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Household Food Security through Wetland Resources with Adaptation to Climate Change: An Empirical Analysis of Ranikor, Meghalaya, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Wetland ecosystems are the most diverse and productive ecosystems on Earth and include marshes, lakes, rivers, flood basins, estuarine deltas, ponds, rice fields, and marine water areas where the depth at low tide does not exceed 6 m. Tangible and intangible diverse resources and

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products of wetland functions have historically provided a source of income and livelihood for human beings. The present study investigated the different causes and the perceived indicators of food insecurity among the wetland dwellers, determined the wetland contribution to household food security and assessed the determinants of wetland based income with a view on the adaptive strategies adopted by the households residing around Ranikor, Meghalaya. Data was collected from 70 wetland resource-user households which was analyzed using simple percentage, t-test, regression analysis and Garrett ranking technique. The wetland resources contributed significantly to the household food security in the study area. It was found that climate change and limited labour were the major causes of food insecurity. Factors like household size, agricultural land area and age of the respondent determined the extraction of resources. Moreover, the study revealed crop diversification, re-digging of canal, construction of embankments and poultry rearing as the adaptive measures in the face of climate change having merits. The study recommends the need to design appropriate food production technologies that ensure sustainable use of wetland resources for food security as increasing population coupled with climate change will have drastic impact on the households relying on wetland for food security and income.

Keywords: Wetland; food security; climate change; crop diversification.

1. INTRODUCTION

"There is now overwhelming evidence that climate change is being caused by humans, and that its negative effects will most directly hit the least developed countries that are susceptible to diminishing food and water security" [1]. "Low-income farmers and others who are directly dependent on natural resources are most at danger as a result of the effects of climate change, which have already started to affect food and water supplies. Flooding, droughts, and storms may be becoming more frequent and intense as a result of global warming" [1,2]. Considering predictions that severe weather and changes in the baseline values of variables like temperature and rainfall will decrease crop output and food security as well, so there is an urgent need to identify and implement adaptation measures to increase the resilience of livelihoods and ecosystems to climate change.

Wetlands can be considered to be the world's most productive ecosystems. Wetlands are "biological supermarkets" because of the extensive food webs and rich biodiversity they support [3]. "Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. This means that a wetland is neither truly aquatic nor terrestrial; it is possible that wetlands can be both at the same time depending on seasonal variability. Thus, wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. Because of their transitional nature, the boundaries of wetlands are often difficult to define. Wetlands do, however, share a few attributes common to all forms. Of these, hydrological structure (the dynamics of water supply, throughput, storage and loss) is most fundamental to the nature of a wetland system. It is the presence of water for a significant period of time which is principally responsible for the development of a wetland" [4]. "The importance of wetlands can be understood by the variety of products and ecosystem services they provide. Out of 75 number of Ramsar site in India, the North East Region of India harbours 3 important Ramsar site namely, Deepor Beel in Assam, Loktak lake in Manipur and Rudrasagar in Tripura. Ranikor is a small town on the border of India and Bangladesh which is located 140 kms from Shillong, Meghalaya. It is one of the last and largest wild fishing spots left in the state of Meghalaya. Wetlands not only support high concentrations of biodiversity, but also offer a wide range of important resources and ecological functions such as food, water, flood moderation, storm protection, carbon storage and climate regulation. Excessive exploitation and the resulting degradation of wetland resources have attracted enormous concern from researchers" [5]. Keeping these facts in mind, the study was undertaken with the twin objectives, namely, to determine the contribution of wetland resources to household food security of Ranikor and to identify the adaptive strategies to climate change by the wetland dwellers.

2. METHODOLOGY

The present study is based on the primary data collected from Ranikor wetland of Meghalaya, a

sister state among the north eastern states of India where primary data was collected using a pre tested standardised interview schedule which covered a wide range of open and close ended questions with a focus on understanding the impact of contribution of wetland resources in the household food security of the study area. Meghalaya was selected as the area of study since the state possesses 3 numbers of wetlands in the region. Convenient sampling technique was used for the selection of respondents. The respondents were selected purposively. The total number of respondents selected was 70. Simple percentage was used to analyse the primary data and calculate the different causes of food insecurity among households, perceived indicators of food insecurity and wetland contributions to household food security.

