particularly for vulnerable groups such as youth and women.

Following the discussion, we examine the relationship between CWR, crop diversification, and sharecropping using data from a nationally-representative farm household living standard survey in Ghana. We utilize the Shannon index as a proxy for crop diversification and an indicator variable for sharecropping. We conducted several robustness checks on the main study findings by estimating different endogeneity correcting models that address endogeneity in CWR. To deepen our understanding of the findings, we explore one pathway - committed time - and conduct heterogeneity analyses based on gender (age and sex), location (northern and southern), and farm size (smallholders and large holders). Our study employs multiple quasi-experimental techniques that controls for endogeneity in access to CWR, enabling a direct attribution of any observed changes in crop diversification and sharecropping to CWR status. Based on the approach, our study aims to provide a comprehensive understanding of the link between CWR and risk-reducing strategies, while also shedding light on specific challenges and opportunities for rural households and community development in Ghana.

Our findings contribute to the literature on socioeconomics and risk mitigation implications of CWR in three ways. First, we provide new evidence on the risk mitigation implications of CWR. Agricultural production in Africa is mainly rain-fed with little opportunities for irrigation in the dry season thus impacting negatively on household food security, income and poverty (Anderson and Silva, 2020; Adaawen et al., 2019). The study focuses on crop diversification and sharecropping given their role as a risk mitigation and dietary diversity strategies in developing economies (Lovo and Veronesi, 2019; Paul et al., 2015). In this context, our study contributes to the discussion on how water availability for agricultural production in the dry season can safeguard farm households from limited food availability through diversification and sharecropping. Second, our research extends the literature by exploring the heterogeneous effects of CWR to guide policymakers on effectively utilising scarce public resources to achieve greater impacts on welfare outcomes. Policy developments should consider these findings when advocating for community water development projects to mitigate the negative impacts of climate change. Third, we identify the potential mechanism, committed time, through which CWR significantly influences crop diversification and sharecropping.

The rest of the article proceeds as follows. Section 2 explores the contextual background of CWR in Ghana, examining the potential mechanisms linking CWR to crop diversification, and sharecropping. Section 3 presents the sampling procedure, details the measurement of variables, and provides summary statistics. Section 4 presents the estimation strategy while the empirical results are then presented and discussed in Section 5. The article concludes with a summary of findings and policy implications in Section 6.

2. Context and Conceptualisation

2.1. Community water resources in Ghana

Ghana's water resource potential consists of surface and groundwater resources. The surface water sources are the Volta, South Western, and Coastal River systems, covering approximately 70%, 22%, and 8% of Ghana's total land area, respectively. Groundwater resources are mainly found in basement complexes, consolidated sedimentary formations, and Mesozoic and Cenozoic sedimentary rocks (Ministry for Water ResourcesWorks & Housing (MWRWH), 2007; Ministry of Sanitation and Water Resources [MSWR], 2023).

Over the years, access to water supply in Ghana has improved. According to the 2021 Population and Housing Census, 87.7% of the population have access to basic drinking water services. However, a notable gap persists between urban and rural areas. In urban areas, approximately 96.4% of the population has access to water, while in rural areas, only about 74.4% do (GSS, 2022). Given that much of the rural populace relies heavily on agriculture, ensuring equitable and reliable access to water is essential for fostering sustainable and productive rural economies (International Labour Organisation [ILO], 2019). Water serves crucial roles in both productive (such as crop and livestock production) and consumptive activities (Abanyie et al., 2023; Namara et al., 2010), playing a pivotal role in food security, personal hygiene, and agricultural and energy production (ILO, 2019), in alignment with SDG 6.

Recognizing the pivotal role of water in rural development and agricultural systems, Ghana has launched several initiatives aimed at enhancing water availability for both productive and consumptive uses. Typically, government-funded water supply projects in rural areas are overseen by the Community Water and Sanitation Authority (CWSA), often in collaboration with the Medium-Term Development Plan (MTDP) of the Metropolitan, Municipal, and District Assemblies (MMDAs). Additionally, contributions from diverse actors such as the private sector, Non-Governmental Organizations (NGOs), development partners, community-based organizations, and faith-based groups play significant roles in advancing water-related initiatives (MSWR, 2023).

Several initiatives, including the Water Supply Improvement Project

(WSIP), Sustainable Rural Water and Sanitation Project-Additional Financing (SRWSP-AF), UNICEF-Assisted WASH Projects, and the Rural Water Utilization Project (RWUP), have been instrumental in enhancing water supply in rural Ghanaian communities (CWSA, 2024). While primarily aimed at improving household water access, some of these projects have also targeted irrigation purposes. Given the agricultural sector's vulnerability to rainfall variability, particularly in Ghana's heavily rain-dependent farming landscape, irrigation infrastructure plays a crucial role in building agricultural resilience. The adoption of small-scale irrigation technologies holds promise for promoting diversification among smallholder farmers, enhancing returns on labour and land, and reducing production risks (Burney and Naylor, 2012). For example, Acheampong et al. (2018) show that small reservoirs in northern Ghana facilitated farmers' diversification of production activities.

Despite the vast potential for irrigation, only 226,909 ha (i.e., 3.18%) of 6.8 million hectares of land under cultivation in Ghana is irrigated. Of these, 84% (189,000 ha) are informal or small-scale irrigation developed by farmers (Ministry of Food and Agriculture, 2021). Currently there are 22 medium and large-scale public sector managed irrigation schemes in Ghana covering over 13,000 ha and mainly financed by international collaborating agencies (International Water Management Institute [IWMI], 2022). Over the years, several projects have been initiated to develop small reservoirs for irrigation purposes. Notably in 2017, the Government of Ghana launched the "One-Village-One-Dam" (1V1D) initiative under the Infrastructure for Poverty Eradication Programme (IPEP). The objective of this initiative was to provide water for year-round agricultural production for small-scale farmers in northern Ghana (Ministry of Special Development Initiative [MSDI], 2018). The plan was to construct and rehabilitate a total of 570 small earth dams within communities across all constituencies in northern Ghana. Each constituency was allocated 10 small earth dams (MSDI, 2018). Anecdotal evidence indicates that about 426 of the proposed 570 dams have been built but several are underutilised and fail to meet expectations due to governance failures, faulty construction, poor operation and maintenance (Acheampong et al., 2018; Birner et al., 2010). Some rural communities rely on rivers/streams, springs, dug-out wells, and tube canals during the dry season to support their agricultural activities.

2.2. Community water resource, crop diversification and sharecropping

Fig. 1 illustrates the interconnection between CWR, crop diversification, and sharecropping. These elements are closely intertwined, with CWR serving as a pivotal resource that transforms rural livelihoods by enhancing household food diversity and mitigating risks (Passarelli et al., 2018). Access to reliable water sources from CWR for dry season agricultural production encourages farmers to diversify crops, prioritize certain crops, and reduce reliance on rain-fed agriculture (Shah et al., 2019), as well as sharecropping practices. Mukherjee (2015) and Zimmerer (2014) highlighted the positive correlation between access to communal water sources and crop diversification in South Asia, underscoring the significance of integrated water management strategies in bolstering agricultural resilience. We hypothesised that water access, crop diversification and sharecropping may be influenced by socioeconomics, farm characteristics, community factors, geographic controls, and agroecology. The conceptual framework centres on the potential mechanisms through which CWR influences crop diversification and sharecropping. We hypothesised that committed time and remittance income are potential channels through which dry season water access influences crop diversification and sharecropping practices.

