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Farmers' Adaptation to Climate Change in Shifting Cultivation: A Case Study of Rangamati Sadar Upazila, Bangladesh

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Climate Change; Shifting Cultivation; Agricultural Adaptation; Perception of Farmers.

Abstract

Shifting cultivation, locally known as Jhum, is a traditional agricultural practice among the indigenous communities of the Rangamati Hill Tracts. Climate change—characterized by long-term shifts in temperature and weather patterns—poses increasing challenges to this system. Since agricultural productivity relies heavily on climatic factors such as temperature, rainfall, light intensity, radiation, and sunshine duration, the growing irregularity of these elements due to global warming threatens the stability of Jhum cultivation.

This study examines the impacts of climate change on shifting cultivation and explores the adaptive strategies adopted by local farmers. Data were collected through field surveys, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) with farmers and agricultural experts. Rainfall emerged as one of the most influential climatic factors, particularly because Jhum farming is rain-fed and highly sensitive to precipitation variability. Farmers have become increasingly aware of climate unpredictability and are adapting through crop diversification, adjusted planting calendars, improved water management, increased use of agricultural inputs, and tree planting. These strategies draw on community knowledge and help reduce environmental risks while promoting economic resilience. Strengthening such adaptive measures is crucial for sustainable development, minimizing losses from extreme weather events, and supporting long-term agricultural productivity in the region.

1. Introduction

Local climate is a major contributor to the success of agriculture work because temperature and water are factors that are crucial to agricultural production and productivity (Quaye, Nadolnyak & Hartarska, 2018). Climate change presents a particular risk to Bangladesh, an agrarian-dependent nation, by virtue of its exposure to extreme weather such as heatwaves, flooding, droughts, hail and

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windstorms, which have direct implications on agricultural productivity. These extremes are not the only threats in agriculture threatening, in the same time, the weed species, the pest pressures, the soil impoverishment etc. (Basak, 2012). Yet, adaptive strategies, as seen in some regions of Bangladesh, enable farmers to build resilience against climate change (Roland Fadina & Barjolle, 2018).

In the lowland areas of northeastern Bangladesh, farmers have adopted several methodologies as responses to the climate menace (Anik & Khan, 2012). Upstream agriculture in the hills of the catchments, notably slash-and-burn shifting cultivation practices, is rain-fed and the catchments are prone to soil erosion and irrigation constraints (Ahammad & Stacey, 2016). The native Chakma population in Rangamati, part of Chittagong Hill Tracts, is particularly vulnerable to shifting monsoons, lower levels of rainfall, and erratic weather patterns causing loss of cultivable land (Irfanullah & Motaleb, 2011). Now however, with the shortening of the land rotation cycle from 7-8 to 3-4 years for quick rotation replacing in situ soil fertility (resulting in much reduced crop yield) slash and burn (shifting) cultivation becomes much less sustainable (Hossain, 2011) as erosion increasingly depletes soil fertility.

However, despite these difficulties, the CHT region is characterized by an appreciable variation in climatic pattern with diversity of fruits but now it is under greater pressure due to the fast changing climate. In these villages women are the champions of maintaining agro-diversity, they are the conservers of seeds and the transmitters of traditional knowledge requisite for adaptation to Climate Change and food security (Das & Das, 2014). Capacity to adapt, the faculty to cope with changes and to reduce damage, is important for community response to a climatic risk (Kim, 2015).

Farmers in the Himalayas bear the impacts of changing patterns of rainfall and temperatures, droughts, and reduced crop yields and food security (Jethi, Joshi, & Chandra, 2016). Poor soil fertility, pest infestations, and vagaries of weather have also reduced farm output by reducing crop yields and water availability (Jamir & Khan, 2019; Raghuvanshi, Amardeep, & Ansari, 2017). Ecosystems, food production, sanitation, water supplies, and public health are disrupted in every region due to climate change on a worldwide scale (IPCC, 2014). The conventional Jhum chash farming system in Rangamati is being increasingly challenged by soil erosion and declining fertility, as well as by a decreasing land rotation period that undermines sustainability (Hossain, 2011). This sort of agricultural system, especially the slash-and-burn type has been a point of contention because of its adversarial negative environmental effects such as the depletion of the forest, soil degradation and the ever-increasing contribution to climate change as the rate of emission of greenhouse gases increases (Chakma & Ando, 2008). On top of all this, the effects of climate change – higher temperatures, changes in precipitation, and diminished access to irrigation – are compounding the problems of agriculture.

