Awareness, knowledge and Perception of forest dependent communities on Climate Change in Malawi: A case of Mchinji and Phirilongwe Forest Reserves in Malawi

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Abstract

Projected climate change presents many challenges and opportunities for individuals, households and wider society on how to adapt. Local knowledge is key to help smallholder farmers to cope with climate change and variability to attain sustainable forest management. However, there is limited understanding of what shapes human adaptation to climate change in various sectors at local level including forestry in sub-Saharan Africa. Therefore, this study explored the awareness, knowledge and perception of forest-dependent communities on climate change and variability around Phirilongwe and Mchinji forest reserves in Malawi. Empirical data was collected using household surveys (n = 422), key informant interviews (16), and focus group discussions (8). Results suggest that 60 % of respondents in Mchinji were aware of climate change as compared to only 35% in Mangochi. Results record that respondents perceived increased erratic rainfall, high temperatures and strong winds and changes in seasons. The main factors influencing their climate perception includes possession of farming skills (p=0.002), Education (P=0.04), gender (P=0.002) and possession of livestock keeping skills (p=0.02). However, the cube root stratification method indicates that their level of knowledge falls in the low-level category. Although negligible proportion of climate skepticisms was exposed, a strong belief in anthropogenic causes of climate change and willingness to adopt environmental friendly intervention measures were revealed. However, the presence of the believers in the cultural and spiritual causes of climate change in the study area presents a challenge to mobilize them towards implementation of climate intervention measures and forest management. We therefore recommend their participation in the climate adaptation intervention designs and multiple use of various strategies and methods that will help to address their livelihoods at the same time improve their climate information and knowledge.

Key words: *Awareness, Climate change, variability, perceptions, knowledge, forest-dependent community, beliefs*

1. INTRODUCTION

Climate change and variability presents a huge threat for indigenous people whose livelihoods mostly depend on climate-sensitive activities such as agriculture and exploitation of natural resources (FAO, 2020; Chidumayo, et al 2011; IPCC 2019). IPCC (2007) reported that the increase in carbon dioxide concentration in the atmosphere primarily by human activities, is the main attributable cause of climate change and variability. The report further highlights the projected impacts of climate change which includes sea level rise, warmer global temperatures, more intense natural events such as fire, floods, storms, snow, and the melting of ice caps among others (IPCC, 2007). It is further reported that climate change is here to stay and its impact will continue to manifest as long as there are no significant emission reductions (IPCC, 2014). As such, climate change has been tagged as the major threat to the attainment of sustainable development due to its adverse effects on health, infrastructure, agriculture and food security, and forest ecosystems (IPCC, 2018).

Malawi, being located in Sub-Saharan African, is vulnerable to climate change because of its narrow economic base which is dominated by rain-fed agriculture (Singh et al., 2020; GoM, 2019). In the past two decades, Malawi has experienced a variety of climatic hazards, the most serious being dry spells, seasonal droughts, intense rainfall, and flash floods (Singh et al. 2020; GoM, 2018a; Munthali et al. 2016). Fujisawa et al (2020) assert that the increased frequency, intensity and magnitude of climate change and variability over the last two decades, have adversely impacted food and water security, water quality, energy and sustainable livelihoods of rural communities in Malawi. Given that national climate change projections suggest that the impacts of climate change and variability will become ever more severe (Edward et al. 2019; GoM, 2018a; IPCC, 2019), it is therefore critical that Malawi prepares for these changes at all levels. In addition to being exposed to climate change shocks, Malawi rural communities are also faced with socioeconomic challenges which includes high unemployment rates, poverty, and low opportunities for economic development (Singh et al. 2020; GoM, 2019, Stringer et al. 2010).

Ribeiro et al (2020) identified forest- dependent communities and their neighbors to be particularly at the risk of the impacts of climate change and variability due to their strong connection to the forest ecosystems for their livelihood. Previously, Davidson et al (2003) attributed the

vulnerability of forest dependent communities to their geographic locations which totally exposes them to persistent environmental threats. Such threats include forest fires, pest and disease outbreaks, and prolonged droughts which have been aggravated by climate change. This puts a notable proportion of the world's population to be vulnerable to the impacts of climate change. As such, the future sustainability of the forest resources is blurred.

Despite the various challenges posed by climate change and variability to the overall livelihood of the forest communities, Locatelli et al (2008) argues that forest-dependent people have not been adequately represented in most vulnerability studies. This is a challenge that is expected to affect the well-being and the lifestyle of the forest dependent communities globally and thus affecting the sustainability of their adjacent forests. Juana et al (2013) hypothesizes that most communities would decide to adopt any climate adaptation initiatives that address their local perceptions. In support of this proposition, Piya et al. (2012) stressed that the understanding of how rural people perceive climate change is a building block in designing local-scale climate adaptation strategy. Furthermore, it is argued that realizing certain changes that are going on around communities is paramount to inform the communities to take actions in adjusting to respond to those changes (Füssel and Klein 2006; Deressa et al. 2011; Nursey-Bray et al. 2013). In addition, it may be worthy to note that understanding rural people's perception of climate change contribute much needed information to policy and decision makers (Juana et al., 2013; Piya et al., 2012). Arndt et al. (2014) argue that local people have experience and knowledge of local climatic patterns accumulated over years which might not be noticed by scientific research. Additionally, this knowledge and experience is under threat and over time it will be rendered unreliable as global climate evolves (Arndt et al. 2014). As such, it is essential to understand the attitude, knowledge and perception of forest dependent communities towards climate change and variability and utilize this information in policy and decision making.