The first channel is committed time due to out-migration, which poses a significant challenge for rural households residing in areas with water scarcity. Climate-related events such as droughts or floods can precipitate an income shock, prompting households to either consider migration in search of better economic opportunities (Benonnier et al., 2022; Fishman and Li, 2022) or engage in a fixed rental arrangement or sharecropping. The rationale for this arrangement is typically grounded in the landowner's profit-maximization strategy or the tenant's need for risk mitigation (Otsuka and Hayami, 1988). Marchiori et al. (2012) and Cai et al. (2016) demonstrated that agrarian economies are particularly vulnerable to climate-induced migration. As water resources become increasingly scarce, households reliant on agriculture for their primary

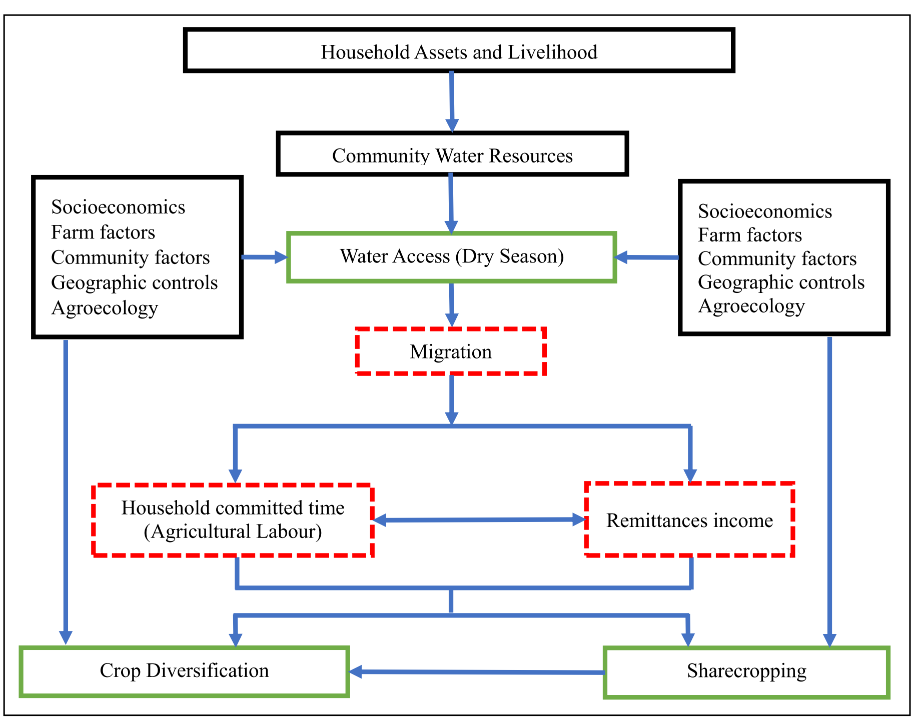

Figure 1. Conceptual link between CWR, crop diversification and sharecropping

income are more likely to migrate, leading to a shortfall in labour for those remaining behind. This labour deficit impacts both agricultural and non-agricultural activities, subsequently influencing decisions regarding crop diversification and sharecropping. For instance, Qian et al. (2016) found that migration encourages rural family members who stay behind to shift towards less labour-intensive subsistence grain production or to even abandon farmland altogether in favour of more capital-intensive livestock cultivation. With labour becoming more readily available, farm households may opt to cultivate multiple crops or engage in sharecropping, depending on the balance between agricultural and household demands.

The second channel involves household remittance income, which stems from migration. Income generated from remittances can significantly impact the activities of households left behind. Remittance income often facilitates the adoption of more capital-intensive agricultural practices, such as crop diversification, crop-livestock integration, or the cultivation of cash crops (Qian et al., 2016; Wouterse and Taylor, 2008). With the influx of remittances, households may opt to reduce their commitment to labour-intensive agricultural activities, substituting labour for more capital-intensive endeavours (Wouterse and Taylor, 2008). Conversely, if remittance income is directed towards non-agricultural pursuits, households may allocate less time to crop production, leading to a decline in crop diversification. This scenario may arise when households prioritize leisure over work, as leisure is considered a normal good (Phadera, 2016). In the absence of remittance income, households may resort to sharecropping arrangements as their commitment to agricultural activities increases due to the absence of migration.

The framework also underscores the intricate relationship between sharecropping and crop diversification. Sharecropping arrangements exert a significant influence on the crop diversification strategies of tenant farmers, as evidenced by Deininger and Jin (2012). Various factors, such as profit-sharing ratios and responsibilities for input provision, shape farmers' cropping decisions within these agreements. Flexible terms, including the choice of crops and risk-sharing arrangements, prompt tenant farmers to experiment with diversified cropping systems, aiming to maximize returns. Additionally, sharecroppers prioritize crops with higher market value and lower production risks, thereby enhancing income and reducing reliance on landlords (Mukhamedova and Pomfret, 2019). Trust and reciprocity play crucial roles in crop selection within sharecropping arrangements, with landlords and tenants negotiating mutually beneficial terms to optimize resource utilization and risk-sharing (Hartvigsen, 2014). Duflo and Udry (2021) further highlight that sharecroppers invest in diversification as a risk management strategy, particularly in contexts where access to credit and insurance is limited, underscoring sharecropping's adaptive capacity in risk mitigation. Sharecropping also serve as a strategy for providing a steady source of income as landowners receive a portion of the harvest without having to manage day-to-day farming activities. This is especially beneficial for absentee landlords or those with limited capacity to directly farm the land (Bardhan and Rudra, 1980).

3. Data, variables, and summary statistics

3.1. Data

We used a component of a nationally-representative data compiled by the GSS from October 22, 2016 to October 17, 2017. The data evaluates the living conditions and well-being of Ghanaians households. A two-stage stratified sampling design was used. In the first stage, one thousand (1,000) enumeration areas (EAs) were selected to form the Primary Sampling Units (PSUs). The PSUs were then allocated into the 10 administrative regions based on probability proportional to population size (PPS). The sampling frame for the EAs was based on the 2010 Population and Housing Census. At the second stage, 15 households from each PSU were systematically selected. The total sample size came to 15,000 households nationwide. In all 14,009 households responded to the survey, resulting in a response rate of 93.3 percent. The data serves as basis for policy formulation. The data offers comprehensive insights into household socioeconomics, health, agriculture, non-farm enterprises, time use, energy, and general living conditions (Ghana Statistical Service, 2018).

Based on the research questions, we relied on the agricultural component of the data which consist of 5,982[1] households out of the 14,009 successfully enumerated households. Detailed description of the specific variables used for the analysis is described in the subsequent sections. Fig. 2 presents a map of the study area, highlighting the varying levels of community water access. The Upper East, Upper West, and Northern regions have the highest proportion of households with access to community water resources, followed by the Ashanti and Brong Ahafo regions. In contrast, the Greater Accra Region recorded the lowest proportion of households with access to community water resources.

3.2. Measurement of outcome variables

3.2.1. Crop diversification

Crop diversification is strategy used to build resilience and establish sustainable production systems capable of meeting farmers' requirements amidst challenges such as climate change, resource scarcity, and market volatility. Particularly in Sub-Saharan Africa (SSA), where crop insurance may be lacking, diversification serves as a crucial risk-management approach to enhance farming efficiency (Iizumi and Ramankutty, 2015). We computed crop diversification using the Shannon index, a metric widely used in previous studies (Martey, 2022; Zhang et al., 2022; Mahy et al., 2015). The Shannon index is specified as:

$$CI_i = -\sum_{i=1}^{n} p_i \log(p_i)$$

where CI_i is crop diversification index; p_i is the proportion of area planted to the *ith* crop in a reference area; $\log(p_i)$ is the log of the share of area planted to the *ith* crop. A value of $\log(p_i) = 0$ where $p_i = 0$ implies that household does not cultivate any crop and the diversification is zero. n is the number of crops cultivated by the household. A higher value of crop diversification indicates greater variety of crops planted by the household and thus the higher the uniformity of the distribution of variety of crops across the planting area. The main crops cultivated by the farm households in our sample are cereals (maize, sorghum, millet, and rice), starchy staples (cassava, yam, cocoyam, and plantain), and legumes (groundnut and beans).