The net area sown has been reduced gradually and hydrology of crops including rice, wheat and other food grains decreased significantly due to the erratic rainfall, delayed hailstorms, and untimely winter rain (Meena *et al.*, 2015). Such dry to wet swings in climate have effectively increased the susceptibility of agriculture, which is highly dependent on temperature, humidity and rainfall (IPCC, 2011). These changes resulted in impacts such as loss of household assets, loss of biodiversity and degradation of soil quality, which have direct implications on the indigenous people's lives in the CHT in terms of sustenance, who rely on natural resources for their existence (Salick & Byg, 2012). Many farmers observed this kind of change in the last 5-15 years with different frequencies of bout and the time of bout just after sowing, which has become an acute problem for crop production (Kamruzzaman, 2015). With climate models predicting a rise in temperature of 2°C by 2050, more challenges to agriculture and public health are expected, shifting climates adding to the risks of crop failures and ecosystem health (IPCC, 2007). Climate change, as anthropogenic alteration of the composition of the global atmosphere, has major implications specifically for agriculture, since it is one of the most susceptible activities (UNFCCC). The impact of the climatic changes on agricultural productivity has been tremendous, with increased temperature and decrease in rain and dry seasons affecting farming and the lives of rural dwellers (Hengeveld, Bush & Edwards, 2016). During the last decade, farmers have copiously informed about the impacts of insufficient rain, intermittent drought and scarcity of water, which results in lower output of crop and less animal mass (Filho & Ayal, 2019). Temperature and precipitation regimes are changing, resulting in climates moving towards drier conditions, adding additional stresses to agriculture which is heavily reliant upon climate for key environmental variables such as temperature and precipitation (IPCC, 2011). Climate change is a "threat multiplier" that is likely to exacerbate global environmental, social and economic concerns, and to have its impact most acutely felt at the local level in regions like Rangamati, where agricultural production is already under pressure due to extreme weather events (Tarhule & Lamb, 2013; Mengistu, 2011). Shifting cultivation is an important traditional practice in the Chittagong Hill Tracts, and it has been a key aspect of the indigenous way of life, although it has decreased in recent times (Bhagawati *et al.*, 2015). In that working context, as adaptation has become crucial even the potential of adaptation ability for nice adaptation is a subject to culture the seeds of resilience against adverse effects of climate change (Kim G. C., 2016). There is a definite research gap in how jhum farmers in Rangamati specifically see and adapt to increasingly unpredictable climate especially on the aspect of change in planting time and decisions that rely on rainfall. Though earlier researches have attempted to investigate the overall climate susceptibilities at the Chittagong Hill Tracts, it offers less information regarding the specifics of the practice-level adaptation of shifting cultivators to irregular monsoon arrival, rain variations in intensity, and extended dry seasons. Lack in the specific knowledge on how farmers decipher the climatic signals and how perceptions affect the preparation and timing of land and seeding, or how aboriginal knowledge interacts with adaptation techniques used by modern farmers. In addition, the available literature examines the limitations within the scope of their ability to adapt to changes including limited access to water management technologies, diminishing fallow cycles, and increasing cost of production. This paucity of localized and empirical evidence on adaptation behavior in Rangamati complicates the development of context-specific interventions that can be applied to promote sustainable shifting cultivation in the face of climate change. Thus, farmers' perception and adaptive practices to the changing climate adopts in the shifting cultivation towards this end need to be evaluated in the Rangamati Sadar Upazila and the objectives are given below:

- Determine recurrent climatic situations, which can refer to temperature and rainfall regime, of the area.
- To explore farmers' perceptions to climate change and impacts on agriculture.
- To analyze the coping mechanisms farmers are employing to deal with climate change.

2. Conceptual Framework

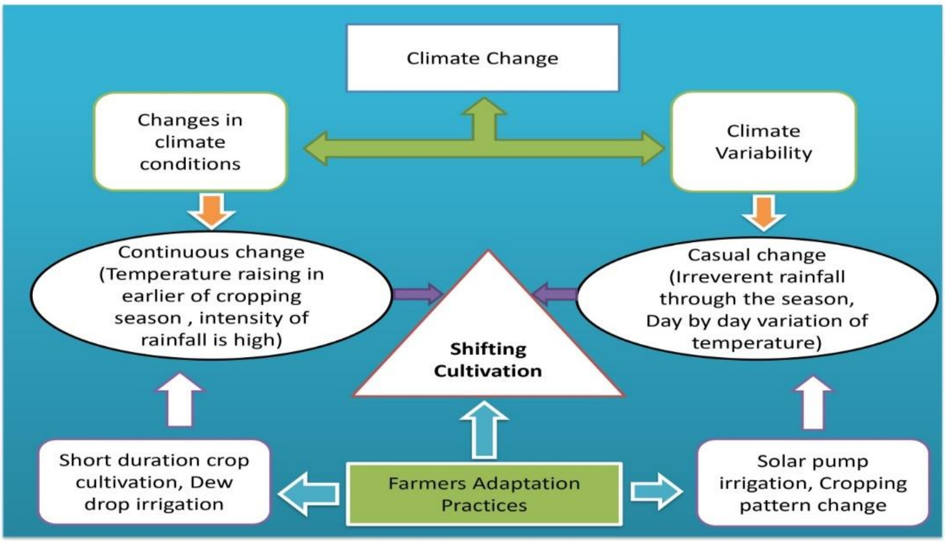


Figure 1: Conceptual Framework of this study

The analytical framework of the study explores the effects of climate change on agricultural activities, especially jhum cultivation in Rangamati, Bangladesh. Agriculture covers only 6% of the land in the area yet supports nearly 70% of the households with a substantial number using shifting cultivation, now an increasingly difficult practice in terms of both land and economy. Jharkhand State in India-Traditional subsistence farming practice of shifting cultivation is being increasingly confronted with the vagaries of rain fall, temperature increase and occurrence of pests and diseases forcing the farmers to revise their planting dates to adapt to these changes. Adoption of modern high-yielding varieties (HYVs) as a response to low productivity is costing a lot high because of increased use of external fertilizers. As climate change disrupts patterns of rainfall and temperature, agriculture becomes more exposed, leading to direct impact on food security and farmer's income. Adaptation measures such as changing sowing time, technology used for cultivation etc., have been recognized to be crucial for coping up with the fallouts of climate to make agriculture resistant and inform future development policies in the region (BBS, 2017; Hossain, 2011; IPCC, 2011; Filho & Ayal, 2019).

3. Materials and Methods

3.1 Study Area

The Rangamati Sadar Upazila was deliberately chosen because of its high reliance on shifting (jhum) agriculture, high density of indigenous agricultural groups, and extreme susceptibility to climate changes, unpredictable rain, landslides as well as shifts in temperatures. The area is one of the most climate-sensitive areas of Bangladesh, and thus, a suitable and relevant case study in terms of analyzing the impact of climatic change and the strategies employed by farmers in the hill agriculture systems.

Figure 2: Study Area

Rangamati Sadar is located at 22.6500 N, 92.1833 E. It has 13814 house units and a total area of 546.49 km2. It is divided into Rangamati Municipality and six union parishads: Balukhali, Bandukbhanga, Jibtali, Kutukchari, Mogban, and Sapchari. The union parishads are subdivided into 21 mauzas and 178 villages. According to the 2011 Bangladesh census, Rangamati Sadar had a population of 124,728. The population is 55.79% male, and 44.21 female.

