



Food Security through Food Habit Change as an Adaptation Process to Climate Change

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Authors' contributions

This work was carried out in collaboration between both authors. Author MAP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Author MAR managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Adverse effects of climate change such as drought continue to be a major threat to rural livelihoods. This study investigates farmers' perceptions of climate change and adaptation process through food consumption and food habit change using a two community peoples' perception in Kurigram district Bangladesh. Study revealed that the daily livelihoods has affected due to climate change. Farmers' perceptions on adaptation to droughts were associated with food habit change. However, food habit change is not the complete solution. This may be an adaptation to the changes that may real, controllable

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and within their reach. Therefore, people have to adapt to climate change such as drought and do that by producing and promoting fresh, sustainable, reachable, cost effective crops that can withstand environmental changes through food habit change. The extent to which farmers' perceived agricultural diversity as a climate changes adaptation strategy may suitable.

Keywords: Climate change; drought; food habit change.

1. INTRODUCTION

Climate change may affect food systems in several ways [1]. The increase in frequency of extreme climate events worldwide [2] would exacerbate the problem of food insecurity. This may obvious for a number of developing countries. Food security in some particular regions of densely populated Asia may also be affected by the uncertainties exacerbated by climate change. Food and Agricultural Organization [3] reported that two-thirds of the world's hungry populations live in only seven countries which are India, China, Congo, Bangladesh, Indonesia, Pakistan, and Ethiopia.

The unobstructed growth of greenhouse gas (GHG) emissions elevates the earth's temperature. The frequent event of climate change combined with global population and income growth, threatens food security everywhere. High temperatures eventually reduce yields of desirable crops. Changes in precipitation trends increase the probability of short-run crop failures as well as long-run production declines. The consequence effects of climate change may affect in farming/cropping systems which may extent on people's daily food consumption. For example, the land currently suited for corn in a particular area may change to paddy rice. Similarly, paddy rice in particular area may be converted to corn, cotton or vegetables. These may finally affect on food habit and/or diet change for a particular community.

The overall impacts of climate change on agriculture are expected to be negative, threatening global food security.

Since global agriculture as well as food security are vulnerable to climate change [4,5], it is an emerging concern to prioritize the climate change adaptation process for present and future food security [6]. Individually, household level food security is of more serious concern than national food security. Because, food security systems in rural areas are mainly based on natural resource while urban areas are more dependent on imported food.

A number of examples of climate change represent increase in frequency of drought such as in the U.S. Corn Belt in 2012 [7], the extended drought during 2011 and 2012 in Texas [8], and bush fires in southeastern Australia in January 2013 [9]. The higher growing season temperatures can adversely impact agricultural productivity [10].

The frequency, the severity and the impacts of drought have been affected by climate change [11]. Drought is the most complex of all natural hazards [12] and a particular climatic disaster which may add significant costs for farmers and their agricultural systems extensively. Although drought has not been well described and defined [13], the natural resource-dependent sectors such as agriculture are the most vulnerable to the impact of this phenomenon. Drought is a periodic feature that could lead to the loss of crop production, food crisis and famine [14]. Drought impacts can manage at macro (national), meso (local)

and micro (village and household) levels [15]. However, the micro-level management which is '*what the farmers do in response to drought*' is of great importance [15]. That means how they (drought affected farmers) cope with drought or what is their adaptation strategy is need to be identified in the present circumstances that may allow to develop policy to mitigate drought at the national level through '*down to top*' approach.

Eskandari [16] reviewed the literature of the long-term annual precipitation trends which indicated that drought had a worldwide return frequency of every 20-30 years. Record shows that Bangladesh has experienced approximately 19 [17] drought events between 1960 and 1991 which mean a drought every 1.6 years. The Northern part of Bangladesh is among the most vulnerable regions to climate change impacts [18]. The majority of the population lives in this area in abject poverty. People are extremely dependent on rainfed agriculture for their daily livelihood. As a consequence, the abnormalities in rainfall patterns and temperature adversely impact their socio-economic and environmental survival [19]. The long-term climate variability impacts include significant changes in rainfall patterns and temperature. Extreme climate variability, such as drought in the northern part of Bangladesh, is recurrently accompanied by ecological decline and widespread food scarcity [18].

The northern part of Bangladesh experiences droughts regularly. In the last three to four decades when climate change reported to be observed in the northern Bangladesh, the situation has gradually decreased [20]. In Bangladesh, the agricultural activities are mainly rain-fed and heavily depend on rainfall [18]. This dependence makes this northern region particularly vulnerable to the adverse impacts of climate change. It has been reviewed in the literature that the scope (geographic coverage), frequency and magnitude of climatic changes and environmental degradation such as deforestation, water level decreasing and soil erosion have been gradually increasing in this region [21]. The potential adverse effects of climate change on this region's agricultural sector are of a major concern because of this dependence.

The climatic changes particularly drought, are becoming the major forces challenging the livelihoods of most farmers [20]. Although the country's crop production and productivity seems increasing since 2006's [18,19,22], the problem of food insecurity at national level remains the concern because of severity of food production constraints in this northern region. The rural population in this region, for whom agriculture is the primary source of food, direct and/or indirect employment and income, will be most affected due agriculture's vulnerability to climate changes [19]. As the sector is the largest consumer of water resources, variability in water access has a major influence on health and welfare of agriculture dependent poor. Mbugua [18] indicated in his report that *Kurigram* district in the northern part of Bangladesh is among the most vulnerable regions because of higher frequencies of drought and floods, lower access to technologies, fewer institutions dealing with climate related hazards, and lack of infrastructures.

