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Impact of climate change on sustainable crop production and consumption (SDG-12): empirical evidence from rural Bangladesh

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Abstract

The present study sheds light on recent climate change and its connection with sustainable production and consumption in the northern region of Bangladesh. The study adopted various qualitative research tools to explore research questions and study-specific objectives. It utilized non-probability purposive sampling technique to choose the study locations and 20 informants from the selected study areas. The research applied Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs), as qualitative tools to obtain the necessary information from the selected informants. Utilizing the thematic analysis technique as part of the qualitative method, the study categorized the collected data into a range of sub-themes central to the significant findings of this study. The study found that various climatic events, such as less rainfall, drought, and heat waves, decreased agricultural land fertility, seriously affecting crop production, and diversification. Additionally, recent climate change led to market oscillation, enhanced financial risks, and price hikes in some daily necessary foodstuffs. These climatic events further contributed to reducing food availability and stability of crop production in the study area, worsening the current food security among the study group. It is recommended that the Government of Bangladesh (GoB) should take evidence-based measurements, for instance, climate-resilient agricultural loans, better seeds, and regular irrigation, which are required to promote climate-resilient crop production and to ensure better nutritional food production among the country's people.

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Problem statement

Globally, climate change and variability dynamics profoundly influence human societies and diverse forms of life. The functioning of ecosystems, agriculture, food security, infrastructure, water resources and human health are all being negatively impacted by the rising sea levels, temperature increases, altered rainfall patterns, and an increase in the frequency and intensity of extreme weather events reported by the Intergovernmental Panel on Climate Change (IPCC)[1]. Significant contention exists regarding the extent of climate change severity across the various regions. Climate change might benefit developed nations in temperate zones and have fewer adverse effects than the developing world[2]. Most scientists agree that low-income, non-industrialized countries in tropical and sub-tropical regions are more vulnerable to the adverse effects of climate change[3,4]. One of the extreme global challenges is to participate in environmental sustainability with economic growth and welfare by decoupling environmental degradation from economic growth and doing more with less. Resource decoupling and impact decoupling are needed to promote sustainable consumption and production (SDG-12) patterns and to make the transition towards a greener and more socially inclusive global economy. To ensure sustainable consumption and production (SDG-12) practices necessarily entail respecting the biophysical boundaries of the planet and to reduce current global consumption rates to fit with the biophysical capacity to produce ecosystem services and benefits.

The progress and existence of humans are frequently threatened by several environmental, social, ecological, and economic problems brought about by global climate change[5]. Climate change has dramatically impacted crop productivity, substantially impacting agriculture and food security[1,6,7]. In addition, the agriculture industry may be negatively impacted by other factors such as pest and disease incidence, coastal soil salinity, and extreme weather events[8]. Due to climate variability, the agricultural sector in Bangladesh is most likely to face significant yield reduction in future[9]. Most importantly, crop agriculture is the most vulnerable to climate change among different sectors of the country. One major determinant of fluctuations in crop yield is year-to-year changes in climatic variables[10]. Despite technical advancements, the climate continues to be a critical factor in determining agricultural output, with rainfall and temperature serving as the main drivers of crop production and rural food security[3,11]. Only temporarily, higher crop yields under higher atmospheric carbon dioxide (CO_2) would mitigate some of the adverse effects of climate change[12]. It has been estimated that, in the absence of CO_2 fertilization, climate change would result in a 17% reduction in crop production for several crops in various parts of the world[13]. Building on these concerns, numerous studies have examined how climate change may affect farm households at present and in the future in terms of agricultural output, net farm incomes, and farmland values[14,15].

It is also essential to keep in mind that by 2050, there will likely be 9.7 billion people on the planet, increasing the strain on agricultural lands to supply the growing need for food that is already being impacted by climate change[16]. Since agriculture and climate change are closely related, the rapid rate of weather changes threaten global food security[5,7]. Due to the world's expanding population and increased food demand, intensive agricultural methods

have been adopted. These activities include using agrochemicals in an unprecedented amount, resource exploitation, discharge of greenhouse gases from agricultural activities, the situation has taken a downturn, and natural resources have been contaminated.

Bangladesh stands out among the nations that are the most vulnerable to the effects of climate change and natural calamities[17]. The country is immersed in low-lying floodplains at the meeting point of the Meghna, Ganges, and Brahmaputra, three mighty Asian rivers, and many of their tributaries[18]. In Bangladesh, there have already been noteworthy changes in rainfall patterns and a dramatic temperature rise[19,20]. Over the previous 40 years, Bangladesh's average daily temperature has grown by 0.103 °C every decade[19]. Additionally, reports of seasonal rainfall patterns and spatial variability discrepancies have been made[21]. Due to dramatic changes in rainfall patterns and increasing temperature, the pattern of agricultural production and consumption have been significantly affected in many parts of the country, especially in the northern region.