3.2 Methodology

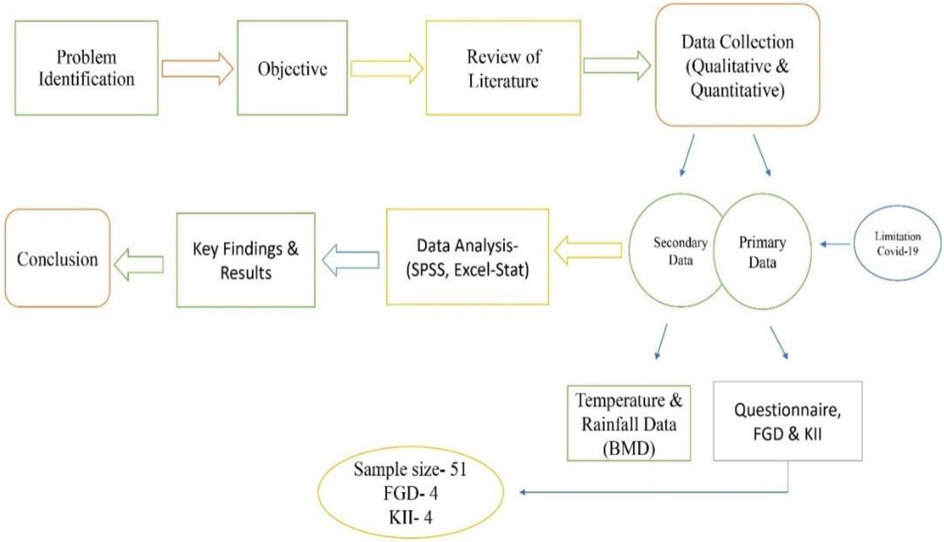


Figure 3: Methodological Flowchart

This research utilized the random sampling technique of probabilities to select the respondents among small and large scale shifting cultivators in Rangamati Sadar Upazila. To minimize selection bias, random sampling was selected to make sure that farmers who possessed varying experience, landholding size and adoption practices equally had an equal opportunity of being chosen in the survey. The standard normal deviate (z) of 0.68 was used to determine the sample size which is calculated based on the assumption that the population would vary to maximum, that is, p = 0.50, q = 0.50, and the desired level of precision of 5%. According to this statistical formula the minimum sample size was estimated to be 46 respondents. A 10 percent contingency was applied to explain the possibility of non-response and incompleteness of questionnaires which led to the final sample of 51 respondents.

A ratio of 50% confidence level is lower than the traditional confidence level of large scale surveys; nevertheless, it is acceptable in the case of exploratory and perception based studies conducted in geographically remote, resource practicing and socially sensitive regions such as the Chittagong hill tracts. Large sample collection is frequently limited in such circumstances by the difficulty of access, spread of settlements and cultural restraints.

Qualitative data were also collected using Focused Group Discussions (FGD) and Key Informant Interviews (KII). Two male and two female groups were held for the FGD on the issues of climate change, effects of climate change on economy of people and agriculture, and adaptation practices. The KII consisted with a Sub-Assistant Agriculture Officer, a Regional Agricultural Information Officer, an NGO functionary, and an elderly person and/ or local head. A random sampling method was used to gather primary data through a survey questionnaire, where male respondents accounted for 55% of the respondents and female respondents 45%. The data were collected during 2021 and climatic data including rainfall and temperature were received from the Rangamati Weather Station for the years 1990 to 2020.

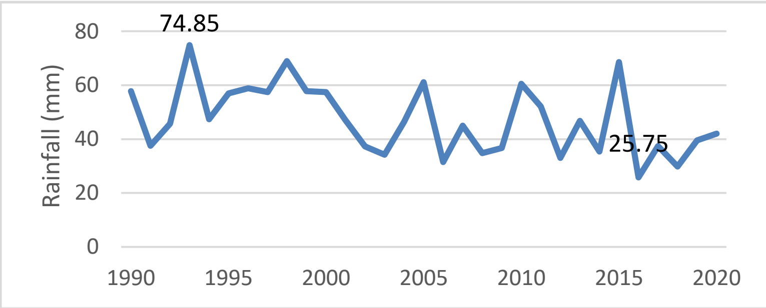
A lot of ethical considerations were observed during the study. Before data were collected, all the participants were made to understand the objectives and the purpose of the research. Each respondent gave informed verbal consent to use the questionnaire, Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs). The participation was voluntary and the respondents knew that they could pull out at any point without any repercussions. No personal identifiers were noted to give confidentiality and anonymity and the data obtained were utilized only to academic and research purposes. The research was conducted in accordance to the required ethical requirements in social science research on human subjects.

4. Results and Discussion

4.1 Periodic Climatic Status

4.1.1 Rainfall

The Bangladesh Meteorological Department (BMD) provided valuable data on temperature and rainfall trends from 1990 to 2020, highlighting the shifts in climate patterns. These data, which form the foundation for short-term weather forecasts and longer-term climate projections, are essential for understanding how climate is evolving over time. A graph (figure 4) of the 30-year average of the daily maxima of the rainfall (which quantifies the average maxima between 1990 and 2020) shows notable variability around the last 30 years. The average maximum rain fall was 74.85mm in 1993 and for the average minimum was 37.52mm in 1991. In the subsequent decade (2000-2010), the maximum rainfall recorded was 61.14 mm in 2005, while the minimum was 31.41 mm in 2006. Maximum rainfall (68.58mm) was recorded in 2015 and minimum (25.75 mm) in 2016 during the period 2010–2020. The greatest standard deviations for the mean maximum value of precipitation were between 11.52 and 15.05 mm (which was influenced by the most significant decrease of precipitation during the last 30 years).