The study was aimed to generate primary information from the farming communities of *Kurigram* district related to climate change. This study also examined the perception of target farmers on the trend of climate change and related abnormalities, existing coping strategies in place to secure food through food consumption and food habit change. It would also draw an implication that would assist policy makers to decrease the vulnerability of rural farming communities to adverse impacts of climate change to secure food in drought area.

Limited study has conducted regarding the knowledge, attitudes and experiences on food consumptions and/or daily dietary changes due to the impact of drought in micro level

means from individual household level in Bangladesh. Therefore, the objective of this study was to evaluate the perceptions and attitudes of experiences on food consumptions and/or daily dietary changes due to the impact of drought and resilience food security associated with drought from micro level.

2. MATERIALS AND METHODS

2.1 Study Area

The study areas were selected in the drought prone northern part of Bangladesh where a farmers' community practices their food habit change as an adaptation process. Two Uapzila *Bhurungamari* and *Chilmari* in *Kurigram* district was selected based on the study objectives.

2.2 Required Data

The study investigated and tried to find out the answers through the research questions given below; is there any relation between drought and livelihood particularly agricultural crops for food production among the target population in the study area? What practices they are used to cope with the situation? What are their perceptions and attitudes about the adaptation they are practicing? A cross-sectional study of perception, attitudes and experience of traditional and present agricultural activities for food production and food consumption practice was carried out.

2.3 Ethical Considerations

Ethical considerations are essential to any form of data collection in a humanitarian opinion. Prior to filling the questionnaire, informed consent was obtained. Participants were treated fairly and with dignity. The fieldworkers were required to sign a statement that they would not reveal identifying information to anyone outside the research. Furthermore, code names were used in all field notes. A master key was retained for un-coding the personal data at the end of the study, at which time all keys were destroyed.

2.4 Selection of the Study Group

Based on the socio-economic circumstances in the study area, initial observation suggested that a number of significant and distinct groups of people are affected due to drought in the selected study areas such as; ultra-poor, marginalized people, middle income population and high income. However, other consequences were also considered to identify the subject people such as; educated population, illiterate and ethnic community. Having identified these potentially significant groups, each group was sampled according to a sampling plan appropriate to that type of population. Number of subjects was sampled according to 95% confidence intervals using a Population Proportionate to Size (PPS) stratified plan considering the study subjects. The sample size was allocated to different groups on a PPS basis, with redistribution of the sample to ensure that the minimum sample size required for any group in both of the Upazila. A total of $n = 210$ (*Bhugungamari* = 101 and *Chilmari* = 109) participants were surveyed across the selected groups by purposive and authoritative sampling techniques. Each participant was given a unique code number with sex (Rs1- Rs 210). Various factors including gender, age, access to irrigation water, occupation, income, ethnicity and land holding size were considered during sampling.

2.5 Data Collection

An observational approach was adopted which reduces the impact of the data collection process on the behaviours of the observed population. The principal investigator watched the actions and behaviours of selected participants in their usual settings, noting the routine aspects of daily life and nature of work activities. At the same time third person listening approach was applied to observe the interaction between two or more individuals within the pragmatic social and cultural environment of their daily livelihoods. A semi-structured questionnaire survey including a separate part of self-reported perception survey (scale 1-11) and Likert scale survey (1-5) was arranged, as judged appropriate in each individual circumstance, including demographic information, occupational activity, questions dealing with agricultural activities and finally adaptation with drought in the changed climate and coping strategies. An informal dialogue approach was also applied where formal techniques were not being judged appropriate. The dialogue approach involved face-to-face interviews between the researcher and selected informants at times and places where the participant's interest could be obtained and retained. Focus Group Discussions (FGDs) were conducted to generate information on the perception of the farmers to climate change and existing coping strategies from each of the various subject groups. This group setting has provided a forum that encouraged the participants to disclose their personal experiences with droughts. Tools such as food habit identification and characterization, food habit behavior, food habit ranking matrix were used to acquire information on subject populations' perception on agree or disagree of food habit changes, priority and finally satisfaction on changes. The satisfactory Likert Scale ranked was very satisfactory-satisfactory-neither satisfactory or nor dissatisfactory-not satisfactory and the rating number converted to percent to assess satisfaction level.

2.6 Data Analysis

Qualitative data were analysed using a wide range of qualitative mode of study in order to provide an understanding of study subjects attitudes and perceptions. Manual line-by-line in-vivo microanalysis of the interview data was conducted. Each line of text was read and assigned a code utilizing the respondents' own words. The researcher examined the interview narratives and field notes looking for indications of categories. Categories of data were then combined to create over-arching themes. Likert Scale data and other perception data were coded and analysed by descriptive statistics and presented by graphical representation. Photographic data were also collected and used to support and interpret the result more effectively.

3. RESULTS

General beliefs about drought related to coping strategies by food consumption and food habit change were extracted in summarized form as presented bellows. Study revealed through qualitative discussion among the subject populations that some changes are occurred in nature which may describe as climate change. One of the respondent (Rs 24, male; aged 38) stated when asked about the changes that;

"...there are confusing differences in the seasons between when we were young and nowadays. There is many confusion, it gets cold in the night during the summer when it is not supposed to and gets hot when it wants, rains are no longer well... but it is not common nowadays because of hotness...seasons are confusing nowadays..."