Qualitative and quantitative data were analyzed using regression analyses in SPSS 11.5 (SPSS Inc., Chicago, Illinois, USA). Two-sample t-tests were used to compare the wetland resource incomes to the household economies. The socioeconomic factors that affected wetland based income were determined using ordinary least squares (OLS) regression. The explanatory variables included in OLS regression were household size (HHS), education of the respondent (EDU), the walking distance from the sampled household to the wetland (DIST), the age of the respondent (AGE), and the total agricultural land area (LAND) of the sampled household in kattha (1 kattha = 333 m^2). The explanatory variables and their hypothesized direction of influence are listed in Table 2. The model was specified as:

$$WI = \alpha + \beta_1 HHS + \beta_2 EDU + \beta_3 AGE + \beta_4 LAND + \beta_5 DIST + \varepsilon$$

Where,

HHS = Household size
EDU = Education of the respondent
AGE = Age of the respondent
LAND = Total agricultural land area
DIST = Distance to wetland

Moreover, the Garrett Ranking Technique was used to prioritize the adaptive strategies adopted by the wetland dwellers due to climate change. The adaptive strategies were prioritized by using the following formula:

$$\text{Garrett's ranking score} = \frac{100\ (R_{ij} - 0.5}{N_j}$$

Where,

R_{ij} = Rank given for the i^{th} variable by j^{th} respondents
N_j = Number of variable ranked by j^{th} respondents

The percent position estimated is converted into scores. Then for each factor, the scores of each individual are added and then total value of scores and mean values of score is calculated.

The percentage position of each rank was converted into scores using Garrett Table given by Garrette and Woodworth [6]. For each constraint, scores of individual respondents were added together and divided by total number of respondents for whom scores were added. Then, mean score for each constraint was ranked by arranging them in the descending order. Ranks were assigned and most important factors were identified.

3. RESULTS AND DISCUSSION

This subsection analyses the different causes and the perceived indicators of food insecurity among the wetland dwellers, determined the wetland contribution to household food security and assessed the determinants of wetland based income with a view on the adaptive strategies adopted by the households residing around Ranikor, Meghalaya using primary data from a survey conducted using a phone based survey and face to face personal interview using a pre tested questionnaire having both open and close ended questions.

Over 80% of the households reported experiences of food insecurity during the past few years and attribute it to a variety of causes (Fig. 1). The most frequently mentioned cause among the respondents was climate change which accounted for 34.29 per of the total respondents. Along with the mention of the cause of climate change, included in this category is the explicit mention of limited labour (15.71%), selling of food crops (14.29%), limited access to land (12.86%), pest and disease (10%), lack of see to plant (7.14%) and adoption of primitive farming methods (5.71%). The findings are in line with the findings of Turyahabwe *et al*. [7].

A number of factors were perceived as indicators of food insecurity (Fig. 2), but main ones which were listed by the respondents were situations of low household food harvest (32.86%) and lack of perennial crops (22.86%) and people buying

locally grown food items (15.71%). The other factors reported from the study area were lack of capital and no easy access to food stores where both accounted for 14.29%. The findings correspond with the findings of Turyahabwe *et al*. [7].

Contribution of wetlands to household food security: Wetlands were reported to contribute to household food security through provision of various wetland products and services. Over 75% of the respondents acknowledged that wetlands directly contribute to their household food security. They do so in a number of ways, but the most pervasive are three; direct consumption of wetland products, sale of wetland products for generating cash to buy food and wetlands providing space for growing crops.

Direct consumption of wetland products: Wetlands are reported to be a source of a variety of resources that are directly consumed among 31.43% of the sample households. Water was identified by up to 50% of the sample households as the most important product directly obtained for domestic and livestock use. Other important product included fish. Moreover, mainly indigenous fruits and various other vegetables were also harvested in the study area. There was a significant association between collection of wetland products for direct home use and the income level of the respondents also. Furthermore, 10% of the respondents reported to fishing from the wetland for consumption purpose. Other noticeable variations included variation in harvesting of fish with gender, age and household size. Fish collection is closely associated with males, younger individuals and members of larger households. The harvest of herbs also played an important role in maintaining the health of local people.

