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PII: S2665-9727(24)00015-1

DOI: https://doi.org/10.1016/j.indic.2024.100347

Reference: INDIC 100347

To appear in: *Environmental and Sustainability Indicators*

Received Date: 24 December 2021

Revised Date: 29 August 2023

Accepted Date: 18 January 2024

Please cite this article as: Musa, F.B., Katundu, M.C., Lewis, L.A., Munthali, A., Gender and livelihood assets: Assessing climate change resilience in phalombe district – Malawi., *Environmental and Sustainability Indicators* (2024), doi: https://doi.org/10.1016/j.indic.2024.100347.

Gender and Livelihood Assets: Assessing Climate Change Resilience in Phalombe District – Malawi.

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Abstract

Access and use of livelihood assets are pertinent to recovery from impacts of climate change for rural households. This study investigated role of livelihood assets to recovery from the impacts of climate change for male and female headed households in Phalombe district in Malawi. Using exploratory sequential mixed methods design, qualitative data was collected using Participant Observation coupled with interviews in two successive phases and lastly quantitative data was collected using household questionnaire involving 217 households. Results show that erratic rainfall and floods are the main impacts of climate change in the study area. Male headed households have better access to human, financial and natural assets compared to female headed households. There is no significant difference on the recovery period from erratic rainfall for either households, but male headed household recover much quicker from floods than female headed households. Results show that social assets are key to recovery from both erratic rainfall and floods for both male and female headed households. Natural assets contribute to recovery from erratic rainfall for male headed households while human assets are important for female headed households. Human assets are vital for recovery from floods for both male and female headed households while physical assets are important for male headed households. The study shows that enhancing social capital and developing human assets especially for female headed households can significantly contribute towards resilience to the impacts of climate change.

Key words

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1.0 Introduction

Varying climate change resilience depends on among other factors access to resources across different strata of the society (Asmamaw et al., 2019). Resilience to the impacts of climate change is contingent on among key factors social inequalities, rights and access to resources, underlying poverty, and lack of representation (Tanner et al., 2015). Studies in developing countries have showed that gender inequality significantly influences access to livelihood resources especially in the rural communities of developing countries (Paudel Khatiwada et al., 2018; Ankrah et al., 2020). The skewed distribution of livelihood resources consequently leads to deferential resilience capacities between male and female-headed households (Andrijevic et al., 2020).

Literature has showed that gender inequality on access to resource has persisted for generations (Giuliano, 2017). Gender norms, the gender division of labour and differing levels of access to productive resources, not only make women more vulnerable but also affect women's ability to develop resilience to the impacts of climate change (Ampaire et al., 2019). Studies in poverty, rural livelihood and climate change have revealed that gender related limitations on distribution of resources produces unequal outcomes between male and female-headed households (Manandhar et al., 2018; Cole et al., 2020). Additionally, the IPCC AR6 noted that socioeconomic inequities linked to gender causes low resilience to the impacts of climate change (Schipper et al., 2022) and Wanjala, (2021) further reported that women are less resilient to livelihood shocks in Africa because of low access to productive resources.

Malawi ranks in the bottom quintile of countries on the Gender Inequality Index (Nash et al., 2019). The gender inequality situation worsens the ability of female-headed

households to weather climate change related shocks compared to their male counterparts. For instance, UN Women in Malawi found that about 56% of those displaced by the 2015 floods and 59% of those displaced by Cyclone Idai in 2019 were women (UN Women, 2019). Lower capacity to withstand the shocks reveal underlying gender inequalities in accessing livelihood resources. Despite this information, there is not detailed research that has showed how livelihood assets contribute towards recovery from the impacts of dry spells and floods in rural communities in Malawi.

1.1 Background

Malawi, like most developing countries in the Sub-Saharan region, is considered less resilient to the impacts of climate change (Mango et al., 2018; GoM, 2018). Low resilience is in some literature associated with increased unequal distribution and access to resources across different strata of the populations (Papadopoulos et al., 2019). Previous studies have demonstrated that availability of livelihood assets is one while access to the same resources is another. Scholars such as Thomas et al., (2020) concluded that access to resources entails complex social relationships and power structures that enable sidelining of some groups in a society.

Summary statistics in appendix 1 show national level gender disaggregated indicators for livelihood resources organized using Sustainable Livelihood Framework (SLF). In general, statistics show that female-headed households have lower resource base to build resilience than male counterparts. Lovell (2021) noted that Malawi is a highly patriarchal society and gender inequalities are deeply entrenched in many ways evidenced by women's engagement in low-income activities, limited access to resources and assets, higher illiteracy rates, inadequate access to systems and services

while widowhood, divorce, and separation are associated with lower social inclusion. Albeit knowledge of existing discrepancies on resource endowment not much has been explored on how these differences contribute to unequal resilience outcomes between male and female headed households in Malawi.

Our study adapted the conceptual framework developed by Aryal et al., (2020). The framework depicts how male and female headed households upon being exposed to climate shock use available livelihood assets to adapt. Our however demonstrate that differences in resource base between male and female-headed households result into varying adoption of livelihood activities. Male headed-households have more resources thus they will have a variety of livelihood activities to recover or build resilience than female headed-households. Consequently, the male headed-households (MHH) recover quicker from the shock than female headed-households (FHH).

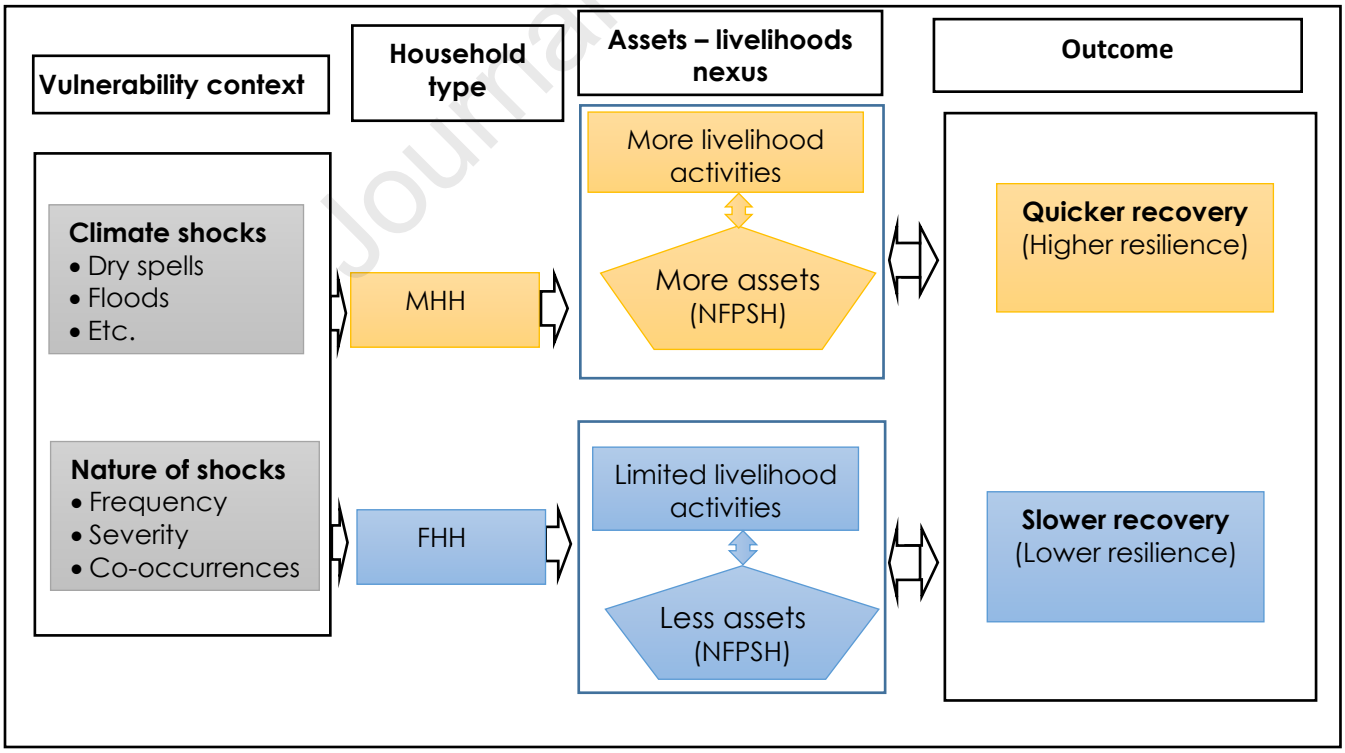

Figure 1. Conceptual framework for the engendered climate change resilience study

2.0 Methods

2.1 Study area

Phalombe district has been designated as one of the most vulnerable districts in Malawi and has had episodes of climate change related shocks for the past 3 decades (GoM, 2012). It is also one of the poorest districts in Malawi with 83.2% of its population considered poor against 51% national average while 50.6% of the population is considered ultra-poor compared to the national average of about 25% (NSO 2020a). According to Mussa (2017) female headed households are poorer than male headed households in rural areas with per capita consumption of about 17% lower than that of male headed households.