3.2.2. Sharecropping

Sharecropping is a land leasing arrangement between a landlord and a tenant, where the landlord rents out land to the tenant, who then compensates the landlord after the harvest, typically in the form of a proportion of the harvested crop (Singh, 2000). Sharecropping is a risk-sharing strategy between landlords and tenants (Quibria and Rashid, 1984), often based on social relationships and trust. In this study, we operationalised sharecropping as a binary variable, denoted by one for farm households who rent out land to tenants during the last cropping season, and 0 otherwise.

3.3. Summary statistics

Fig. 3 shows the regional distribution of crop diversification and sharecropping in Ghana. The results show a fluctuating trend across the regions. Comparatively, crop diversification is higher for the Guinea, and Sudan agroecological zones (Northern, Upper East and Upper West

[1] The data used to establish the relationship between CWR, crop diversification, and sharecropping consists of 43% of the total sample size.

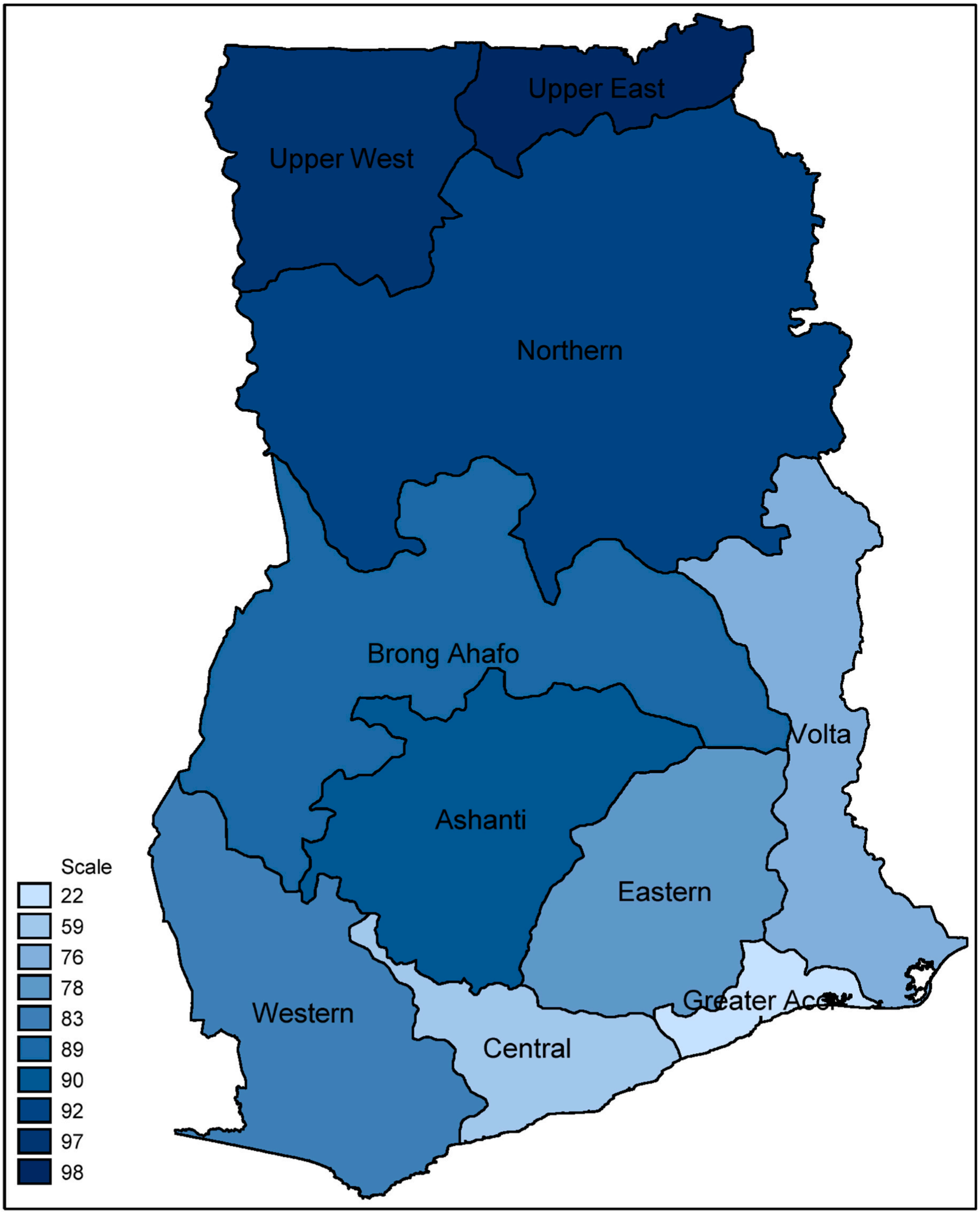

Figure 2. Map of the study area showing varying levels of community water access

regions) than the Transition, Coastal and Forest zones (Greater Accra, Central, Western, Eastern, Brong-Ahafo, and Ashanti regions) of Ghana. Conversely, the Transition, Coastal and Forest zones exhibit higher levels of sharecropping than the Guinea, and Sudan agroecological zones of Ghana. These observed disparities may stem from differences in the agroecological characteristics, such as the number of crop seasons and the level of risks faced by farmers. For instance, the Guinea and Sudan Savanna agroecological zones typically experience a unimodal annual average rainfall of approximately 1000 mm, lasting between 5 and 6 months (Owusu, 2018), which is lower than that of the rain forest and deciduous forest zones of Ghana. Additionally, the varying levels of agricultural risks across different agroecological zones may contribute to the observed trend.

Fig. 4 illustrates the relationship between access to CWR and crop diversification. It shows that farm households with access to CWR exhibit greater crop diversification compared to those without such access. This suggests that CWR access facilitates the cultivation of a wider variety of crops, particularly during the dry season when water availability is limited. In Fig. 5, we observe a different pattern regarding sharecropping. Absence of CWR access may compel farmers to resort to

