



## Climate Change Patterns and Problems that Faced by Smallholder Farmers for Taking Adaptation Decision

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**Abstract:** Bangladesh has experienced more variable climate patterns, and the mostly affected parties are smallholder farmers. Although farmers faced by different problems, they want to take adaptation decision for reducing the climate change impacts. Thus, the studies aim to conduct climate change patterns and problems faced by smallholder farmers for taking adaptation decision. The study uses primary data that are collected from the Godagari upazila of Rajshahi district through multistage random sampling technique. The result indicates that rainfall, surface and ground water decreased where as temperature increased. Farmers also observed rainfall and surface water level decreased 'medium degree', ground water level decreased 'high degree', and temperature increased 'high degree'. Among the climatic hazards as experienced by farmers, the result of weighted average index indicates that the rate of occurrence of drought is ranked highest and increased length of summer season is ranked lowest. Problem confrontation index indicates among the different problems that faced by farmers, the lack of access water is ranked highest and the high cost of chemical is ranked lowest. This study suggests meteorological agency needs to improve the prediction of future weather condition and should take necessary steps to solve the problem that faced by farmers for taking adaptation decision.

**Keywords:** *Climate Change, Adaptation Decision, Smallholder Farmers, Weighted Average Index, Problem Confrontation Index.*

**Introduction:** The term "climate change" is defined as any change in the average daily weather pattern such as higher and more variable temperature, changes in precipitation patterns and increased occurrence of extreme events like droughts and floods [1] over an extended period of time, usually for decades or longer [2]. In 1979, the first World Climate Conference introduced human being as the main culprit for changing climate. In that time, the changes were small and it did not grow global attention. It becomes the concerning issue when the IPCC (1988) expresses the negative consequences of climate change in the world [3]. The greenhouse effect, increase in world temperature, decrease of surface and ground water, uncertainty of rainfall are the major negative consequences of climate change [4]. These negative consequences impact on agriculture adversely as it directly depends on the climatic conditions. Moreover, the consequences of climate change on world agriculture are not same. In the tropical regions, small amounts of warming reduced the crops harvested. In the cold areas, crop harvests may increase for moderate increase in temperature firstly, and then falls. Higher temperature creates large decline in cereal (e.g. rice, wheat) production around the world [5].

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Since all climatic factors are directly related to agricultural production, the agriculture sector is affected by the adverse impacts of climate change.

In Bangladesh climate change has become a serious concern because of its adverse effects on agriculture sector. The agriculture of Bangladesh is characterized by smallholder farming due to frequent land fragmentation. As they are poor, they are unable to increase production easily due to lack of capital for investment in modern technology. In addition, they are highly vulnerable to natural disasters [6] and they are resource poor in terms of land and capital endowments. As a result, they are badly affected by the impacts of climate change as they cannot cope with it [7]. Although adaptation is an essential strategy to enable farmers to cope with the adverse effect of climate change and variability which in turn increase the agriculture production of the poor farm households [8], smallholder farmers in Bangladesh have limited information on their overall vulnerability and adaptation needs [9].

Moreover, smallholder farmers are faced by the various limitations in adapting climate change outcomes because of lack of information on climate change and the suitable adaptation measures as well as lack of loan [10]. Again, when they want to choose particular adaptation decision, the farmers face inherent barriers like, shortage of water, land, funds, seeds, capital, loan, lack of information and unpredictable weather [11, 12]. Poor planning is also observed as a hindrance in choosing particular adaptation decision. According to Sarker *et al.* (2013) most important barriers of smallholder farmers in Bangladesh for choosing adaptation decisions are lack of weather information, lack of knowledge on appropriate adaptation strategies and a lack of loan [13]. So from the above analysis it indicates that for reducing climate change impact on agriculture of smallholder farmers it needs to know what types of climate pattern occur and to take the right decision about adaptation it needs to know what types of problem faces. Thus, the study tries to analysis the changing patterns of climate and problems that faced by smallholder farmers when they want to take adaptation decision.

**Materials and Methodology Study Area and Sample Selection:** The study uses primary data collected through field survey from the smallholder farmers of Godagari upazila in Rajshahi district. Most of the people of Godagari area are dependent on agriculture for their livelihood-support. But the climate is characterized by high temperature and low rainfall which make it severely drought-prone. As a drought-prone region, apart from the production loss, smallholder farmers of the upazila are facing numerous problems like; land degradation, lower employment opportunities, losses of livestock assets, increases in illnesses and chronic energy deficiency among workers.