The net agricultural income of Bangladesh is susceptible to the weather, particularly the seasonal temperatures. Climatic variability plays a vital role in terms of changing pattern of crop production and income generation. Peasants in locations with adequate irrigation facilities saw a favorable correlation between temperature rise and net crop income[11]. According to the estimated marginal impact, a monthly increase in rainfall of 1 mm and a temperature increase of 10 °C will increase net crop income per hectare in Bangladesh between USD$4 and 15 (Ibid). The effects will, however, differ significantly in terms of location and season. Robustness tests, such as index replacement, quintile regression, and tail reduction, demonstrated the detrimental solid impact of climate change on agricultural productivity. During the climatic parameters, annual precipitation was shown to have no significant effect on agricultural output growth. In addition, temperature and wind speed negatively impact agricultural productivity considerably. In essence, the influence of climate change on agricultural output is a problem for both ecological growth and food security. In most developing nations, agricultural output is directly linked to the long-term needs of humankind for food and nutrition, as well as the subsistence of peasants[22].

The relationship between global food production and climate change seems to be well-established in climate studies. To evaluate the effect of climate change on agricultural productivity, two models have been developed: the Ricardian model, and the agroeconomic model[23]. Mendelsohn et al. claim that the Ricardian model demonstrates both the direct effects of climate change on food security, such as changes in crop productivity, and the indirect effects, such as the replacement effect of production inputs and changes in farmland utilization because of climate change[24]. This is supported by the Food and Agriculture Organization of the United Nations[25], which conceptually linked climate change and the food system's vulnerability and showed how climate change could impact all aspects of food security, including food availability, accessibility, utilization, and system stability. The two main food crops in Bangladesh, rice, and wheat, are found to be significantly influenced by rainfall and temperature, both at the maximum and minimum levels[26]. Maximum temperature harms cropping area and production of both rice and wheat, but rainfall has a significant negative impact solely on the Aman variety of rice.

The assessment of the effects of climate change on crop cultivation in Bangladesh is still lacking in evidence[20,26–30]. Several studies have been examined to assess how agricultural productivity has been affected by the recent climate changes. A few research showed how crop output is impacted by climate change, but very few studies have been carried out on how agricultural productivity is affected by climate change. Studies that addressed Bangladesh and the global south's sustainable production and consumption practices are limited. Earlier studies have provided evidence on how climate change affects people's living ability and the following market oscillation. However, a few studies discuss how the changing climate affects people's consumption patterns and the agricultural output of peasants. As a result, the present study aims to investigate the recent changes in the climatic events, shifts in agricultural production, changes in people's consumption patterns, and the factors related to these changes among the informants living in the study area. The research establishes the pertinent goals: (i) to explore how recent climate changes have affected peasants' agricultural food production, (ii) to reveal how food consumption has been impacted due to recent climate change occurrences.

Conceptual framework: climate change and sustainable crop production and consumption

The study developed a conceptual framework (Fig. 1) highlighting relevant works that addressed the ideas related to the central research question and specific objectives of this research. It facilitates the organization of the study's overarching goals and helps to examine the primary objectives of this research. Figure 1 reveals that the factors, for instance, less rainfall, drought, heat waves, flash floods, and windstorms are the results of climate change. It also illustrates the factors affecting sustainable production and consumption, which have a causal relationship with climate change.

Methods, tools, and sampling techniques

Research design

Various qualitative techniques and instruments were used in this study's data collection and analysis processes. These techniques included a few tools like interview schedules and checklists to accomplish the goals of this research. Using qualitative research methods, the study gathered in-depth information to deeply analyze the data and provide a profound grasp of people's experiences and viewpoints on the subject. The study evaluated the current state of crop diversity and its effects on development, sustainable production, and consumption in the study area. Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) have been used to collect primary data, while secondary data was collected from already published relevant literature. Two sets of interview guides were created, one for in-depth interviews and another for focus group discussions (FGDs), with open-ended questions to ensure the in-depth interviews and FGDs matched the research objectives. When developing these guidelines and checklists, several elements were considered, such as carrying out a systematic literature review on diversified production, choosing indicators based on the conceptual framework, and conducting a field visit during the pre-testing phase. Open-ended questions allowed participants to express their subjective opinions, cognitive insights, and experiential narratives without being constrained by predetermined response choices, facilitating the space to elicit meaningful answers. These answers were then translated into Bangla, the local language, to guarantee greater understanding and the participants' active involvement. A pre-test of the open-ended interview guide was run to improve the procedure. Participants were taken through the interview guide and checklist throughout the in-depth interviews, assisting them in addressing questions that had not been asked or explored. This encouraged thorough responses. Every interview was taped to preserve the gathered data, and transcriptions were made.