In the past decade, studies specifically concentrating on the perception of the forest communities on the risks of climate change and its impact on the forest ecosystem and their livelihood has received major attention. Williamson et al. (2005) investigated the perception of researchers and government experts about the risks for forest ecosystems and communities posed by climate change in Canada. In another study, Ofoegbu et al. (2016) assessed the local perception and

attitudes of the forest communities in Vhembe district in South Africa. Recently, Basu (2017) explored the vulnerability of the tribal forest communities around Sonamukhi forest area in India. To this date, there are no published studies assessing the knowledge, attitude and perception of forest communities on climate change in Malawi. This study therefore was designed to begin to address that gap by exploring the awareness, knowledge and perception of forest dependent communities on climate change and variability in Phirilongwe and Mchinji forest reserves in southern and central Malawi. The understanding and conceptualization of the forest dependent communities on climate change may influence their willingness towards adopting certain climate adaptive and mitigative strategies that affect sustainability of their forests. In this study, the theory of planned behavior is operationalized as an analytical approach to help understand the willingness of the respondents to adopt certain environmentally friendly behaviours. The theory of planned behavior is a theory used to predict and understand behaviors. It posits that behaviors are immediately determined by behavioral intentions, which in turn are determined by a combination of three factors: attitude toward the behavior, subjective norms, and perceived behavioral control.

The study examined the forest dependent communities' understanding and perceptions on climate change and variability. To address this study objective, the following research questions were used to guide this research in Mangochi and Mchinji districts of Malawi;

- What is the understanding and knowledge of forest dependent communities on climate change and variability in their locality?
- What is the most attributable cause of climate change and variability in the study area?
- Are the forest dependent households, willingness to adopt new forest utilization and management options in the context of climate change?

2. MATERIALS AND METHODS

2.1 The study site

The study focused on two sites in Malawi (Figure 1): Mchinji district targeting 12 villages in three Traditional Authorities (TAs) surrounding Mchinji forest reserve in the central region and Mangochi district where 20 villages were targeted in three Traditional Authorities (TAs) surrounding Phirilongwe forest reserve in the southern region. Mchinji forest reserve was gazetted

in 1924 with a total forest area of 20,885 ha whereas Phirilongwe forest reserve, situated on the western side of Mangochi district was gazetted in the year 1924 with a total forest area of 16,129 ha (GoM, 2020). Vegetatively, both Mchinji and Phirilongwe forest reserves and the surrounding customary forest are covered with Miombo woodland with Brachystegia as a dominant tree species. The common tree species in these reserves are Brachystegia/Julbernadia species such as *Julbernadia paniculata* (Benth) Troupin, *Julbernadia globiflora* (Benth), *Uapaca kirkiana* (Müll.Arg), *Pericopsis angolensis* (Baker) Meeuwen, and *Pterocarpus angolensis* DC. On the other hand, a major available non-timber forest product being harvested in the Phirilongwe forest reserve is the *Oxytenanthera abys-sinica* (A. Rich) Munro (local bamboo) which commonly grows naturally on the escarpment of the Phirilongwe Mountain.