Year	SD
1990	12.81
1995	12.53
2000	11.52
2005	12.39
2010	13.16
2015	15.05
2020	12.81

Figure 4: Periodic Climatic Status in Rainfall (Average Maximum Rainfall 1990-2020)

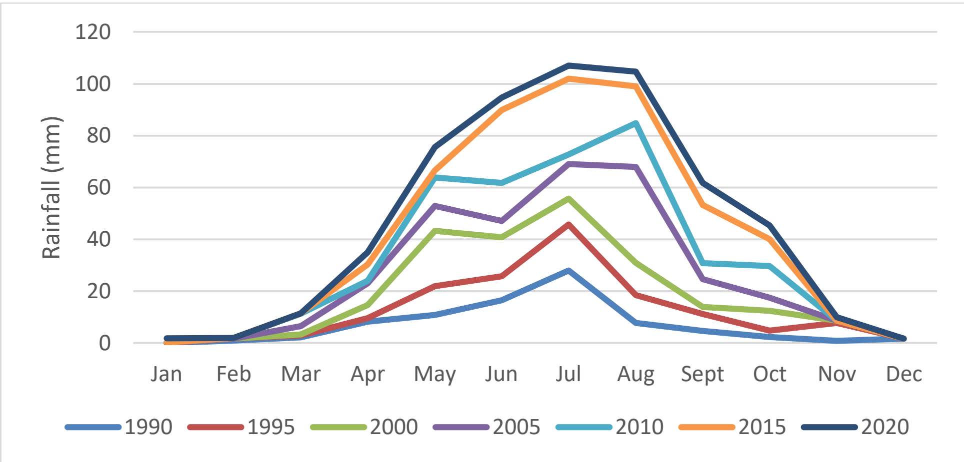


Figure 5: Periodic Climatic Status in Rainfall (Average Rainfall 1990-2020)

According to meteorological data, yearly rainfall in the study region is not consistent and fluctuates from month to month and year to year. The rainfall data of the study was collected from Hill Tract Agricultural Research stations. Analysis of the available data (figure 5) from 1900 to 2020, Interval of 5 years. It was seen that the average highest amount of rainfall was found in the year 1990, 27.91 mm in the month of July. In 1995 average highest rainfall was recorded at 17.77 mm in the month of July. The Year 2000 maximum average of rainfall was recorded in May month 21.29 mm. In the month of August maximum average rainfall was found at 36.92 mm in 2005. In the year 2010 highest average rainfall was recorded in August month 16.89 mm. In 2015 maximum average rainfall was found on July

29.17 mm. The year 2020 maximum average rainfall was recorded in September month 8.43 mm.

4.1.2 Temperature

Planting period of shifting cultivation between April- June month. According to this graph (figure 6) 2010, April month was recorded maximum average temperature was 29.50 °C, and in 1990, April was recorded at a minimum temperature of 26.20°C. The year of 1990 average maximum temperature record on June 28.45 °C and the average minimum temperature record on March 25.69 °C. In this graph year 2000 average maximum temperature record on April 28.05 °C and the average minimum temperature record on March 27 °C. In this graph year 2010 average maximum temperature record on April 29.50 °C and the average minimum temperature record on March 26.25 °C. In this graph year 2020 average maximum temperature record on May 28.65 °C and the average minimum temperature record on March 25.70 °C. 90s decades shifting cultivation starts from the month of March- April but this graph shows March-April month contain the highest temperature during the period. Now farmers are trying to change in this time period to getting the constant temperature in the May-June-July month. But some of the farmers are cope up with the situation are planting fertilizer management, leafy vegetables, quick, short growing field and horticultural crop.

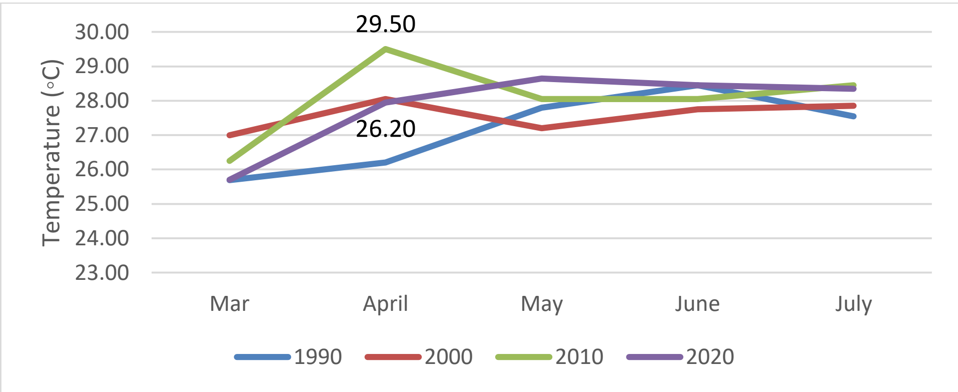
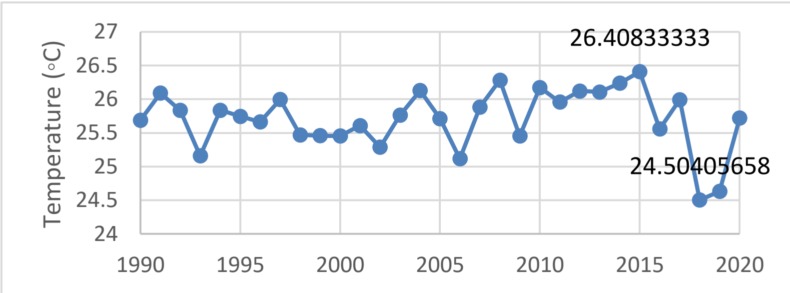


Figure 6: Temperature Variation in Different Planting Periods

This graph (figure 7) is about the yearly average temperature in the study area from 1990-2020. In this graph maximum average temperature in the year found in 2015 was 26.40 °C and the minimum average temperature recorded in the year 2019 was 24.50 °C. In the year 1990-2000, the average maximum temperature in a year was found at 26.09 °C in 1991, and the average minimum temperature in a year record at 25.15 °C in 1993. In the year 2000-2010, the average maximum temperature in a year was found at 26.28 °C in 2008, and the average minimum temperature in a year record at 25.11 °C in 2006. In the year 2010-2020, the average maximum temperature in a year was found at 26.40 °C in 2015, and the average minimum temperature in a year record at 24.63 °C in 2019.The standard deviations are considerably different, despite the fact that the annual average temperature was 0.57. The yearly average temperature value range has a standard deviation of 0.44 to 0.75. In the previous 30 years, there has been a significant change in the yearly average temperature.