Another respondent (Rs 73, male; aged 62) claim;

“At the present time rain just comes confusingly, whenever it wants... and goes anytime... sometimes it rains continuously that we cannot do any work and sometimes instead of the rains reducing and stopping, it continues and falls heavily devastating our crops that were ready for harvesting. It is confusing to understand the rains nowadays...”

The in-depth question such as *“why do you think to change your agricultural activities?”* a respondents (Rs 61, male; aged 56) replied due to the previous stated reason;

“...as because therefore, we need to change our life style such as cropping pattern, food consumption, daily dietary particularly plant-based food and frequency of the daily diet.”

About the changes some of the respondents (Rs 20, male; aged 38; Rs 89, male; aged 35, Rs 102, male; aged 43) among many define in another way and revealed the answer when asked *“what do you think causes this change?”* replied one of them (Rs 20, male; aged 38)

“This is the changes of modern world. People are practicing technological irrigation and disturb the nature like soil, so that water goes down as a result weather are changing.”

A few number of respondents (Rs 109, male; aged 30; Rs 145, male; aged 46; Rs 110, male; aged 48) out of the sampled populations believed that climate change is a natural and normal process as reflected one of the respondents (Rs 109, male; aged 30) with intellectuality from many;

“Nature keeps changing since the earth creation and human civilization. It is a cycle of nature.”

Another (Rs 201, male; aged 51) added with him that,

“...nature is normal but we are experiencing climate change in a short time frame.”

These qualitative findings are consequently observed in the structural analyses which are presented in the following graphical distribution.

Fig. 1 shows the occupational situation of the respondent's in the study area. Non-farm economic activities are found to be higher than farm economy for both of the study area. But the situation was different before 50 years stated a number of respondents. As the farm economic activities are disturbed due to drought, people are occupied themselves nowadays in non-farm economy. Consequently, this has influence on crop diversity and finally people are changing their food habits which have also observed in the sampled area.

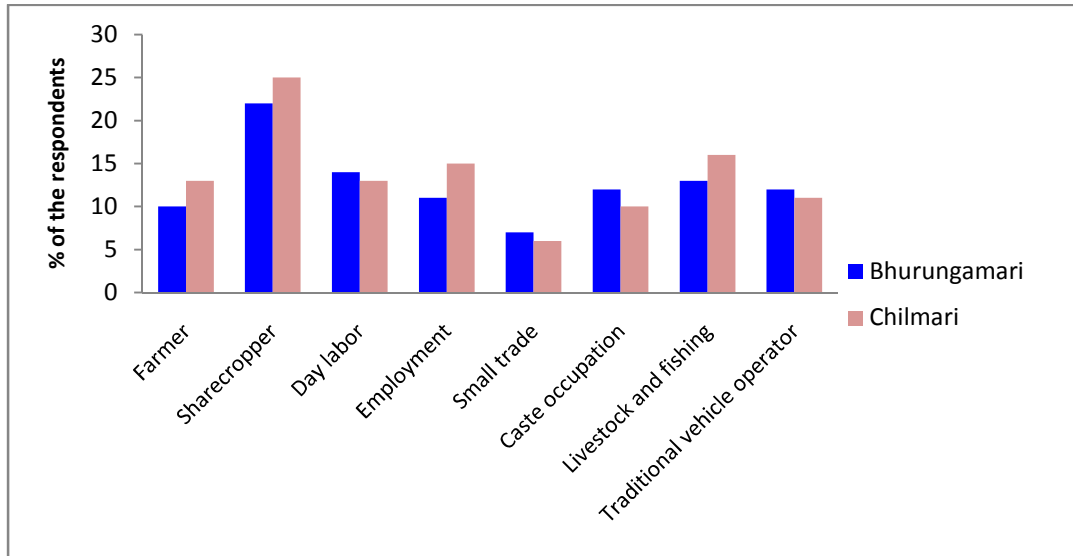


Fig. 1. Occupational situation of the respondent’s in the study area

The similar result has reflected on the economic activities which are shown in Fig. 2. In the *Chilmari*, non-farm economic activities are significantly higher than farm economy (χ^2 test). This may be due to drought. In the field survey, it was observed that people are suffering of water scarcity. Therefore, some of them are not interested on agricultural activities due to weather constraints. In that particular area, the main source of water for irrigation is ground water or rain water. However, due to the decreasing of water level and increased temperature people cannot do their traditional agricultural activities. In a particular time, people experience on water from rain and natural water bodies. Due to the scarcity of water at present time, farmers have to pay more for agricultural activities from before. Therefore, people are changing in non-farm activities and the rate of non-farm economic activities are increasing. They don’t need to wait for natural blessings. They can earn more money to survive. If they earn good amount of money, they believe it may help to solve any problem such as food consumption and food choice. They have secured the ownership on their food choice and can change their daily dietary.

Fig. 3 shows the perception of the respondents on patterns of temperature change in the study area where the perception on temperature increasing is significantly high. Consequently Fig. 4 shows the patterns of rainfall in the study area where the perception on decreasing of rainfall is significantly high. In both of the figure shows the changed behaviour of climate which is the indication of drought. The pictorial data of the study area in Fig. 5 is also support the indication of drought.