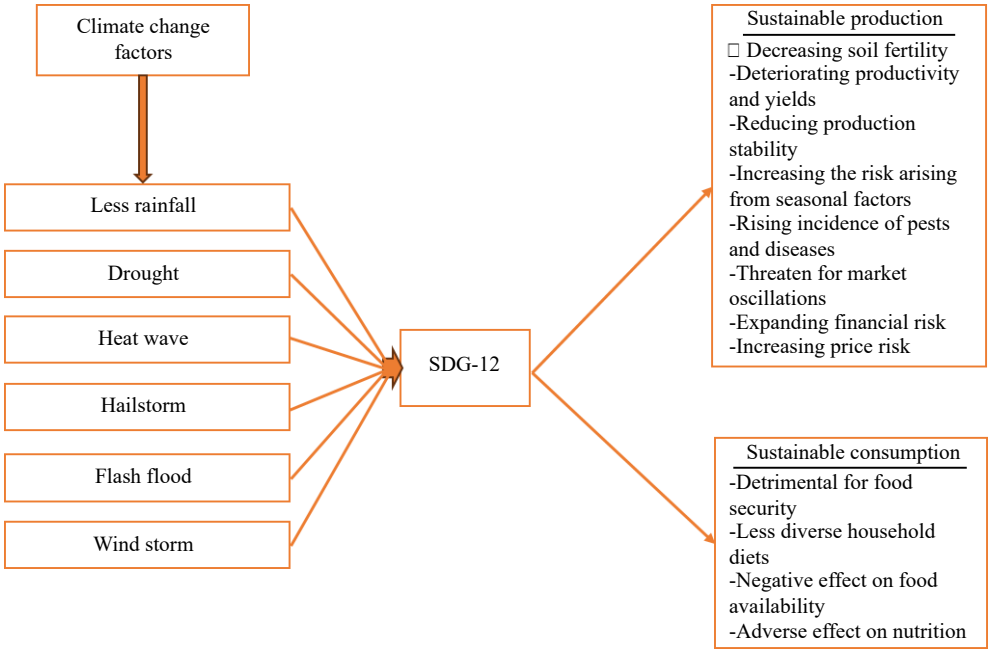

Fig. 1 The conceptual framework (climate change and SDG-12).

Selection of study area

The study focused on a few northern regions from the Rajshahi Division (Bangladesh), which are well-known for their substantial contributions to food production through agriculture because of their advantageous geographic location and land use. The study has chosen a specific area based on purposive sampling due to this region's significant food cultivation. When choosing research areas, four different zones were deliberately in the district. Two main elements drove this decision: first, a sizable community of small-scale food producers, or peasants, living in these areas (28,921)[31]. In contrast to other districts, this region is notable for having an extraordinarily high food production output. Furthermore, the researcher's are located near the selected research site.

In-depth interviews (IDIs)

The study selected 20 key informant interviews (KIIs) for in-depth interviews. Based on the purposive sampling method, respondents who were residents of the study area and possessed extensive knowledge of local food production and its connection to SDG-12 were selected. Before settling on the interview schedule, three interviewing processes were tested with informants outside the research area. This ensured the procedures were understood and to see if any changes or additions were needed. A tape recorder was used to record every interview with the participants' full consent. Every interview was recorded to protect the data, and transcriptions were completed. The data was collected between September 12, 2023, and November 26, 2023.

Focus Group Discussions (FGD)

The study conducted five Focus Group Discussions (FGDs) with 40 participants of various socioeconomic backgrounds. To accommodate their preferences for taking part in in-depth talks, the study participants were consulted before the FGDs to choose the place and timing of these sessions. To guarantee a homogeneous group for every FGD session, the research ensured that participants in a given session had similar attributes. Each FGD session was audio-recorded and documented by one of the co-researchers. Six informants participated in the first FGD, which was held in the *Amrito Para*, and seven people attended the second, which was held in Dhushpara. Eight people attended the third Focus Group Discussion (FGD) in the Rahimpur area, while seven attended the final FGD in the Bakna area. Lalpur is a sub-district (Upazila) located in the Natore district of Rajshahi division in the northern region of Bangladesh. Natore district itself is known for its historical significance and cultural heritage. Lalpur Upazila is characterized by its rural landscape, agricultural activities, and community life typical of many parts of rural Bangladesh.

Data analysis techniques

Analyzing the large amount of data collected using a qualitative method was problematic. To remedy this, a thorough data curation process was conducted, excluding information that did not directly correspond with the study's aims. The central ideas pertinent to the study's goals were listed. The data was then carefully examined for errors, incompleteness, or irrelevance, and eliminated. As a result, a thorough examination was carried out to ensure everything complied with the main objectives. Using a thematic approach to data analysis, recurring themes and patterns in the narratives that emerged from the interviews were identified (see Table 1). This theme analysis discovered the data's shared and unique characteristics. Table 1 showed that the data was coded, separated, and presented in the next step in line with the goals of the study. The concepts of narrative and interpretative analysis served as the basis for the coding procedure. To support the informants' sense-making, which is crucial in this research, a forum was provided to draw from their knowledge, viewpoints, and experiences gained from their own experiences. The study utilized the 'member checking' technique to verify the reliability and authenticity of the data collected by providing the study informants with a summary of the key findings.

