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Vulnerability of the fishery-based households to the impact of climate change in Rift valley lakes of Ethiopia: Chamo & Hawassa

Hiwot Teshome*, Esayas Alemayehu* and Abebe Cheffo*

*Ethiopian Institute of Agricultural Research, National Fishery and aquatic life research center P.O. Box 64, Sebeta

ABSTRACT

This study examines the vulnerability of fishery-based households in Ethiopian rift valley lakes Chamo and Hawassa. The vulnerability assessment approach used vulnerability indicator method which is composed of both biophysical and socioeconomic indicators of fishery-based households. The indicators selected were classified into exposure, sensitivity and adaptive capacity. Principal component analysis (PCA) was used to give weight to the vulnerability indicators. The result shows that the fishery-based households around Lake Chamo are more vulnerable to climate change than in Lake Hawassa. The result of this study stresses the immediate need for appropriate adaptation and/or mitigation measures to help the livelihood of the fishermen in the study areas. The results of this study should be considered for future decision making when mitigation and adaptation mechanisms are selected.

Key words:

Vulnerability, fishery-based households, climate change, rift valley lakes

***Correspondence to Author:**
Ethiopian Institute of Agricultural Research, National Fishery and aquatic life research center P.O. Box 64, Sebeta

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Introduction

It is obvious that current climate change is already imposing significant challenge to aquatic and marine ecosystems and fishery-based livelihoods. Therefore, small-scale fisheries that supports livelihoods of more than 90% of capture fisher folk and produce about 50% of global seafood catches (FAO, 2012) which are also affected by climate variability and change. These impacts include not only those on fish populations (Brander, 2010) but the natural climatic variability, compounded with climate change will adversely affect millions of livelihoods around the world (IPCC, 2007). The rural communities in the developing countries are expected to be highly affected due to their extensive dependence on climate sensitive livelihood options, and limited adaptive capacity to adapt to the changes (UNFCCC, 2009).

Especially in developing and least developed countries the consequences of the change has been clearly seen. Therefore, they have been trying to cop-up with a problem to maintain their life but some fail to maintain this and are seeking for emergency aid from external bodies. The Fisheries and aquaculture sector employs 43.5 million people, many of these in developing countries, and the processing, marketing, distribution and supply industries associated with fishing and aquaculture employ up to another 200 million people (Cochrane *et al*., 2009).

Lake Fisheries has a very negligible role in terms of rural economy, employment, income generation and nutrition. Very gradually this situation has changed over the past decades: in 1965, the total annual production of fish was estimated between 70 and 100 tons per year (ELFDP, 1993). Currently the total fish harvest increased to over 15,000 tones (FAO, 2003). Based on current population growth the minimum demand for fish will research 94,526 tones in 2015 and 117,586 tones in 2025, factors other than population are not considered (FAO, 2005). Despite the estimated production figure shows increasing rate, the actual current production is not promising as expected. Based on the current situation open fishing is not appreciated in the major rift valley lakes of Ethiopia this is due to huge number of people already engaged in fishery and to protect the commercially important fish species from loss.

Since then the demand for fish has increasing likewise the number of people engaged in fishery has also increasing. Consequently the fish production has become deteriorating especially commercially important fish species. Some reasons have been raised as a result for the low production of fish; the first reason is temperature rise, loss of some fish species and mass killing of fish are among the reasons. Though open fishing in lakes is prohibited, huge numbers of illegal fishers are still engaged in fishing.

In Ethiopia the country policy in agriculture specially in livestock sector is not yet well considering capture fishery and aquaculture as a basics income generating activity for the poor so that there is no fishery and aquaculture based extension system rather as a par time job which is depend on the personal willingness of the development agents and experts from other disciplines. Thousands of people are straggling on this sector for the past many decades as their permanent income generation, without no improvement. So the vulnerability of these people to the natural disaster, climate change and policy issues need to address well Therefore, the main focus of this study is to analyze vulnerability of the fishery based household to the impact of climate change and the following are specific objectives that will be addressed in parallel.

ü Examine the vulnerability of the fishery based households,

ü Assess climate change mitigation mechanisms practicing by fishery-based households.