Thus, this area is chosen as the study area of the present study. The study uses five-point Likert scale to observe the pattern of climatic events and also used weighted average index to rank the different climatic hazards as experienced by smallholder farmers. Again when farmers want to take adaptation decision, they face different problems. For this reason problem confrontation index is used to rank problems that faced by farmers.

The primary data are collected randomly from the 100 smallholder farmers. The survey is conducted in 2019 (August-September). The primary data have been collected from smallholder farmers through interviewing them face to face using a well-designed questionnaire that is prepared with great care on the basis of research questions. The questionnaire includes both close ended and open ended questions. For sample selection, multi-stage random sampling technique is applied. Rajshahi district consists of 9 Upazilas and 4 Thana. The upazilas are Bagha, Bagmara, Charghat, Durgapur,

Godagari, Mohanpur, Paba, Puthia and Tanore upazila and the Thana are Boalia, Motihar, Rajpara and Shah Makdam. Among them Godagari upazila is selected purposively. In this upazila, there are 1 Paurashava, 9 unions, 389 mouzas and 396 villages. Firstly, the researcher selected two unions randomly, which are Matikata and Godagari. In the next step, from each union two villages are selected randomly. The selected villages are Saharogaci and MatikataVata from Matikata, Saguan and Uzanpara from Godagari. Table1 represents the total sampling information.

**Table 1.** Selection of the Respondents

Name of the Union	Village	Number of Respondents
Matikata	Saharogaci	25
	MatikataVata	25
Godagari	Saguan	25
	Uzanpara	25
Total	2	4
		100

**Calculation of Weighted Average Index:** To identify how smallholder farmers perceive their local climate, that is, to identify the perceptions on the state of the local climate for the past 10 years. Perceptions on climate change are divided into three categories: increasing, decreasing and don't know. The increasing and decreasing patterns of the climatic events are not same. In order to that, for measuring degree of the climatic events five-point Likert scale is used. Respondents are asked to score on a 0-4 Likert scale (i.e., in terms of not at all, low, moderate, high and very high degree). In the study area, smallholder farmers are also experienced by climatic events and variability indicators. The degree of occurring climatic events and variability indicators are not same. So, in measuring the rate of occurrence of different climatic events that experienced by smallholder farmers, a weighted average index is used. The weighted average index is formulated in the following way:

$$WAI = \frac{F_4W_4 + F_3W_3 + F_2W_2 + F_1W_1 + F_0W_0}{F_4 + F_3 + F_2 + F_1 + F_0}$$

$$WAI = \frac{\sum_{i=0}^4 F_i W_i}{\sum_{i=0}^4 F_i}$$

Where, F= Frequency

W= Weight of each scale

i= 0, 1,2,3,4

and, 0= Not at all; 1= Low degree; 2= Moderate degree; 3= High degree; 4= Very high degree

If the value of index is high then it signifies high rate of occurrence of the climatic event. If the value of index is low then it signifies low rate of occurrence of the climatic event.

**Calculation of Problem Confrontation Index:** To identify the problems that faced by smallholder farmers when they want to take adaptation decision, a ranking was conducted using the Problem Confrontation Index (PCI). Respondents were asked to grade their perceived problems based on a 0–4 Likert scale (i.e., ranging from “not a problem” to “very highly problematic”). The PCI value was estimated using the formula below:

$$PCI = P_n \times 0 + P_l \times 1 + P_m \times 2 + P_h \times 3 + P_v \times 4$$

Where

PCI = Problem Confrontation Index;

$P_n$  = Number of respondents who noted as no problem;

$P_l$  = Number of respondents who noted as low problem;

$P_m$  = Number of respondents who noted as moderate problem;

$P_h$  = Number of respondents who noted as high problem.

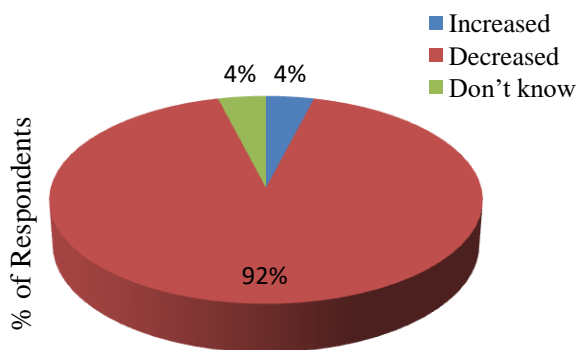
$P_v$  = Number of respondents who noted as very high problem.