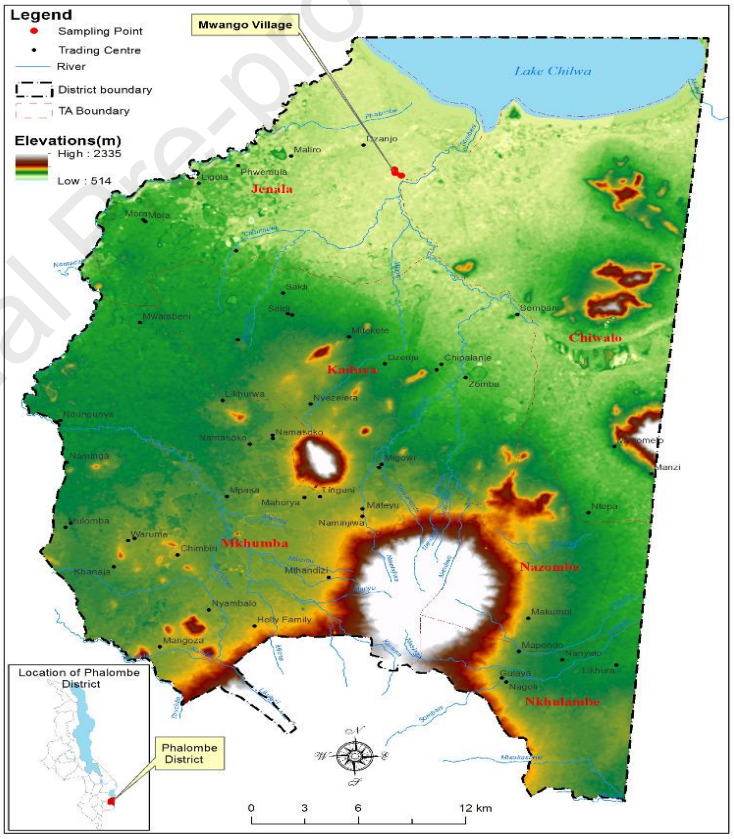

Figure 2. Map of the study area

The study was carried out in Mwango Village within Traditional Authority Jenala in Phalombe district. It is located at (-15.537860S and 35.692347E) about 600 metres above sea level on the southeastern side of Lake Chilwa (Figure. 2). According to NSO (2018) Traditional Authority Jenala has 20,250 households and Mwango village has about 650 of which about 200 are female headed. The study area experiences sub tropical

118 climate with temperature ranging from 21^{0}C to 35^{0}C and average rainfall of about
119 1626mm per annum (Nangoma & Nangoma, 2010). Unimodal rainfall starts around
120 November and ends in April (Svesve, 2016). Most district's population depend on
121 rainfed agriculture as the main livelihood activity. They also depend on natural
122 resources such as forests and wetlands for alternative livelihood activities (GoM, 2012).
123 Increased frequency and intensity of the impacts of climate change such as erratic
124 rainfall and floods have been considered as to threats to livelihood sustainability in the
125 district (GoM, 2018).

126 The area is highly populated by the Lomwe tribe who follows matrilineal system of
127 inheritance and Uxorilocality. Land in a matrilineal culture is inherited by women and girl
128 while husbands have user rights to the same (Kishindo, 2010; Berge et al., 2014). Limited
129 control over land negatively affects long-term investment at both household and
130 community for men (Ng'ong'ola, 1986). This socio-cultural nexus was also considered as
131 interesting feature for an investigation on male and female-headed households'
132 access and use livelihood assets to recover from impacts of climate change.

133 **2.2 Study approach**

134 This study adopted the exploratory sequential mixed methods design (Ivankova et al.,
135 2006). Data was collected in three phases. The first and second phases involved
136 Participant Observation, interviews, and Focus Group Discussions (FGDs) while the last
137 phase was for household survey using a semi – structured questionnaire.

138 The first two phases principally involved in-depth qualitative data collection through
139 observations, interviews, and discussions on livelihood activities and how households
140 reorganize resources to recover from the impacts of climate change. The Lead

141 researcher lived in the study area for an average of 5 weeks in each phase between
142 February and December 2020. In between the phases, data was analyzed to identify
143 data gaps to be addressed in the subsequent phase. Qualitative data analysis
144 consequently informed development of a household questionnaire that was
145 administered to household heads or spouses during the last phase of the study.

146 *Qualitative data collection*

147 One – on – one interviews, and Key Informant Interviews (KII) were conducted (Table 1).
148 Additionally, participatory rural appraisal methodologies were used to facilitate 4 Focus
149 Group Discussions (FGD), disaggregated by gender. Discussions focused on livelihood
150 activities and the role of livelihood assets in recovering from the impacts of climate
151 change *vis-a-vis* floods and erratic rainfall. Ethical clearance for the study was obtained
152 from the Malawi National Commission for Science and Technology reference number
153 NCST/RTT/2/6 and University of Southampton ERGO II 52686.

154 **Table 1**: List of study participants

Interviews	**Age range (Years)**	**Male**	**Female**	**Total**
One - on - one interviews	21 - 44	7	7	14
Key Informant Interviews (KII)	36 – 68	9	3	12
Total		**16**	**10**	**26**

155

156 Semi structured checklists were used to interview locals and Key Informants. Equal
157 numbers for both genders were achieved for one-on-one interviews but fewer (3)

158 females were found as key informants compared to (9) for males. Key informants
159 included the agricultural extension agent, representatives of local development
160 structures and the chief. Fewer available female key Informants shows some disparities
161 in representation of women in key decision-making position at local level. Four (4) FGDs,
162 two for each gender were conducted. According to Nelson et al., (2002) response
163 mechanisms and strategies to climate related shocks vary between males and females,
164 therefore, FGDs involving male and female household heads were conducted
165 separately. Each FGD involved between eight to ten participants.

166 *Quantitative household survey data*

167 Qualitative data analysis informed the design of the household survey questionnaire to
168 capture context specific variables on livelihood assets. Households were sampled
169 randomly, and sample size was calculated using the Cochran formula with a 5% margin
170 of error (95% confidence level) and a 50% sample proportion (Tejada & Punzalan, 2012).
171 The total sample was 217 households of which 140 are male headed while 77 were
172 female headed households. Data was gathered on household socioeconomic
173 characteristics, livelihood assets, livelihood sources, income, and period to recovery
174 from erratic rainfall and floods.

175
176 **2.3 Choice of variables**

177
178 The qualitative interviews and observations helped understanding of the local context
179 especially the impacts of climate change and role of various assets used to recover
180 from the shocks. Choice of variables to estimate impact of assets on livelihood depends
181 on a thorough understanding of the research context (Campbell et al., 2001; Uy et al.,

182 2011). A sustainable livelihood framework (SLF) was used to organize variables under the
183 five types of assets (Erenstein et al., 2010; Quandt, 2019; Nasrnia & Ashktorab, 2021). The
184 variables were selected using both a literature review and prior analysis of the
185 qualitative data Table 2.

186
187 **Table 2.** Livelihood assets categories and their respective variables

Categories	Quantitative variables	Rationale	Source
Physical	Value of productive assets	Assets can be sold to smoothen consumption.	Fang et al., 2014 and Pour et al., 2018
	Value of owned livestock	Livestock can be sold to smoothen consumption if hit by shock.	Pour at al., 2018
	No. of Habitable houses	More houses are alternatives if one falls due to floods.	Qualitative research
Human	Education of household head	Educated household heads able to make informed decisions.	Soltani et al. 2014
	Productive people in the household	More labour helps pursue several livelihood activities at the same time.	Ellis, 2000
	Sickness during farming season	Thwarts agriculture production – main livelihood activity	Qualitative research
Social	Relations and friends to the household	Immediate sources of help when household cannot manage a crisis	Quandt, 2019
	Membership to formal/informal groups	Network of people that can support a household to offsets impacts of a shock	Soltani et al. 2014 & Pour et al., 2018
Financial	Membership to savings group	Access to finances to build other assets or mitigate impacts of a shock	Panman et al., 2021
	Whether the household	*Katapila* result into losses during rice	Qualitative research

	got *Katapila* (Loans)	harvesting because of high interest.	
	Income from regular source in a month	Regular income entails the ability to build other assets to offset future shocks	Pour et al., 2018
	Savings by the household	Saving can be used to manage immediate impacts of shocks	Panman et al 2021
Natural	Size of owned arable land	Key productive asset that determines rainfed crop production	Qualitative research
	Ownership of a plot at the wetland	Irrigation in the wetland is the alternative to rainfed crop failure.	Quandt, 2019
	Distance from water body to the garden	High dependence on residual moisture and low-cost irrigation technologies require proximity to water source.	Qualitative research
	Involvement in fishing	Fishing is one of the lucrative livelihood activities that smoothens consumption.	Qualitative research

2.4 Analytical approach

Qualitative data were transcribed verbatim and were organised using NVIVO 12th edition for thematic analysis (Jauffret-Roustide & Cailbault, 2018). All the data transcripts were read by two people for verification before coding started. During coding, sub themes were merged, which were eventually fused into themes (Braun, & Clarke, 2012). Charts and drawing from FGDs were analysed by connecting and linking various aspects of livelihood activities and assets identified during discussions.