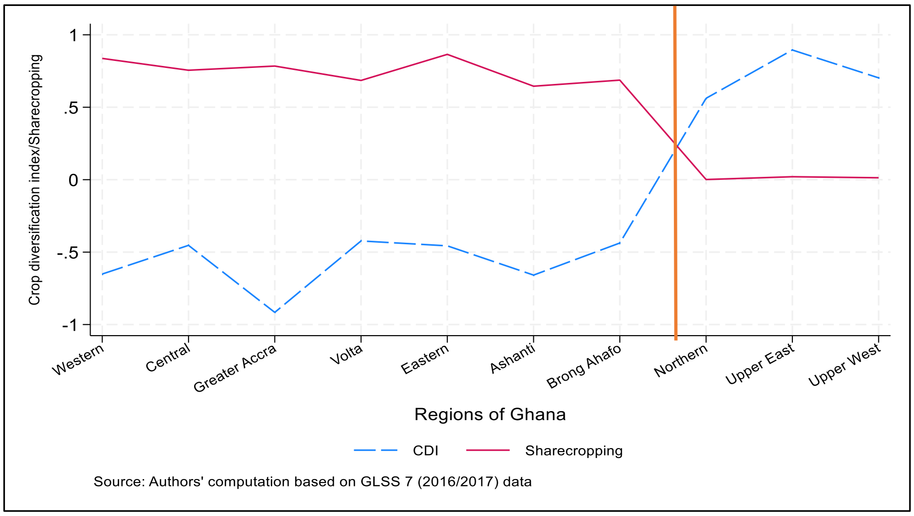

Figure 3. Crop diversification and sharecropping by regions in Ghana

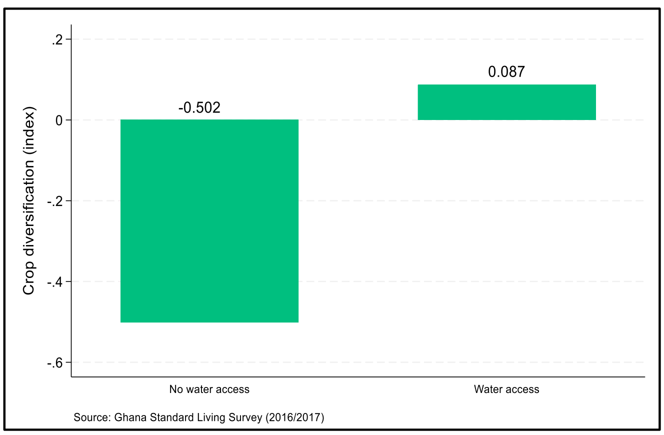

Fig 4. CWR and crop diversification

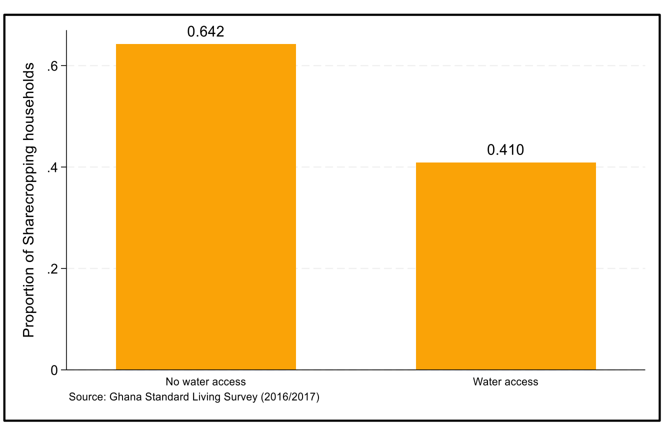

Fig 5. CWR and sharecropping

sharecropping as a risk-sharing strategy to mitigate the challenges posed by limited water resources.

Table 1 provides descriptive statistics for the variables included in the estimation model. Approximately 85% of the sampled farmers have access to Community Water Resources (CWR) during the dry season, and 76% are male. The average age of farmers is 49 years, with average education level of 4 years, indicating primary education. About 24% of

Table 1
Descriptive statistics of variables used in the estimation models.

Variable	Mean	SD
Access to community water resource (1/0)	0.852	0.355
Socioeconomic characteristics		
Sex (1 = male)	0.764	0.424
Age (years)	48.740	15.480
Education years (years)	4.213	6.220
Household size (number)	5.165	3.175
Ratio of adult members	24.408	29.892
Employed (1 = yes)	0.821	0.383
Own work (1 = yes)	0.109	0.311
Unpaid trainee work (1 = yes)	0.002	0.043
Voluntary work (1 = yes)	0.009	0.096
No work or activity (1 = yes)	0.059	0.236
Farming (1 = yes)	0.925	0.263
Trading (1 = yes)	0.044	0.205
Non-trading activities (1 = yes)	0.031	0.172
Farm size (acres)	2.485	2.411
Smallholder (1 = yes)	0.123	0.329
Livestock value (GHS)	251.432	667.872
Sells crop (1 = yes)	0.627	0.484
Log of household income (GHS)	6.856	3.188
Community variables		
Motorable road to community (1 = yes)	0.892	0.310
More rain in community (1 = yes)	0.558	0.497
Participate in agricultural cooperatives (1 = yes)	0.122	0.327
Ease to find work in community (1 = yes)	0.925	0.263
Electricity in community (1 = yes)	0.588	0.492
Community development project (1 = yes)	0.515	0.500
Financial institution in community (1 = yes)	0.185	0.388
Health personnel in community (1 = yes)	0.084	0.277
Geographic variables		
Rural households (1 = yes)	0.844	0.363
Western Region	0.107	0.309
Central Region	0.083	0.276
Greater Accra Region	0.009	0.092
Volta Region	0.120	0.325
Eastern Region	0.108	0.310
Ashanti Region	0.052	0.223
Brong Ahafo Region	0.104	0.305
Northern Region	0.154	0.361
Upper East Region	0.115	0.318
Upper West Region	0.150	0.357
Agroecological zones		
Coastal ecological zone	0.117	0.321
Forest ecological zones	0.373	0.484
Savannah ecological zone	0.510	0.500
Accra	0.001	0.026
Observations	5982	

Note: SD is standard deviation.

the farm households consist of adult members. Regarding employment, 82% are employed, 11% are self-employed, and very few are engaged in unpaid or voluntary work. The majority (93%) are primarily engaged in farming, while a smaller percentage are involved in trading or non-trading activities. The average farm size is 2.5 acres. Smallholder[2] farmers represent approximately 12% of the sampled households. The average value of livestock and log income is GHS251 and GHS7, respectively. Around 63% of farmers sell their crops. Community variables show that most households have access to motorable roads (89%), while a significant portion experience increased rainfall (56%) and participate in agricultural cooperatives (12%). The majority also find it easy to secure work in their communities (93%) and participate in community development projects. Less than 19% have access to financial institutions and healthcare personnel in their communities. Geographically, 84% of sampled farmers are in rural areas, with the majority located in the savannah agroecological zones. Regional distributions of sampled farmers are also presented.

4. Empirical strategy

4.1. Baseline estimation

We first estimated a linear regression model which establishes the relationship between CWR, crop diversification, and sharecropping as follows:

$$Y_i = \alpha + \beta CWR_i + \psi X_i + \zeta_r + \varepsilon_i \tag{1}$$

where Y_i represents crop diversification and sharecropping of household i. CWR_i is community water resource (i.e., dummy that takes a value of 1 for access to community water resources and 0 otherwise). X represents a vector of control variables and ψ is a vector of parameters estimates for these controls and ε_i is the random error term. ζ_r is region fixed effects. The parameter of interest β measures the relationship between CWR and the outcome variables (crop diversification, and sharecropping). We expect a positive relationship ($\beta > 0$) between CWR and crop diversification which suggests that access to CWR is likely to increase crop diversification. In contrast, we expect a negative association ($\beta < 0$) between CWR and sharecropping. We estimated both linear probability model (LPM) and Ordinary Least Squares (OLS) regressions to account for the binary and continuous nature of the outcome variables, respectively.

Estimating equation (1) using LPM and OLS will bias the estimated parameter β due to endogeneity in access to CWR. We identify three main sources of endogeneity - measurement error, unobserved heterogeneity, and reverse causality. We do not anticipate a measurement error in the outcome variable. With reference to unobserved heterogeneity, it is possible that factors such as preferences, risk, non-cognitive skills, motivation, and managerial abilities may be associated with both CWR, crop diversification, and sharecropping. Households who are risk averse and have high preferences for food security would likely practice crop diversification and sharecropping to hedge against crop losses due to drought and diseases as well as reduce the tendency of sharing harvested crops that may subsequently impact negatively on revenue and household consumption. Controlling unobserved heterogeneity is challenging with cross-sectional data; therefore, we include additional control variables in our model and observe coefficient stability with and without these control variables. Regarding reverse causality, access to water can motivate farm households to either diversify their crop portfolio or discourage sharecropping to increase their income and food security. Conversely, households that diversify their crop portfolio or sharecrop are more likely to reside in communities with water during the dry season.