Methods

Both primary and secondary data were collected using structural questionnaire, participatory appraisals (PA) and focus group discussion (FGD). The Vulnerability can be assessed using knowledge of the three components - exposure, sensitivity and adaptive capacity. An assessment is supposed to consider vulnerability from both the individual and community scale. The vulnerability assessment approach using vulnerability indicator method contains both biophysical and socioeconomic indicators of fishery-based households. Thus the statistical method principal component analysis (PCA) was used to weight the vulnerability indicators. SPSS V-16 was used for assigning the weights for each indicator

PCA starts by specifying each variable normalized by its mean and standard deviation.

Normalized value= (observed value-mean)/

standard deviation

The loadings from the first component of PCA are used as the weights for the indicators, the weights assigned for each indicator varies between -1 and +1

The normalized variables are then multiplied with the assigned weights to construct the indices

$$I_i = \sum_{i=1}^{k} bi \left[\frac{a_{ij} - x_i}{s_i} \right]$$

Where, '*I*' is the respective index value

'bi' is the loadings from first component

'a' is the indicator value

'x' is the mean indicator value

's' is the standard deviation of the indicators

Model specification

The vulnerability index development is given as developed by the Intergovernmental Panel on Climate Change IPCC (2012) that vulnerability is the net effect of adaptive capacity (socio-economic) and sensitivity/exposure (biophysical) therefore vulnerability is calculated as:

Vulnerability= Adaptive capacity − (Sensitivity + Exposure) ------------- (1)

When the adaptive capacity of the household exceeds that of its sensitivity and exposure, the household becomes less vulnerable to climate change impacts and the reverse is also true. The table 1 below shows that each set (adaptive capacity, sensitivity and exposure) is composed of different variables. The model specification detail is expressed as Principal Components Analysis a technique for extracting from a set of variables those few orthogonal linear combinations of variables that most successfully capture the common information. Intuitively, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables.

For example, suppose we have a set of *Z*-variables (a^*1j to a^*Zj) that represents the *Z*-variables (attributes) of each study sites *j*. PCA starts by specifying each variable normalized by its mean and standard deviation. For instance, $a1j = (a^*1j – a^*1)/s^*1$, where a^*1 is the mean of a^*1j across regions and s^*1 is its standard deviation. The selected variables are expressed as linear combinations of a set of underlying components for each study sites *j:*

$a1j = y11\ W1j + y12W2j + … + y1zWzj$

$… j= 1 … J$

$az1j = yz1W1j + yz2W2j + … + yzzWzj$, --------------- (2)

Where the *W*'s are the components and the *y*'s are the coefficients on each component for each variable (and do not vary across study sites). Because only the left side of each line is observed, the solution to the problem is indeterminate. PCA overcomes this indeterminacy by finding the linear combination of the variables with maximum variance (usually the first principal component W1*j*), Then finding a second linear combination of the variables orthogonal to the first and with maximal remaining variance, and so on. Technically, the procedure solves the equations $(\mathbf{R} – \lambda \mathbf{I})\mathbf{v}n = 0$ for λn and $\mathbf{v}n$, where **R** is the matrix of correlations between the scaled variables (the *a*'s) and $\mathbf{v}n$ is the vector of coefficients on the *n*th component for each variable.

Solving the equation yields the characteristic roots of **R**, λn (also known as Eigen values), and their associated eigenvectors, $\mathbf{v}n$. The final set of estimates is produced by scaling the $\mathbf{v}n$s so that the sum of their squares sums to the total variance—another restriction imposed to achieve determinacy of the problem. The scoring factors from the model are recovered by inverting the system implied by equation (2).

This yields a set of estimates for each of the *Z*-principal components:

$W1j = b11\ a1j + b12\ a2j +… +b1z\ azj$

$… j = 1 … J$

$Wzj = bz1\ a1j + bz2\ a2j +… +bzz\ azj$, -------------(3)

Where the *b*'s are the factor scores. Following Filmer and Pritchett (2001), the first principal component, expressed in terms of the original (un normalized) variables is an index for each sites in Ethiopia based on the following expression:

$W1j = b11\ (a^*1j – a^*1)/(s^*1) + … + b1z\ (a^*Zj – a^*Z)/(s^*Z)$ -------- (4)

Previous studies by (Adger 1999, Temesgen et al. 2008, Teso et al. 2012) noted that vulnerability ranges from local/households level to global (Brook et al. 2005). Based on the collected data in two study sites (Hwassa and Chamo), the focus of this study was to examine vulnerability at household/local level.