2.5 Livelihood assets measurement

198 Quantitative data was organised and analysed using Microsoft Excel. Analysis was
199 done using the method for computing the Human Development Index (UNDP, 1994;
200 Pandey & Jha, 2012; Quandt, 2019). This method involves identification of variables
201 under each of the five livelihood assets categories. Maximum and minimum values
202 under each variable are determined and then an index is computed using the
203 equation (1) below. Results from this standardization ranges from 0 to 1, where 0 is the
204 least desirable state while 1 is the most desirable state.
205

$$I_{ij} = \frac{\mathrm{Max}X_i - Xij}{MaxX_i - MinX_i} \quad (1)$$

206

207 Where

208 Xij is the value attained by the jth Household in *i*th variable.

209 Max *Xi* is the maximum value in the data series *i.*

210 min *Xi* is the minimum value in the data series *i.*

211 For continuous variables the computation involved calculating as illustrated in formula
212 (1) however for categorical variables no calculation was done because the answers
213 were already yes or one (coded as 1 for yes and 0 for no in the data). For the variable
214 of a loan (*Katapila*) under financial assets, the question was asked in reverse so that
215 'yes' could denote 'did not get the loan' while 'no' meant did get the loan. This was to
216 ensure that getting a loan is depicted as an undesirable condition and vice versa
217 because needing a loan indicates vulnerability. To compute an index for each
218 livelihood asset category, a composite index was created by an additive method from
219 variables standardized under each category by the equation (2). Computation was
220 done for each household and then analysed for male and female headed households.

$$C_i = \sum I_{ij} \quad (2)$$

Where

C_i is the index from ith livelihood asset.

I_{ij} is the index of from the individual variable.

The simple linear regression function was used to estimate contribution of the livelihood assets indices to recovery from impacts of erratic rainfall and floods for male and female headed households. Recovering from floods and erratic rainfall was conceptualized as reverting to pre shock status in terms of food security at household level. Choice of food security status as recovery measure was based on literature which shows that it is a primary goal of most livelihood activities in rural areas of most developing countries (Conceição, et al., 2016). The recovery period was therefore determined as number of months from the onset of food scarcity due to the shocks to the time of recovery. Five livelihood asset indices were considered as independent variables (equation 3).

$$Rec_{(Months)} = \alpha + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \beta 5x5 \quad (3)$$

Where

$Rec_{(Months)}$ is the number of months to recovery from a shock (floods or erratic rainfall)

α Is the constant

β_1 to β_5 are the coefficients.

x_1 to x_5 are the livelihood asset (Physical, Human, Financial, Social, and Natural)

3.0 Results

Firstly, results are presented on the impacts of climate change on existing livelihood activities and associated effects. Secondly results on role of livelihood assets are presented and thirdly implications of livelihood assets on recovery from the shocks for male and female headed households.

3.1 Impacts of climate change on livelihood activities.

The study area, like most of the rural Sub-Saharan Africa, primarily depends on subsistence farming as a main livelihood activity. It was therefore not surprising that the main impacts of climate change were associated with thwarting rainfed farming and small-scale irrigation. Table 3 below shows local perceptions on the main impacts of climate change on livelihood activities and their resultant effects on households.

Table 3. Local perceptions on climate related shocks and their effects on livelihood activities

Climate related shock	Livelihood activity	Immediate impacts	Long term impacts
Erratic rainfall	• Rainfed farming • Winter farming • Fishing	• Low rainfed crop yields • Multiplication of pests • Low fish catches	• Food shortage • Income shortage
Floods	• Rainfed farming • Casual labour	• Loss of crops • Loss of infrastructure • Loss household assets	• Food shortage • Income shortage • Increased vulnerability

Qualitative analysis identified erratic rainfall and floods as the main impacts of climate change in the area. Erratic rainfall occurs in form of late onset of rains; intermittent precipitation during crop growing period and early cessation of rains before crops mature. Erratic rainfall is one of the key shocks that negatively affect both rainfed and small-scale irrigation farming. Dry spells during rainy season also necessitate multiplication of Fall Army Worms (*Spodoptera frugiperda)* which reduces maize (*Zea mays*) yields. Insufficient rainfall thwart small-scale irrigation farming because of its high dependence on residual moisture from rainy season. Failure of winter farming deepens the food security crisis because of its role as an alternative to the less reliable rainfed farming. Erratic rainfall also foils rice production, which is one of the main income earners from rainfed farming that consequently result into income loss. Low water levels in the lake due to erratic rainfall results into low fish catches. Farming and fishing are main sources of casual labour therefore when they fail opportunities for casual labour are also scarce.

Floods commonly happen at the peak of rainfall period between January and March when main food and cash crops are grown. Floods negatively affect arable rainfed farming by washing away crops especially maize. Floods also destroy houses and carry away vital household assets. Washing away of crops, destruction of houses and loss of vital household assets deepen food and income insecurity as households struggle to recover in the middle of crop production period. Loss of crops due to floods also limit opportunities for casual labour.

3.2 Gender disparities on access to livelihood assets

Available assets determine the choice of livelihood activities that a household is likely to pursue while trying to recover from the impacts of climate change. There are differences in access and use of assets for male and female-headed households (figure 3).

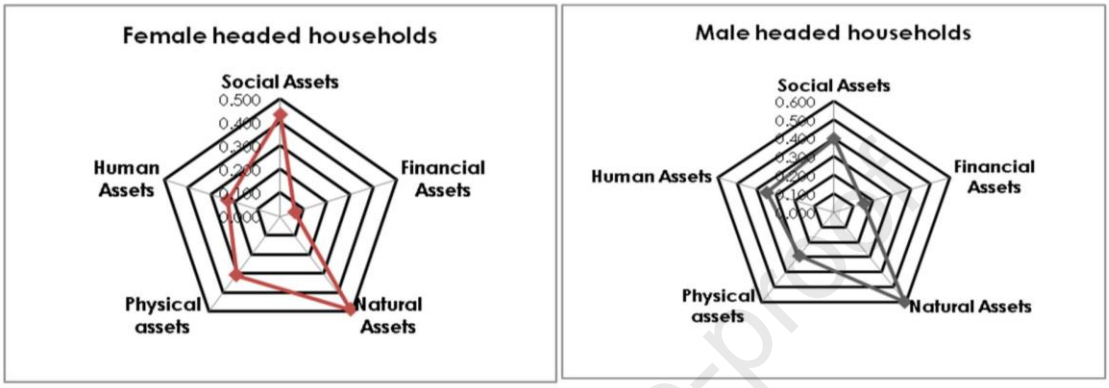

Figure 3. Spider diagram of livelihood assets for male and female headed households

The results show similarities and differences in resource endowment for male and female headed households. Independent t-test of means between male and female headed households shows statistically significant difference for human, financial and natural assets (table 4).

Table 4. Independent t-test of asset indices

Asset categories	Mean male headed	Mean female headed	t	df	Sig.
Natural assets	0.593(0.158)	0.488(0.117)	5.076	215	0.000***
Social assets	0.396(0.229)	0.435(0.285)	-1.081	215	0.281
Financial assets	0.156(0.160)	0.062(0.043)	5.038	215	0.000***

Human assets	0.346 (0.175)	0.227(0.155)	4.963	215	0.000***
Physical assets	0.287 (0.166)	0.307(0.145)	-0.906	215	0.366

Significance levels * significant at 10% ** Significant at 5% ***Significant at 1%.

3.2.1 Natural assets

Rural households in developing countries highly depend on natural resources for survival and recovery from climate change related shocks (De Silva & Kawasaki, 2018; Brown et al., 2019). Results show a higher natural assets index for male headed households (M = 0.593, SD=0.158) compared to female headed households (M = 0.488, SD=0.117) with a significant difference, t (215) = 5.07, p = 0.00). Access to natural assets especially land may be skewed towards females considering the matrilineal traditions that are common in the study area. Almost all key informants indicated that land is inherited through females in the area. If marriage ends by any cause, land is owned by the women. However, high average index for male headed households might have been due to exclusion of women from fishing. During both male and female FGDs it was mentioned that fishing is exclusively for males thus low proportion of female headed households that are involved in the enterprise. This might have been the major contributor towards higher natural asset index for male headed households in the area.

3.2.2 Social assets

The social assets comprise of a social network that a household or individual exist in through which information and resources flow. Female headed households have stronger network of friends and relatives within their locality owing to the uxorilocality arrangement that required men to settle in their wives' villages. However, other variables such as membership to social and religious groups might have levelled the

311 social assets gap for the male headed households. Their connections to non-relation in
312 the community might be the crucial social network through which they may depend on
313 in times of climate induced shock. Independent t-test shows that there was no
314 significant difference in social assets endowment by male and female headed
315 households. This implies that both male and female headed households have
316 comparable social assets.

317 *3.2.3 Financial assets*

318 Financial assets enable a household to purchase immediate household needs, such as
319 food in case of a shock. Table 4 shows a higher financial assets base for male headed
320 households (M = 0.156, SD=0.160) compared to female headed household index (m =
321 0.062, SD=0.043) with a significant difference, t (215) = 5.03, p = 0.00. Higher financial
322 asset base for male headed household might have been due to higher income earned
323 by males from more lucrative enterprises especially fishing. Although financial assets
324 are considered flexible and easy to use within a short period after a shock, most of the
325 respondents during FGDs said that such assets are rather elusive because they can be
326 used for non-shock recovery expenses such as leisure especially by males.