Fig. 6 shows the awareness of the perceptions on drought in the study area where significant number of respondents’ is experiencing on drought and most of them are aware about it. Similarly significant number of the respondents’ are thinking that it affects their daily livelihood.

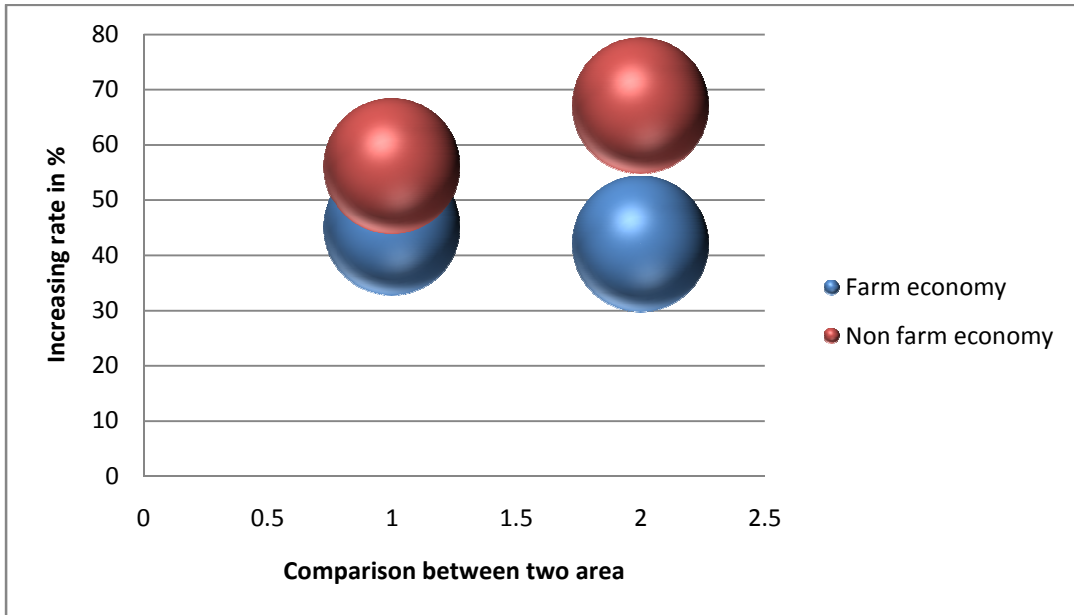


Fig. 2. Economic activity in the study area

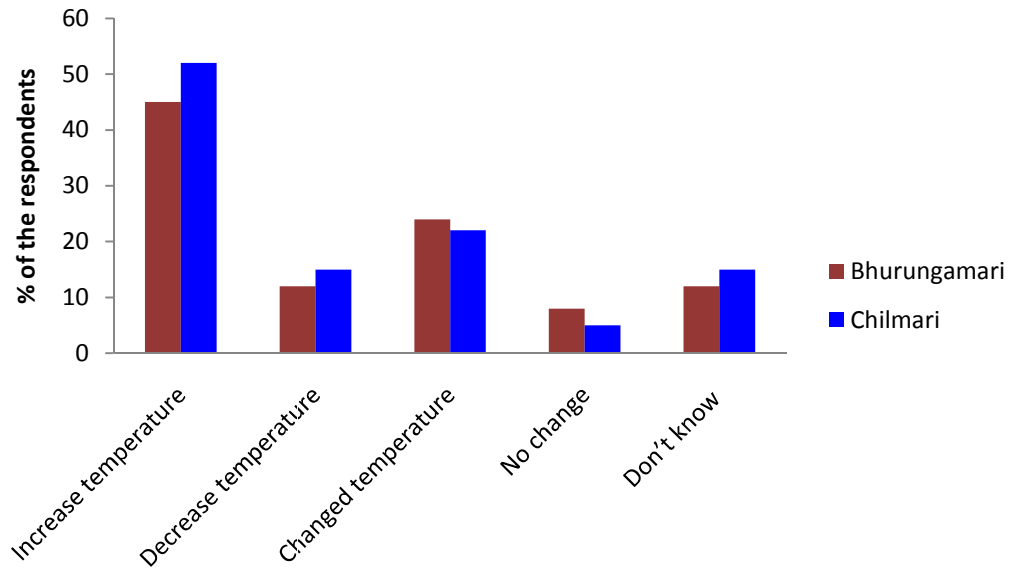


Fig. 3. Respondents' perception on patterns of temperature change in the study area