Description of model variable

This study adopts the IPCC (2001) definition which stats economic wealth, technology, information and skills, infrastructure, institutions and equity are the main features to determine a community or region's adaptive capacity. Some of the indictors were adopted from (Glwadys 2006), (Temesegen *et.,al* 2008) and identification of the types of indicators and attachment of the scale of analysis was done by NFALRC. The scale of analysis of each indicator was at household level. Table 1 shows indictors and their units of measurement and their descriptions used in vulnerability analysis.

Results and Discussions

This study focused on the micro-level of assessing the variability across different fishery-based households in two rift valley lakes of Ethiopia namely Hwassa and Chamo. Fishery-based households have different perceptions and definitions for climate change, therefore the definitions they are trying to explain the change is also affected by different household characteristics such as Age; education level and the family size.

Fishery-based household's perceptions

Households were perceived that there exists temperature increasing from time to time. Result from focus group discussion with old fishers showed that there is a great difference is recognized as compared to the past 20 years. Not only is the temperature becoming warmer, the water volume of lakes are also declining through time. Thus based on the survey result out of the total sample respondents 70.48% of the respondents believe that water temperature is increasing and it is a main cause for declining fish catch. On the contrary 12.38% of the respondents perceived that the water temperature is decreasing and the rest 5.71% and 11.43% believe that the water temperature is as it is and it is variable so that not easy to conclude, respectively.

Risk coping mechanisms practiced by fishery-based households

In order to cope risks caused by climate change/ temperature variation, fishery-based households have developed different mechanisms through time which is different from place to place, and among fishery-based households. 77% of the fishery households in both study sites have no specific risk coping mechanism rather live with the problems.

Result from propensity score analysis (PCA)

To compute the vulnerability index, indicators of adaptive capacity, which are positively associated with the first principal component analysis, and indicators of sensitivity and exposure, which are negatively associated with the principal component analysis, were used. Thus the variables considered in the equation include off-fishing income, livestock ownership, access to training in fishery and microfinance. However, for the exposure and sensitivity, all the variables were considered in the analysis. This is because adaptive capacity is considered as positively contributing to the reduction of vulnerability, while exposure and sensitivity are negatively contributing to vulnerability reduction.

Thus, the larger the factor score the more important is the variable and contributes more to the household's vulnerability. The first principal component analysis shown in Table 3 was based on the indicators listed in Table 1 by using statistical package for social scientists (SPSS). The PCA of the data set on vulnerability indicators gave two components with eigen values greater than one. Thus, two components explain 95% of the total variation, the first principal explains cumulative proportion at first principal component 73.21% and the second explains 22%. Therefore, the first PCA which explains most of the variation and has at least positive association with the many adaptive capacity and negative with both exposure and sensitivity indicators for this case was selected as vulnerability index.

Thus, the vulnerability indices for the selected of adaptive capacity (positively associated with the first PCA) and all the indicators of sensitivity and exposure negatively associated with the first PCA remaining total indices of 7. Therefore, the higher value of the vulnerability index shows less vulnerability and the lower value show high vulnerability.

Households were classified into three categories using the vulnerability index: less vulnerable are households that are in a vulnerable situation but can still cope; moderately vulnerable households are those that need urgent but temporary assistance in case of shock and stresses; and the highly vulnerable are those households that are almost at a point of no return. The result shows that the majority of households fall within the moderately vulnerable category, with 74.5% households having an index from −1.00 to 1.00. The less vulnerable households had an index of 1.1 to 3.0 and constitute 18.9%, while the highly vulnerable households had an index of −0.9 to −3.0 but are 6.6% of the total sampled households. Based on this result the vulnerability indices of the two study sites lake Chamo and Hawassa are summarized in figure 2.

Conclusion

The vulnerability assessment was done at household level across the two study sites. thus vulnerability index was calculated for each sample households and compete the result based on the previous study vulnerability category done by (Opiyo et al., 2014) was to measuring household vulnerability to climate-induced stresses in pastoral rangelands of Kenya therefore, households having an index from −1.00 to 1.00. The less vulnerable households had an index of 1.1 to 3.0 while the highly vulnerable households had an index of −0.9 to −3.0.