327 *3.2.4 Human assets*

328 The human asset index is comprised of education background of the household head;
329 incidents of chronic sickness during main production season (rainfed farming season) as
330 well as the number of productive members of the household (people aged between 15
331 and 64 years). Analysis shows a significant difference in human assets between male
332 and female headed households. Male headed households had higher human asset
333 (M=0.346, SD = 0.175) compared to female headed households (M=0.227, SD=0.155)

depicting t (215) = 4.96, p = 0.00. Most of the respondents during qualitative data collection said human assets are key in times of food shortage because able members engage in casual labour or fishing to source food and income. Therefore, if more people work more income and food are sourced and thus enable the household to quickly to recover. It was also observed that relatively more educated people easily find opportunities to source food and income as they can access information and work with organisations in the area as volunteers or part time workers.

3.2.5 Physical assets

Physical assets are also necessary to enable households to recover and withstand the impacts of climate change. The index includes the total value of productive assets; the value of livestock owned by a household and the number of habitable houses owned the household. Independent t – test results showed no significant difference in the physical assets index for male and female headed households. This implies that neither male nor female headed households have superiority in terms of access to physical assets. Village Key Informants indicated that under the dominant uxorilocal post marital settlement, after divorce or separation, the husband is only allowed to leave with assets he brought in marriage. Similarly, in case of death of the husband, his relations are only allowed to inherit assets their relative owned before marrying. The implication is that women eventually inherit almost all the assets that might have been accumulated together with the husband while they were married.

In summary, although literature shows that although all the five categories of livelihood assets are vital for recovery from shocks, Eriksson et al., 2018)found that human and

social assets are crucial for recovery while Asmamaw et al., (2019) reported that physical, financial, and social assets are critical for recovery from climate change related shocks.

3.3 Gender differences on the contribution of livelihood assets to resilience

In order to understand how five livelihood assets contribute towards recovery from the impacts of shocks, the study inquired about the number of months from the onset of the impacts of floods and erratic rainfall to the time food security is restored. Table 5 shows analysis of the period to recovery in months for male and female headed households.

Table 5. Mean comparison of the period (in months) to recovery from erratic rainfall and floods for male and female headed households

Impact of climate change	Male headed	Female headed	T - Statistic	df	Sig
Erratic rainfall	3.49 (1.958)	3.35 (2.043)	-0.118	214	0.906
Floods	3.23 (1.943)	4.13 (2.572)	-2.906	215	0.004

Figures in parathesis are Standard Deviation (SD)

Results show that the recovery period from the impacts of floods was significantly different between male and female-headed households. Male headed households recover from the impacts of floods within 3.23 months while female headed households recover within 4.13 months ($p<0.01$). The agricultural Extension Officer for the area indicated that floods are the most difficult shock for female-headed households to recover from because of multiple damage they cause. Eventually it takes relatively longer for female-headed household to recover from floods compared to male-

376 headed households because of differences in amount of resources especially labor to
377 simultaneously restore both infrastructural and crop damage.

378 ***3.3.1 Implications of livelihood assets on recovery from erratic rainfall.***

379 In order to determine contribution of the five livelihood assets indices to recovery from
380 erratic rainfall, a simple linear regression analysis was used with time (in months) to
381 recovery as the dependent variable while livelihood assets indices as independent
382 variables. Results of the analysis by gender are in Table 6 below.

383 **Table 6.** Regression output for the livelihood assets categories against period of
384 recovery from erratic rainfall disaggregated by gender.

Assets	Male headed households			Female headed households		
categories	Coef.	t	P value	Coef.	t	P value
Natural assets	-1.851	-1.87	0.063*	-1.684	-0.93	0.358
Social assets	-2.510	-3.72	0.000***	-3.039	-4.06	0.000***
Financial assets	2.421	2.49	0.014**	-7.919	-1.62	0.110
Human assets	-1.443	-1.63	0.105	-3.102	-2.23	0.029**
Physical assets	-1.207	-1.29	0.198	-2.130	-1.45	0.151
Constant	6.054	8.27	0.000***	7.512	6.57	0.000***

Significance levels * significant at 10% ** Significant at 5% ***Significant at 1%

Number of observations= 140	Number of observations= 76
R-squared= 0.167	R-squared= 0.258
F (5, 134) = 5.36	F (5, 70) = 4.87
Prob > F = 0.000	Prob > F = 0.000

386
387 The regression model results for both male and female headed households show that
388 the model is broadly consistent with the estimated results. The model output shows that

389 livelihood assets indices explain approximately 17% of the variance of dependent
390 variable for male headed household and 26% for female headed households. In
391 general, regression output shows that livelihood assets contribute to recovery from the
392 impacts of erratic rainfall. Signs on the coefficients show the direction of the
393 relationship, while magnitude suggests the effects on recovery from the impacts of
394 erratic rainfall.

395 The results (Table 6) show that there is a negative and significant correlation between
396 natural and social assets to the period of recovery from erratic rainfall while there is a
397 positive and significant correlation with financial assets for male headed households.
398 The results show that a unit increase in natural assets for the male headed households
399 ($p < 0.1$) can decrease the recovery period by about 1.8 months while a unit increase in
400 social assets can decrease the period of recovery from erratic rainfall by 2.5 months (p
401 < 0.01). Furthermore, a unit increase in financial assets increase the recovery period
402 from erratic rainfall ($p < 0.05$) by about 2.4 months for male headed households. Most
403 male respondents during one-on-one interviews indicated that food shortages due to
404 erratic rainfall are often abated by the proceeds of fishing. During men FGDs, it was
405 learnt that financial resources are open for a range of uses apart from buying food, thus
406 do not guarantee speedy recovery from food shortages due to erratic rainfall.

407 Analysis shows that there is a negative and significant correlation between social and
408 human assets to the period of recovery from erratic rainfall for female headed
409 households. A unit increase in social assets will decrease recovery by about 3 months (p
410 < 0.01). Similarly, a unit increase in human assets will decrease the period to recovery
411 from the impacts of erratic rainfall ($p < 0.05$) by 3.1 months. It was agreed during female

412 FGDs that women primarily depend on casual labour in other people farms to earn
413 income and buy food during lean period. In case of humanitarian assistance from
414 policy actors, female respondents during both one-on-one interviews and FGDs said
415 sharing of food in critical months is what ensures that all survive together. These
416 responses indicate that household assets are critical for recovery at household level,
417 however, social capital becomes vital for survival in most dire situation if some have
418 benefited from humanitarian assistance.

419 ***3.3.2 Implications of livelihood assets on recovery from floods.***

420 Similarly, the simple linear regression analysis outputs show the contribution of livelihood
421 assets to recovery from floods for male and female headed households (Table 7).

422 **Table 7**. Regression output for the livelihood assets categories against period of
423 recovery from floods disaggregated by gender.

Assets	Male headed households			Female headed households		
categories	Coef.	t	P>t	Coef.	t	P>t
Natural assets	-1.085	-1.07	0.286	-3.645	-1.58	0.118
Social assets	-1.835	-2.65	0.009**	-3.803	-4.03	0.000***
Financial assets	1.258	1.26	0.210	0.562	0.09	0.927
Human assets	-1.599	-1.76	0.080*	-4.108	-2.33	0.022**
Physical assets	1.964	2.05	0.042**	-2.162	-1.17	0.247
Constant	4.393	5.85	0.000***	9.129	6.34	0.000***

Significance levels * significant at 10% ** Significant at 5% ***Significant at 1%

Number of observations= 140	Number of observations= 77
R-squared= 0.108	R-squared= 0.248
F (5, 134) = 3.26	F (5, 71) = 4.70

Prob > F = 0.008 Prob > F = 0.000

Like results in 3.3.1, the regression model results for both male headed and female headed households show that the model is generally consistent suggesting the estimated results are reliable. The model output shows that livelihood assets explain approximately 11% of the variance of dependent variable for male headed household and about 25% for female headed households. In general regression output shows that livelihood asset contributes to recovery from the impacts of floods for both male and female headed households.

Social and human assets depict a significant and negative correlation with the recovery period from floods while physical assets depict a positive and significant relationship for male headed households. The results show that a unit increase in social assets will decrease recovery period by 1.8 months (p<0.00) similarly, a unit increase in human assets will decrease recovery period from the impacts of floods by 1.6months (p<0.1). The results however show that a unit increase in physical assets will increase recovery period by 1.9 months (p<0.05). It was observed that since males under uxorilocality cannot own assets like infrastructure after divorce their dependance on such assets is largely low and consequently their investment in such assets is equally low.

For female headed households, results show that social and human assets have a significant but negative correlation to the period of recovery from the impacts of floods. A unit increase in social assets will reduce recovery period from floods by 3.8 months (p < 0.01) while a unit increase in human assets will decrease recovery period by 4.1 months (p < 0.05). This signifies the importance of human and social assets that play

447 acritical role in recovery because female headed households are excluded from fishing
448 thus, they depend on casual labour or social network to survive through period of
449 extreme food shortages.

450 **4.0 Discussion**

451 **4.1 Impacts of climate change on livelihood activities**

452 In general, the study has showed main impacts of climate change that affect livelihood
453 activities in the study area. It has further showed the comparative distribution of
454 livelihood assets and their contribution towards recovery from the impacts of floods and
455 erratic rainfall for male and female-headed households.

456 **4.2 Contribution of macro and micro factors towards access to livelihood assets and**
457 **resilience**

458 Albeit the paper's focus is on micro level dynamics that influence gender disparities in
459 climate change resilience, we know that macro-level factors equally contribute to the
460 phenomenon. For instance, Aryal et al., (2021) and Yasin et al., (2021) recognized poor
461 governance, ineffective policy formulation and implementation as macro factors that
462 affects climate change resilience across population strata. In Malawi, Lovell (2021)
463 noted that although there have been efforts to address gander inequalities at policy
464 and programming levels, evidence shows uneven outcomes on resilience between
465 male and female-headed households due to gender-irresponsive budgets, policy
466 incoherence and lack of coordination across sectors and scales. These challenges
467 imply unequal support to increase access to livelihood assets for even resilience
468 outcomes between male and female-headed households.