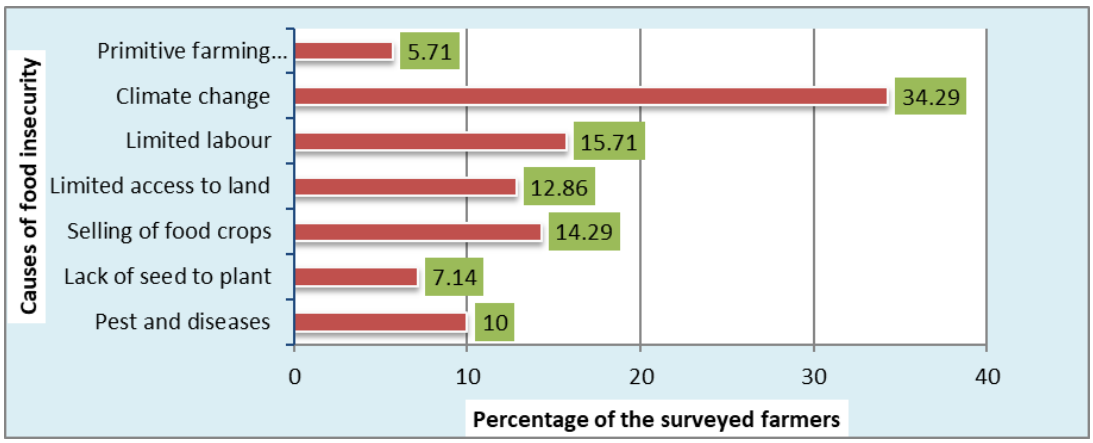

Fig. 1. Different causes of food insecurity among households
Source: Authors compilation from field survey

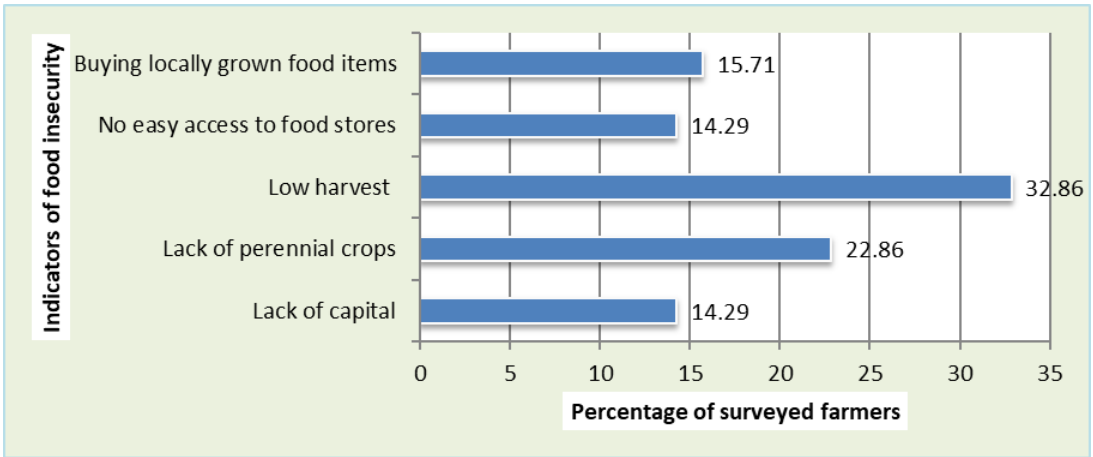

Fig. 2. Perceived indicators of food security among households
Source: Authors compilation from field survey

Growing of crops in wetlands: Wetlands also contributed to food security through providing space for growing crops (21.43%), and the sale of wetland products to raise cash income that is then used to purchase food. The main crops grown by respondents in wetlands were vegetables and paddy. Paddy was the staple crop grown in the study area. The main vegetables grown were cabbages, tomatoes, pumpkins, watermelons and potato. The other crops grown were sweet potatoes, fruits and ground nuts. There are observable significant differences in the extent of use of wetlands for growing crops across the vicinity of the wetland.

Sale of wetland products for cash to buy food: Wetlands also indirectly contributed to food security through provision of resources sold for cash that was used to buy food. About 25.71% of the respondents harvested and sold wetland resources for cash to purchase food for them and their family. Of these, about 40% spent one quarter of the income generated from sale of wetland products to buy food, about 25% one quarter to half, 25% spent a half to three quarters and 10% about three quarters. Main food items bought with such cash were mainly food security crops such as millet, maize flour, fish, meat and other cereals.

Wetland services: Wetlands provided services to local people that enhanced their livelihoods in meeting their food and nutritional security requirements. The most pervasive of these services include weather modification, cleaning water before local use, acting as breeding grounds for fish, and provision of water transport and tourism.

Variables that affect the extraction of wetland resources were identified in the study area. The income that was derived from the use or sale of wetland resources was considered as an indicator of resource extraction. The results of regression analysis for determining wetland income from the various socioeconomic variables are presented in Table 1. The F-ratio that was used to determine the model's overall goodness of fit was highly significant. From Table 1, it was clear that the explanatory variables included in the regression function described around 39.2 per cent variation in the dependent variable. From the analysis it was found that the explanatory variables viz., household size ($p<0.05$), age of the respondent ($p<0.1$) and the agricultural land area ($p<0.1$) has a significant effect on the wetlandbased income. All other variables in the model fail to show any significant effect. These findings coincide with the findings of Lamsal *et al.* [8] from their study of sustainable livelihoods through conservation of wetland resources: A case of economic benefits from Ghodaghodi Lake, western Nepal. Similar findings were also reported by Das *et al.* [9] in their study in West Bengal, India.