The value of PCI index indicates the importance of problem that faced by smallholder farmers. If the value of index is high then it indicates the highest problem faced by smallholder farmers. If the value of index is low then it indicates the lowest problem faced by smallholder farmers.

## Results and Discussion

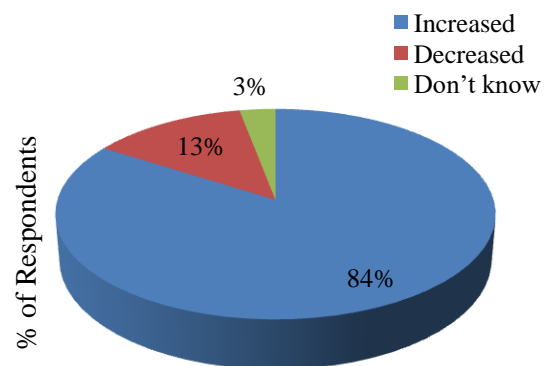
### Perception of Smallholder Farmer about Rainfall and Temperature Changes:

The respondents in the study area perceived about rainfall and temperature. Based on the perception of farmers, they are classified into three categories such as 'increased', 'decreased' and 'don't know'. Smallholder farmers' perceptions on rainfall and temperature are presented below in figure 1 and 2.



Responses

**Fig. 1:** Changing Patterns of Rainfall



Responses

**Fig. 2:** Changing Patterns of Temperature

The result in figure 1 and 2 signifies that 92 respondents have noticed the decreasing pattern of rainfall while only an insignificant 4 respondents have noticed the increasing pattern of rainfall. Moreover, only 13 respondents have noticed the decreasing pattern of temperatures while 84 respondents have noticed the increasing pattern of temperature. So, most of the respondents have noticed that the temperature is increasing and rainfall is decreasing. But the perceptions of the farmers regarding the patterns of

decreasing rainfall and increasing temperature are not same. The decreasing patterns of rainfall and the increasing patterns of temperature that observed by smallholder farmers are given below in table 2.

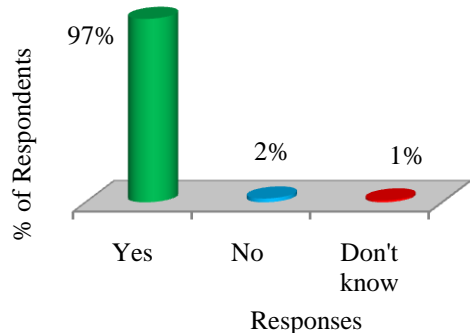
**Table 2.**Decreasing Patterns of Rainfall and Increasing Patterns of Temperature that Observed by Smallholder Farmers

Response	No. of Respondents	
	Rainfall	Temperature
Very high degree	21	29
High degree	23	40
Medium degree	26	9
Low degree	18	4
Very low degree	4	2
Total	92	84

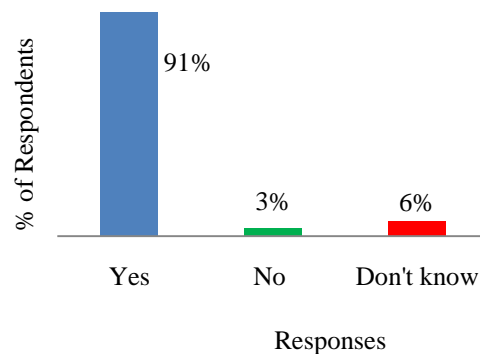
In table 2, it represents that most of the respondents observed that rainfall patterns have decreased by medium degree whereas temperature have increased by high degree. But only few respondents perceived that decreased rainfall and increased temperature patterns is very low.

### Perception about Surface and Ground Water Level Changes

The researcher also collects data about another important climatic variable such as ground and surface water level changes. Smallholder farmers responded about these variables over the past several years. Farmers' views on these variables are shown in figure 3 and 4.



**Fig. 3:** Changing Patterns of Surface Water Level



**Fig. 4:** Changing Patterns of Ground Water Level

Figure 3 and 4 shows the smallholder farmers perception about the changes in availability of surface water and availability of ground water. In figure it indicates that the small portion of the respondents noticed 'don't know' and 'increased' about the changes of surface and ground water. Again, it reveals that most of the farmers noticed the decreasing pattern of the availability of surface and ground water. According to the perception of farmers, the decreasing patterns of surface and ground water are not same. It is shown in table 3.