Data collection and management

The 'what' aspect of crop diversity was the main focus of this study. Later, the methodological framework was used to analyze the 'why', and 'how' questions of crop diversity. These three elements are intimately related, as are their diversification-related dimensions. The gathered data underwent a thematic analysis to identify the key themes and patterns from the respondents' narratives. Table 1 reveals thematic analysis, illustrating how the obtained data have

Table 1. Framework illustrating themes, and sub-themes.

	Themes	Sub-themes	Coding	Informants
i	Less rainfall and reducing crop production stability	Variability of temperatures and less precipitation	Year-round variations in temperature and precipitation, decreased and delayed rainfall significantly.	R1, R2, R3
		Decreases farmers' cost of agricultural output	Extreme heat, drought catastrophically impair our farming system.	R4, R5, R6
ii	Less rainfall and crop cultivation	Less rainfall, leading to reduced crop yields	Less rainfall leads to reduced crop yields and affects peoples' livelihoods as well as impacts on the national economy.	R4, R5, R6
iii	Climatic factors and crop diversification	Producing diversified crops on their lands	Climate variability affects to crop diversification.	R7, R8, R9
iv	Climatic factors and soil fertility	Less rainfall decreases the quantity and quality of agricultural land	Crop diversification largely depends on soil fertility.	R13, R14, R15
v	Climate change, market oscillation, financial risks, and price hikes	Extreme weather leads to fluctuation of prices regularly	Current state of climate change has caused financial difficulties for farmer.	R16, R17, R18
vi	Climate change, less food availability	Peasants harvests low-yielding crops	Climate change affects the peasants to stock adequate crops.	R18, R19
vii	Climate change, food stability	Lack adequate nutrition	Climate change affects the stability of local food supply.	R19, R20

been organized, presented, and compared in terms of both similarities and differences followed by themes and sub-themes. Using a manual approach, the data was divided into categories based on the analysis, structuring, organizing, and coding processes (see Table 1). Subsequently, the collected data were divided into smaller groups and segmented on particular themes.

Data sources and ethical considerations

Conducting in-depth interviews with key informants facilitated the collection of primary data. To conduct the interviews, a checklist, and an interview guide were developed. In-person interviews with the informants took place at their favored locations. To prevent awkward or embarrassing situations, the interviewer tried to get the informants' oral agreement and have a friendly conversation with them. When further clarification was needed, the questions were repeated, and examples were provided.

Data findings and analysis

The following sub-themes have been developed to examine the research-specific objectives. All sub-themes have emerged from the data collected from the study informants. These sub-themes have also been created, keeping this research's central aims and objectives in mind.

Less rainfall and reduced crop production stability

Figure 2 explains that rainfall and temperature are related to climate variability. The location's year-round variations in temperature and precipitation can be used to explain its climate. Furthermore, long-term, substantial changes in a location's climate are called climate change. The figure found that there has been a change in the environment in the northern part of Bangladesh over the last 10 to 12 years. Several informants stated that 'there is a decrease in rainfall and a rise in temperatures', along with a reduction in rainfall that occurs later than typical. It began to rain in early April, and after a few days, it started to rain again. This process has continued until the middle of October. Agricultural land uses rainfall to collect water for crop cultivation and rainfall to obtain fertilizer for crop production (stated by R1, R2, and R3). Furthermore, the peasants grew enormous crops because of this downpour. Additionally, it decreases a farmer's cost of agricultural output. Decreased and delayed rainfall significantly impacts agricultural productivity in areas like the Lalpur sub-district in the Natore district. Bangladesh's agriculture relies heavily on monsoon rains for crop irrigation and growth, so any deviations from standard rainfall patterns can severely affect crop yields. A reduction of more than 30% in crop production solely due to less rainfall is a concerning statistic. Peasants in these regions often face challenges such as water scarcity, reduced soil moisture, and prolonged dry periods, which can hinder crop growth and development (stated by R4, R5, and R6). This situation impacts local livelihoods and poses broader economic and food security challenges for the region (see Fig. 2). The study also found that temperatures and drought rates have increased as rainfall has decreased. Extreme heat, drought, and little rainfall deplete soil fertility and catastrophically impair the farming system. As a result, there has been a decrease in crop yield overall.