4.2. Instrumental variable estimation

We implement an instrumental variable (IV) estimator to control for the residual endogeneity in CWR using a two-stage least squares (2 S LS) regression model. The first stage (equation (2)) involves regressing access to CWR on an instrument, and control variables to obtain the estimated values of CWR ($\widehat{CWR}_i$). In the second stage $\widehat{CWR}_i$ is included in the equation to determine its effect on crop diversification and sharecropping.

$$CWR_i = \phi + \varphi H_i + \delta X_i + \zeta_r + \nu_i \tag{2}$$

$$Y_i = \alpha + \beta \widehat{CWR}_i + \eta X_i + \zeta_r + \mu_i \tag{3}$$

where H_i is the proposed instrument which captures surface elevation. The surface elevation, representing the steepness of the ground surface, is measured as the tangent of the surface. Our proposed instrument is based on the premise that areas with relatively high steepness in elevation are more likely to have water during the dry season. Higher altitude is associated with cooler temperatures, which can reduce evaporation rates and further contribute to water retention in the soil and surrounding environment. The choice of the instrument is inspired by previous work by Duflo and Pande (2007), who recommend targeting areas with moderate river gradients for irrigation dam construction. The variable serves as a plausible instrument because community elevation is likely to influence water availability during the dry season, indirectly affecting crop diversification and sharecropping through access to CWR. Importantly, surface elevation is exogenous to farmers' location and is a natural feature of the landscape.

4.2.1. Threats to identification strategy

The primary challenge with the instrument is the possibility that crop diversification and sharecropping could be influenced by factors other than elevation. For instance, rainfall distribution may vary across districts, leading to differences in water access during the dry season. To address this potential confounding factor, we include a variable that accounts for the probability of a community experiencing higher rainfall in a given year. Second, it is conceivable that farmers might self-select into communities with higher rainfall in a year to enhance agricultural production during the dry season and subsequently adopt risk-reducing behaviours. However, we contend that farmers in our sample are not intentionally migrating to communities with water availability during the dry season, but rather inheriting land passed down through generations. Moreover, rural Ghana's land rental markets are imperfect, and households may be hesitant to lease land near water resources. Our data indicates that most recorded migration is due to marriage and job searching, with job seekers often migrating to larger towns or district capitals. To mitigate this challenge, we control for economic activities in our model. Third, the elevation of the community may also inform the placement of development projects, potentially influencing the outcome variables through channels unrelated to CWR. To address this concern, we include controls for community development projects in our analysis. Finally, communities at lower altitudes are more susceptible to flooding, which may prompt farmers to form cooperatives to attract support from governments and NGOs. This, in turn, could influence crop diversification and sharecropping. To address this potential confounding factor, we include controls for membership in cooperatives in our analysis.

This study refrains from making causal claims due to the inability to completely eliminate all forms of endogeneity. Consequently, our results should be interpreted as associations. To enhance the robustness of our

[2] Smallholder farmers are individuals who cultivate less than five acres (Chamberlin, 2007).

findings, we employ additional endogeneity-correcting models, namely the control function approach (CFA[3]) and the Conditional (recursive) Mixed Process (CMP[4]).

5. Results and discussion

5.1. Baseline results

Table 2 presents the baseline estimates for the relationship between CWR, crop diversification, and sharecropping. Columns 1 and 3 show the results without regional fixed effects, while columns 2 and 4 control for region fixed effects. Overall, the findings suggest that households with access to CWR during the dry season are more inclined to cultivate multiple crops but less likely to partake in sharecropping. Specifically, households with CWR access exhibit a 0.162 standard deviation increase in crop diversification (column 2) and an 11% decrease in the probability of engaging in sharecropping. This indicates that CWR access mitigates farmers' risks, facilitates year-round production of multiple crops, and promotes self-production in anticipation of favourable harvests. Water availability is crucial in agriculture, as water-intensive crops are typically grown in regions with ample water resources and then traded to water-scarce areas (World Bank, 2022). De Sousa et al., (2017) demonstrates that water access enables year-round cultivation and crop diversification, mitigating seasonal price fluctuations.

Furthermore, the availability of water reduces the need for farmers to engage in sharecropping, as labour becomes more readily available for direct employment on agricultural lands. Second, land owners are more likely to engage in fixed land rental contracts given that such arrangement guarantee a steady income regardless of production outcomes (Otsuka and Hayami, 1988). These findings are consistent with Zhang et al. (2022), who illustrate how labour migration diminishes crop diversification efforts aimed at addressing climate change.

5.2. Instrumental 2SLS estimates

We present the 2SLS results for the model utilising altitude as an instrument to address endogeneity concerns (Table 3). Across all models, the first-stage F-statistics exceed 10, indicating that the instrument is not weak (Stock and Yogo, 2002). The highly significant coefficient on the instrument suggests a strong correlation between altitude and community water availability, consistent with prior research (Duflo and Pande, 2007). The robust chi-square values also indicate the endogeneity of access to CWR. Failure to address this issue can lead to biased estimates of the relationship between CWR, crop diversification, and sharecropping. Controlling for region fixed effects (columns 2 and 4) reveals that households residing in communities with water availability exhibit a 2.270 standard deviation increase in crop diversification, coupled with a 194% reduction in the likelihood of engaging in sharecropping. A comparison of the effect sizes between the 2SLS and OLS estimates suggests that endogeneity related to CWR leads to a downward bias in the OLS estimates. The IV estimators provide estimates of the local average treatment effect.

Our result aligns with the findings of LaFevor and Pitts (2022), who observed a strong correlation between the percentage of irrigated cropland and the diversity of crop species richness and evenness. Some studies in Africa and Asia have found similar results (Passarelli et al., 2018; Thapa et al., 2018; Mukherjee, 2015). When farmers are exposed to risks due to external drivers such as climate and poor or degraded soils, they either tend to adopt lower risks strategies such as allocating land to different crops and livestock (Kray et al., 2018; Cole et al., 2017) or engage in fixed land rental arrangement thus reducing sharecropping practices (Bardhan, 1984).

Table 2
OLS estimates of CWR, crop diversification, and sharecropping.

Variables	Crop diversification		Sharecropping	
	(1)	(2)	(3)	(4)
Community water resource (1/0)	0.178***	0.162***	−0.133***	−0.112**
	(0.058)	(0.057)	(0.048)	(0.046)
Sex	0.067**	0.043	−0.092***	−0.060***
	(0.031)	(0.031)	(0.019)	(0.018)
Age	−0.000	0.000	0.002***	0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
Education years	−0.018***	−0.015***	0.017***	0.013***
	(0.002)	(0.002)	(0.001)	(0.001)
Household size	0.022***	0.014**	−0.018***	−0.008***
	(0.006)	(0.006)	(0.003)	(0.003)
Adult ratio	−0.002***	−0.003***	0.001*	0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
Own work	0.396***	0.417***	−0.214***	−0.241***
	(0.062)	(0.062)	(0.032)	(0.033)
Unpaid trainee work	−0.007	−0.046	−0.270**	−0.220**
	(0.251)	(0.247)	(0.111)	(0.110)
Voluntary work	0.316**	0.280*	−0.289***	−0.243***
	(0.157)	(0.166)	(0.046)	(0.055)
No work or activity	0.022	0.012	−0.184***	−0.172***
	(0.054)	(0.054)	(0.031)	(0.031)
Farming	−0.085	−0.096	−0.294***	−0.280***
	(0.097)	(0.094)	(0.076)	(0.074)
Trading	−0.102	−0.135	−0.271***	−0.229***
	(0.219)	(0.227)	(0.071)	(0.073)
Smallholder	−0.197***	−0.182***	−0.067**	−0.087***
	(0.039)	(0.038)	(0.026)	(0.026)
Livestock value	0.000***	0.000***	−0.000***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Sells crop	0.751***	0.727***	−0.140***	−0.109***
	(0.043)	(0.044)	(0.027)	(0.026)
Log of household income	−0.007	−0.006	0.010***	0.008***
	(0.005)	(0.005)	(0.003)	(0.003)
Motorable road to community	0.035	0.030	−0.061	−0.055
	(0.099)	(0.099)	(0.060)	(0.059)
More rain in community	−0.106*	−0.102*	0.081**	0.077**
	(0.057)	(0.057)	(0.036)	(0.035)
Participate in agricultural cooperatives	0.022	0.000	0.038	0.066
	(0.072)	(0.071)	(0.053)	(0.050)
Electricity in community	−0.194***	−0.193***	0.069*	0.067*
	(0.068)	(0.067)	(0.041)	(0.040)
Community development project	−0.013	−0.024	0.040	0.054
	(0.060)	(0.059)	(0.037)	(0.036)
Financial institution in community	0.106	0.122	0.066	0.045
	(0.081)	(0.081)	(0.055)	(0.055)
Health	0.034	0.028	−0.101	−0.094
	(0.092)	(0.090)	(0.068)	(0.065)
Rural	0.191***	0.224***	0.018	−0.024
	(0.071)	(0.069)	(0.054)	(0.053)
Region FE	No	Yes	No	Yes
Constant	−0.694***	−0.725***	0.559***	0.598***
	(0.160)	(0.160)	(0.101)	(0.099)
Observations	5982	5982	5982	5982
R-squared	0.346	0.356	0.249	0.318