**Table 3.** Decreasing Patterns of Surface and Ground Water that Observed by Smallholder Farmers

Response	No. of Respondents	
	Surface Water	Ground Water
Very high degree	19	22
High degree	24	24
Medium degree	25	21
Low degree	11	14
Very low degree	14	7
Total	93	88

The data presented in table 3 indicates that the highest portion of the respondents observed the surface water decreased in medium degree. Again, most of the respondents perceived the ground water decreased in high degree.

### Climatic Hazards as Experienced by the Smallholder Farmers

In the study area, the farmers observed the climatic hazards such as drought, floods, off-seasonal rainfall, increases unpredictability weather and so on. Farmers have responded about these variables that occurred during the last 10 years. Farmers view on these variables is shown in table 4.

**Table 4.** Climatic Hazards as Experienced by Smallholder Farmers

Categories	No. of Respondents	
	Yes	No
Drought	98	2
Floods	62	38
Heavy/Off-seasonal rainfall	63	37
Increased unpredictability of weather	60	40
Short winter season	78	22
Increased length of summer season	47	53
Fog (coolness)	90	10
High winds	68	32

From table 4, it is observed that about 98 respondents noticed the presence of drought, the remaining 2 respondents observed that the drought did not occur in the study area. Besides, about 62 respondents observed the presence of floods while the remaining 38 noticed the absence of floods. On the other hand, about 63 respondents confirmed about off-seasonal rainfall; the remaining 37 responded that there did not happen any off-seasonal rainfall. In addition, about 60, 78, 47, 90, 68, 2 of the respondents perceived the presence of increased unpredictability of weather, short winter season, increased length of the summer season, fog and winds respectively, while 40, 22, 53, 10, 32, of the respondents noticed the absence of these climatic variables, respectively. In table 4 it reveals most of the farmers observed the presence of various variability indicators. But the changing patterns of these variables are not same. The changing patterns of different climatic hazards are presented in table 5.

**Table 5.** Changing Patterns of Climatic Hazards as Experienced by Smallholder Farmers

Categories	Changing Patterns				
	Very high degree	High degree	Medium degree	Low degree	Not at all

Drought	25	48	13	12	2
Floods	4	11	27	20	18
Heavy/Off-seasonal rainfall	9	15	25	14	37
Increased unpredictability of weather	7	13	21	19	40
Short winter season	6	20	24	28	22
Increased length of summer season	1	9	14	23	53
Fog (coolness)	7	35	30	18	10
High winds	3	15	25	25	32

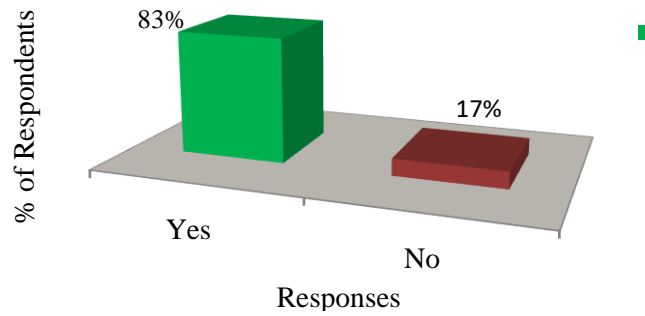
In table 5 represents the changing patterns of different climatic hazards that experienced by smallholder farmers. But the rates of occurrence of all variables are not same which are presented in table 6.

**Table 6.** Rank of Climatic Hazards According to Rate of Occurrence that Experienced by Smallholder farmers

Categories	Frequency of Each Level of Experience					WAI	Rank
	Very high degree	High degree	Moderate degree	Small degree	Not at all		
Drought	25	48	13	12	2	2.82	1
Fog (coolness)	7	35	30	18	10	2.11	2
Short winter season	6	20	24	28	22	1.60	3
Heavy/off seasonal rainfall	9	15	24	14	38	1.45	4
High winds	3	15	25	25	32	1.32	5
Increased unpredictable weather	7	13	21	19	40	1.28	6
Floods	4	11	27	19	39	1.23	7
Increased length of summer season	1	9	14	23	53	0.82	8

Table 6 shows that the frequency of flood is decreasing due to decreasing rainfall trends. In addition, the occurrence of increased length of summer season in the study area is very few. The weighted average index calculates the larger value for the drought than other events. This indicates that the rate of occurrence of drought is highest. Similarly, flood is ranked seventh and increased length of summer season is ranked lowest as there is few evidence of its occurrence.