Year	SD
1990	0.44
1995	0.46
2000	0.51
2005	0.56
2010	0.63
2015	0.75
2020	0.44

Figure 7: Periodic Climatic Status in Temperature (Yearly Average Temperature)

4.2 Farmer's perception on Climate Change

From the table 1 it is observed that most of the farmers exhibit different farming experiences in Rangamati and the highest have 30 years of experience (33.57%) and then 35 years (26.80%), 25 years (19.14%). As few as 2.36% of farmers are aged 20 and 16.49% are aged 40. When queried about climate changes, 13% reported perceiving such changes in the last 5 years, 44% in the last 10 years, 29% in the last 15 years, and 14% in the last 20 years. The observation of climate change is also important, since 22% of the respondents claim that extreme changes are occurring, (31%) notes a few changes, (34.5%) perceives some changes, and 13% observes many changes.

It is revealed from study that 63.64% of the farmers are perceiving climate change as high intensity and 36.36% of the farmers are associating it with uncertainty in rainfall. In recent years, the farmers of Rangamati have observed the slow variation of climate, especially the start and end of the seasons. In the monsoon season, 36% respondents have seen delays in both start and end; 64% said the monsoon comes late, but ends early. 8% saw delays both in beginning and ending the summer season, and 92% said it began early and ended late. Only 11 percent reported delayed service in the winter, but 89 percent wrote that it starts later and stops earlier.

Farmers also noticed variation in temperature and rainfall. There was unanimity among the respondents for warmer summer but 33% recorded increased rainfall during the rainy season, and 67% experienced decline. Fifteen percent in winter observed that the temperature increased, 85 percent observed a decrease of winter temperatures. These results reflect increased attention to the actual and potential impacts of climate change in the area and for effective adaptation measures.

Table 1: Farmer's Perception for Climate Change

Farming Experience					
20 year	25 year	28 year	30 year	35 year	40 year
2.36%	19.14%	1.65%	33.57%	26.80%	16.49%
Climate Changed in last					
5 years	10 years	15 years	20 years		
13%	44%	29%	14%		
Change in Climate					
Extreme	Moderate	Low	No		
22%	47.55%	31%	0		
Nature of Rainfall					
Erratic Rain	High Intensity				
36.36%	63.64%				
perception on Season (Season Start to Ending)					
Type	Rainy Season	Summer Season	Winter Season		
Delay-Delay	36 %	8 %	11%		
Delay-Early	64 %	-	89%		

Early-Delay	-	92 %	-
Duration Increase	33%	100%	15%
Duration Decrease	67%	-	85%

4.3 Farmers' Adaptation to Climate Change

4.3.1 Crop Selection and Seed Usage in Shifting Cultivation

Different crops have different soil, thatch, woody plant and water requirements and have different growing season water requirements whose estimates are affected by the climate. Selecting the appropriate crop for the given conditions can aid in maximizing yields and minimizing the amount of water needed for irrigation. For crop selection and planning (Figure 9), 52% of the survey's respondents make their own decisions, 30% decide based on family need, and 19.5% decide based on market demand.

Agricultural and horticultural seeds are important for production in shifting system, while vegetables are crucial for raising income. But these crops are difficult to harvest because they take long periods of time to mature. These are farmers who store seed locally from one year to the next, said the survey, watchful about sharing seed with other farmers. In figure 8 showed such farmers make up 60% of the survey's respondents who store for the next year's crop, while the rest, amounting to 40%, use hybrid seeds, which they believe increase yields. Vegetable crop is more dependent on local seeds, whereas for rice cultivation hybrid variety of seeds are favored. 20-25 varieties of local rice (Kamrangdhan, Gallongdhan, Binne rice, etc.) used to be cultivated traditionally, but in recent years only 3-4 types are widely grown, with Binne rice playing a major role. Local food preferences guide vegetable seed selection although the crop pattern has mostly stayed the same and short duration rice is coming up in place of traditional rice.