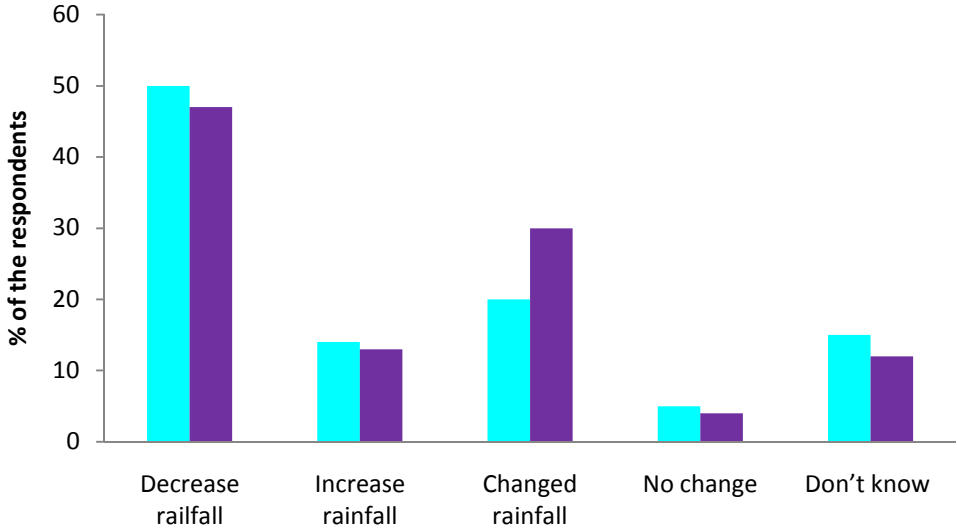


Fig. 4. Respondents' awareness of perception on patterns of rainfall change in the study area



Fig. 5. The drought symptoms of the study area

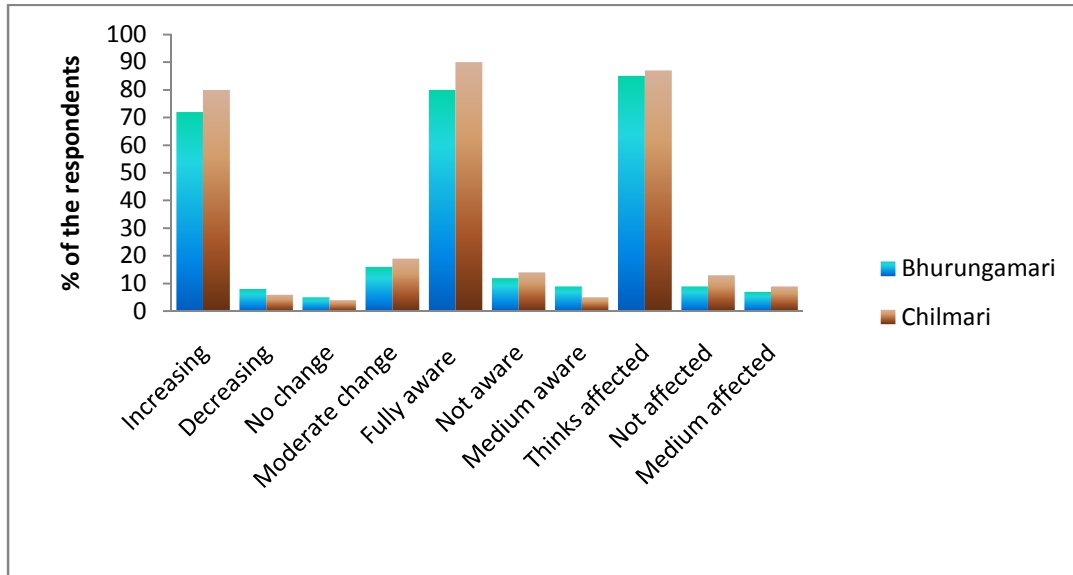


Fig. 6. Respondents' perception on drought in the study area

Fig. 7 shows the impact of drought on daily livelihood of the subject population in the study area according to their perception. Self-reported perception analysis was applied to assess the prevalence of impact of drought on daily livelihood among the subject population in the study area. The survey was conducted simultaneously in *Chilmari* and in *Bhurungamari* to eliminate the confounding effect of seasonal variation on livelihood response. Since many respondents were illiterate and poorly educated, the investigators explained the drought related questions. Self-reported perceptions were scored by using the pseudo-score system [23]. This system was chosen for its ease of interpretation. The respondents were asked to prioritize the impact which affected them and to rank daily livelihood according to priority. A daily livelihood option (phenomenon) which was given first priority was allocated 11, second priority was allocated 10 and third priority was allocated 9 and so on. The first priority was allocated 11 because the highest number of phenomena was found to be 11 among all the respondents. Finally the analysed summaries of data are presented in graphical arrangement.

It was observed that a number of daily activities are impacted where the prevalence of the impact was observed to be higher on cropland, food consumption and finally on food habit change indicates that the target populations have already been adapted with changed food habit. This result also reflected on the other analysis presented in Fig. 8.

Fig. 9 shows the respondent's perception on food habit change in daily dietary using Likert scale that they are agreed with the changed habit or not. The result indicates that most of the people are agreed to change their food habit which may help them to adapt to drought. However, a few numbers of respondents have found with no comments and not concerned.

Fig. 10 shows the final analysis of the satisfaction on food habit change among the studied population using satisfaction Likert scale. The analyzed data shows that most of the studied populations are happy and satisfied about their food habit change in both of the study area. This may suggest that the peoples have already started the 'food habit change' as an

adaptation process. However, the result indicates that food habit change in daily dietary can be a suitable adaptation process to climate change. This may be an effective adaptation process in the area where local crop cultivation and production is affected due to climate change. But the farmers need to be habituated with the diversified crop and farmland. This also indicates that plant-based food production and consumption will be affected more than animal-based dietary. Changes in the diet toward more plant-based foods can help to mitigate climate change in an energy-efficient manner [24].