The net effect of adaptation, exposure and sensitivity is positive for Hawassa but negative for arbaminch. This indicates that the fishery-based households in Arbaminch are relatively vulnerable than fishery-based households in Hwassa. The high vulnerability is associated with low access to infrastructure, extension services, training and microfinance survives whereas lesser vulnerability is associated with good access to infrastructure and other services. Different places are not equally vulnerable to the negative impacts of change the need for policy intervention accordingly.

References

Brander .K (2010). Impacts of climate change on fisheries. Journal of Marine Systems; 79:389–402.

Cochrane, K., De Young, C., Soto, D. & Bahri, T., eds. (2009). Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp.

FAO (2012). The state of world fisheries and aquaculture. Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations. Rome

IPCC 2007. Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Pachauri RK, Reisinger A (eds). Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Tesso, G, B Emana, and M Ketema. 2012. Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethiopia. Agricultural Sciences 3:871–888.

Opiyo et al., (2014): Measuring household vulnerability to climate-induced stresses in pastoral rangelands of Kenya: Implications for resilience programming. Pastoralism: Research, Policy and Practice 4:10.

Table 1A. Vulnerability Indicators, description and units of measurement

Determinants of vulnerability	Vulnerability Indictors	Description of indictors	Hypothesized relationship between indicators and vulnerability
Adaptive Capacity		Off-fishing income (dummy)	The higher percentage of households having off-fishing income, Remittance and gift, , ownership of livestock, the lesser vulnerability
Remittance and gift (dummy)			
Ownership of livestock (dummy)			
Institutions and infrastructure	Microfinance (dummy)	The higher percentage of the household access to infrastructure, extension services, health care and coping mechanisms the lesser the vulnerability	
	All-weather road (dummy)		
	Access to electricity (dummy)		
	Telephone service (dummy)		
	Access to training (dummy)		
	Access to extension services (dummy)		
	Access to health service (dummy)		
	Coping mechanisms (dummy)		
Sensitivity	Extreme climate	Climate effect (dummy)	The higher the effect, the more vulnerable
Exposure	Change in climate	Change in temperature (category)	Increasing temperature, increasing vulnerability

Source: Glwadys (2006) and Temesgen et al., (2008)

Scale of analysis: household (HH)

Table 1B. Household characteristics of the fishery based-households

Variables	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age	105	19.00	71.00	33.6415	10.21035
Education level	105	.00	12.00	5.6132	3.37094
Family size	105	1.00	12.00	5.5000	2.45435

Source: Own survey, 2014

Table 2 fishery-based household's perceptions on climate change/temperature variation

Climate condition	place of study %		Total
Chamo n= 78		Hawassa= 27	
Temperature increases	74.36	59.26	70.48
Temperature decreases	7.69	25.93	12.38
As it is	6.41	3.70	5.71
Variable	11.54	11.11	11.43