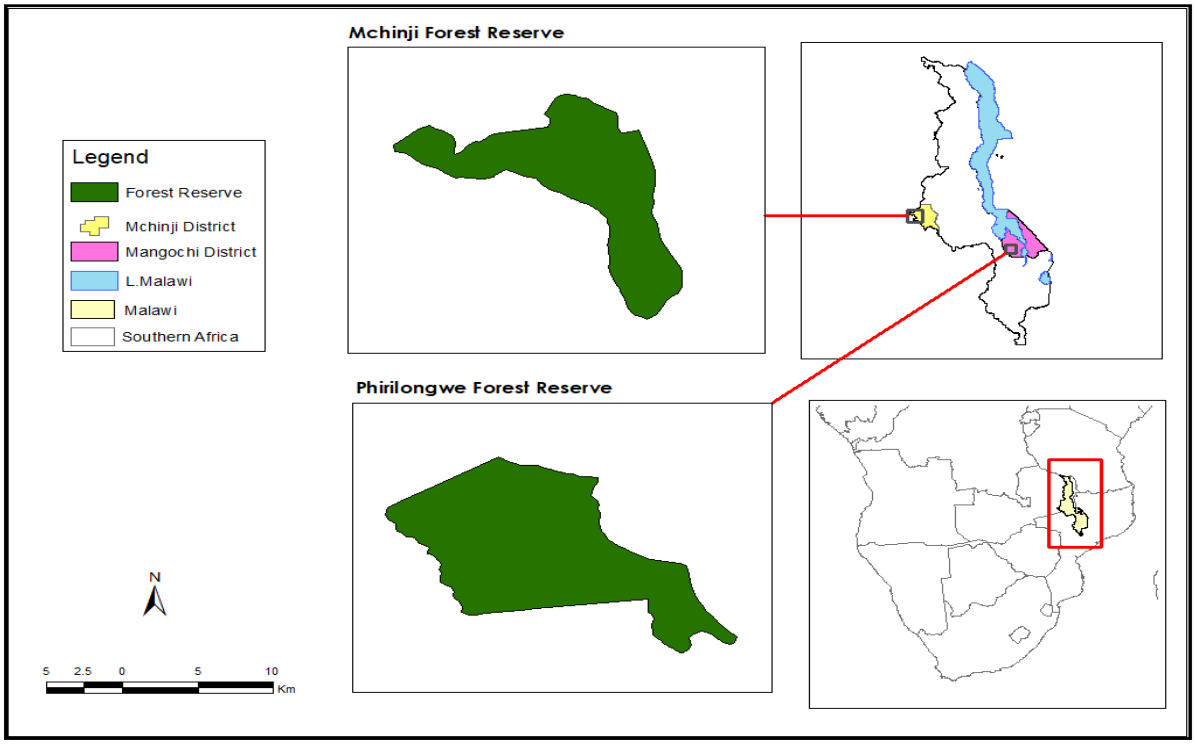

Figure 1 Map of the Location of Mchinji and Phirilongwe Forest Reserves in Malawi

2.2 Sampling frame and Sample Size

We employed a multistage sampling technique approach, which ensures that all responses were represented in the study (Kelley et al 2003). The study targeted two (2) regions out of the four

Malawian regions and purposively selected two (2) districts, one in each region and the two forest reserves, one in each district thus Mchinji and Phirilongwe forest reserves. In these two reserves, no government intervention or project is being implemented. We randomly selected the Traditional Authorities (TAs) and their respective villages falling within 5-kilometer radius of the selected reserves to collect a representative sample. Lastly, purposive sampling was used to select the households and key informants in this study. To qualify as a respondent of the household in this study, the member of the household ought to have lived in the study area for over 10 years during the time of data collection and aged 21 years and above. The surveys targeted the household head or any older member of the household in the absence of the household head. Sample size determination was adopted from Krejcie and Morgan (1970). The list of households surrounding Mchinji and Phirilongwe forest reserves was accessed from the respective district councils. The total population of the forest-dependent communities was used at a 95% confidence level, thus a 5% confidence interval to arrive at the sample size. Since the population size of the forest-dependent communities was provided, we used the following formula to capture a representative sample proportion required in this study;

$$S = \frac{(X^2 NP(1-P))}{[(d^2(N-1)+X^2(P(1-P)]} \quad \text{(Equation 1)}$$

Where, S = required sample size, X = Z value at the desired confidence level in this case 1.96 for 95%, N = is the population size, P = Population proportion expressed as decimal and assumed to be 50%, thus 0.5. Thus, 50% prevalence was given and d = degree of accuracy (5%) expressed as proportion thus 0.05.

From this model, we interviewed 422 households from the two forest reserves in Mchinji and Mangochi districts. The study sampled 227 households in Mchinji (N=134,799) distributed in three Traditional Authorities surrounding Mchinji forest reserve. These were 71 households in T/A Mlonyeni, 75 households in T/A Nyoka and 81 households in T/A Mkanda. On the other hand, 195 households were sampled in Mangochi district (N=152,879) distributed in three traditional authorities around Phirilongwe forest reserve. These were 64 households from T/A Mponda, 64 households from T/A Chilipa and 67 households from T/A Mtonda. The difference in the number of households sampled in these sites is based on the size of the forest reserve. In this case, the

Mchinji forest reserve is large as compared to the Phirilongwe forest reserve. In addition, differences in size of the Traditional Authorities also affected the number of households sampled.

2.3 Data Collection

Data collection was held between April and November 2019. We employed three data collection methods which are household survey interviews, focus group discussions (FDGs) and key informant interviews (KIIs). For efficient and effective data collection process, we formed a research team which comprised of the researcher as a lead and the recruited ten (10) research assistants. This hastened and shorten data collection period as most forest dependent communities are farmers and were busy with other farming and business economic activities. The recruitment of the research assistants was based on their relevant academic qualifications and field experience in handling and implementing household questionnaire surveys. The questionnaire was translated into the dominant local language (Chichewa) of the study populations to ensure that respondents were communicated in their local language. In addition, the research assistants recruited were conversant with the local languages of the study population. Before data collection exercise, the research assistants were trained two weeks before data collection exercise to introduce them to the research objective and the survey questions. It is at this workshop where the research questionnaire interpretation was perfected and revised. Prior to data collection exercise, the questionnaire was pre-tested in Mchinji Forest Reserve in order for the research assistants to get field experience in administering the questionnaire before the actual field work. The pretesting also established the time taken to administer the questionnaire and acceptability of the communities towards the designed questions. The reflection session after the pretesting exercise aided in proper planning for the implementation of the field data collection exercise.

2.4 Data Analysis

The analysis of the data to respond to this objective involved computing frequencies, percentages, conducting chi-square and a binary logistic regression analysis. The analysis of the data on the perception and the level of knowledge of respondents to climate change, a Likert-type scale ranging from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = don't know/undecided, 4 = agree and 5 = strongly agree) was used. Thus, variables were measured on an ordinal scale. We then distributed all respondents who indicated that they had knowledge on climate change into five (5)

categories of knowledge levels which are very low, low, medium, high, very high, using cumulative Cube root frequency method of stratification (Singh and Mangat, 1996) as presented below:

$$L_i = y_{i-1}\left(\frac{\frac{S_k}{L} - S_{i-1}}{\sqrt[3]{f_i}}\right)(y_i - y_{i-1}) \qquad \text{(Equation 2)}$$