Less rainfall and crop cultivation

Figure 2 shows that the primary crops grown in the region include jute, rice, wheat, sugarcane, lentils, and corn. 'Typically, peasants plant jute in early April and grow it until August. They prepare the ground by giving fertilizer and plowing it before planting the jute seeds (stated by R4, R5). Twenty to 25 d later, they eradicate the weeds for the first time and then apply fertilizer once more. Informants argued that 'we usually take care of the weeds one last time when the jute is between 50 and 60 d old. We cut the jute when the jute age is 110–120 d. Later, the peasants submerge the jute in water for 15 to 22 d. After that, they remove the fibers from the tough stems and give them a water wash. The removed fibers are dried and given another water wash to ensure the right hue. To sell it in the primary market, they finally tie it into little bundles. To grow jute, they require rainwater at every stage' (R5, R6). Ten to 12 years ago, they had rainwater available for cultivation. However, now, there is less rain and more heat waves, and rainfall does not always occur at the ideal moment. As a result, the peasants' jute production has suffered. In this regard, several FGD informants stated: 'The intense heat waves have burned and destroyed a lot of jute' (R4, R5, R6). Because there is less rainfall to produce jute, some villagers employ irrigation systems, which raises the cost of jute cultivation.

Figure 3 also explains that the impact of decreased rainfall on crop production, including jute and other crops in this region, can have far-reaching consequences beyond local agricultural outputs. When peasants face challenges due to less rainfall, leading to reduced crop yields, it not only affects their livelihoods but also impacts the national economy. Reduced jute and other crop production due to less rainfall directly affects their income who depend on agriculture. Jute is an important export commodity for Bangladesh. Any decrease in production can lead to lower export revenues, affecting the country's balance of trade and foreign

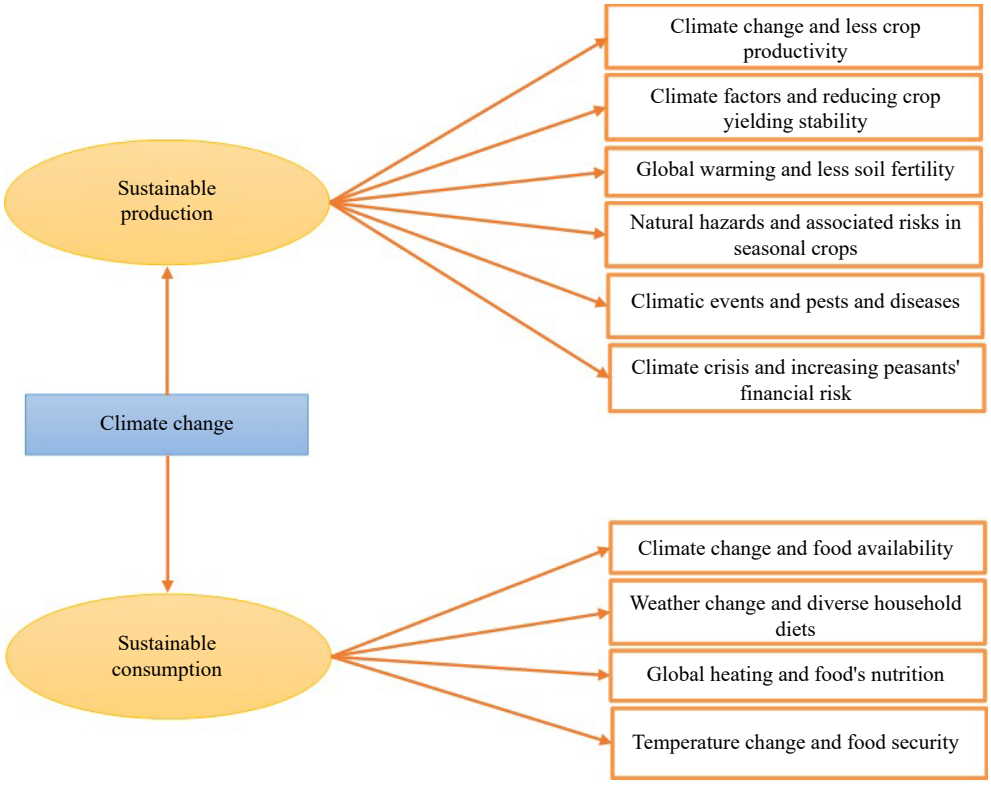

Fig. 2 Climate change and sustainable crop production and consumption (SDG-12).

exchange earnings. Also, a decline in agricultural output due to climatic factors like less rainfall can, therefore, impact the overall GDP growth of the country, (R5, R6). Also, agriculture, including jute cultivation, employs a large segment of the population in rural areas. A decrease in crop production can lead to reduced employment opportunities and affect the rural economy. To address these challenges, the government and agricultural stakeholders may consider implementing strategies as follows.