4.3 Role of livelihood assets on climate change resilience

This study focused on micro level analysis to understand role of resource distribution contribute towards recovery from floods and erratic rainfall. This study found that ability and speed to recovery from the impacts of floods and erratic rainfall depend on resource endowment that enable households to pursue alternative livelihood activities. (Asmamaw et al., 2019; Gyawali et al., 2020). Male and female-headed households in Phalombe district access different assets differently owing to institutional, socio-cultural, and economic factors.

4.3.1 The impact of human assets on resilience

Human assets play a vital role in sustaining livelihoods especially in rural communities of developing countries (Pour et al., 2018). The results revealed that male-headed households have relatively higher human assets compared to female-headed households. This finding concurred with studies from South Africa and Ghana that found that male-headed households had more human assets than female-headed households (Flatø et al., 2017; Kpoor, 2019). The human asset index is comprised of the education level of the household head, incidents of sickness during the rainfed crop production period and available household labor. The study found that male heads were relatively more educated than female heads. This finding concurs with Graetz et al., (2018) who also found that male-headed households exhibit higher education compared to female headed households in most Africa countries. The study found that female-headed households reported higher proportions of sick people during rain-fed production season. It was reported during Female FGD that most common diseases during rainy season are diarrhea, cholera, and malaria. This finding concurred with the

492 government report which indicated that the study area is often plagued with water
493 and vector borne diseases such as cholera, malaria, and bilharzia during rainy
494 season(GoM/DSoER, 2012). Respondents attributed higher frequency of sickness in
495 female-headed households' poor sanitation and low participation of female heads in
496 household chores as they are committed to crop management activities in their fields.
497 In terms of sickness during rain-fed production season, Furthermore NSO (2020a) also
498 reported a higher proportion of individuals (10.8%) who suffered chronic illnesses in
499 female-headed households compared to 7.9% in male-headed households. Our results
500 agreed with Flatø et al., (2017) who found that male-headed households had more
501 labor than female-headed households. This also concurred with analysis by NSO
502 (2020a) that showed that showed that on average male-headed households have 4.6
503 people in the household compared to 3.9 for female-headed households.

504 Our findings show that human assets were vital to recovery from the impacts of erratic
505 rainfall for female headed but not for male-headed households. Despite having lower
506 human assets compared to male-headed households, the study found higher reliance
507 on the meagre household assets because female-headed households highly depend
508 on narrow livelihood options, mostly casual labor thus slight changes in labor causes
509 significant impact on recovery period from erratic rainfall. Kakota et al., (2011) in
510 Malawi found that female-headed households pursued limited livelihood activities
511 because of other responsibilities such as childcare. Considering that male-headed
512 households had more educated and healthier labor, fewer members could earn more
513 income from a range of activities including fishing, which could not be possible for
514 female-headed households where most of the labor relied on narrow livelihood base
515 especially casual labor to earn income.

However, human assets were vital for recovering from floods for both male and female-headed households. This was because floods caused a wide range of damage from washing away crops to destruction of houses as such higher labor endowment hastened recovery for both type of households as more people implied division of labor to attend to both infrastructural restoration and fending for the household. Our findings agreed with Uy et al., (2011) in Philippines who found that human assets significantly contribute towards climate change resilience.

4.3.2 The impact of social assets on resilience

Social assets form a basic network for rural households to draw various resources and recover from a shock (Endris et al., 2018). In our study there was no statistically significant difference in social assets between male and female headed households. Nguyen et al., (2018) found that rural households rely on complex social networks largely comprised of family and friends who mobilize support to enable a household to recover from a range of shocks. However, Pour et al., (2018) found weak social assets endowment amongst natural resources dependent communities. According to Cerrato & Cifre (2018), males easily connect with a wider community because of their ease of mobility unlike adult females who often strongly connect with smaller networks within the community. Dependence on such networks is contingent on complex socio-cultural factors that can either impede or enhance resilience.

Social networks are main sources of support in rural communities in times of shocks (Smith et al., 2012; Ntontis et al., 2020). According to Uy et al., (2011) strengthening social networks helps households to diffuse the impacts of climate induced shocks. However, MacGillivray (2018) reported there is a non-monotonic relationship between

social capital and disaster resilience. In this study, it was found that both types of the households sought income and food from friend and family to recover from the impacts of dry spells and floods. Our findings suggested that social networks were key assets that locals depend on to recover from the impacts of climate change. Incidents of sharing food between community members during times of crisis have also been previously reported (Kita, 2019; Margolies, 2019). Sustainability of interventions aimed at strengthening rural capacity to recover from the impacts of climate change may require understanding and strengthening of social capital for both male and female-headed households.

4.3.3 The impact of natural assets on resilience

The results of this study revealed that male-headed households had significantly higher natural assets compared to female-headed households. The index comprised of ownership of agricultural land, distance between a plot and water source at the wetland and involvement in fishing. Berge et al., (2014) found that women have higher ownership of land in Phalombe because of uxorilocal post marital arrangement. However, increased incidents of sale of customary land as reported by Kambewa (2005) and Chiwaula et al., (2012) has steadily increased land ownership by males in male headed households. Key Informants in this study further indicated that local leaders offer land under quasi-contractual arrangements which enable both males and females to access land if they can afford it. Proximity to water sources at the wetlands was random as such no specific type of the household had an advantage over the other. However, this enables a household to irrigate crops using low-cost technologies or residual moisture. This study found that fishing is for males and thus female-headed

562 households without a male adult do not rely on fishing as a livelihood activity. Male
563 dominance in fishing was also reported by Chiwaula (2012).

564 Natural assets are a significant source of livelihood resilience for rural households in
565 developing countries (Uy, 2011; Fischer, 2018 Quandt, 2019). Our results in this study
566 revealed that natural assets contribute significantly to recovery from the impacts of
567 erratic rainfall for male-headed households, unlike for female-headed households.
568 Apart from proximity to water sources and ownership of land, males have
569 disproportional advantage in fishing that enables them to earn income unlike females
570 from female-headed households. Shortage of food and income are often experienced
571 during fishing season thus males from male-headed households switch to fishing as the
572 main livelihood activity unlike female-headed households who cannot benefit from fish
573 resources. This is possibly the main distinguishing factor that enhance the speedy
574 recovery by male-headed households compared to female-headed households.
575 Interventions to increase the usefulness of natural assets for female-headed households
576 may require investment in irrigation and land productivity interventions to maximize their
577 gains from farming since traditionally they cannot engage in fishing. Alternatively,
578 deliberate interventions can be implemented to increase participation of women in the
579 fish value chain as off takers or processors in order to benefit from the fish resources.

580 *4.3.4 The impact of physical assets on resilience*

581 Physical assets comprise household possessions that are owned as valuables. Physical
582 assets play a vital role in abating the impact of shocks (Hedner et al., 2011). The
583 physical assets index constituted a summation of the value of owned household
584 property; value of livestock owned, and the number of habitable houses owned by the

household. This study revealed that male and female-headed households have comparable physical assets. This contradicted findings by Gaddis et al., (2018) who reported that male-headed households are known to own relatively more household assets than female-headed households. However, prevalent uxorilocal post marital arrangements in the study area might have caused female-headed households to equally retain comparable amount household assets in instants of divorce, separation or even death.

This study found that physical assets significantly contribute to a longer period to recovery from floods by male-headed households. It was noted that husbands under uxorilocal arrangement were less committed to asset accumulation and long-term investments at the household level. A study in Nigerian matrilocal society reported that males were less committed to their families and the village in general because of low sense of security on their investments (Ene-Obong et al., 2017). The same was echoed during a Key Informant Interview in this study where the chief cited the low commitment of men to their families and to village development activities. Physical assets are therefore not critical in enabling male-headed households to hasten recovery from floods and erratic rainfall; however, walling materials are vital in enabling households to withstand the impacts of floods.

4.3.5 The impact of financial assets on resilience

Financial assets are a readily source of capability to offset losses that are experienced due to various shocks (Jezeer et al., 2019). The results from this study showed that male headed households have a significantly higher financial base than female headed households. This finding concurred with Kpoor, (2019) who found that male-headed

608 households have relatively higher financial assets than female headed households.
609 Similarly, the results echoed Idris, (2018) who also noted that males easily source
610 financial assets because of their ability to pursue a wide range and lucrative livelihood
611 activities unlike their female counterparts who are largely burdened with reproductive
612 and household chores.

613 Regardless of male-headed households having more financial assets, the results of this
614 study showed that financial assets increased the period of recovery or retards recovery
615 from the impacts of erratic rainfall for male-headed households. A study in Southeast
616 Nigeria found that expenditure and savings patterns for male heads were often focuses
617 on immediate consumption needs while the rest of the earnings were spent outside
618 their homes (Opata et al., 2020). Barners et al., (2020) also reported no relationship
619 between financial assets and resilience. However, Sujakhu et al., (2019) reported that
620 financial assets increase resilience to the impacts of climate change. Disparities in the
621 importance of the assets towards resilience might be due to specific socio-economic
622 context in which the financial assets are used.