Notes: Robust standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

5.3. Robustness checks

Consistent with the 2SLS results, we observe that CWR is correlated with a 2.057 standard deviation increase in crop diversification and a 151% reduction in the likelihood of engaging in sharecropping (Table 4). Additionally, the CMP estimates yield similar findings to the 2SLS and CFA. However, the effect sizes are slightly lower. Specifically, households with access to CWR exhibit a 1.190 standard deviation increase in crop diversification and a 107% decrease in the probability of engaging in sharecropping (Table 5). Despite minor variations in effect

[3] See Wooldridge (2015) for detailed exposition on the control function approach (CFA).

[4] See Roodman (2011) for detailed exposition on the Conditional (recursive) Mixed Process (CMP).

Table 3
IV estimates of CWR, crop diversification, and sharecropping.

Variables	Crop diversification		Sharecropping	
	(1)	(2)	(3)	(4)
Community water resource (1/0)	2.627***	2.270***	−2.387***	−1.943***
	(0.820)	(0.735)	(0.676)	(0.566)
Other controls	Yes	Yes	Yes	Yes
Region FE	No	Yes	No	Yes
First stage				
Altitude	0.048***	0.051***	0.048***	0.051***
	(0.012)	(0.013)	(0.012)	(0.013)
Diagnostics				
F value	16	16	16	16
Robust chi2	22.405***	17.558***	41.456***	29.041***
Observations	5982	5982	5982	5982

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. Refer to Table A1 in the supplementary materials for the full results. ***$p < 0.01$.

Table 4
Control function estimates of CWR, crop diversification, and sharecropping.

	Crop diversification	Sharecropping
Community water resource (1/0)	2.057***	−1.512***
	(0.211)	(0.117)
Residual	−1.940***	1.434***
	(0.214)	(0.117)
Other controls	Yes	Yes
Region FE	Yes	Yes
First stage		
Altitude	0.050***	0.050***
	(0.014)	(0.014)
Diagnostics		
F value	13	13
Observations	5982	5982
R squared	0.365	0.337

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. ***$p < 0.01$.

Table 5
CMP estimates of CWR, crop diversification, and sharecropping.

	(1)	(2)
	Crop diversification	Sharecropping
Community water resource (1/0)	1.190***	−1.073***
	(0.136)	(0.312)
Other controls	Yes	Yes
Region FE	Yes	Yes
First stage		
Altitude	0.307***	0.311***
	(0.069)	(0.087)
lnsig_1	−0.144***	
	(0.024)	
atanhrho_12	−0.866***	0.453**
	(0.102)	(0.211)
Observations	5982	5982

Notes: All controls are the explanatory variables reported in Table 1. The coefficients of atanhrho_12 are the transformed versions of rho which indicate the correlation between the error terms of CWR, crop diversification and sharecropping. Standard errors are clustered at the community level. ***$p < 0.01$, **$p < 0.05$.

sizes, the positive association between CWR and crop diversification, as well as the negative association with sharecropping, persist across different estimation techniques addressing endogeneity. This underscores the robustness of the relationship between CWR, crop diversification, and sharecropping, suggesting that CWR can serve as a viable strategy for managing farmers' risk and income diversification strategies.

5.4. Heterogeneous effects

The results so far have shown that access to CWR is positively associated with crop diversification but negatively associated with sharecropping. However, in this section, we explore whether the CWR effect masks significant differences among households. To achieve this, we introduce interaction terms between our measure of CWR access with sex, age cohorts, location of the household, and farm size (smallholder and large holders). Given the importance of gender in development issue and as captured in the Sustainable Development Goal5,[5] our data allows us to test the association between access to CWR, crop diversification, and sharecropping based on sex (male and female) and age category (youth and adult). We defined age category based on a threshold of 35 years. Youth are individuals below or equal to 35 years of age whiles the adults are those above 35 years.

The first and second columns of Table 6 present the estimates for the sex and age disaggregated groups. The interaction term show that there are statistically significant differences between male and females and adults and youth. Male-headed households living in communities with access to water in the dry season are more likely to cultivate multiple crops and reduce sharecropping practices than female-headed households. The results indicate that there is more work to be done to improve women's access to production resources to boost their empowerment and welfare outcomes. The coefficient of the interaction term between CWR and age category variable suggests that the relationship between access to CWR and crop diversification is substantially higher for youth headed households than for the adult headed households (column 3 of Table 6). The insignificant coefficient of the interaction term between CWR and youth in the sharecropping model suggests that the difference in the association between youth and adults in terms of sharecropping is not statistically significant.

In columns 5 and 6, we explore whether the location of households influences the relationship between access to CWR, crop diversification, and sharecropping. The results suggest that this relationship is notably stronger for households in northern Ghana compared to those in southern Ghana. This finding is expected, as northern Ghana experiences only one major rainy season, whereas southern Ghana encounters both a major and a minor wet season within the same year. Crop diversification likely serves as a coping strategy against the risk of crop failure and represents a crucial source of dietary diversity to address nutritional challenges. Additionally, sharecropping is more prevalent in southern Ghana due to limited access to land for agricultural production compared to the northern regions.

In columns 7 and 8, we find that the relationship between access to CWR, crop diversification, and sharecropping is substantially higher for smallholder farmers (farm size less than 5 ha) than for large holders. Smallholder farmers who live in communities with water resources during the dry season are more likely to significantly diversify their crop portfolios but less likely to engage in sharecropping than large holders. The high cost of irrigation may discourage large holders from significantly diversifying their crop portfolios but rather intensify crop production. Similarly, large holders are more likely to engage in sharecropping

[5] The SDG 5 seeks to achieve gender equality and empower all women and girls. Some of the targets per this goal include; end all forms of discrimination against all women and girls everywhere; Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws; Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women; Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels (UN Economic and Social Council, 2017).

Table 6
Heterogeneous effects by household, location and farm characteristics.