Climatic factors and crop diversification

The study pointed out that many crops are harvested once a year, such as sugarcane (see Fig. 3). Some peasants cultivate sugarcane on their agricultural land. 'Most of the peasants in this area produce diversified crops on their land. Rice is one of the diversified crops in our area. It takes only 3 months for harvesting' (R7, R8). The study revealed initially, there was sufficient rainfall to support rice cultivation in the past. However, recent years have seen a decrease in

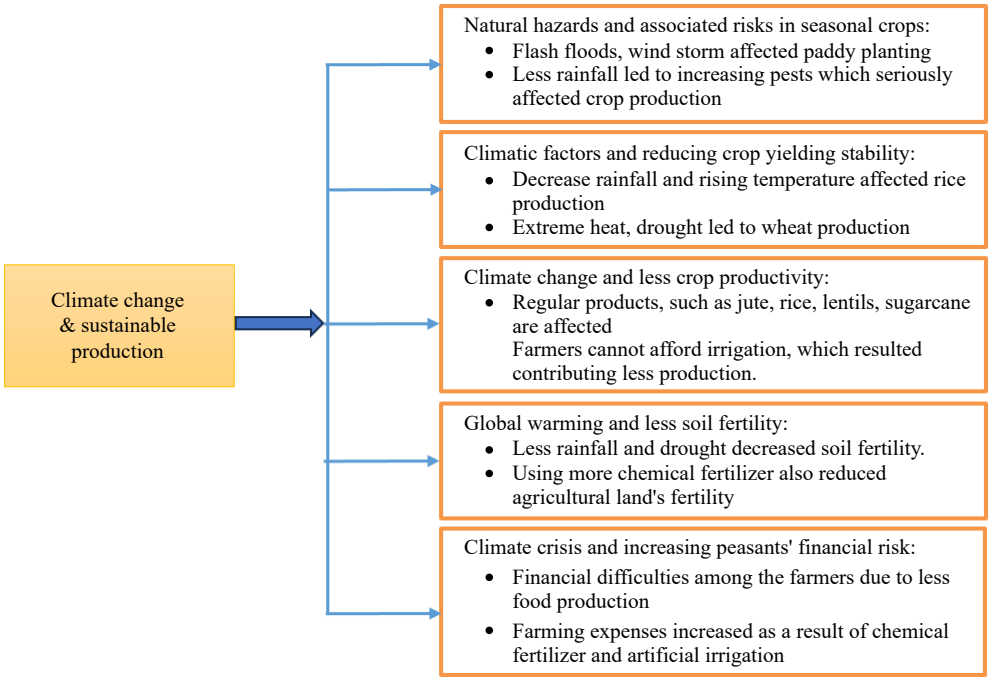

Fig. 3 Climate change and sustainable production.

rainfall and increasing drought and heat waves during the rice-growing season. This shift necessitates greater reliance on irrigation systems, increasing their costs. 'Peasants began cultivating rice after farming jute. Beginning in early August, rice is planted. At first, they plant the seeds in beds that have been prepared. After the seedlings have grown for 20 to 30 d, they move them to a field that has been prepared and cover them with 1 to 2 in of water. After transplanting them, peasants fertilize the paddy field 21–25 d later, and 41–45 d later. They typically harvest rice from the paddy field in the middle of November. Since there is no rain during the rice-growing season, they require more rainwater from seeding to mature the paddy to produce rice successfully. It was pouring heavily 10 or 12 years ago. The precipitation provided adequate water bodies for the paddy field. The rate of rainfall has decreased more recently due to climate change' (R7, R8, R9).

Peasants thus rely on the irrigation system. As a result, growing rice has come at a hefty cost to the peasants. Many informants stated, 'because of climate change, it not only decreased the amount of rainfall but also increased natural hazards'. There are instances when flash floods happen, submerging many of their paddy fields. Additionally, the frequency of hailstorms has increased as of late. 'The hailstorm severely damages a large number of paddy crops. Furthermore, the frequency of windstorms has grown in recent times. The windstorm has pushed many paddies to the ground. The pace of output for paddy planting has decreased. The study pointed out that the frequency of windstorms, hailstorms, and flash floods has increased recently due to climate change (Fig. 2). Additionally, the number of diseases and pests has increased due to climate change. Peasants have applied additional insecticides to paddy fields to control diseases and pests' (R10, R11, R12). Several informants argued that 'the use of pesticides in rice fields has resulted in a loss in soil fertility and increased paddy cultivation costs. Consequently, it is challenging to produce rice for them because of recent climate change. Climate variability also affects crop diversification, as rice is one of the diversified crops in the area' (R8, R9).

Climatic factors and soil fertility

The study showed that after harvesting rice, peasants typically begin cultivating wheat, corn, lentils, potatoes, or onions (see Fig. 3). The type of crop growing on a particular agricultural land depends entirely on the peasants. 'Wheat is typically grown by the majority of producers in their fields. It begins in mid-November and ends with harvest at the end of March (stated by R13, R14, and R15). Many informants stated that peasants prepare their agricultural fields by plowing the ground and applying fertilizers. They then sow wheat seeds on the ground. To cultivate wheat, peasants typically irrigate their fields two or three times. They usually fertilize their wheat land twice after seeding. Numerous climatic and soil conditions are required for the cultivation of wheat. It needs bright sunshine and dry conditions. The study found that the typical timeframe from seeding to harvesting is 100–120 d'.