Where;

L = No. of strata
L_i = Upper limit of the $_i$th strata
y_{i-1} = Lower limit of the class in which L_i lies
S_k = Cumulative total of $\sqrt[3]{f_i}$
$\sqrt[3]{f_i}$= Cube root frequency of the $_i$th class in which L_i lies
S_{i-1}= Cumulative cube root of the frequency of preceding class to the class to which L_i lies
y_i = Lower limit of the class in which L_i lies
$y_i - y_{i-1}$= Width of the class in which L_i lies

Furthermore, a binary regression logistic model was used to test the household level factors that influenced their climate change perceptions their willingness to adopt environmentally friendly forest utilization and management options. The applicability of this model (good of fitness) on the data was tested using the Hosmer-Lemeshow and Pearson Chi-square tests. A p-value of < 0.05 represented statistical significance in hypothesis testing and a 95% confidence interval was employed to describe the estimation of the unknown variables. Qualitative data collected through focus group discussion and key informant interviews were analyzed using content analysis.

Specifications of the logistic regression model employed

The standard binomial logit regression model with dichotomous categorical dependent variables was specified in this study. In order to model the perception on climate change variability, the dependent variables were '*perceive*' and '*not perceive'*.

In the binary regression analysis, perceiving climate change was framed as a binary choice model with the assumption that respondents "perceived" or "*not perceive*". Similarly, the dependent variable employed in modelling their willingness to embrace environmentally friendly behaviours were framed as '*willing*' and '*is not willing*. Explanatory variables are presented in table 3.

Table 1: **Perception of forest dependent communities on changes in climatic events**

Variable	Response	Proportion of respondents (%)		Chi-square Results	
		Mchinji (n=227)	Mangochi (n=195)	X^2	p-value
Erratic Rainfall	Increase	83.3	95.4	17.699	0.000
	Decrease	11.9	4.6		
	Constant	4.8	0		
Serious floods	Increase	64.3	59.0	44.901	0.000
	Decrease	10.6	33.3		
	Constant	25.1	7.7		
Flush Floods	Increase	81.5	84.1	5.612	0.060
	Decrease	8.8	11.8		
	Constant	9.7	4.1		
High temperatures	Increase	71.4	79.5	8.020	0.018
	Decrease	9.7	11.3		
	Constant	18.9	9.2		
Prolonged dry spells	Increase	74.4	84.6	11.120	0.004
	Decrease	14.1	4.6		
	Constant	11.5	10.8		
Hailstorms	Increase	29.6	46.2	21.918	0.000
	Decrease	37.4	39		
	Constant	33.0	14.9		
Strong Winds	Increase	75.8	89.7	20.934	0.000
	Decrease	8.8	7.7		
	Constant	15.4	2.6		
Landslides	Increase	48.9	53.8	9.483	0.009
	Decrease	24.2	31.3		
	Constant	26.9	14.9		

Table 2: Factors influencing Respondents' perception on climate variability and change

Parameter Tested	df	Estimate (X)	Chi-square Wald	Exp (X)	P-value
Age (<35, >35)	1	-0.398	7.378	0.67	0.006
Education (Formal, No formal)	1	0.557	4.056	1.75	0.044
Gender	1	1.171	8.847	3.23	0.002
Culture and Language Skills	1	-1.318	4.456	0.27	0.034
Farming skills	1	3.177	9.308	23.97	0.002
Livestock keeping skills	1	1.112	5.027	3.04	0.024

Table 3: Respondents Perception on the causes of Climate change and variability

Belief Category	Causative Agent	Response	Proportion of Respondent (%)		Chi-square Results	
			Mchinji (n=227)	Mangochi (n=195)	X^2	P-value
Spiritual Causes	Anger from God	Cause	30.8	35.9	3.298	0.192
		No cause	61.7	60.9		
		Don't know	7.5	3.2		
	Ancestors punishment	Cause	19.4	24.2	1.093	0.579
		No cause	71.8	70.6		
		Don't know	8.8	5.2		
Anthropogenic Causes	Population growth	Cause	82.4	85.6	1.456	0.483
		No cause	13.2	10.3		
		Don't know	4.4	4.1		
	Uncontrolled harvesting of forest resources	Cause	94.3	96.4	0.616	0.735
		No cause	3.1	2.6		
		Don't know	2.6	1		
	Poor farming practices	Cause	77.4	78.4	1.041	0.594
		No cause	16.8	18		
		Don't know	5.8	3.6		
Natural phenomenon	Natural variation	Cause	59.3	66.4	9.351	0.009
		No cause	24.8	21.2		
		Don't know	15.9	12.4		

Table 4: Factors influencing respondents' willingness to engage in certain behaviors