623 **Conclusion**

624 The study investigated impacts of climate change on various livelihood activities and
625 the contribution of livelihood assets towards recovery from erratic rainfall and floods.
626 The study has showed that male and female-headed households have varying access
627 to the livelihood assets, which contribute differently towards main livelihood activities.

628 The findings have demonstrated that gender influence access to and the utilization of
629 various assets to recover from the impacts of climate change. Male-headed
630 households have better access to human, financial and natural assets that add

advantage for them to abate the impacts of erratic rainfall and floods. These differences are due to both macro factors such as gender insensitive resource allocation for resilience interventions and micro factors such as cultural traditions and norms that exacerbate differences in access to livelihood assets and resilience outcomes between male and female headed households. Considering that farming is the principal livelihood activity, female-headed households need interventions to increase productivity of human and natural assets to increase their resilience. In practice, there is a need to increase access to education for women and girls as well as access to health services to strengthen their human assets base. Cognizant that females headed households are less connected to wider financial networks, deliberate interventions can also be directed towards improving women's access to financial resources such as loans. The major difference in natural assets for male and female-headed households might have emerged from the social exclusion of women from fishing. Interventions should therefore be designed to increase women participation in the fish value chain so that they can start to significantly benefits from fisheries resources. Women can be empowered with various fish processing and preservation skills to add value and sale in high value urban markets.

At macro level, studies show that different climate change resilience outcomes between male and female headed households are rooted in unequal resource allocation towards climate change resilience interventions. It can therefore be recommended that deliberate budgetary allocation for policy and programme implementation can promote equity between male and female headed households in terms of access to vital livelihood assets to build climate change resilience.

654 This paper has shown that social assets are key to recovery from the impacts of erratic
655 rainfall and floods for both male and female-headed households. Interventions to
656 enhance social cohesion should incorporate education through skills development in
657 enterprise management to diversifying livelihood sources. A similar study should be
658 done to explore how matrilineal and patrilineal traditions contribute to access and
659 ownership of livelihood assets. This would generate evidence around the role of the two
660 traditional systems in climate change resilience for male and female-headed
661 households.

662 *"This work was funded through the 'Building REsearch Capacity for sustainable water*
663 *and food security in drylands of sub-Saharan Africa' (BRECcIA) which is supported by*
664 *UK Research and Innovation as part of the Global Challenges Research Fund, grant*
665 *number NE/P021093/1."*

666 **Reference**

667 Ampaire, E. L., Acosta, M., Huyer, S., Kigonya, R., Muchunguzi, P., Muna, R., & Jassogne,
668 L. (2019). *Gender in climate change, agriculture, and natural resource policies: insights*
669 *from East Africa. Climatic Change.* doi:10.1007/s10584-019-02447-0

670 Andrijevic, M., Crespo Cuaresma, J., Lissner, T., Thomas, A., & Schleussner, C.-F.
671 (2020). *Overcoming gender inequality for climate resilient development. Nature*
672 *Communications, 11(1).* doi:10.1038/s41467-020-19856-w

673 Ankrah, D. A., Freeman, C. Y., & Afful, A. (2020). Gendered access to productive
674 resources – evidence from small holder farmers in Awutu Senya West District of Ghana.
675 *Scientific African, 10, e00604.* doi:10.1016/j.sciaf.2020.e00604

676 Aryal, J. P., Sapkota, T. B., Rahut, D. B., Marenya, P., & Stirling, C. M. (2021). Climate risks
677 and adaptation strategies of farmers in East Africa and South Asia. *Scientific*
678 *reports*, *11*(1), 10489.

679 Aryal, J. P., Sapkota, T. B., Rahut, D. B., Krupnik, T. J., Shahrin, S., Jat, M. L., & Stirling, C. M.
680 (2020). *Major Climate risks and Adaptation Strategies of Smallholder Farmers in Coastal*
681 *Bangladesh. Environmental Management.* doi:10.1007/s00267-020-01291-8

682 Asmamaw, M., Mereta, S. T., & Ambelu, A. (2019). Exploring households' resilience to
683 climate change-induced shocks using Climate Resilience Index in Dinki watershed,
684 central highlands of Ethiopia. *PloS one*, *14*(7), e0219393.

685 Barnes, M. L., Wang, P., Cinner, J. E., Graham, N. A. J., Guerrero, A. M., Jasny, L., …
686 Zamborain-Mason, J. (2020). *Social determinants of adaptive and transformative*
687 *responses to climate change. Nature Climate Change.* doi:10.1038/s41558-020-0871-4
688 Berge, E., Kambewa, D., Munthali, A., & Wiig, H. (2014). Lineage and land reforms in
689 Malawi: Do matrilineal and patrilineal landholding systems represent a problem for land
690 reforms in Malawi? *Land Use Policy*, *41*, 61-69.
691 Braun, V., & Clarke, V. (2012). Thematic analysis.
692 Brown, P. R., Afroz, S., Chialue, L., Chiranjeevi, T., El, S., Grünbühel, C. M., ... & Williams, L.
693 J. (2019). Constraints to the capacity of smallholder farming households to adapt to
694 climate change in South and Southeast Asia. *Climate and Development*, *11*(5), 383-400.

695 Campbell, B., Sayer, J. A., Frost, P., Vermeulen, S., Ruiz Perez, M., Cunningham, A., et al.
696 (2001). Assessing the performance of natural resource systems. Conservation Ecology,
697 5(2), 22. Retrieved from: http://www.consecol.org/vol5/iss2/art22.

698 Cerrato, J., & Cifre, E. (2018). Gender inequality in household chores and work-family
699 conflict. *Frontiers in psychology*, 9, 1330.
700 Chuwaula, L.S., Jamu, D., Chiweza, R. & Nagoli, J (2012). The structure and margins of
701 the Lake Chilwa fisheries in Malawi; a value chain analysis. *The world Fish Centre,*
702 *Penang, Malaysia. Project Report 2012 – 12. 34pp*.

703 Cole, S. K., Mullor, E. C., Ma, Y., & Sandang, Y. (2020). "Tourism, water, and gender"—An
704 international review of an unexplored nexus. *Wiley Interdisciplinary Reviews: Water*, *7*(4),
705 e1442. https://doi.org/10.1002/wat2.1442

706 De Silva, M. M. G. T., & Kawasaki, A. (2018). Socioeconomic vulnerability to disaster risk:
707 a case study of flood and drought impact in a rural Sri Lankan community. *Ecological*
708 *Economics*, *152*, 131-140.

709 Ellis, F., (2000). Rural Livelihoods and Diversification in Developing Countries. *Oxford*
710 *University Press*, Oxford.
711 Endris, G. S., Kibwika, P., Obaa, B. B., & Hassan, J. Y. (2018). Does the implementation of
712 social safety net intervention affect indigenous social capital systems for coping with
713 livelihood shocks? Ethnographic evidence of agro-pastoral communities in eastern
714 Ethiopia. In *Financing sustainable development in Africa* (pp. 269-316). Palgrave
715 Macmillan, Cham.
716 Ene-Obong, H.N., Onuoha, N.O., &Eme. P.E. (2017) Gender roles, family relationships
717 and household food and nutrition security in Ohafia matrilineal society in Nigeria.
718 *Maternal & child nutrition, 13, e12506*

719 Erenstein, O., Hellin, J., & Chandna, P. (2010). Poverty mapping based on livelihood
720 assets: Ameso-level application in the Indo-Gangetic Plains, India. Applied Geography,
721 30, 112–125. https://doi.org/10.1016/j.apgeog.2009.05.001.

722 Fang, Y.-P., Fan, J., Shen, M.-Y., Song, M.-Q., (2014). Sensitivity of livelihood strategy to
723 livelihood capital in mountain areas: empirical analysis based on different settlements in
724 the upper reaches of the Minjiang River, China. *Ecol. Ind. 38, 225–235.*

725 Fischer, A. P. (2018). Pathways of adaptation to external stressors in coastal natural-
726 resource-dependent communities: Implications for climate change. *World*
727 *Development*, *108*, 235-248.

728 Flatø, M., Muttarak, R., & Pelser, A. (2017). Women, weather, and woes: The triangular
729 dynamics of female-headed households, economic vulnerability, and climate
730 variability in South Africa. *World Development*, *90*, 41-62.

731 Gaddis, I., Lahoti, R. S., & Li, W. (2018). Gender gaps in property ownership in Sub-
732 Saharan Africa. *World Bank Policy Research Working Paper*, (8573).

733 Government of Malawi, (2012) Phalombe District State of Environment and Outlook
734 Report 2012 – 2015.

735 Government of Malawi (2018) National Resilience Strategy (2018 – 2030) Breaking the
736 Cycle of Food Insecurity in Malawi. Department of Disaster Management affairs. P.O
737 Box 30136 Lilongwe, Malawi.

738 Graetz, N., Friedman, J., Osgood-Zimmerman, A., Burstein, R., Biehl, M. H., Shields, C., ...
739 & Hay, S. I. (2018). Mapping local variation in educational attainment across Africa.
740 *Nature*, *555*(7694), 48-53.

741 Giuliano, P. (2017). *Gender: An Historical Perspective*. doi:10.3386/w23635

742 Gyawali, S., Tiwari, S. R., Bajracharya, S. B., & Skotte, H. N. (2020). Promoting sustainable
743 livelihoods: An approach to postdisaster reconstruction. *Sustainable*
744 *Development*, *28*(4), 626-633.