Climate change has severely impacted agricultural productivity, especially in the study areas. 'The production of wheat, as well as corn, lentils, potatoes, onions, and all kinds of crops depends on soil fertility. Previously, when jute and rice were grown during harvesting, it was used to rain adequately. The rainwater increased soil fertility and decreased pests and diseases in agricultural fields. As a result, the productivity of wheat, corn, lentils, potatoes, and onions was equally impacted and thus increased their production' (R13, R14, and R15). However, the climate has dramatically changed, so rainfall has decreased the quantity and quality of jute and rice cultivation. Conversely, drought and heat waves have increased, which badly deteriorated the soil fertility and increased pests and diseases on the agricultural land. As a result, they cannot produce more crops from their land because of declining soil fertility due to climate change.

Climate change, market oscillation, financial risks, and price hikes

Figure 3 illustrates that the rate of crop production has decreased because of climate change, and peasants are also failing to harvest their crops in the season due to extreme heat waves, severe droughts, and decreased rainfall. Therefore, they face different financial risks. On the other hand, in the local market, market prices fluctuate regularly. The study showed that the current climate change has resulted in a decline in rainfall rates and an increase in the trend of drought and heat waves. As a result, some peasants' crops suffer terrible destruction, and others obtain inadequate yields from their fields. In addition, the current state of climate change has caused financial difficulties for them. 'Climate change is to blame for the current increase in the rate of drought. In response to the growing drought, the peasants irrigate their agricultural fields repeatedly. Moreover, the number of diseases and pests is also increasing due to environmental change. They apply more pesticides in their farms. Because of pesticides and irrigation, their expenses are rising. Nevertheless, regarding their farming expenses, they cannot set fair prices for their production' (argued by R16, R17).

Climate change, less food availability

Several informants argued that 'some crops have been devastated by severe drought, low rainfall, and intense heat waves. As a result of climate change, the peasants also harvest low-yielding crops from the agricultural areas' (R18, R19). Figure 4 shows that the quantity of crops grown, particularly from April to August, increases crop destruction among them. Furthermore, some of the small-scale producers yield less crop than others. 'Due to climate change, they cannot stock enough crops for their food and cannot provide as many agricultural products to the market as before. Additionally, they are employing fewer laborers to work on their farms. For laborers and peasants, this has resulted in a decrease in their income. Unfortunately, due to their poor income, laborers and peasants have altered their food consumption' (R18, R19).

Climate change, food stability

Figure 4 highlights that the agricultural output of the study area region has decreased, and the quality of the food produced has declined. The study found that a couple of years ago, the peasants supplied more crops in the local market and kept a variety of crops in their houses to supplement their diets. However, due to climate change, they cannot stock a diverse range of crops in their home or increase the number of products they sell in the neighborhood markets. Thus, they lack adequate nutrition, which is essential for their health. 'A few years back, the peasants used to produce more harvests in their agricultural areas. However, they cannot plant as many crops in their fields because of climate change as they did before. This affects the stability of our local food supply because they cannot consistently deliver additional crops to the local market' (R19, R20).

Discussion

The results of this study showed that dryness and decreased rainfall are significant factors that lowered crop production stability in the study area. Recent studies by Rahman et al. & Hossain et al. stated that the world's climate is already marked by variations in rainfall and global temperature, which substantially impacts the sustainable production of necessary daily foods[7,32]. Furthermore, Fagbemi et al. contend that climate change is putting South Asian agriculture at risk[33]. Consequently, adaptation of new strategies is

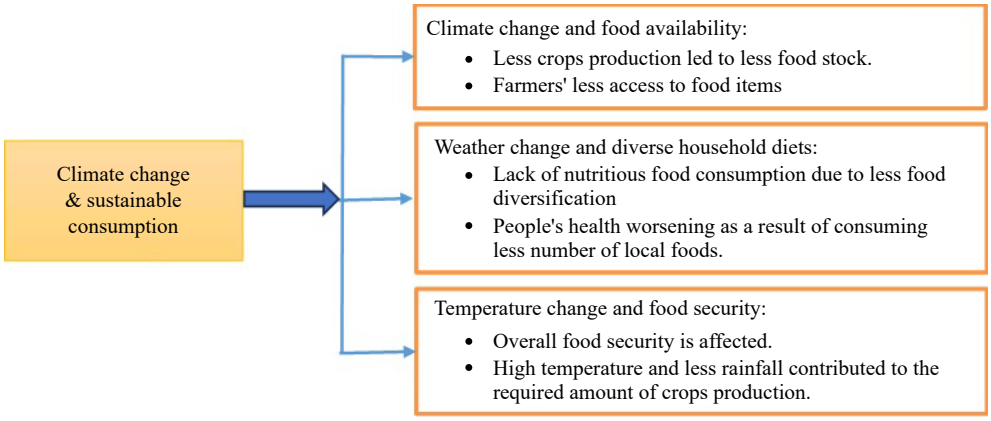

Fig. 4 Climate change and sustainable consumption.

needed to maintain agricultural productivity, lower vulnerability, and increase the farm system's resilience to climate change.