Parameter Tested	Behavior	Estimate (X)	Wald	P-Value	Exp (X)
Age	Engage in REDD+ initiatives	-0.374	3.712	0.054	0.688
	Engage in Green Credit Scheme	-0.158	5.002	0.025	0.854
	Diversify income from NTFPs	-0.13	3.133	0.076	0.878
Education Qualification	Accept training in good forest exploitation practices.	0.526	9.663	0.002	1.692
Household size	Plant more Trees	0.564	8.758	0.003	1.758
	Use clean fuel efficient stoves	0.925	9.662	0.001	2.522
	Diversify income from NTFPs	0.393	5.266	0.020	1.481
	Engage in REDD+ and GCS	0.427	6.937	0.009	1.533
Gender	Use clean fuel efficient stoves	0.499	4.239	0.039	1.647
	Engage in REDD+ and GCS	0.668	7.994	0.004	1.950
Art and craft skills	Plant more trees	1.507	6.352	0.011	4.513
Hunting skills	Use alternative cooking energy	-0.815	4.285	0.038	0.443
Culture and Language skills	Plant more Trees	-1.082	5.627	0.017	0.339
	Engage in REDD+ and GCS	-0.921	5.422	0.020	0.398
Farming skills	Diversify income from NTFPs	2.324	14.107	0.000	10.216
	Plant more trees	1.414	3.976	0.046	4.112
	Use clean fuel efficient stoves	2.324	14.107	0.000	10.216
	Engage in forest co-management	2.387	12.372	0.000	10.881
Livestock keeping skills	Engage in forest co-management	0.779	10.955	0.001	2.179

Let Ti represent a dichotomous variable that equals 1 if respondents *perceived climate change* and 0 if *not perceived*. Thus, the probability of perceiving climate change in each case, Pr (Ti = 1), which is the cumulative density function F evaluated at $X_i \beta$, where Xi is a vector of explanatory variables and β is a vector of unknown parameters (Pitt, 1983). The cumulative density function was modelled using the following logistic probability function:

$$\Pr(Ti = 1) = \frac{\exp(Xi\,\beta)}{1+\exp(Xi\,\beta)} \qquad \text{(Equation 3)}$$

We analyzed the perception and willingness to embrace environmentally friendly behaviours separately. Supplementary Table 1 presents the list of explanatory variables used in the binary logistic regression model. The goodness of fit of the models was assessed using the Chi-square test at 0.005 significant level.

3. RESULTS

3.1 Demographic Characteristics of the Respondents

The results of the demographic characteristics of the respondents revealed that Mchinji was dominated by male (53%) respondents, while Mangochi was dominated by female (56%) respondents. This might be attributed to the fact that most men in Mangochi are fishermen and therefore spend most of their time on the lake while their male counterparts in Mchinji are mostly farmers. Concerning age >35 years, Mangochi had 76.92% compared to 68.3% in Mchinji. However, we only analyzed the responses of participants whose ages were 35 and above to understand their local climate awareness and trends because the study had set 20 years as a recall period. In terms of household size, 45.7% (n = 195) of the households in Mangochi had a household size greater than 6 compared to 32.6% in Mchinji. The results also indicate that 84% of respondents in Mangochi were married compared to 75% in Mchinji. In terms of education, 33% of the study population in Mchinji had accessed secondary education compared to only 10% in Mangochi. Furthermore, 24% of the respondents in Mangochi had no formal education compared to only 8% in Mchinji. The results show that 39 % of the respondents were unemployed and 52.6% were self-employed through small scale business enterprises. As regards to income sources, 90.5% of the respondents relied on farming. The rest of the sampled population were engaged in piece works, small scale businesses, art and crafts, selling forest produce/non timber forest products, remittances and lending out lands. The estimated monthly income per household ranged from MK200 to MK500, 000 per month with the mean monthly income of MK18, 395.26.

3.2 Awareness and knowledge on climate change and variability

In terms of climate change awareness and its effect amongst the sampled population, generally high awareness of the term "*climate change*" was recorded in Mchinji (60%, n=227) as compared to Mangochi (35%, n=195) Forest Reserves. Seven percent (7%) of the forest-dependent communities in both study sites reported that they have never heard about climate change. The Pearson Chi-square test performed reveals that these results were statistically significant (p =0.000; X^2 =29.45, DF=2) amongst the forest-dependent communities.

The results further record that 90.3 % and 88.2% of the forest dependent communities have knowledge on climate change and its effects in Mchinji and Mangochi, respectively. Analysis of

the level of knowledge from the cumulative Cube root frequency method of stratification revealed that only 22.8% and 23.6% of the respondents fall in the very high and medium knowledge levels respectively. On the other hand, 38.6% and 15.0% of the respondents had low and very low levels of knowledge of climate change and its effects respectively. Computed total knowledge scores ranged from 26 to 74 with the mean of 50. Figure 2 presents the detailed results on the level of knowledge by study site. The Pearson Chi-square test shows significant differences across the sites of these results (p = 0.001, X^2 = 20.989, DF=3).

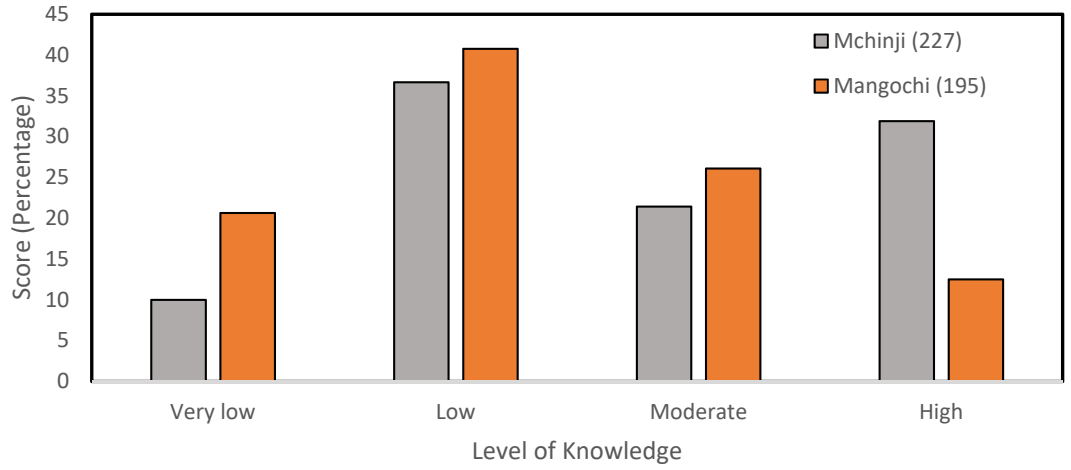

Figure 2 Knowledge levels of the Forest Dependent Communities

3.2.1 Perception on variability of climate events and seasons

We recorded high level of perception in the variability of climatic events and seasons in this study as presented in table 1. Results reveal that 83.3% and 95.4% of the forest dependent communities in Mchinji and Mangochi respectively perceived an increase in erratic rainfall. The Pearson Chi-square test shows that these results are statistically significant (p = 0.000, X^2 =17.699, DF=2) at both study sites.

Respondents also perceived the increase in the frequency of both serious floods (61.7%) and flush floods (82.8%) at both areas. However, results of the Pearson Chi-square test performed reveal that the perception of flush floods were not statistically significant at both sites (p =0.06, X^2 =5.612, DF= 2). Furthermore, respondents perceived increase in incidences of high temperatures in

Mchinji (71.4%) and Mangochi (79.5%). The other climate events varying at the study sites are reduction in the incidences of hailstorms, increased incidences of strong winds and dry spells. The observed variations in strong winds, hailstorms, and landslides were revealed to be statistically significant in both sites.

Respondents had also perceived changes in the onset and offsets of seasons across the study sites as presented in Supplementary Table 2. The results show that 74% and 65.6% of the respondents in Mchinji and Mangochi, respectively observed delay in the onset of the rainy season. In contrast, the offset of the rainy season was revealed to be early resulting in the shortened rainfall season at both study sites. We record early onset of the hot dry season in Mchinji, 43.3% and Mangochi 50.2%. However, the offset of hot dry season was delayed resulting in lengthened hot dry season at both study sites. Pearson Chi-square tests reveal that results on the onset of all the seasons are not statistically significant compared to the results of offsets of these seasons which were statistically significant ($p < 0.05$).

Results from the binary logistic regression model used to test the factors influencing forest dependent's perception of the changes in the climate variability and change are presented in Table 2. The results indicate that having formal education doubles the likelihood of perceiving climatic changes in the study sites by forest dependent communities. Gender and the possession of livestock keeping skills increases the likelihood of perceiving climate change three times, respectively. The most influencing factor is the possession of farming skills which increase the likelihood of perceiving climatic changes twenty-three times.

3.2.2 Awareness of specific indicators of climate change in their agro-ecosystem

Respondents were asked to list the any observed changes in their forest and agro-ecosystem as probable indicators of climate change and results are presented in figure 3. The results reveal that 98 % and 96% of respondents observed new agriculture and forest diseases in Mchinji and Phirilongwe forest reserves respectively. In addition, 86% and of respondents in both sites observed changes in the flowering and fruiting time of various plant and tree species in their local agro and forest ecosystems. Another key finding is that only 58% and 62% of the forest dependent communities in Mchinji and Phirilongwe forest reserves respectively, observed new plant species in their farms or forest ecosystems. An example of the strange Army worms and Eucalyptus aphids

were mentioned. Other notable observed changes which scored highly were the death of livestock and the scarcity of water sources due to drying of rivers and ponds.

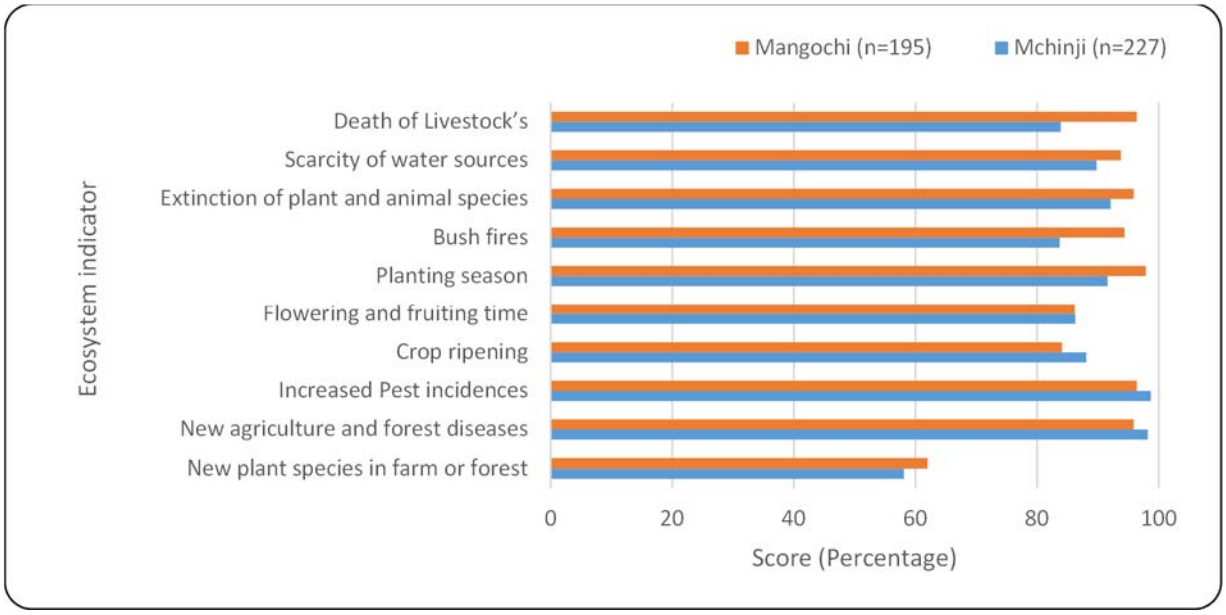

Figure 3 Respondents' awareness of their ecosystem changes

3.3 Perception on the most attributable causes of climate change and Variability

We requested participants to explain their most attributable cause of climate variability and change in their locality and results are presented in Table 3. The results record that the belief in anthropogenic causes of climate variability and change is high among the study participants. In Mchinji, 94.3% and 77.4% of the study participants attribute climate variability and change to uncontrolled harvesting of forest resources and poor farming practices respectively. On the other hand, 96.4% and 78.4% of the forest dependent communities in Mangochi also attribute climate change and variability to uncontrolled harvesting of forest resources and poor farming practices respectively. On the other hand, 59% and 66% of the respondents in Mchinji and Mangochi respectively believe that climate change is a natural phenomenon showing the presence of climate skeptics among the forest dependent communities. There were statistically significant differences in the results on attribution of climate change to natural phenomenon only in this study ($p= 0.009$, $X^2 = 9.351$, $DF= 2$).

3.4 Willingness to adopt climate intervention measures

The results show that the respondents agreed to embrace certain environmentally friendly behavior changes as presented in Supplementary table 3. Notably 80% and 59% of the respondents in Mchinji and Mangochi respectively strongly agreed to stop unregulated harvesting of forest resources. Other behaviors such as accepting training in good forest exploitation practices scored 61% in Mchinji and 47% in Mangochi, and use of alternative cooking sources and clean fuel energy saving cooking stoves with 53% and 48% strongly agreeing in Mchinji and Mangochi respectively. The Pearson Chi-square test shows that these results are statistically different across the study sites ($p<0.05$).

3.4.1 Household level factors Influencing Participants' willingness to embrace certain behavior changes that address climate change

Results reveal certain social economic factors that influence willingness to embrace specific climate friendly behaviors as presented in table 4. The results indicate that increase in household size, two times increases the likelihood of forest dependent households to accept use of clean fuel-efficient cook stoves. Likewise, gender of the respondents positively influences two times their willingness to use clean fuel-efficient cook stoves, and engage in REDD+ programme and green credit schemes. Households with farming skills are ten times more likely to diversity income through non timber production, use clean energy efficient cook stoves and accept to engage in forest co-management. In addition, the possession of art and craft skills positively influenced four times the willingness of the forest based households to plant more trees on farm and homestead significantly. Likewise, livestock keeping skills possession increased the likelihood to engage in forest co-management with forestry department twice.

4. DISCUSSION

4.1 Awareness and Knowledge on climate change among forest dependent communities

The findings of this study suggest that forest dependent communities in Mchinji and Mangochi are aware of climatic changes happening in their localities although their knowledge levels were low. The study further demonstrates that respondents perceived increased frequencies of erratic rainfall, high temperatures, strong winds and flooding incidences. On the other hand, hailstorms and landslides were observed to have reduced in their frequencies. In addition, delayed onset of rainy season and its early offset resulted in the shortened rainfall season. Finally, forest dependent

communities were able to report some of the observed changes in their agro-ecological systems as probable indicators of climate change and variability such as changes in flowering and fruiting seasons, new plant species, pest and diseases, and drying of streams and rivers.

Farmers' knowledge on climate change supports the findings of Mkomwa et al (2014) in Chikhwawa and Munthali et al (2016) in Rumphi where local communities reported increased erratic rainfall and high temperatures. Outside Malawi, the results are similar to those of Chikosi et al (2019) in Ga-Dikale, Limpopo, South Africa where changes in rainfall patterns and temperature increase were reported. In another study in Ethiopia, Wolka and Zeleke (2017) reported increased temperatures and changes in rainfall patterns perceived by the Karetha Watershed communities. Recently, in Kenya, smallholder farmers also perceived reduced rainfall and delayed onset of rainfall season (Nyang'au et al, 2021). Elsewhere, outside Africa, a study in Amazon also recorded the awareness of the Amazonian Communities in rainfall variations (Funatsu et al. 2019).

The disproportionate level of climate change awareness and knowledge may also be attributed to the district literacy rate. The recent National Statistical Report revealed that Mangochi has the lowest literacy rate (53%) in Malawi as compared to Mchinji district with a literacy rate of 66% (GoM, 2018c). The accessibility of these forest reserves for various services including awareness campaigns may also be attributed. In this case, Phirilongwe forest reserve is far from Mangochi Boma and only accessible through one untarred road which cuts through the forest. On the contrary, Mchinji forest reserve is fairly close to the Mchinji Boma and accessible through a tarmac road. The poor climate awareness in Mangochi may hinder effective participation in climate intervention activities which may increase their vulnerabilities.

Furthermore, our study has shown that climate change perception is largely influenced by possession of farming skills apart from other social-economic factors. Since Malawi's farming system is largely rain-fed (Singh et al. 2020), possession of farming skills influences much on the perception of climatic changes. In addition, having formal education increased the likelihood of perceiving and being aware of local climate change and variability. Education opens peoples understanding and start keeping information on their environment (Juana et al. 2013). As regards to gender, males are more exposed to local community trainings and meeting than females in Malawi (Munthali et al. 2019).

4.2 Perception on Belief of the causes of climate change

As regards to the perception and belief on the causes of climate change and variability, our study revealed a strong belief in the anthropogenic climate change. A higher proportion of forest dependent communities attribute climate to the anthropogenic causes in the study area. The strong belief in anthropogenic causes of climate change presents strong indications of the reality of climate change and possible public acceptance of climate change by the rural communities. These findings are not new, strong belief in anthropogenic climate change were also revealed by Ofoegbu et al (2016), and Cyprian et al (2014) among the rural communities in South Africa. Nevertheless, a negligible proportion of the forest dependent communities in our study also perceived cultural issues such as punishment from the ancestral spirits as causes of climate change. In addition, a small proportion of the forest dependent communities attribute climate change to be natural phenomenon. This reveals the existence of climate skeptics within the rural people of Malawi. Ofoegbu et al (2016) argued that skepticism amongst the rural people is not strange. These results concur with the findings of Marsden et al (2009) in Australia, Capstick et al (2012) in United Kingdom and Ofoegbu et al (2016) in South Africa. The existence of the skepticism among the forest dependent communities presents the need to educate the rural people on the concept and causes of climate change. These people might be difficult to be convinced to participate in the climate change interventions.

4.3 Willingness to adopt climate intervention measures

The study revealed that forest dependent communities in Malawi are willing to stop unregulated harvesting of forest resources and accept trainings in good forest exploitation practices. This may be attributed to the climate risk perception they have on forest resources and their knowledge and awareness on climate change. Meijer et al (2015) postulated that the perception farmers have regarding an innovation are closely related to the knowledge they have about that innovation. This suggests that perception determines the attitude towards an intervention. In support of these findings, Munthali et al (2019) noted that farmer's possession of technical knowledge regarding an innovation drove them to accept timber out grower scheme. Furthermore, Juana et al (2013) hypothesizes that most communities would decide to adopt any climate adaptation initiatives that address their local perceptions. Furthermore, it is argued that realizing certain changes that are going on around communities is paramount to inform the communities to take actions in adjusting

and respond to those changes (Füssel and Klein 2006; Deressa et al. 2011; Nursey-Bray et al. 2013). Thus, our study revealed that education, household size, gender and possession of farming, livestock keeping, and art and crafts skills enhanced their willingness to adopt certain environmental behaviors as climate interventions.

4.4 Implication of the study results to climate change and forest management

The results entail that efforts to reduce the exposure of forest communities to climate change must include actions taken to enhance climate awareness and understanding amongst the forest residents. This may be accomplished through continuously engaging them in climate discourse and capacity building and tailor-made climate information packaging must be geared towards these communities to improve information flow. Apart from knowledge level gap, the study has unearthed the presence of climate skeptics who may present challenges in the adoption of environmentally friendly interventions including sustainable forest management interventions.

4.5 Study Weakness

The study employed the case study approach in which Mchinji and Phirilongwe Forest Reserves were purposively chosen to operationalize the IPCC vulnerability assessment framework to unravel the forest residents' vulnerabilities. As such, the results are limited to these Forest Reserves and may not be generalized to other areas in Malawi. This leaves a caution in applying these findings and replicating elsewhere.

5. CONCLUSION

This paper explored the awareness, knowledge and perception of forest dependent communities on climate change and variability in Phirilongwe and Mchinji forest reserves. Precisely, the study contextualized on the local awareness of the term climate change, level of knowledge on climate change, observed changes in climatic events, seasons, and agro-ecological systems, most attributable climate change causes and willingness to adopt climate friendly interventions. The findings suggest that Mchinji Forest dependent communities are more aware of climate changes than those of Phirilongwe forest reserve though the knowledge levels are poor. Results further record respondents perceived increase in erratic rainfall, flooding incidences, high temperatures and strong winds. On the contrary, frequencies of hailstorms and landslides have decreased significantly. Results further show delayed onset and early offset of rainfall season thus reduced

rainfall season. In the agro-ecological systems, respondents reported new agriculture and forest pest and diseases, changes in flowering and fruiting time, new plant species, dying of livestock, and scarcity of water sources as indicators of climate change and variability. Although a negligible proportion of respondents exposed climate skepticisms, the study revealed a strong belief in anthropogenic causes of climate change presenting strong indications of the reality of climate change and possible public acceptance among them. However, the presence of the believers in the cultural and spiritual causes of climate change in the study presents a challenge to mobilize them towards implementation of climate intervention measures which has may affect their participation in forest related activities. Finally, we established that forest dependent communities in Mchinji and Mangochi are willing to stop unregulated harvesting of forest resources and accept trainings in good forest exploitation practices which is key in sustaining forest resources. We therefore recommend their incorporation in the climate adaptation interventions and multiple use of various strategies and methods that will help to address their livelihood at the same time improve their climate information and knowledge.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data is publicly available with the University of Pretoria repository.

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