745 Hedner, T., Abouzeedan, A., & Klofsten, M. (2011). Entrepreneurial resilience.

746 Idris, I. (2018) Barriers to Women's Economic Inclusion in Tanzania, K4D Helpdesk Report.
747 Brighton, UK: Institute of Development Studies.

748 Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential
749 explanatory design: From theory to practice. *Field methods*, *18*(1), 3-20.

750 Jauffret-Roustide, M., & Cailbault, I. (2018). Drug consumption rooms: comparing times,
751 spaces, and actors in issues of social acceptability in French public debate.
752 *International Journal of Drug Policy*, *56*, 208-217.

753 Jezeer, R. E., Verweij, P. A., Boot, R. G., Junginger, M., & Santos, M. J. (2019). Influence of
754 livelihood assets, experienced shocks and perceived risks on smallholder coffee farming
755 practices in Peru. *Journal of environmental management*, *242*, 496-506.

756 Kambewa, D. (2005) Access and monopoly over wetlands in Malawi. International
757 workshop on *African Water Laws: Plural Legislative Frameworks for Rural Water*
758 *Management in Africa*, 26 -28 January 2005, Johannesburg, South Africa.

759 Kakota, T., Nyariki, D., Mkwambisi, D., & Kogi-Makau, W. (2011). Gender vulnerability to
760 climate variability and household food insecurity. *Climate and development*, *3*(4), 298-
761 309.

762 Kishindo, P. (2010). Emerging Reality in Customary Land Tenure: The Case of Kachenga
763 Village in Balaka District, Southern Malawi. *African Sociological Review/Revue Africaine*
764 *de Sociologie*, *14*(1), 102-111.

765 Kita, S. M. (2019). Barriers or enablers? Chiefs, elite capture, disasters, and resettlement
766 in rural Malawi. *Disasters*, *43*(1), 135-156.

767 Kpoor, A. (2019). Assets and Livelihoods of Male-and Female-Headed Households in
768 Ghana. *Journal of Family Issues*, *40*(18), 2974-2996.

769 Lovell, E. (2021). Gender equality, social inclusion, and resilience in Malawi.

770 MacGillivray, B. H. (2018). Beyond social capital: The norms, belief systems, and agency
771 embedded in social networks shape resilience to climatic and geophysical hazards.
772 *Environmental science & policy*, *89*, 116-125.

773 Manandhar, M., Hawkes, S., Buse, K., Nosrati, E., & Magar, V. (2018). *Gender, health and*
774 *the 2030 agenda for sustainable development. Bulletin of the World Health*
775 *Organization, 96(9), 644–653.* doi:10.2471/blt.18.211607

776 Mango, N., Makate, C., Mapemba, L., & Sopo, M. (2018). The role of crop diversification
777 in improving household food security in central Malawi. *Agriculture & Food Security*,
778 *7*(1), 1-10.

779 Margolies, A. E. (2019). *Seeding Change? Improving and Understanding Household*
780 *Food Security in a Nutrition-Sensitive Agriculture Program in Malawi: A Mixed-Methods*
781 *Study* (Doctoral dissertation, Johns Hopkins University).

782 Mussa, R. (2017). Poverty in Malawi: Policy Analysis with Distributional Changes.

783 Nangoma, D., & Nangoma, E. (2010) Climate change and adaptation strategies: a
784 case study of the Mulanje Mountain Forest Reserve and its surroundings Malawi.
785 Nasrnia, F., & Ashktorab, N. (2021). Sustainable livelihood framework-based assessment
786 of drought resilience patterns of rural households of Bakhtegan basin, Iran. *Ecological*
787 *Indicators, 128, 107817*. doi:10.1016/j.ecolind.2021.107817
788 National Statistical Office (NSO) (2020). Malawi Poverty Report. *National Statistics Office*.
789 Zomba, Malawi.
790 National Statistical Office (NSO) [Malawi] and ICF. (2017). Malawi Demographic and
791 Health Survey 2015-16. *National Statistics Office*. Zomba, Malawi, and Rockville,
792 Maryland, USA. NSO and ICF.
793 Nash, K., O'Malley, G., Geoffroy, E., Schell, E., Bvumbwe, A., & Denno, D. M.
794 (2019). "Our girls need to see a path to the future"--perspectives on sexual and
795 reproductive health information among adolescent girls, guardians, and
796 initiation counselors in Mulanje district, Malawi. *Reproductive health*, *16*(1), 1-13.
797 National Statistical Office (NSO) [Malawi] (2018) The 2018 Malawi Population and
798 Housing Census report. *The Malawi National Statistical Office*. Zomba, Malawi.
799 www.nsomalawi.mw
800 National Statistical Office (NSO) [Malawi] (2020a). The fifth Integrated Household Survey
801 (HIS5) 2020 report (2020). *The Malawi National Statistical Office*. Zomba, Malawi.
802 www.nsomalawi.mw
803 Nelson. V, Meadows.K, Cannon. T, Morton.J, and Martin. A, (2002) Uncertain
804 predictions, invisible impacts, and the need to mainstream gender in climate change
805 adaptations. *Gender and Development* Vol. 10, No.2

Ng'ong'ola, C. (1986). Malawi's agricultural economy and the evolution of legislation on the production and marketing of peasant economic crops. *Journal of Southern African Studies*, *12*(2), 240-262.

Nguyen, C. H., & Nordman, C. J. (2018). Household entrepreneurship and social networks: Panel data evidence from Vietnam. *The Journal of Development Studies*, *54*(4), 594-618.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2020). What lies beyond social capital? The role of social psychology in building community resilience to climate change. *Traumatology*, *26*(3), 253.

Opata, P. I., Ezeibe, A. B., & Ume, C. O. (2020). Impact of women's share of income on household expenditure in southeast Nigeria. *African Journal of Agricultural and Resource Economics*, *15*(311-2020-1780), 51-64.

Pandey, R., & Jha, S. (2012). Climate vulnerability index-measure of climate change vulnerability to communities: a case of rural Lower Himalaya, India. *Mitigation and Adaptation Strategies for Global Change*, *17*(5), 487-506.

Panman, A., Madison, I., Kimacha, N. N., & Falisse, J. B. (2021). Saving Up for a Rainy Day? Savings Groups and Resilience to Flooding in Dar es Salaam, Tanzania. In *Urban Forum* (pp. 1-21). Springer Netherlands.

Papadopoulos, A. G., Fratsea, L. M., Karanikolas, P., & Zografakis, S. (2019). Reassembling the rural: socio-economic dynamics, inequalities, and resilience in crisis-stricken rural Greece. *Sociologia Ruralis*, *59*(3), 474-493.

827 Paudel Khatiwada, S., Deng, W., Paudel, B., Khatiwada, J., Zhang, J., & Wan, J. (2018). *A*
828 *Gender Analysis of Changing Livelihood Activities in the Rural Areas of Central Nepal.*
829 *Sustainability, 10(11), 4034*. doi:10.3390/su10114034

830 Pour, M. D., Barati, A. A., Azadi, H., & Scheffran, J. (2018). Revealing the role of livelihood
831 assets in livelihood strategies: Towards enhancing conservation and livelihood
832 development in the Hara Biosphere Reserve, Iran. *Ecological Indicators*, *94*, 336-347.

833 Quandt, A., Neufeldt, H., & McCabe, J. T. (2019). Building livelihood resilience: what role
834 does agroforestry play? *Climate and Development*, *11*(6), 485-500.

835 Rahut, D. B., Aryal, J. P., & Marenya, P. (2021). Ex-ante adaptation strategies for climate
836 challenges in sub-Saharan Africa: Macro and micro perspectives. *Environmental*
837 *Challenges, 3, 100035.* doi:10.1016/j.envc.2021.100035

838 Tanner, T., Lewis, D., Wrathall, D., Bronen, R., Cradock-Henry, N., Huq, S., ... & Thomalla, F.
839 (2015). Livelihood resilience in the face of climate change. *Nature Climate Change*,
840 *5*(1), 23-26.

841 Tejada, J. J., & Punzalan, J. R. B. (2012). On the misuse of Slovin's formula. *The Philippine*
842 *Statistician*, *61*(1), 129-136.

843 Thomas, K. A. (2020). The problem with solutions: Development failures in
844 Bangladesh and the interests they obscure. *Annals of the American Association*
845 *of Geographers*, *110*(5), 1631-1651.

846 Schipper, E.L.F., A. Revi, B.L. Preston, E.R. Carr, S.H. Eriksen, L.R. Fernandez-Carril,
847 B.C. Glavovic, N.J.M. Hilmi, D. Ley, R. Mukerji, M.S. Muylaert de Araujo, R. Perez,

S.K. Rose, and P.K. Singh, (2022). Climate Resilient Development Pathways. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. *Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2655–2807*, doi:10.1017/9781009325844.027.

Smith, J. W., Anderson, D. H., & Moore, R. L. (2012). Social capital, place meanings, and perceived resilience to climate change. *Rural Sociology*, *77*(3), 380-407.