Wetlands throughout the world have long been subject to high levels of degradation and loss caused by human activities [10-12]. Table 2 shows the major adaptive strategies to climate change adapted by the respondents of Ranikor, Meghalaya. To rank the strategies, the Garret ranking technique has been used. From the analysis it was found that crop diversification was the main adaptive strategy with a mean score of 72.64 and second rank was given to poultry rearing with a mean score of 69.36 by the respondents. The third and the fourth rank after calculation was found out to be re-digging of canals (62.98) and income diversification (61.45), respectively. The fifth rank goes to construction of embankments with the mean score of 57.74. The results correspond with the results of Finlayson et al. [13] in their study on policy considerations for managing wetlands under a changing climate[14-19].

Table 1. Determinants of wetland based income

Variable	Coefficient	Standard error	t-ratio
Constant	694.12	103.61	2.44
Household size	39.57**	41.36	5.46
Education of the respondent	84.72	183.6	1.58
Age of the respondent	24.89*	14.44	1.78
Agricultural land area	21.58*	8.47	2.46
Distance to wetland	7.03	5.62	1.27
n=70			
R^2=0.392			

*Note: **and * indicate p< 0.05 and p< 0.1*

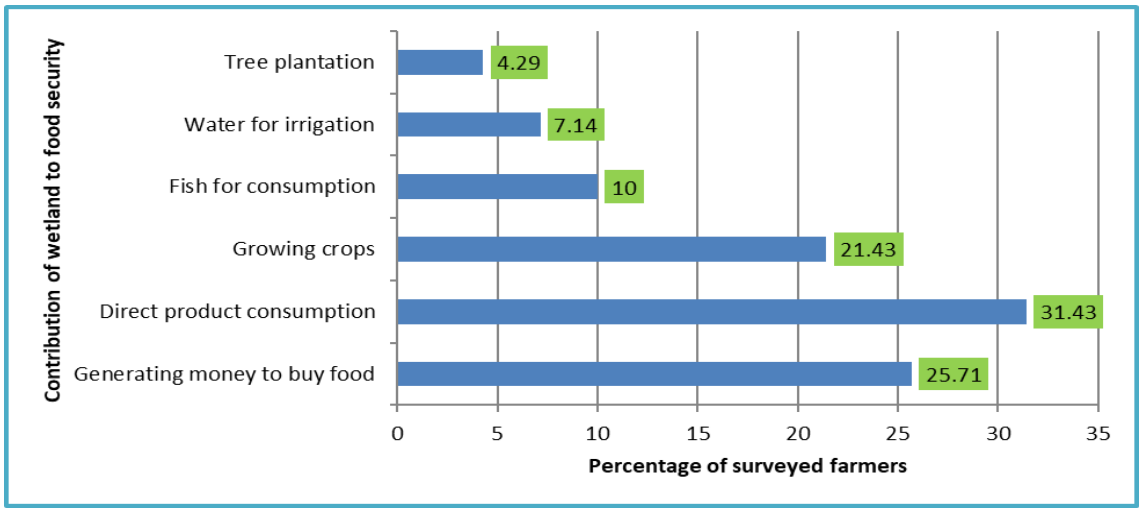

Fig. 3. Wetland contribution to household food security
Source: Authors compilation from field survey

Table 2. Adaptive strategies to climate change

Sl. no.	Particulars	Per cent Score	Rank
1.	Crop diversification	72.64	I
2.	Poultry rearing	69.36	II
3.	Re-digging of canals	62.98	III
4.	Income diversification	61.45	IV
5.	Construction of embankments	57.74	V

4. CONCLUSION

The present study revealed that wetland resources played a vital role in household food security of the wetland dwellers of Ranikor, Meghalaya. Prior to using wetland resources, there is a need for sustainable management of the wetland, keeping the situation of climate change in mind. However, implementing adaptive climate change solutions that are worthwhile in the study area requires careful consideration and ongoing research. The future viability of farmers who are heavily reliant on wetlands for a variety of resources has been determined to require both technology and policy solutions. Research efforts should be put towards addressing the climate change related challenges *vis a vis* revamping and judicious exploitation of the fisheries potential of the wetland. Most of the research carried out on wetland in India deals to the ecological and hydro-biological and biodiversity aspects. However the importance of wetlands in relation to climate change implications in fisheries, livelihood and nutritional security of the community has not been adequately addressed. The study urges the development of adequate food production technologies that guarantee the sustainable use of wetland resources for food security because climate change and population growth would have a significant negative impact on households that depend on wetlands for their livelihood.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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