**Problem Faced by Smallholder Farmers for Taking Adaptation Decision:** Smallholder farmers are faced with different problems when they want to take adaptation decision. For this reason, it is necessary to identify the percentage of respondents who face problems at the time of taking adaptation decision which represents in figure 5.



**Fig. 5:** Distribution of Respondents by Problems of Taking Adaptation Decision

Figure 5 indicates that in the study area 83% smallholder farmers have faced problems at the time of taking adaptation decision when they want to reduce the climate change impact in their farming. The remaining 17% farmers have not faced any problem. Since the study area is drought-prone, the farmers feel to the source of irrigation. But there is small portion of farmers consume the opportunity of irrigation. Moreover, the farmers are experienced by frequent flood. So, it is not unknown among farmers the impact of flood on the agriculture. As a result, sometimes it is necessary the late and early planting of seed due to the great havoc of flood. But, the major problem in case of farmers is inadequate farm land. Among these problem, the farmers are also face other problem such as unavailable of seed and chemical, high cost of chemical, limited market access and improper opportunity of weather information. The patterns of problems as faced by the smallholder farmers when they want to take adaptation decision are shown below.

**Table 7.** The Patterns of Problem that Faced by Smallholder Farmers

Categories	Patterns of Problem that Faced by Respondents				
	Very high degree	High degree	Medium degree	Low degree	Not at all
Shortage of seed	4	15	21	12	31
High cost of seed	3	14	24	11	31
Lack of access to water resources	24	31	15	10	3
Inadequate farm land	10	19	25	16	13
Lack of capital	18	24	15	15	11
Lack of loan	14	20	21	14	14
Limited access to agricultural market	1	18	21	20	23
Shortage of chemical	4	14	20	14	31
High cost of chemical	3	13	17	4	46
Lack of access to timely weather information	8	20	23	17	15

Table 7 represents that smallholder farmers faces different problems when they want to take adaptation decision. Most of the farmers face high and very high degree lack of access to water resources when they want to take adaptation decision. Again, inadequate farm land is the medium degree and limited access to agricultural market is observed low degrees. In this way the relative measure are not possible. So the Problem Confrontation Index is used. The results of this index are shown given below.



**Table 8.** Rank of Problems that Faced by Smallholder Farmers (n=83)

Problem Faced by Farmers	Degree of Problems					PCI	Rank
	Very high degree	High degree	Moderate degree	Small degree	Not at all		
Lack of access to water resources	24	31	15	10	3	229	1
Lack of capital	18	24	15	15	11	189	2
Lack of credit	14	20	21	14	14	172	3
Inadequate farm land	10	19	25	16	13	163	4
Lack of access to timely weather information	8	20	23	17	15	155	5
Limited access to agricultural market	1	18	21	20	23	120	6
High cost of seed	3	14	24	11	31	113	7
Shortage of chemical	4	14	20	14	31	112	8
High cost of chemical	3	13	17	4	46	89	9

From table 8, it is found that among the problems faced by the smallholder farmers in the study area, 'lack of access to water resources' is ranked first and thus it has more importance for taking adaptation decision when they want to use. 'Lack of capital problem' is ranked as the second. The third most problem is the lack of credit. High cost of chemical is ranked as the least problem for taking adaptation decision when they want to use.

**Conclusion:** The findings of the present study reveal that the majority of the smallholder farmers observed rainfall and surface water level decreased 'medium degree', ground water level decreased 'high degree', and temperature increased 'high degree'. Moreover, smallholder farmers are experienced by different climatic hazards such as 'high degree drought and fog', 'low degree flood, and 'not at all' increased the length of summer and winter season'. The result of weighted average index show that among the climatic hazards as experienced by smallholder farmers, the rate of occurrence of drought is ranked highest and increased the length of summer season is ranked lowest. Again, findings from the problem confrontation index reveal that among the different problems that faced by smallholder farmers, the lack of access water is ranked highest and the high cost of chemical is ranked lowest. Policies should therefore ensure that farmers need to be prioritized access to information about better production techniques and climate change. Government and non-government organization should run different projects on the crucial role of providing information about better production techniques and enhancing farmers' awareness. Again, it is also strongly recommended that the government and non-government organizations of Bangladesh should take necessary initiatives for removing all problems so that smallholder farmers can take easily adaptation decision when they want.

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