Variables	Sex		Age		Location		Farm size	
	CDI	Sharecrop	CDI	Sharecrop	CDI	Sharecrop	CDI	Sharecrop
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CWR	1.962**	−1.446***	2.020***	−1.497***	0.082	−0.149	1.915**	−1.373**
	(0.765)	(0.547)	(0.782)	(0.553)	(0.477)	(0.372)	(0.787)	(0.549)
CWR*Sex	0.119**	−0.092***						
	(0.059)	(0.035)						
CWR*Youth			0.132**	−0.052				
			(0.062)	(0.034)				
CWR*Northern					1.076***	−0.743***		
					(0.093)	(0.051)		
CWR*Smallholder							0.162**	−0.158***
							(0.072)	(0.034)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−2.529***	1.918***	−2.654***	1.988***	−0.966**	0.853**	−2.585***	1.982***
	(0.784)	(0.546)	(0.787)	(0.546)	(0.472)	(0.354)	(0.785)	(0.544)
Observations	5982	5982	5982	5982	5982	5982	5982	5982

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. CWR is community water resources; Zone is a dummy (1/0) which refers to: 1 = farm households in the northern zone of Ghana and 0 = otherwise; CDI is standardized crop diversification index; Smallholder is a dummy (1/0) which refers to: 1 = farm households with less than 5 ha and 0 = otherwise; ***$p < 0.01$ and **$p < 0.05$.

given they own large parcels of land that can be given out to other farmers and the harvest shared based on an agreed term.

Households may pursue both risk mitigation and income diversification strategies due to water access. We further examine the relationship between CWR and income diversification strategies in Table 7. The results indicate that while CWR is associated with an increase in off-farm income, there is no significant association with agricultural income. Even with water access, households may still face other risks, such as pest outbreaks or market fluctuations, prompting them to seek alternative income sources like petty trade, wage labour, or non-farm enterprises. With improved water access, household labour may be more efficiently utilised in agriculture, freeing up family members, especially women and youth, to pursue other economic activities. Access to water might also allow households to engage in higher-value agricultural activities (e.g., growing cash crops, horticulture, or livestock farming), which may lead to new market opportunities. In response, households may diversify their income by moving into different segments of the value chain, such as processing, marketing, or transportation of agricultural goods (Dercon, 2002; Barrett et al., 2001; Reardon et al., 2001).

5.5. IV quantile regression estimates

The heterogeneity analysis of CWR, based on quantile regression, is presented in Fig. 6 and Fig. 7, and the detailed results can be found in Tables A2 and A3 in the supplementary materials. Fig. 5 illustrates that, except for households with the lowest and medium levels of crop diversification (q30 and q50), all households (q40, q60, q70, and q80) with high crop diversification significantly benefit from accessing CWR. Based on the findings, we conclude that households in the low quantile of crop diversification are more likely to benefit from accessing CWR. LaFevor and Pitts (2022) found a similar pattern where irrigation is predominantly higher in low diversity quantile compared with high-diversity quantiles.

Regarding sharecropping, the most substantial reduction in sharecropping is observed for households in the highest quantile (q60) of sharecropping (Fig. 7). This suggests that CWR is most beneficial to households classified as experiencing high levels of reduction in sharecropping. The results underscore the significance of CWR as a risk minimisation and dietary diversity strategies for rural livelihoods.

Table 7
IV estimates of CWR, off-farm and agricultural income.

	(1)	(2)
	Off-farm income	Agricultural income
Community water resource (1/0)	306,269.902***	2535.417
	(88,167.137)	(2684.067)
Other controls	Yes	Yes
Region FE	No	Yes
First stage		
Altitude	0.051***	0.051***
	(0.013)	(0.013)
Diagnostics		
F value	16	16
Robust chi2	30***	0.96
Observations	5982	5982

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. Refer to Table A1 in the supplementary materials for the full results. ***$p < 0.01$.

5.6. Underlying mechanism: migration and committed time

Our results so far show that CWR is positively (negatively) associated with crop diversification (sharecropping). The study identifies two main mechanisms through which CWR influences crop diversification: migration and labour effect (committed time). Committed time refers to the time allocated to both paid and unpaid activities. Migration and committed time are considered potential channels if their inclusion in the crop diversification and sharecropping equations lead to a reduction in the coefficient of the CWR variable or renders it statistically insignificant. To ensure consistency in the analysis, we used the IV estimation and same set of covariates as used previously in Table 3. In the first step, we assess the association between CWR, migration, and committed time. In Columns 1 and 2 of Table 8, we see that CWR is significantly associated with a decline in migration and committed time by 46% and 2.6 h, respectively. Access to CWR during the dry season reduces migration thus making labour available for farm work. The reduction in migration is associated with lower remittance income (see Table A4).

In the second step, we separately include migration and committed time as covariates in the crop diversification and sharecropping models and assess the magnitude of the coefficients on the CWR variable. In Columns 1 and 2 of Table 9, we observed that migration is significantly associated with crop diversification but not sharecropping while CWR is associated with a 2.306 standard deviation increase in crop diversification and a 194% decrease in sharecropping. In columns 2 and 4, we find that committed time is negatively (positively) associated with crop diversification (sharecropping) while CWR is associated with a 2.240 standard deviation increase in crop diversification and a 192 percentage

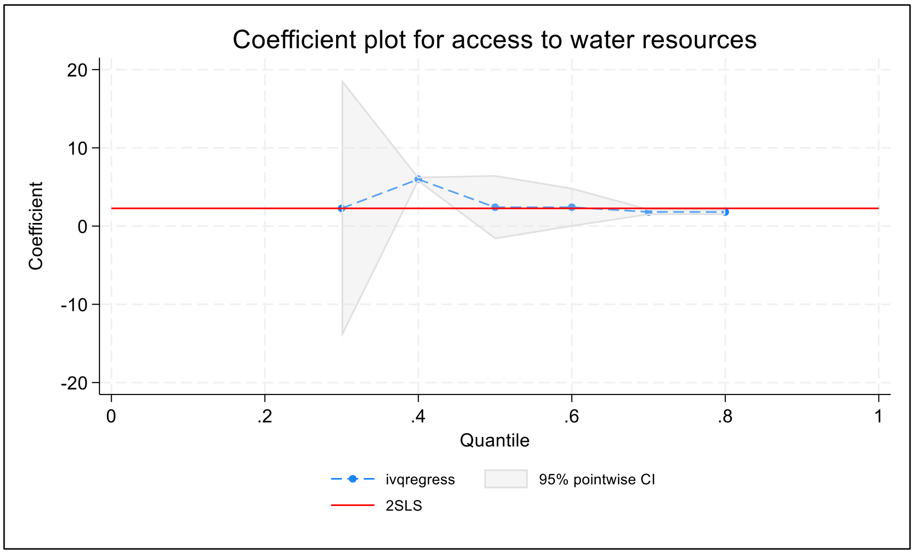

Fig. 6. Effect estimates for community water resources quantile regression (crop diversification). Notes: The full results are presented in Table A2 in the supplementary material. The controls used in the regression are presented in Table 1. The Kolmogorov-Smirnov statistic of 35.177 is greater than the critical value of 10.310 which suggests that the null hypothesis of exogeneity is rejected.

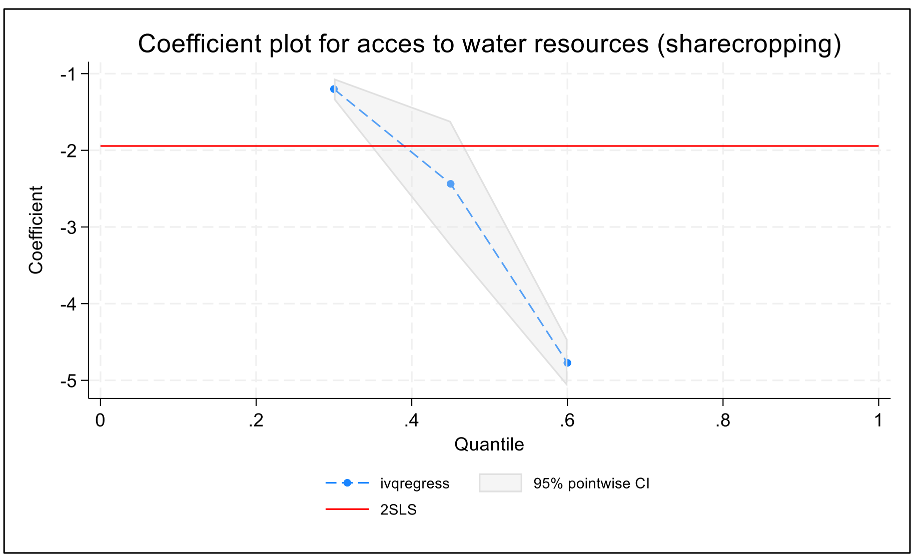

Fig. 7. Effect estimates for community water resources quantile regression (sharecropping). Notes: The full results are presented in Table A3 in the supplementary material. The controls used in the regression are presented in Table 1. The Kolmogorov-Smirnov statistic of 30.468 is greater than the critical value of 3.049 which suggests that the null hypothesis of exogeneity is rejected.

points decrease in sharecropping.