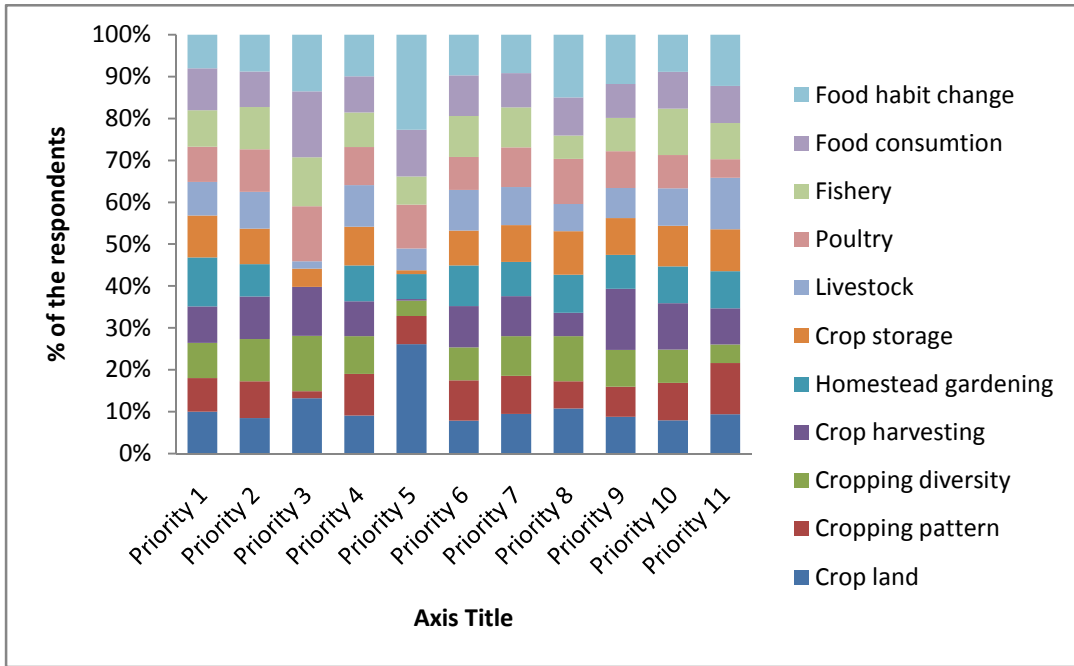


Fig. 7. Respondents' perception on drought impact in the study area

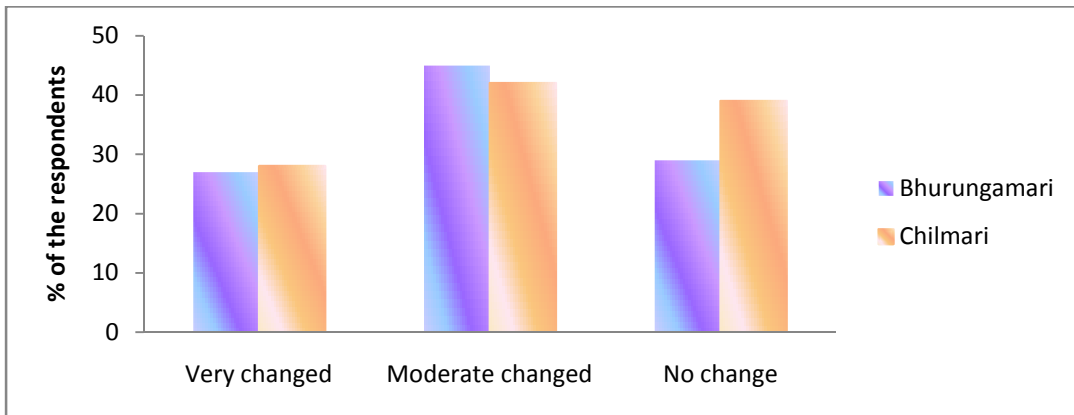


Fig. 8. Respondents' perception on food habit change in the study area

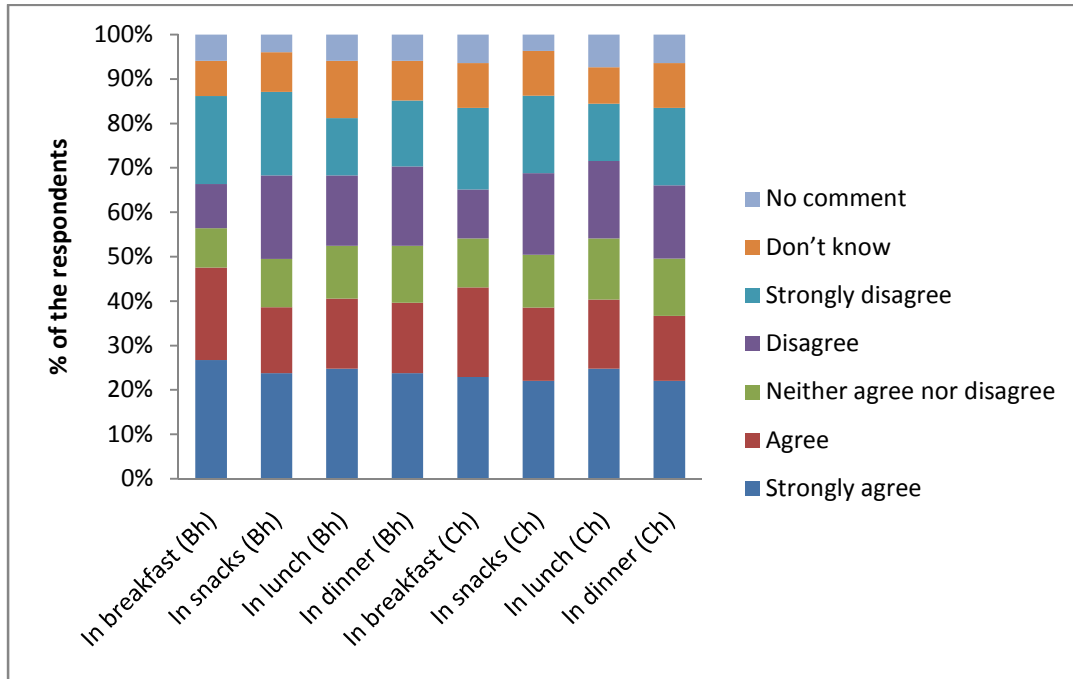


Fig. 9. Respondents' perception on food habit change in daily dietary in the study area

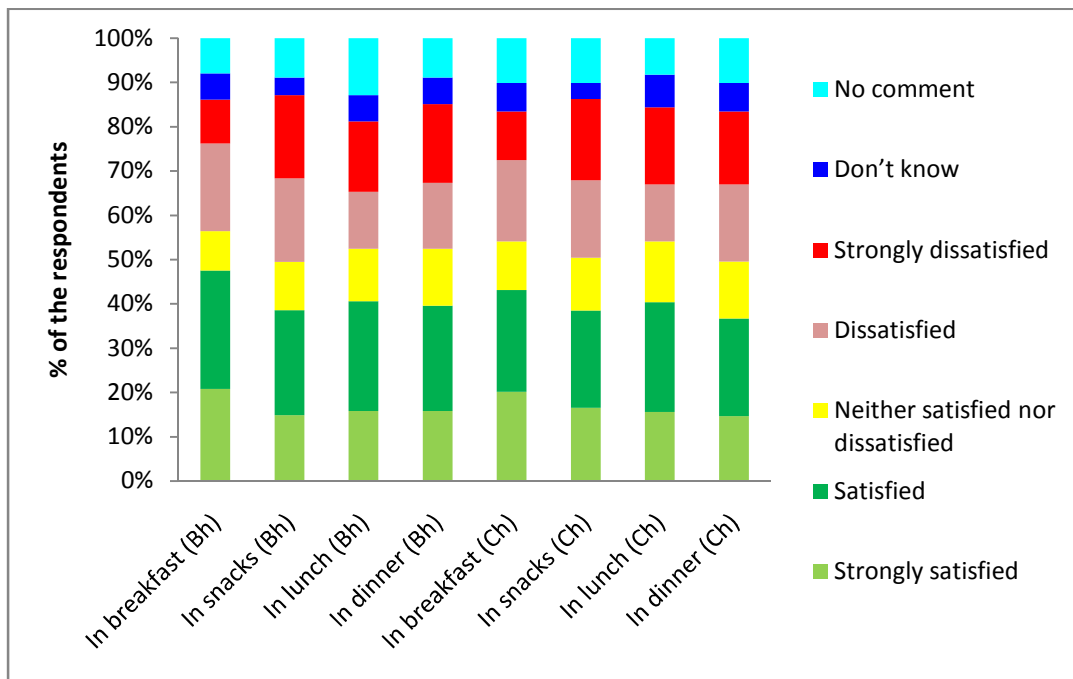


Fig. 10. Respondents' perception on satisfaction about food habit change in the study area

4. DISCUSSION

Farmers apply various strategies to reduce the impacts of drought. Some applications have a limited impact on drought mitigation and some strategies increase farmers' responsibility during drought [25]. However, when natural, physical and financial resources are limited, the need for an accurate assessment of coping strategies becomes acute. In that case, farmers' play vital role in individual micro level adaptation strategy. In the present study, the subject farmers' coping strategy is in individual micro level. People are practicing their personal choice to mitigate the drought and adapt to climate change. They are practicing their personal food habit, food consumption and daily dietary change. This is the initial stage of micro level adaptation strategy. This strategy is fully related to crop diversification. In the present study, it was found that some of the respondent farmers are already changed their crop production and some are changing. Because, in the study area, it was also found that the land which was suited for paddy rice is now changed to corn production. Similarly, a number of agricultural lands are changed from previous agricultural production. Therefore, the people who are consumer of the agricultural production grown on that particular land area have to change their food habit and daily dietary. This is happened in the study area. In addition, study revealed that people are more changing their plant-based food habit as most of the people are living on abject poverty. They are taking their protein mainly from vegetable sources as they cannot afford animal based protein. They may afford fish-based protein in some cases, but due to scarcity of water fish is not available for round the year in the water body. Plant-based protein is helpful and suitable for environmental health. Although some animal products are fairly climate efficient but more "climate efficient" is to produce protein from vegetable sources than from animal sources [24]. Rice consumption per person per year seems to be unchangeable in the study area but wheat-corn consumption transition in the study area needs to be considered. These results may think for wider community.