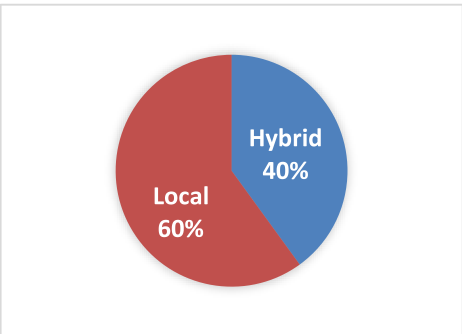


Figure 8: Type of seed using in the cultivation

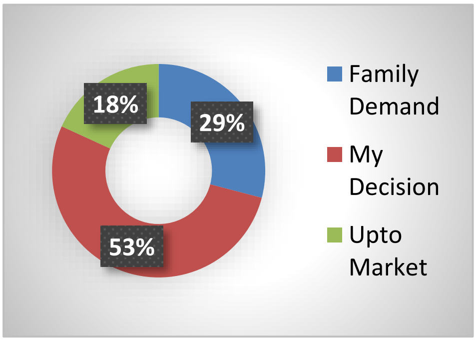


Figure 9: Choosing Crops for Cultivation

4.3.2 Agricultural Land for cultivation

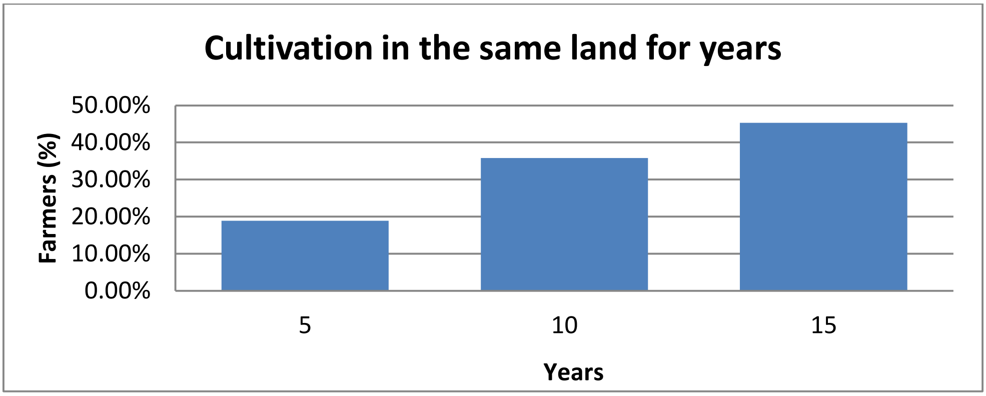
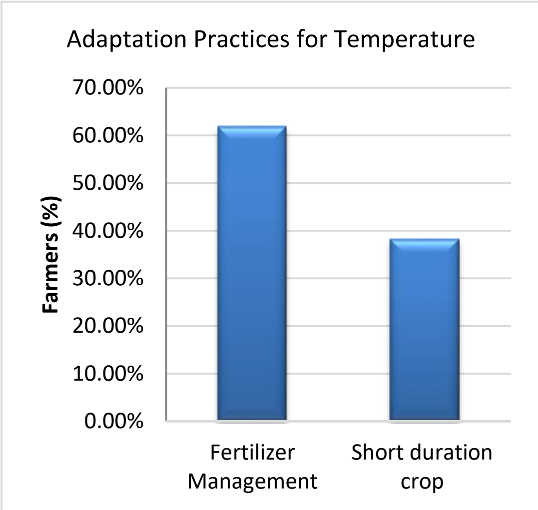


Figure 10: Continue Cultivation in Same Land

Swidden can be environmentally sustainable if there is enough land for restorative fallow periods (10–20 years), but increasing population pressures and demands reduce the viability of resource-based subsistence agriculture. As land gets depleted after 2–3 cropping cycles, farmers rotate land patches used for bush fallowing. The survey says (figure 10) 45% of those surveyed have been cultivating the same tract of land for 15 years, 35% for ten years and 19% for five years. To make the land keep yielding, farmers now supplement whatever fertility in the soil remains with fertilizers, and add water via irrigation to the same land.

4.3.3 Adaptation Practices for Temperature and Rainfall

Adaptation to climate change helps people, communities and systems that are already experiencing the effects of climate change take the steps necessary to lower the capacity to damage that risk can have, to protect themselves, their community and their livelihoods, and to prepare themselves to respond. Climate change particularly threatens agriculture; changes in temperature and rainfall can hurt productivity. To cope, 54% of farmers change planting dates, 26% plant mixed crops and 16% irrigate their fields (Figure 11b). High temperatures are a significant threat to agriculture, especially crops like wheat, as they have a detrimental effect on shoot and root development, which leads to decreases in total crop yield. To deal with these changes, 61.82% of farmers apply fertilizers and 38.18% use other crop varieties (Figure 11a). Rain-fed agricultural regions are very dependent on rainfall, so are exposed to its variability. Adaptation options involve crop and livelihood diversification and responsive strategies such as seasonal climate forecasting, water storage, irrigation, and no-regrets strategies (early warning systems). Enhancing agricultural water throughputs is a fundamental method to resist climate pressure and guarantee food security under climate change.



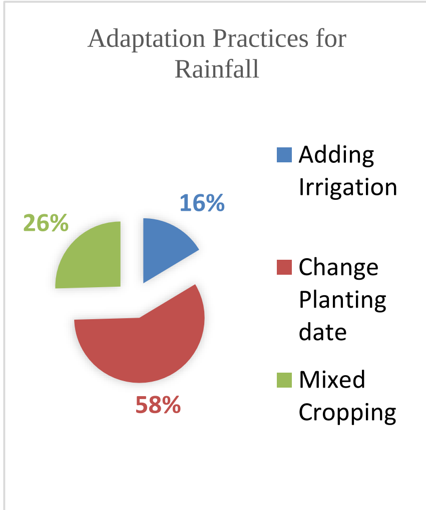


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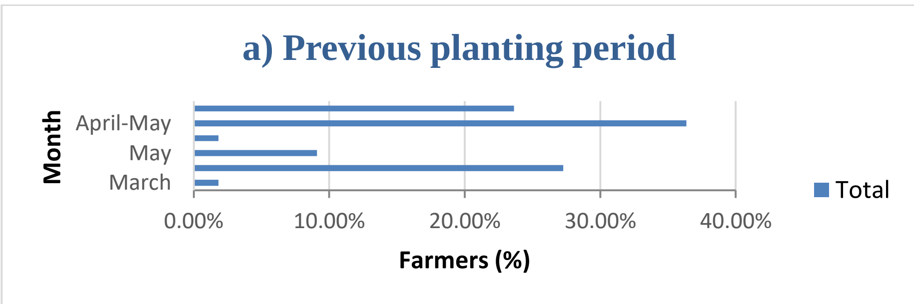
Figure 11: Farmers Adaptation Practice for Rainfall & Temperature

4.3.4 Changes in Planting Period



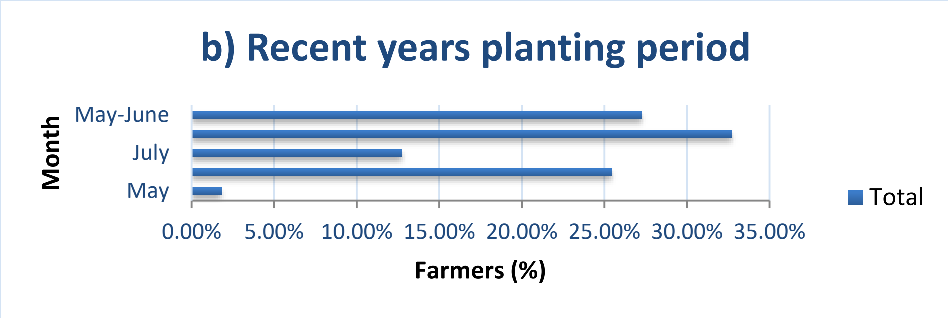


Figure 12: Previous and Recent Planting Periods

Sowing time in the practice of shifting cultivation is dependent on the rainfall pattern and availability of irrigation. As per the survey, 36.36% of farmers use previous season (April-May) for sowing as there is change in climatic conditions, 23.64% plant in March-April, 27.27% from April, 9.09% in May and only 1.82&in March and June respectively (Figure 12a). The best planting time is whenever the farmer is prepared, weather conditions are suitable, and there is excess water during the first year. In figure 12b farmers are currently sowing 32.73% between June-July, 27.27% between May-June, 25.45% in June while 12.73% in July. Just 1.82% are still planting in May.

4.3.5 Farmer's perception on Climate Change

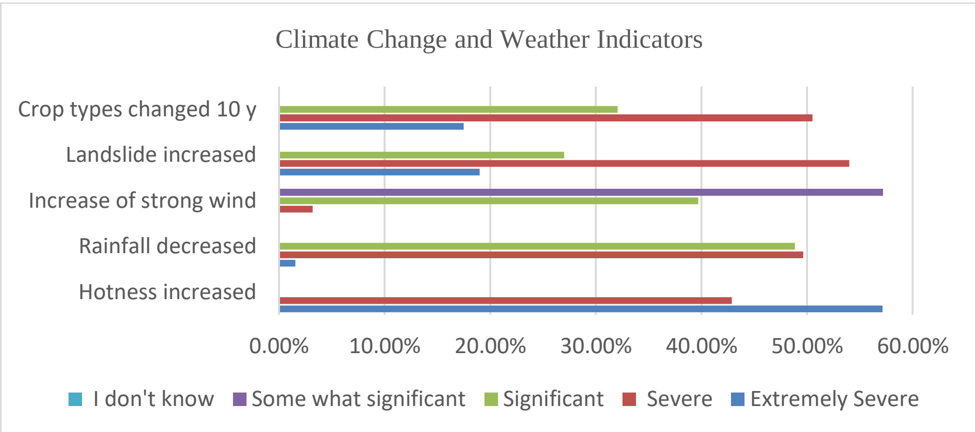


Figure 13: Farmer's perception on Climate Change

The survey finds opinions on climate change differ by topic showed in figure 13. Regarding being hot, 57.14% thought it was very serious and 42.86% thought it was serious. For rainfall reductions, 49.61% found it to be severe, 1.55% extremely severe and 48.84% significant. Regarding the development of strong winds, 57.14% perceived it as somewhat important, 39.68% did as important and 3.17% as very important. Regarding landslides, 54% said it was severe, 27% significant and

19% extremely severe. Regarding the extent of alterations in crop types during the last 10 years, 50.49% perceived severe, 32.04% significant, and 17.48% extremely severe.

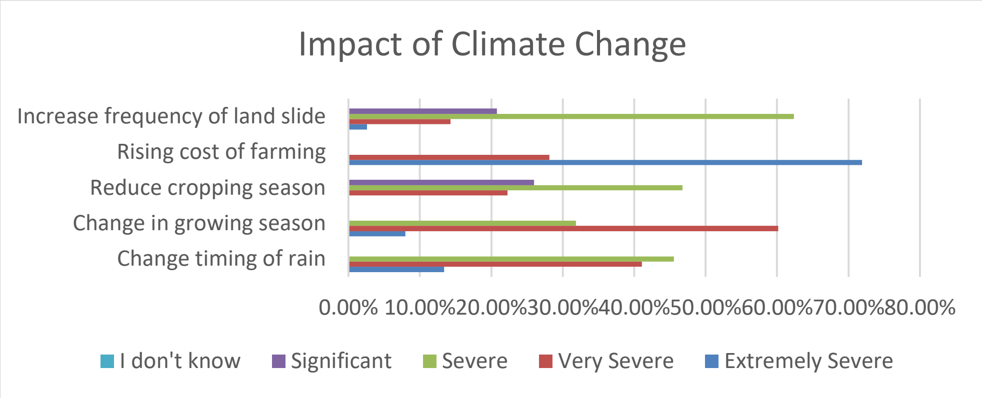


Figure 14: Farmer's perception on Impact of Climate Change

In term of the second factor in figure 14, timing of rainfall shift, 50% of respondents assessed it to be severe, 40% very severe and 10% extremely severe. For changes in the growing season, 60% of the respondents perceived it as very severe, and 30% as severe. For crop seasons shortened, 51%, 28%, and 21% expressed it as severe, high and very severe, respectively. Regarding the farmers' financial situation, 70% perceived it as extremely severe while 30% saw it as very severe. Finally, 69% considered the increased frequency of landslides to have been severe, 26% significant and 5% extremely severe.

5. Discussion on the Results

This study has significant implications on the study of the sustainability of shifting cultivation in the Rangamati Hill Tracts in the face of escalating climate stresses. The high perception of increasing temperatures and changing rainfall by farmers captures not just an experiential concept of changing climate but also the direct risk to the livelihoods of the farmers due to changing climate. Other similar instances of perception-based reactions have been reported among the smallholder farmers in Bangladesh and other climate-exposed areas where experiential knowledge commonly leads to less formal climate information in decision-making (Anik and Khan 2012; Kamruzzaman 2015).

Table 2: Key Findings from the Study

Key Aspect	Key Finding	Interpretation	Policy / Practical Implication
Climate	Increasing	Indicates heightened	Need for localized

Key Aspect	Key Finding	Interpretation	Policy / Practical Implication
trends	temperature and erratic rainfall over the last three decades	climate stress and growing uncertainty for rain-fed jhum cultivation	climate information services and early warning systems
Farmers' perception	Strong perception of warming, rainfall variability, landslides	Farmers' experiential knowledge reflects real livelihood risks	Farmer perceptions should be integrated into adaptation planning and extension programs
Cropping calendar	Shift from March–April to May–July planting	Adaptive response to temperature stress and delayed rainfall onset	Extension services should support flexible, climate-responsive cropping calendars
Crop choice and diversity	Increased crop diversification and short-duration varieties	Risk-spreading strategy to reduce climate-related crop failure	Promotion of climate-resilient and short-duration local varieties
Seed system	Continued use of local seeds alongside hybrid varieties	Blending indigenous knowledge with modern inputs enhances resilience	Support community seed banks and conservation of local germplasm
Land use	Reduced fallow period and repeated cultivation on same land	Structural pressure threatens long-term sustainability of shifting cultivation	Land-use planning and agroforestry interventions are needed
Input use	Increased fertilizer and irrigation use	Short-term yield stabilization but higher costs and environmental risks	Promote climate-smart, low-input farming practices
Overall	Incremental,	Demonstrates adaptive	Policy should

Key Aspect	Key Finding	Interpretation	Policy / Practical Implication
adaptation pattern	autonomous adaptation by farmers	capacity but limited by institutional support	strengthen local adaptation rather than replace it

The adaptive practices that have been noted include shifting planting dates, diversifying crops, short-duration and hybrid varieties, more intensive use of fertilizers and irrigation that suggests that there has been a progressive change of the traditional jhum practices into flexible and risk-taking methods. Similar adjustments have been observed in the hill farming systems of northeastern India and Nepal where farmers modify the cropping calendars and diversify the crops to adapt to changes in rainfall and temperatures (Jethi *et al.*, 2016; Joshi *et al.*, 2017). Nevertheless, farmers in Rangamati remain combining indigenous knowledge in such aspects as seed selection, crop choice, and land-use decisions despite modern systems gaining momentum in other areas, which has proven to increase the resilience of indigenous farming communities (Das & Das, 2014; Irfanullah & Motaleb, 2011; Salick and Byg, 2012).

Meanwhile, the reduction in fallow duration and the extension of cultivation time on the identical land are some of other indicators of structural constraints that may have contributed to the being a threat to the sustainability of shifting cultivation in the Chittagong Hill Tracts that include land scarcity and population pressure (Hossain, 2011; Chakma & Ando, 2008). Although the scale of the use of fertilizers and irrigation can stabilize the yields in the short-term, other researchers warn that in the approach of relying on external inputs, the cost of production and environmental degradation can rise in case they are not managed in terms of climate-smart (Roland Fadina & Barjolle, 2018; Meena *et al.*, 2015). Further, when the practices of Rangamati farmers to climate change adaptation are compared with the ones in other climate-sensitive areas, one can assume that local adaptation is a part of a larger global trend of smallholder adaptation to climate change (IPCC, 2011). Nevertheless, that indigenous knowledge systems persist remains a key feature of this region and explains why place-based strategies of adaptation are necessary instead of a technology-wide solution.

On balance, the paper indicates that to effectively adapt to changes in the climate with shifting cultivation systems, policy support is needed to enhance the adaptive capacity of localities, but not to substitute it. Practical implications involve enhancing access to localized climate data, fostering agroforestry and mixed cropping practices, facilitating the use of climate resistant local crop varieties as well as incorporation of indigenous knowledge in formal agricultural extension services. These are needed to improve resilience, ecological sustenance, and the long-term sustainability of switching cultivation in response to increasing climate change.

6. Conclusion

This research emphasizes the deleterious effects of climate change on jhum cultivation in Rangamati, focusing in particular on changing patterns of rainfall, increasing temperatures, and the implications for agricultural productivity. The analysis of rainfall and temperature data of Hill Tract Agriculture Research stations from 1990 to 2020 indicate high variability of the climate during the period with increased hotness and unpredictability of rainfall trends which directly impact the sowing dates and crop yields. Local farmers have also observed these changes and have responded by adjusting planting calendars, diversifying crops, adopting hybrid seeds and applying fertilizers and irrigation to counterbalance the adverse effects of the erratic weather.

The research demonstrates that climate change is making farmers more vulnerable, especially those who depend on rainfed agriculture, with many farmers noting that less rain is falling and that temperatures are rising. Need for adaptive options such as sowing alterations, growing of short duration varieties and irrigation interventions are increasingly recognized among farmers. In spite of this, the traditional shifting cultivation system is less viable with extreme climate variability.

The results highlight the need to promote climate smart agricultural practices, improve farmers' access to climate information and help guide more organized and science-backed adaptation actions. Mixed and integrated systems containing crops with trees/shrubs or cropping systems with trees could represent attractive alternatives for increasing the sustainability and profitability of shifting cultivation. The government must continue to conduct research to enhance their understanding of shifting cultivation vis-a-vis real-time climate change and provide policies that can help shift-cultivating farmers adapt to climate change.

As a whole, the study underscores the immediate need to modify agricultural practices to meet the challenges of a changing climate, and to provide farmers in the region with the resources and knowledge needed to prosper amidst climate change.

Conflict of interest

There is no potential conflict of interest regarding the publication of this work, as declared by the authors.

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