Many studies, such as the ones by Aryal et al. & Fagbemi et al., claimed that agriculture in South Asia and many other regions is susceptible to climate change[33,34]. This study confirmed other research by determining that drought and decreased rainfall significantly impact main food crops such as corn, rice, wheat, jute, sugarcane, and lentils[11]. The study demonstrated how the increased frequency of windstorms has negatively impacted many paddy fields. As a result, the rate of production for paddy planting has decreased. Hossain et al. showed that food production has declined due to changing climatic circumstances[32]. This is a severe problem for the years to come.

The study reveals that soil fertility is gradually declining due to current climatic hazards such as less rainfall, increasing heat waves, and drought. Recent studies showed that soil moisture is expected to change due to current global warming[35,36]. The chemical properties of soil, such as salinity, nutrient cycle, acquisition, and cation exchange capacity, are affected by climate change[37]. Hamidov et al. pointed out that climate change affects soil functions directly, such as temperature, precipitation, and moisture regime changes, and indirectly, such as irrigation, crop rotation changes, and tillage practices[38]. Pareek argued that recent climate change has significantly impacted agriculture, negatively impacting crops, soils, livestock, and pests[39].

Le Dang et al. argued that peasants appear to have different risks at which climate change highly impacts their physical health, finances, and production[40], and this current study confirms this result. The findings of this research have also been confirmed by other research, which revealed that rural peasants are more affected by climate change through increased temperature, prolonged dry seasons, floods, and drought, which leads to low harvest and, in turn, low income[41]. Problems associated with climate change seriously affect agriculture, forestry, and natural ecosystems, as stated by Farauta et al.[42].

The nation's food production is plagued by persistent difficulties that make it difficult to feed its excessive population. Faroque et al. also showed how the country's food security has been impacted by the escalation of production and environmental stability brought on by a lack of agricultural sustainability[43]. Food accessibility and availability have significantly decreased due to recent climate events, as noted by Rahman et al.[7] and confirmed by the current study. This study showed how global warming and related variables impacted the country's food security, which was corroborated by other studies regarding the stability and consumption of food today.

Conclusions, limitations, and future research scopes

The research focused on how some areas of Bangladesh are affected by climate change in terms of sustainable food production and consumption. The study used qualitative research methods to explore the informants' perspectives and views on the study's central objectives. By examining changing climate elements and their relationships with agro-food production and people's consumption preferences, the study aimed to understand how climate change influences food production, consumption patterns, and food security for different populations. This holistic approach helped develop strategies to mitigate risks and adapt to the challenges a changing climate poses.

Natural disasters have impacted various crops, which have decreased food availability, stability, and usage while affecting people's access to daily necessities. This study examined current climate events and their effects on food production systems across the nation, developing a conceptual framework. The different climate elements and their relationship to the decline in recent food production, shifting food consumption, and their impact on people's food security, food availability, etc., are given particular attention in this study. The study revealed that higher temperatures can affect crop growth negatively or positively depending on the crop and local conditions. Temperature patterns can alter the traditional growing seasons, affecting planting and harvesting times. Increased temperatures impact evaporation rates, affecting crops' soil moisture, and water availability. Erratic precipitation patterns lead to droughts or floods, severely impacting crop yields and food production. Inconsistent rainfall leads to water stress for crops, affecting their growth and productivity. Changes in precipitation patterns require adaptive water management strategies to ensure consistent food production. The research recommends evidence-based solutions: (i) introducing more resilient crop varieties to adapt to changing climatic conditions; (ii) implementing efficient irrigation and water conservation practices; and (iii) developing policies that support sustainable agriculture and mitigate climate risks.

The study used data gathered from the purposively selected informants that might not have been sufficient to identify the study's primary goals. A quantitative analysis may be conducted in future research to investigate the peasants' perspectives on the abovementioned subjects. To properly convey the goals and objectives of the study, it may also touch on how crop diversification and local food production are affected by climate change.

The study results will assist peasants in developing suitable methods and approaches to effectively manage the recent climate

hazards occurrences and generate essential products that are essential for satisfying the needs of the rural population. Additionally, planners and legislators would receive assistance in creating suitable policies to combat climate change and support peasants in growing wholesome food, and other related tasks. The results also have significant ramifications for adopting ecological zone-specific initiatives to mitigate the decline in food production and enhance national food consumption.

Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Rahman MM; data collection: Ferdousee S, Islam A; analysis and interpretation of results: Rahman MM, Islam A; draft manuscript preparation: Mahmud SMA, Ferdousee S. All authors reviewed the results and approved the final version of the manuscript.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflict of interest

The authors declare that they have no conflict of interest.

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