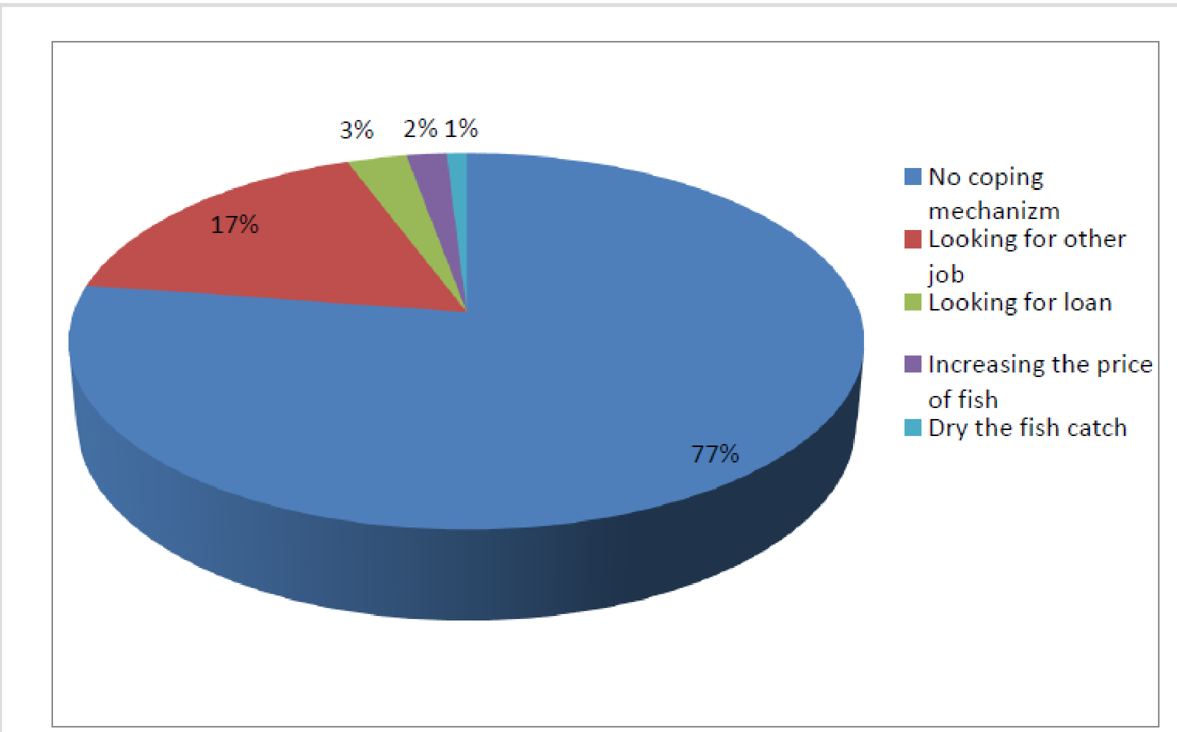

Figure 1 Climate change coping mechanisms by fishery-based households

Table 3 Vulnerability indicators of the first principal component

Vulnerability indictors	Factor scores
Off-fishing income	0.389
Livestock ownership	0.263
All-weather roads	-0.159
Access to electricity	-0.072
Access to telephone services	-0.018
Access to training in fishery	0.098
Access to health services	-0.001
Access to extension services	-0.67
Microfinance	0.007
Change in temperature	-0.106
Climate effect on fishery	-0.041
Coping mechanisms	0.299
Gift and remittances	-0.36
Cumulative proportion	73.21%

Source: Own survey 2014

Table.4. Classification of households according to the range of their vulnerability index

Vulnerability category	Household situation	Vulnerability index	Percentage of HH
Highly vulnerable	Emergency level HHs	−0.9 to −3.5	6.6
Moderately vulnerable	Needs urgent but temporary external assistance to recover	−1.0 to +1.0	74.5.
Less vulnerable	In a vulnerable situation but still able to cope	+1.1 to +3.0	18.9
Total			100

(Source: Opiyo et al., 2014)

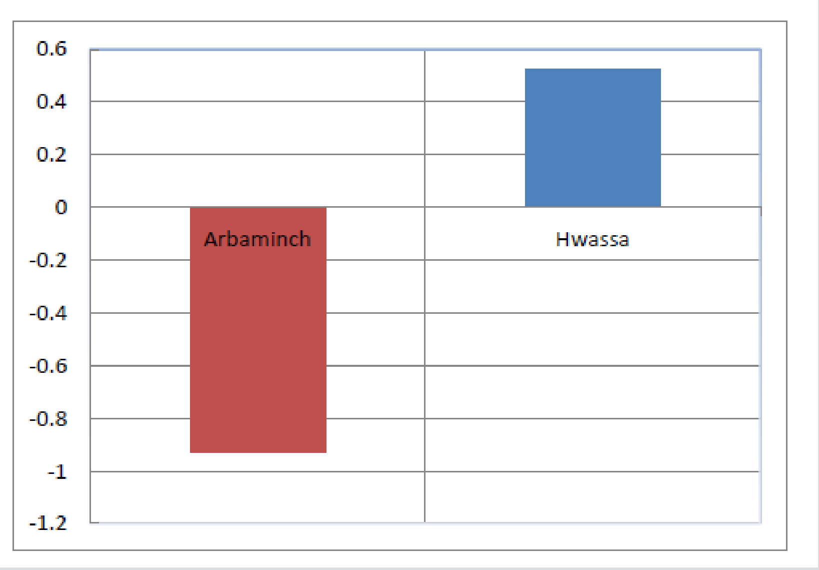

Figure 2 Vulnerability indices of the two study sites