Because of a prolonged dry period in the study area, potato and crop productions are expected to be only half of what they were last year. Similarly, too much rain has negative affect for sugarcane. While climate influences pragmatically all aspects of life, the impact on agricultural production and consequently food consumption is likely to be particularly important. Because food demand is inelastic, the reduction of agricultural production from the direct impact of drought can induce more increase in agricultural price and raise people's food habit change. Sudden spikes in the prices of agricultural production threaten the wellbeing of every individual. This may influence the change of food habit.

It was observed in the study area that, in emerging drought crisis, a new household community has developed whose members have completely different eating habits than their parents' and grandparents' generations. Meat is no longer the luxury it once was with a portion of fish.

Researchers have pointed out that rural people are particularly vulnerable to climate change, especially in the case of extreme weather events such as droughts. In the dry regions of northern districts in Bangladesh such as *Kurigram*, a reduction in rainfall and an increase in the incidence of drought in recent years have been shown to affect local farming activities and farmer income.

In the future, if not adopting adaptation measures such as adjusting crop varieties or improving farm management, it would be difficult to change food habit as an adaptation process. In order to improve adaptation capacities by food habit change through agricultural production, it is not only the role for government to undertake actions such as improving

irrigation strategy and adoption of improved technology or farm management, but also necessary for farmers to make appropriate responses such as cropping patterns change.

In the present study a few options were examined to know the attitudes of farmers on crop cultivation in responding to drought regarding food habit change. Crop choice based on empirical analysis of the selected respondents in the study area, showed that farmers in drought places are more likely to produce peanut, cereals, potatoes, oil crops, spice crops, strawberries and maize and less likely to grow rice, wheat, jute, and sugar. These results indicate that they have already started to make crop planting shifts according to local climatic conditions. Field studies in both Upazilla have showed similar behavior among farmers. Farmers faced with drought are inclined to choose a crop that is more adaptive, multi-functional and high yielding, with better economic returns under such conditions [26].

Despite the importance of improving adaptation capacity to mitigate the impacts of climate change on agriculture sector, the current level of knowledge on climate change and its impacts such as drought is not adequate to support the implementation of strategic plan on adaptations in the study area. The implementation of adaptation plan is constrained by the institutional, socio-economic, attitudinal and behavior barriers and the availability of resources and building adaptive capacity are particularly important for developing countries. How to identify these constraints or barriers is one of the key steps to facilitate the adoption or implementation of suitable adaptation options in the study area. In addition, understanding the effectiveness and cost-benefit of adaptation options are also particularly important for policy makers to design suitable adaptation strategies. Presently, although some scientists have applied the top-down approach (mainly crop model) to examine the effectiveness of some adaptation options [27,28], the bottom-up approach to evaluate the effectiveness and cost-benefit of adaptation practice are still in their infancy. Until now, only a few studies [29] quantitatively analyze the farmers' adaptive responses to climate change (such as adjusting cropping patterns or changing irrigation choice). While Ju et al. [26] analyzed farmers' responses to drought and proposed actions of changing crops or varieties in Ningxia, China, most existing studies are based on macro-level and qualitative analysis [30]. This may be an initial starting to analyze micro-level study using quantitative and qualitative information together.

According to the scholars climate change might force changes in diets around the world as certain staple foods become harder to produce. The present study revealed the similar results with statistical significance in the study area. This may be a suitable adaptation process for the people who are affected due to drought. However, future shortfalls could be balance by diversifying to crops which can thrive in those altered climates.

Some crops in the northern region of Bangladesh are able to adapt. It is an emerging time to have to think about switching out of growing some crops entirely. For example, by later this decade the drought prone area will no longer be suitable for growing some crops such as millet (local name '*coun*'), some edible oil corps (local name *teel*, *tishi*, *kalijira*) and a number of rice varieties. Potatoes, maize, and peanuts are becoming better options. When we start thinking through all that, it means changes in people's diets and these are fairly fundamental cultural changes due to drought. A number of studies have been outlined the predicted impacts of climate change on food production, and also on food security.

Food habit change is not the complete solution. This may be an adaptation to the changes that are real, controllable and within their reach. This has been practicing since the first human being started to grow his own crops. This will help a variety of uncommon food

products, from farmers that want to optimize, safeguard and maintain their and our future existence, without having to worry about environmental issues.

There is still debate that the evolution theory of Charles Darwin no longer applies to us as because human beings species is on the top of the food chain. What's forgotten in this point is that our food chain itself is definitely still part of Darwin's theories on the natural selection and adaptation of species through the environment. Therefore, people have to adapt to climate change such as drought and do that by producing and promoting fresh, sustainable, cost effective crops that can withstand environmental changes though food habit change.

5. CONCLUSION

For the next future, it may recommend a better synergy between environmental and health education to obtain agreement for a dietary change for the general public. Plant based diet has health benefits and environment friendly [31]. In many ways it is suggested for climate-friendly consumption.

Climate-friendly food consumption seems to be challenging for farmers. Adaptation to climatic changes requires a combination of various individual responses at the farm-level and assumes that farmers have access to alternative practices and technologies available in their area. But it mainly involves changes in agricultural management practices in response to changes in climate conditions for agrarian community. Adaptation of people to different hazards vary from household to households and region to region based on existing support system to increase the resilience of affected individuals. Despite growing literatures on the impacts of drought in the northern Bangladesh to climate change and food security through food consumption and food habit change, there are still several research gaps that need to be addressed by the scholars in the near future. Our forthcoming paper will focus on the individual dietary level and food security while concentrate on plant-based or animal-based.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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