Comparing the coefficients of CWR in Panel B of Tables 9–3 indicate that the inclusion of migration as a covariate in the crop diversification and sharecropping models did not reduce the magnitude of the coefficient of CWR. We failed to establish migration as a channel through which CWR influence crop diversification and sharecropping. Columns 3 and 4 of Table 8 reveals that the inclusion of committed time as a covariate in the crop diversification and sharecropping equations reduced the magnitude of the coefficient of CWR. This suggests that committed time is an important channel through which CWR influences crop diversification and sharecropping.

Access to CWR during the dry season and reduction in remittances income influence farm households to embark on crop diversification and sharecropping as risk mitigation strategies to increase or maintain household income and consumption. Similarly, the availability of labour due to non-migration of household members may lead to a reduction in the effective labour per household member. The saved time can be invested in farm activities thus increasing the cultivation of multiple crops and reducing the practice of sharecropping among community members.

6. Conclusion and policy implications

In this study, we examine the association of community water resources with crop diversification and sharecropping using a nationally representative data of 5982 farm households in Ghana. Our results show a significant positive association between CWR and crop diversification. Conversely, access to CWR is negatively associated with sharecropping. The results are robust across different endogeneity-correcting models. Furthermore, we find that the association between CWR, crop diversification, and sharecropping is significantly higher for male and youth-headed households. Based on location, the increasing (reducing)

Table 8
Potential mechanism analysis based on committed time.

Variables	(1)	(2)
	Migration	Committed time
Pabel A: Main results		
Community water resource	−0.457***	−2.620***
	(0.117)	(0.743)
Other controls	Yes	Yes
Region FE	Yes	Yes
First stage		
Altitude	0.051***	0.051***
	(0.004)	(0.004)
Diagnostics		
F value	158	158
Robust chi2	13.745***	14.578***
Observations	5982	5982

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. ***p < 0.01.

association between CWR and crop diversification (sharecropping) is relatively higher for households in northern Ghana than those in southern Ghana. Similarly, smallholder farmers benefit more from community water resources than large holder farmers. The heterogeneity analyses show that households within high distribution of crop diversification and sharecropping benefits significantly from accessing CWR. Our results show that committed time is a potential mechanism through which CWR influence crop diversification and sharecropping.

The study findings offer a couple of policy implications. First, we offer empirical support to the literature that highlights the welfare gains from water availability for dry season agricultural production in a developing country context. Given the negative impact of climate change on rural livelihoods, there is an urgent need for governments to improve water access all year round for agricultural production. The government flagship program "One Village One Dam" must be reviewed through broader consultation with community members and other relevant stakeholders to improve targeting and sustainability. This initiative will increase the welfare of households and communities. However, this welfare gains can be sustained through continuous dredging of the dam and extending the interventions to other communities to improve access and utilization. Second, access to water in the dry season can be a risk mitigation strategy for rural households thus, increasing the cultivation of multiple crops. Crop diversification improves the availability, affordability, and utilization dimensions of food security and also provides opportunities for cultivating more profitable crops. Furthermore, households are likely to engage more in diverse markets and increase income stability through multiple revenue streams by reducing reliance on a single crop commodity that may be subjected to price fluctuation. The implication of the findings is that improving access to water can build resilient and sustainable agricultural systems that can meet the diverse needs of farm households given the challenge of climate change, resource limitation, and market volatility. Third, CWR creates opportunities for farm households to cultivate their own plots with limited or no sharecropping. This further supports the findings of CWR as a risk mitigation strategy and opportunity to increase access to food. Finally, the reduction in committed time due to availability of water leads to a reduction in crop diversification but increase sharecropping. The implication of the findings is that households may reduce their committed time in agricultural production for off-farm work or home-production. This can be reversed through the development and dissemination of agricultural labour-saving technologies to improve farm efficiency.

Despite the robust findings, we highlight some weaknesses and offer suggestions for future studies. First, although the data used for the study is nationally-representative, it is cross-section and makes it difficult to establish causality. In view of this, our findings should be interpreted as association. Panel data can be used to establish causation between CWR, crop diversification, and sharecropping. Second, the construct of CWR does not adequately capture the variability of water access throughout the year, over time, or in terms of water quality and quantity. A construct of CWR that encompasses both the quantity and quality of water can yield valuable insights. Third, we are not able to explore other pathways due to data limitation. Although the study finds a reduction in committed time due to access to CWR, our finding is limited in identifying which household sector benefits more from a reduction in committed time. It will be helpful to ascertain how CWR influences household committed time in agriculture, home-production, leisure, and off-farm work. Further investigation into these dynamics and their implications remains an area for future research.

CRediT authorship contribution statement

Edward Martey: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology,

Table 9
Potential mechanism analysis based on committed time.

Variables	Mediator: migration		Mediator: committed time	
	(1)	(2)	(3)	(4)
	Crop diversification	Sharecropping	Crop diversification	Sharecropping
Pabel A: Main results				
Community water resource	2.306***	−1.943***	2.240***	−1.920***
	(0.742)	(0.568)	(0.257)	(0.181)
Migration	0.078*	0.001		
	(0.045)	(0.031)		
Committed time			−0.011**	0.009***
			(0.005)	(0.003)
Other controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
First stage				
Altitude	0.051***	0.051***	0.051***	0.051***
	(0.013)	(0.013)	(0.004)	(0.004)
Diagnostics				
F value	16	16	159	159
Robust chi2	18.027***	28.743	112.687***	273.311***
Observations	5982		5982	5982
Panel B: see Table 3 results				
Community water resource	2.270***	−1.943***	2.270***	−1.943***
	(0.259)	(0.183)	(0.259)	(0.183)

Notes: All controls are the explanatory variables reported in Table 1. Standard errors are clustered at the community level. ***p < 0.01, **p < 0.05, and * p < 0.1.

Formal analysis, Data curation, Conceptualization. **Prince M. Etwire:** Writing – review & editing, Writing – original draft, Validation, Formal analysis, Data curation. **Collins Asante-Addo:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Francis Addeah Darko:** Writing – review & editing, Validation, Formal analysis. **Mustapha M. Suraj:** Writing – review & editing, Validation, Formal analysis.

Declaration of competing interest

The authors declare that they have no competing interests both financial and non-financial.

Acknowledgements

This study is made possible through data support from the Ghana Statistical Service (SSS). The authors are grateful for financial support received by the GSS from the Government of Ghana, Department for International Development (DFID) and the Dutch Government through the International Development Assistance (IDA) and the Statistics for Results Facility Catalytic Fund (SRF-CF) which was managed by the World Bank under the Ghana Statistical Development Program (GSDP). The authors express their appreciation for the administrative support offered by the CSIR-Savanna Agricultural Research Institute. Finally, we wish to express our profound gratitude to the anonymous reviewers whose contribution has led to a major improvement of this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2024.123838.

Data availability

Data will be made available on request.

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