Soltani, A., Angelsen, A., Eid, T., (2014). Poverty, forest dependence and forest degradation links: evidence from Zagros, Iran. *Environ. Dev. Econ. 19, 607–630.*

Sujakhu, Ranjitkar, He, Schmidt-Vogt, Su, & Xu. (2019). *Assessing the Livelihood Vulnerability of Rural Indigenous Households to Climate Changes in Central Nepal, Himalaya. Sustainability, 11(10), 2977.* doi:10.3390/su11102977

Svesve (2016) Malawi Vulnerability Assessment Committee Livelihood Baselines National Overview Report. FEWS NET Washington. www.fews.net

United Nations Development Program (UNDP) (1994). Human Development Report 1994 Retrieved from: New York, USA: *United Nationals Development Programme*. http://hdr.undp.org/en/content/human-development-report-1994.

UN Women (2019). The gender and age dimensions of floods and drought in Malawi. *UN Resident Coordinator's Office.* Area 40, Plot 7 P.O. Box 30135 Lilongwe 3 Malawi.

Uy, N., Takeuchi, Y., & Shaw, R. (2011). Local adaptation for livelihood resilience in Albay, Philippines. *Environmental Hazards*, *10*(2), 139-153.

Wanjala, B.M. (2021). Women, Poverty, and Empowerment in Africa. In: Yacob-Haliso, O., Falola, T. (eds) The Palgrave Handbook of African Women's Studies. *Palgrave Macmillan, Cham*. https://doi.org/10.1007/978-3-030-28099-4_106

Yasin, H. Q., Breadsell, J., & Tahir, M. N. (2021). Climate-water governance: a systematic analysis of the water sector resilience and adaptation to combat climate change in Pakistan. *Water Policy*, *23*(1), 1-35.

Appendix 1. Key socio-economic and demographic characteristics disaggregated by gender.

Categories	Quantitative variables	National level	Source

		Male headed households	Female headed household	
Physical	Ownership of assets (Poverty)	18.60%	25.30%	Poverty Report 2020
	Ownership of a house	53% (43%)	59% (35%)	MDHS 2015-16
	Value of owned livestock	45.60%	38.30%	Fifth IHS Report
Human	Education of household head	6.6 Years	5.6 Years	MHDS 2015-16
	Household size	4.6	3.9	Fifth IHS Report
	Incidents of sickness	25	28.6	Fifth IHS Report
Social	Help from relations	9.90%	17%	Fifth IHS Report
Financial	Access to loans	18.40%	16%	Fifth IHS Report
	Employment	83.30%	79.60%	PHC
	Savings	6.80%	3.70%	Fifth IHS Report
Natural	Size of owned arable land	1.5 Acres	0.9 Acres	Fifth IHS Report
	Land ownership (Individual)	51% (42%)	58% (37%)	MDHS 2015-16
	Farming during dry season	20.20%	14.30%	Fifth IHS Report
	Involvement in fishing	No data	No data	-

888 PHC [Population and Housing Census] MDHS [Malawi Demographic and Health Survey]

889 IHS [Integrated Household Survey]

890 **Notes**: Results of the fifth Integrated Household survey showed that main source of loans

891 in Phalombe was village bank (39.3) followed by informal moneylender 35.6% and

892 thirdly relatives and friends 10.1%.

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899 **Appendix 2. Example of how livelihood indices were computed.**

PHYSICAL ASSETS				HUMAN ASSETS				SOCIAL ASSETS			FINANCIAL ASSETS					NATURAL ASSETS				
Asset_Index	Livstck_Index	Housings_Index	COMPOSITE PHYSICAL	Edu_Head_Index	Sickness	HH_Labour_Index	COMPOSITE HUMAN	Sup_Index	Group_Index	COMPOSITE SOCIAL	Savings_Index	Reg_Inco_Index	Savings_Gp	No_Katapila_Index	COMPOSITE FINANCIAL	Wetland_plot_Owned	Distance_Index	Upland_Ownership	Fishing	COMPOSITE NATURAL
0.038	0.004	0.000	0.014	0.214	0.000	0.333	0.183	0.000	1.000	0.500	0.000	0.184	0.000	0.000	0.046	1.000	0.280	1.000	0.000	0.570
0.010	0.002	0.000	0.004	0.143	1.000	0.333	0.492	0.000	1.000	0.500	0.000	0.107	0.000	1.000	0.277	1.000	0.554	1.000	0.000	0.638
0.040	0.014	0.500	0.185	0.071	1.000	0.333	0.468	0.000	1.000	0.500	0.000	0.209	0.000	0.000	0.052	1.000	0.330	1.000	0.000	0.583
0.037	0.014	0.500	0.184	0.143	1.000	0.167	0.437	0.000	1.000	0.500	0.000	0.184	1.000	0.000	0.296	1.000	0.040	1.000	0.000	0.510
0.000	0.006	0.000	0.002	0.286	1.000	0.167	0.484	0.000	0.000	0.000	0.089	0.286	1.000	0.000	0.344	1.000	0.107	1.000	1.000	0.777
0.030	0.000	0.500	0.177	0.214	0.000	0.333	0.183	0.222	1.000	0.611	0.000	1.000	0.000	0.000	0.250	1.000	0.498	1.000	0.000	0.624
0.007	0.177	0.500	0.228	0.071	1.000	0.833	0.635	0.000	1.000	0.500	0.000	0.745	0.000	0.000	0.186	1.000	0.330	1.000	1.000	0.833
0.056	0.016	0.000	0.024	0.000	1.000	0.167	0.389	0.000	0.000	0.000	0.000	0.082	0.000	0.000	0.020	1.000	0.063	1.000	0.000	0.516
0.160	0.892	0.000	0.351	0.429	0.000	0.500	0.310	0.000	1.000	0.500	0.000	0.184	0.000	1.000	0.296	0.000	0.029	1.000	1.000	0.507
0.210	0.032	0.500	0.247	0.571	0.000	0.333	0.302	0.111	1.000	0.556	0.000	0.490	1.000	0.000	0.372	1.000	0.275	1.000	0.000	0.569
0.034	0.000	0.000	0.011	1.000	0.000	0.333	0.444	0.222	1.000	0.611	0.000	0.362	1.000	1.000	0.591	1.000	0.051	1.000	0.000	0.513
0.045	0.010	0.500	0.185	0.000	1.000	0.333	0.444	0.000	1.000	0.500	0.222	0.235	0.000	1.000	0.364	1.000	0.516	1.000	1.000	0.879
0.100	0.000	0.000	0.033	0.429	0.000	0.333	0.254	0.056	1.000	0.528	0.000	0.056	0.000	0.000	0.014	1.000	0.126	1.000	0.000	0.531
0.006	0.015	0.000	0.007	0.071	0.000	0.333	0.135	0.000	1.000	0.500	0.000	0.082	0.000	0.000	0.020	1.000	0.007	1.000	0.000	0.502
0.024	0.000	0.000	0.008	0.571	0.000	0.333	0.302	0.000	1.000	0.500	0.000	0.031	0.000	0.000	0.008	1.000	0.163	1.000	0.000	0.541
0.046	0.870	0.000	0.305	0.000	0.000	0.333	0.111	0.222	0.000	0.111	0.000	0.082	1.000	0.000	0.270	1.000	0.107	1.000	0.000	0.527
0.013	0.001	0.000	0.005	0.357	0.000	0.167	0.175	0.000	1.000	0.500	0.278	0.082	0.000	1.000	0.340	1.000	0.000	1.000	1.000	0.750
0.014	0.000	0.000	0.005	0.571	0.000	0.333	0.302	0.000	1.000	0.500	0.000	0.071	0.000	0.000	0.018	0.000	0.107	1.000	0.000	0.277
0.008	0.000	0.000	0.003	0.429	0.000	0.500	0.310	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.008	1.000	0.107	1.000	0.000	0.527
0.012	0.000	0.000	0.004	0.214	1.000	0.167	0.460	0.000	1.000	0.500	0.000	0.133	0.000	0.000	0.033	1.000	0.219	1.000	1.000	0.805
0.014	0.001	0.000	0.005	0.000	0.000	0.333	0.111	0.167	1.000	0.583	0.000	0.056	0.000	0.000	0.014	1.000	0.330	1.000	0.000	0.583
0.432	0.002	0.000	0.144	0.429	0.000	0.333	0.254	0.056	1.000	0.528	0.278	0.082	0.000	0.000	0.090	0.000	0.107	1.000	1.000	0.527
0.289	0.001	0.000	0.097	0.357	1.000	0.333	0.563	0.000	1.000	0.500	0.000	0.031	0.000	1.000	0.258	1.000	0.000	1.000	0.000	0.500
0.020	0.000	0.000	0.007	0.857	0.000	0.167	0.341	0.000	1.000	0.500	0.167	0.133	0.000	0.000	0.075	1.000	0.107	1.000	0.000	0.527
0.009	0.016	0.000	0.008	0.000	0.000	0.333	0.111	0.000	1.000	0.500	0.000	0.031	1.000	0.000	0.258	1.000	0.063	1.000	1.000	0.766

Notes: (a) Equation 1 on page 11 was used to standardise individual variables (between 0 and 1) under each category.

(b) Composite index (Physical, Human, Social, Financial and Natural) were calculated as an average (Quandt, 2018).

(c) Estimation of the contribution of the assets (PHSFN) to recovery were calculated using equation 3 on page 12.

- Social assets are key to resilience for both types of households

- Natural and human assets enable recovery from erratic rainfall for male and female headed households
- Human assets enable recovery from floods for both households
- Enhancing key assets for female headed households can improve their climate change resilience

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: