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RESEARCH ARTICLE

Climate Change Adaptation in Batang Hari, Jambi: A Case Study of Rainfed Paddy Farmers

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Abstract Batang Hari is situated as one of the central rice-producing regencies within Jambi Province. However, the agricultural sector in Batang Hari is severely impacted by climate change in the context of productivity. This study aimed to examine rainfall and temperature trends over the last 20 years (2002 to 2021), assess farmers' perceptions, and identify the current adaptation measures due to the impact of climate change on rainfed paddy fields. This study is of great importance because it employs a holistic approach, integrating quantitative data on climate trends with qualitative insights from farmers. The results showed that rainfall decreased by 20–50 mm/month, and the average temperature increased by 0.4°C in 20 years. The qualitative data on farmers' perceived impact of changes in climate variability reported an agreement with climatological data. The farmers perceived a decrease in rainfall and a concurrent rise in temperatures. Furthermore, a delayed onset of the rainy season was noted, leading to an adjustment of their planting schedules. Certain adaptation measures to adjust to the perceived impact of changes in climate variability on their rainfed paddy fields were also implemented. These measures included crop management as well as socio-economic adaptation. Farmers' adaptation measures included modifying crop varieties, adjusting planting seasons, adopting agricultural machinery, and diversifying income through off-farm activities. It is also important to emphasize technological based adaptation to enhance climate resilience, as well as sustainable land management practices, agroforestry initiatives, and soil conservation efforts for long-term agricultural sustainability.

1. Introduction

Climate change is a significant global challenge and is largely driven by human activities on Earth (IPCC 2007; 2014). Scientific evidence has shown that increasing levels of greenhouse gas emissions due to human activity are causing irregular rainfall patterns and increasing temperatures (Trinh 2018). Agriculture is widely recognized as the sector most severely impacted by climate change affecting productivity (Naylor et al. 2007). In this context, decreased rainfall and increased temperature followed by high evapotranspiration rates lead to water deficits in crops (Sekaranom et al. 2021). However, rainfed agriculture is more vulnerable because the climate variables are the main factors (Rao et al. 2011; Singh 2015). This concept is a crucial contributor to global food production, particularly in developing countries, with an estimated 80% of the world's agricultural area consisting of rainfed systems. Meanwhile, approximately 60% of these systems are located in South Asia (Sathyan et al. 2018; Satishkumar et al. 2013). Climate change has affected the decline of agricultural production globally, including rice production. In Indonesia, the decline reached 0.4% in 2021 compared to the previous year (Ikhwali et al. 2022), as well as 1% in the 2018–2020 period (Arifah et al. 2022). This decline has direct and indirect impacts on the social and economic sustainability of farmers, including loss of income and increased seasonal unemployment (Alam 2011). Therefore, it is important to address climate change's effect by reducing the vulnerability of farmers. The action is to improve adaptability (Jamshidi et al. 2019) and the implementation of appropriate measures is considered to reduce the negative impacts of climate change (Seo 2011).

Several research studies have been carried out to investigate how farmers perceive climate change's effects on agriculture (Adiyoga 2018; Rondhi et al. 2019). However, only a limited number of studies have been conducted to determine the types of adaptation methods for coping with the consequences of climate change (Sekaranom et al. 2021). In this study, rainfed paddy fields in Batang Hari Regency were discussed, one of the central rice-producing regencies in Jambi Province – Indonesia. Batang Hari is one of the regencies in Jambi Province located on Sumatra Island. This regency produces an average of around 25,000 tons of rice annually from 2019 to 2021 (BPS Jambi, 2022). Although the contribution from Batang Hari regency is not significant compared to other regencies and nationally it is not a major rice producer, several studies have indicated the importance of sustainable rice farming in the province (Frimawaty et al., 2013). On the other hand, increasing occurrences of extreme rainfall and floods have caused considerable agricultural losses since 99% of them are rainfed paddy area (Handoko et al., 2024; Fathi and Setiawan, 2019). This has led to an increased agricultural risk in the area, which is predicted to have a significant impact since many farmers are smallholder farmers (Kunz, 2019). The area is also predicted to be severely affected by climate change since the harvested area decreased by 25% in 2021 compared to the previous year due to drought (Jambi Central Agency on Statistics 2022; 2023).

The perceptions of farmers regarding perceived climate change were identified by comparing trends in rainfall and temperature over the last twenty years (2002–2021). Therefore, this study attempts to answer how rainfed paddy farmers perceive these trends and the current adaptation measures are selected. Farmers' insights are important to be recognized, representing the level of perceived impacts. Perception of past climate-related catastrophes ultimately prompted farmers to take adaptation measures (Rondhi et al. 2019). Several studies have shown that farmers have implemented adaptation measures in response to climate change and have generated positive implications on crop yields (Khanal et al. 2018). However, several constraints restrict the implementation of adaptation measures, such as financial, social cultural, and information (Adger et al. 2007).

This research holds significant importance due to its comprehensive approach, which combines both quantitative data on climate trends and qualitative insights from farmers. By integrating these two aspects, the study gains a more holistic understanding of the impact of climate change on rainfed paddy fields in Batang Hari Regency. Quantitative data on climate trends provides a factual basis for assessing changes in rainfall patterns and temperature. On the other hand, qualitative insights from farmers offer a human perspective, revealing how these changes are perceived and experienced on the field. This combination allows for a deeper analysis of the challenges faced by farmers, the adaptation measures, and the effectiveness of these measures in mitigating the impacts of climate change. This study aims to delve deeper into agricultural adaptation by contributing to a broader understanding of climate change issues in Jambi Province, particularly in Batang Hari. The specific objectives of this study are to: 1) assess the long-term trends in rainfall patterns and temperature in Batang Hari Regency over the past two decades (2002-2021), 2) investigate farmers' perceptions of climate change and its impact on rainfed paddy fields in Batang Hari Regency, and 3) identify the adaptation measures currently being implemented by farmers to cope with the effects of climate change on agriculture. In this research, agricultural adaptation encompasses three main types: crop diversification, crop intensification, and socio-economic adaptation (Sekaranom et al., 2021).

2. Methods

The research was carried out in Batang Hari Regency situated in the center of Jambi Province. The area covers 5,180.35 Km^2 with coordinates 1°15'–2°2' S and 102°30'–104°30' E (Fig. 1). Batang Hari experiences a tropical climate characterized by average temperature and annual rainfall range of 20-30°C and 2,264–2,976 mm/year (Batang Hari Government Office, 2012).

The analysis of changes in rainfall and temperature was carried out to determine how these variables have been affected by climate change. The data from 2002 to 2021 were acquired from the online data of the Meteorological, Climatological,

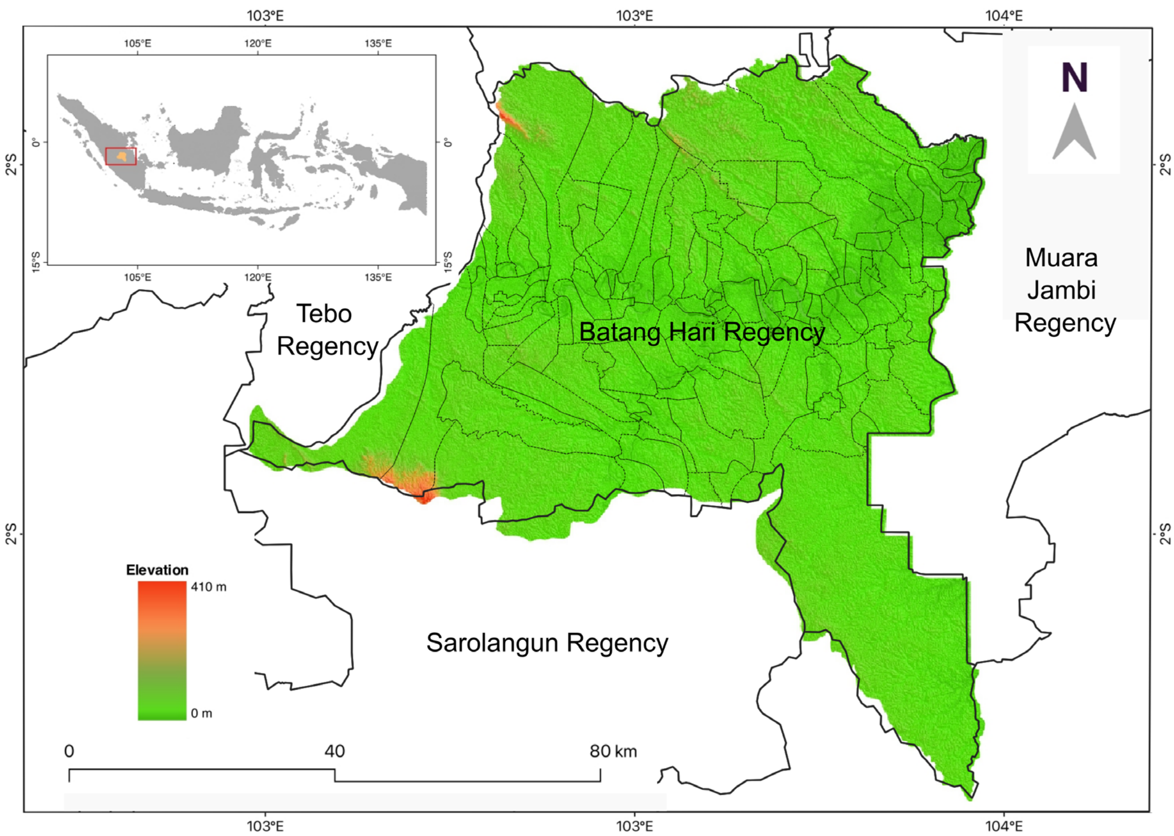

Figure 1. Study area Location (Source: data processing, elevation data from Indonesian Digital Elevation Map Database/ DEMNAS, accessed from https://tanahair.indonesia.go.id/demnas/#/)

and Geophysical Agency of Indonesia (BMKG) website (https://dataonline.bmkg.go.id/home) by selecting the Muaro Jambi climatology and meteorology station (BMKG 2022). The average data from the climatology station from 2002 to 2021 were analyzed for the same time range from 2002 to 2011 and 2012 to 2021. The results of these analyses were used to compare farmers' perceptions of changes in climate variability.

Data on farmers' perceptions and current adaptation measures to climate change were collected through interviews related to perceived changes in climate variability during their agricultural activities and identified using qualitative descriptive methods in 2022-2023. Purposive sampling method was carried out by selecting respondents through several criteria. The characteristics of respondents were male farmers who were heads of households and had paddy fields of less than 10 hectares since rice was their main source of production. Out of 157,318 farmers in Batanghari Regency (BPS Jambi, 2022), 100 respondents from farmer families were selected. This value represents a 10% margin of error from the calculation of determining the sample size based on the Slovin's formula (Wulandari and Kurniasih, 2019). Out of those 100 respondents, interviews were conducted for each sub-district, taking into account the area of rice farming in each sub-district. The highest number of respondents was in Muara Bulian sub-district (21 respondents), while the lowest number of respondents was in Batin Dua Puluh Empat and Maro Sebo Ilir (5 respondents each) as shown in Table 1. Interview questions covered various topics, including changes in rainfall and temperature, farmers' characteristics, adaptation measures, land holdings, and capital resources. Gender issues in climate change have received significant attention since females are considered more vulnerable to the impacts. However, male farmers tend to have greater access to resources and are the head of the household, with a better potential in adapting to climate change (Sekaranom et al. 2021; Perez et al. 2015).

The first question pertains to the respondents' background, including age and education. The second question relates to farmers' perceptions of the most significant impacts of climate change on agricultural activities at the study location. The options include reduced monthly rainfall, increased extreme rainfall, more days with extreme temperatures, and fewer days with cold temperatures. These factors can affect specific types of agricultural crops, and changes in climate variability can be detrimental to farmers. In the next stage, interviews will be conducted regarding the risks of climate change on agricultural activities, especially from a hydrological perspective. This includes severe drought, reduced surface water, soil fertility loss and erosion, floods, increased plant diseases, increased crop pests, decreased groundwater supply, and land fires. Farmers' perceptions are measured regarding the impact of these phenomena categorized into three levels: low, moderate, and high risk.

The two forms of adaptation strategies practiced in the agricultural sector are crop diversification and intensification. Crop diversification can be achieved by planting varieties more tolerant of climate variability or different crop species in a planting season or year, while crop intensification is adjusting the planting season, using sophisticated machinery for agriculture, and applying fertilizers and pesticides (Sekaranom et al. 2021). Meanwhile, socio-economic adaptation is related to the size of land ownership and capital resources. Farmers with larger land sizes will increase adaptation costs and reduce the practices (Rondhi et al. 2019). Capital resources are essential for farmers for the next planting season but the depletion cannot be stopped due to climate change. Therefore, the adaptation measures selected are having a side job or accessing additional financial loans (Sekaranom et al. 2021).

In this research, adaptation is measured from two aspects: agricultural land management and socioeconomic adaptation, including capacity building. Agricultural land management is categorized into agricultural planning, technological related adaptation, soil management, crop management, and land management. Adaptation efforts in agricultural planning consist of 1) availability of information from weather monitoring systems, 2) information related to seasonal predictions, 3) use of simple early warning systems, and 4) availability of agricultural/climate insurance. Land management also includes technology-based adaptation, such as 1) use of machinery in agricultural intensification, 2) rainwater harvesting, 3) groundwater utilization, and 4) use of sprinklers and drip irrigation. Agricultural land management-based adaptation in term of soil management efforts, including 1) fertilizer usage, 2) organic soil nutrient management, 3) conservation tillage, and 4) slow-forming terraces. Another aspect measured is crop management, including 1) crop diversification and new varieties, 2) crop rotation, 3) pest and disease control, and 4) planting date adjustments. Adaptation efforts in land management in term of land management related efforts, such as 1) poultry rearing, 2) livestock rearing, 3) agroforestry, and 4) mixed farming. This entire information is not only processed qualitatively but also quantitatively by categorizing respondents' answers into three classes based on their most significant impact, including low importance, medium importance, and high importance.

The three levels of importance in land management-based adaptation (from low importance to high importance) are also applied to socioeconomic adaptation and capacity building. Several parameters measured include the roles of 1) household farmer associations, 2) farmers' wives associations,

Table 1. Number of Respondents by District in Batang Hari (Source: Data Processing, 2023)

No	Subdistrict	Paddy Field Area (Hectares)	Number of respondents
1	Batin Dua Puluh Empat	351,62	5
2	Maro Sebo Ilir	343,79	5
3	Maro Sebo Ulu	1.351,51	19
4	Mersam	1.352,56	20
5	Muara Bulian	1.607,07	21
6	Muara Tembesi	1.078,43	15
7	Pemayung	1.102,36	15
Total		**7.287,34**	**100**

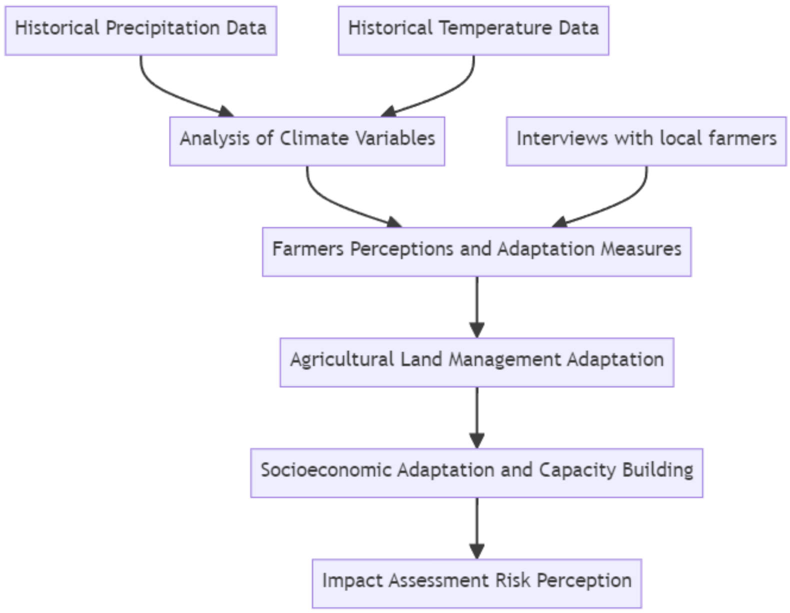

Figure 2. Flowchart of the data processing used in this research (Source: data processing, 2023)

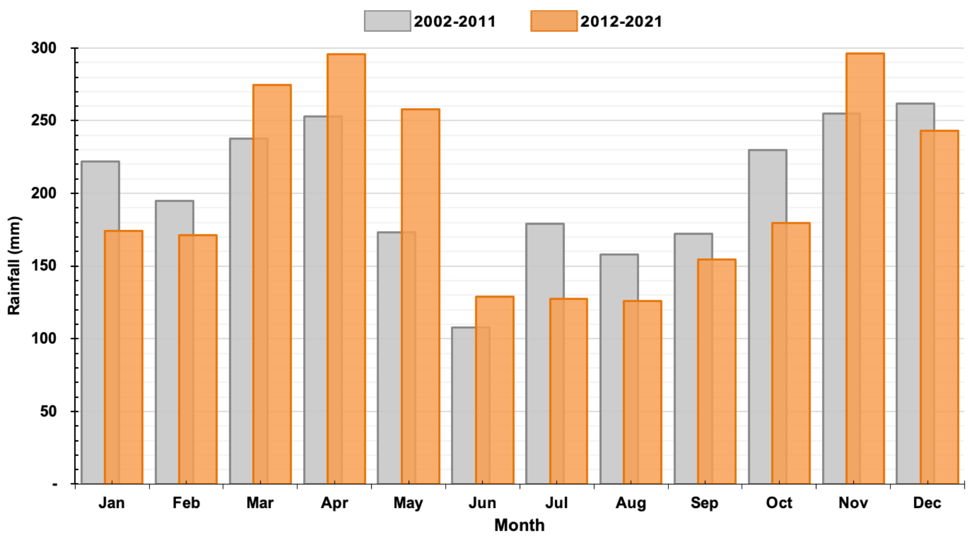

Figure 3. Comparison of average monthly rainfall for the period of 2002-2011 and 2012-2021 in Batang Hari (Source: data processing, 2023)

3) farmer field schools, 4) community-based water resource associations, 5) forest conservation associations, 6) availability of farm work, 7) availability of agricultural loans/credit, and 8) the role of temporary migration. The summary of the method used in this research is shown in Fig.2.

3. Results

3.1. Climate change in Batang Hari

The monthly precipitation data shows that there are two peaks of rainfall in Batanghari, namely around November–January and March–May. Furthermore, the data is separated into two periods, namely 2002–2011 and 2012–2021, as shown in Fig. 3. The amount of rainfall decreased between the most recent period (2012–2021) compared to 2002–2011. The rainfall is increasing in specific months, particularly in November, March, April, and May, while decreasing in others. The increasing precipitation ranges from about 30 to 80 mm/month with the most significant increase in May. This indicates a climatological change where the rainfall in the peak of the rainy season is increasing but decreases in the drier season. The decrease ranges from 20–50 mm/month, with the most significant result in October. This can be associated with more severe drought in the future, which is validated by the interview. In the earlier period, the highest rainfall occurred in December but there is a shift in the most recent period, where the maximum result was obtained in November.

The data from the BMKG Muaro Jambi station showed that the highest and lowest temperatures in Batang Hari occurred particularly in May–June and December–January, respectively. Subsequently, the temperature data is separated into two periods and the result showed an increase of 0.4°C in the most recent period. The average monthly distribution from the periods indicates that the increase in temperature occurs in all observed months, ranging from 26–27.2°C. The temperature ranges increased to about 26.5–27.4°C in the most recent period, as shown in Fig. 4. The maximum increase occurred in December–January, where the differences from the two periods reached about 0.5°C. This condition signifies the influence of climate change in the study area since the coldest month has the highest increase in temperature.

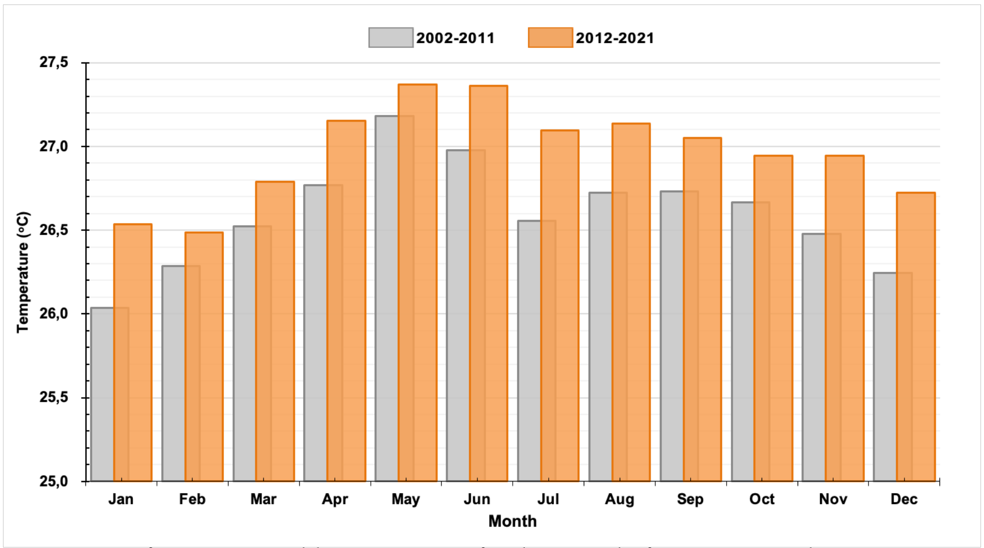

Figure 4. Comparison of average monthly temperature for the period of 2002-2011 and 2012-2021 in Batang Hari (Source: data processing, 2023)

Table 2. Farmers' characteristics as the research respondents (Source: Data Processing, 2023)

Variable	Percentage
Age (years)	
17-25	1%
26-35	6%
36-45	25%
46-55	39%
56-65	19%
>65	10%
Education	
Elementary school/equivalent	49%
Junior high school/equivalent	17%
High school/equivalent	29%
College/equivalent	5%

3.2. Farmers' perceptions of changes in the impact of climate variability

This section focused on the interview results conducted with small-scale farmers related to the impact, mitigation, and adaptation to climate change. Based on Table 2, 39% of farmers were between 46-55 years old, and 49% only had a primary school education level. Several studies have shown that age and education influence the perceptions of climate change and its effect on agricultural activities. Older farmers have more awareness and experience of climate change (Mustafa et al. 2019), while those with better education have easier access to information (Khanal et al. 2018). Questions on climate variability are mostly related to changes in rainfall, temperature, rainy season, and its duration, as well as the determination of planting season. These questions were intended to determine the perceptions of climate change in rainfed paddy fields.

The interview activity that supports the climate change-related data is explained in the previous section. The respondents agree with the increase in rainfall at the peak of the rainy season, particularly shifting from December to November. Some also suggest that the dry season occurred later, particularly between June to August. In the earlier period, the beginning of the planting season was mostly in July. From the most recent period, the beginning of the planting season mostly occurred in August. The dry season in the most recent period was also longer than in the previous. The farmers suggest that there is increasing difficulty in deciding the beginning of the planting season. The determination related to the beginning of the planting season, initially in March–April, was changed to April–May.

The first question of the interview was related to the most important climate variable that affects agricultural productivity decrease and losses in Batang Hari. The results showed that 38% and 35% of farmers experienced a loss in agricultural production due to the increase in extreme temperature events and a decrease in rainfall. This particularly occurred in the dry season where drought becomes the most dominant disaster. In addition, 15% perceived an increase in rainfall in the peak of the rainy season as the main factor causing flooding to their farmland, as well as major agricultural losses in the lowland area. This might be associated with increasing evapotranspiration when temperatures are higher than normal. About 12% perceived a decrease in the number of cold days as the reason for the decreasing agricultural productivity. This is mainly related to the increase in pests and plant diseases.

The interview also measures farmers' perceptions of the significance of event-related climate risks in the future. Each climatic event is categorized to have high, medium, and low risk towards their farmland (Table 4). The results indicate that severe droughts pose a substantial risk to the majority

Table 3. The most significant impact of climate variability on agriculture productivity as perceived by the farmers (Source: interview result, 2022)

Farmers' perceptions on the most significant impact of climate variability	Percentage
Decrease in monthly rainfall	35%
Increase in heavy rainfall	15%
Increasing number of days with extreme temperature	38%
Decreasing the number of cold days	12%
Total	**100%**

Table 4. Climate change risk perception of the farmers (Source: interview result, 2022)

No	Climatic Events	High Risk (%)	Medium Risk (%)	Low Risk (%)
1	Severe drought	76	18	6
2	Surface water depletion	59	34	7
3	Fertility losses due to soil erosion	43	45	12
4	Flooding	30	24	46
5	Outbreak of crop diseases	24	63	13
6	Severe crop pest	20	32	48
7	Groundwater depletion	12	22	66
8	Land fires	5	12	83

of farmers, with 76% acknowledging this climatic event as a significant concern. This might be associated with increasing numbers of extremely high temperatures and decreasing monthly precipitation. Surface water depletion also gains significance regarding their agricultural activities, which are also affected by climatic changes. Soil fertility losses due to erosion placed at the 3rd rank based on farmers' perception of high–risk events. This might be attributed to increasing heavy rainfall at the peak of the rainy season. Flooding, outbreak of crop diseases (by viruses or bacteria), severe crop pests (including insects and rats), groundwater depletion, and land fires are the next in order from highest to lowest rank of high-risk events. In addition, the outbreaks of crop diseases are the most common event in terms of medium risk related to the decreasing number of cold days. Finally, land fires are considered as an event with the lowest risk due to their rare occurrence.

3.3. Farmers' adaptation measures to climate change

Farmers 'perception related to climate change adaptation is measured based on the importance of crop management efforts with a significant effect in reducing the impact. Furthermore, the importance of adaptation practices is classified into high, medium, and low. The practices include adaptation related to agriculture planning, technological adaptation, soil management, crop management, and land management (Table 5). Most farmers consider that crop diversification and varieties gain the highest importance. Farmers planted local paddy varieties to early maturing superior counterparts (105–124 days planting time) with relatively tolerant drought and water stress characteristics. The switching was carried out as an adaptation measure to anticipate the failure of crops due to the impact of erratic changes in climate variability. However, 10% of farmers persisted in cultivating local paddy varieties due to the specific taste and texture demanded by the local community. Other parameters important to be mentioned are related to the high importance of planting time adjustment by 90% of farmers. In the current condition, paddy crops were cultivated by following the planting calendar locally determined. The initial determination of the planting season was determined through consensus among group meetings, the village administration, community leaders, field agricultural extension workers (PPL), the Department of Food Crops and Horticulture (DTPH), and the Indonesian Bureau of Meteorology, Climatology, and Geophysics (BMKG).

The outcomes of the interviews also showed that most farmers did not cultivate other crops instead of paddy, hence crop rotation is less important. In the actual condition, rainfed fields were abandoned after paddy was harvested and used as a place to graze cattle and livestock. Therefore, poultry and livestock rearing have a significant importance. The farmers also implemented technological-related adaptation, particularly by using machinery for cultivating the farmland. A total of 80% of farmers use agricultural machinery to manage their farms, and the utilization is also considered highly important by half of the respondents. The machinery consisted of government-aided tractors distributed through groups, but some farmers opted for conventional methods (hoeing). In addition, the application of fertilizers and pesticides was considered another crucial factor in increasing paddy productivity. The application of this chemical was not conducted by some farmers due to the high cost. Several farmers did not apply pesticides because pests and plant diseases are considered under control.

In the context of socio–economic adaptation, off–farm work is attributed to have the highest importance. The interviews also showed that most of the farmers have off–farm jobs, particularly in the dry season, such as working in palm oil plantations and rubber farms. Off–farm work is a measure of farmer response to the possibility of yield loss due to changes in climate variability. Anticipating the possibility of crop failure can be addressed by providing easy access to loans through farmer groups (Sekaranom et al. 2021). The role of the household farmer association was ranked second in terms of high importance. However, only a small number of could access credit or loans, particularly from the association. This was consistent with several farmers who

Table 5. Perception of crop management importance in reducing the impact of climate change (source: interview result, 2022)

Adaptation Practices		High importance (%)	Medium importance (%)	Low importance (%)
Adaptation related to Agriculture Planning	Seeking information from weather monitoring system	45	43	12
	Seeking information from seasonal to interannual prediction	37	35	28
	Use of decentralized/simple Early Warning System	32	43	25
	Apply for climate Insurance	57	32	11
Technological related adaptation	Machinery for agriculture intensification	50	30	20
	Rainwater harvesting	14	19	67
	Groundwater for irrigation	23	38	39
	Sprinkler and drip irrigation	11	21	68
Soil management	Use of fertilizer	71	16	13
	Organic nutrient management	21	34	45
	Conservation tillage	53	28	19
	Slow-forming terraces	18	26	56
Crop management	Crop diversification and new varieties	73	17	10
	Crop rotation	12	25	63
	Pest management	73	15	12
	Adjust planting times	90	10	0
Land management	Poultry rearing	53	32	15
	Livestock rearing	57	36	7
	Agroforestry	23	14	63
	Mixed farming	31	35	34

Table 6. Perception about socioeconomics adaptation and capacity building in reducing the impact of climate change (Source: interview result, 2022)

Socioeconomic Adaptation Practices	Level of importance		
	High importance (%)	Medium importance (%)	Low importance (%)
Household Farmer Association	91	6	3
Farmers Wife Association	77	20	3
Farmer Field Schools	69	24	7
Community Water Resource Association	60	20	20
Forest conservation Association	14	23	63
Off-Farm Works	92	5	3
Access agricultural loans/credit	34	50	16
Temporary migration	12	18	70

consider loans or credit to be highly important. Meanwhile, farmers 'wife associations have gained importance regarding gender empowerment, particularly related to off–farm work and education. The majority of farmers also considered that field schools and community water resource associations assist in learning and adapting to changing climate characteristics.

4. Discussion and Conclusions

BMKG Muaro Jambi station was reported to record a decrease and an increase in rainfall and temperature for the majority of months, particularly during the dry season in the last 20 years. A study on the relationship between global warming, rainfall, and temperature conditions was conducted and indicated similar results. There was a decrease in rainfall and an increase in temperature throughout Indonesia from 1901-2002, with a reduction of 2-3% mm/year and a rise of 1.2 °C (Febrianti 2009). Meanwhile, the IPCC reported that global precipitation had risen and reduced depending on latitude, while temperature increased by 0.84-1.10 °C from 2001 to 2020 compared to the period of 1850-1900 (IPCC 2021;2014).

The result shown in the previous section indicated that most of the farmers experienced the impact of climate change in their rainfed paddy fields. This expected outcome was consistent with the farming practices in Batang Hari, where paddy cultivation predominantly occurred in rainfed fields, reliant on rainfall as the primary source of irrigation. Therefore, farmers adapted their planting seasons in response to these conditions (Sharmake et al. 2022). The questions were related to changes in rainfall and temperature as well as the impact on agricultural land. There was agreement with the analyzed climatological data due to the decrease in rainfall and an increase in temperature causing several problems, particularly drought and water scarcity. The changes were also caused by the extensive history of land cover change in Batang Hari and influenced by global factors such as *El Niño* (Firmansyah et al. 2022). Land cover in Batang Hari in 2014 was reported to have changed significantly, especially with the expansion of oil palm plantations (Nurwanda et al. 2016). The agreement between the climatological data and the results of the interviews was also shown by the delay in determining the planting month. The delayed planting season was related to the rainy season onset in Batang Hari.

The above finding provides important information about the complex dynamics of climate change and how it affects rainfed agriculture in tropical regions. The global society, particularly in areas confronting comparable difficulties in maintaining agricultural productivity in the face of shifting climatic circumstances, will find interest from these results. There are similarities and differences in the trends and effects of climate change on rainfed agricultural systems when these findings are compared to studies conducted globally. For example, in sub-Saharan Africa (Alemaw et al., 2015), Southern Part of Australia (Anwar et al., 2007), and parts of South America (Llopart et al., 2014) have also documented trends of declining rainfall combined with rising temperatures, resulting in drought and scarce water supplies in rainfed agricultural zones.

Research conducted in sub-Saharan Africa has shown that rainfed agriculture is vulnerable to climatic variability, with crop production and food security being impacted by decreasing precipitation (Alemaw et al. 2015; Biazin et al. 2012). Comparably, changed precipitation patterns have affected agricultural practices and ecological health in regions of South America, including the Amazon basin (Marengo et al. 2011). Studies conducted in Australia have shown how climate change affects rainfed farming systems, highlighting the necessity for enhanced crop variety, better water management, and resilient agricultural techniques (Zeleke, 2021).

Comparison with three regions above emphasizes how rainfed agriculture is impacted by climate change on a worldwide scale and how coordinated adaptation and mitigation actions are urgently needed. Water scarcity, shifting precipitation patterns, and temperature extremes become universal problem despite regional variations in specific difficulties and adaptive strategies. These comparative insights provide a more comprehensive understanding of the opportunities and difficulties in addressing the effects of climate change on rainfed agriculture.

Several adaptation measures have been taken in response to the impact of change in climate variability. The implemented measures to address these challenges were modifying the paddy varieties, reaching a consensus on the planting season, adopting agricultural machinery, and diversifying income through off-farm activities. In addition, the Government of Batang Hari Regency conducted several mitigation actions, including the construction of water catchment ponds to harvest rainwater, dams, boreholes, drainage trenches, and water pump aid. The most important recommendation was to build dams in association with irrigation networks to ensure water availability in the dry season as well as to increase the planting frequencies (Nasution, 2023).

In summary, this research substantially enhances our understanding of the intricate relationship between Indonesia's rainfed agriculture and climate change. By meticulously analyzing data on rainfall patterns and temperature shifts over distinct time periods, the research underscores the effects of climate change on agricultural productivity in Batang Hari. For example, the observed decrease in rainfall and concurrent increase in temperature, particularly during the dry season, highlight the pressing challenges faced by farmers in this region. The similar results were also found in several other regions in Indonesia, including Java, Bali, and Nusa Tenggara (Safura et al. 2024; Sekaranom, 2023). Through interviews with farmers, the study unveils practical adaptation measures implemented, such as adjusting planting seasons and adopting resilient crop varieties. These insights are invaluable for crafting targeted policies aimed at bolstering climate-resilient agricultural practices.

The study's conclusions may lead to recommendations for early warning systems, weather monitoring systems, and investments in agricultural infrastructure like rainwater harvesting systems. These kinds of measures not only provide farmers with up-to-date information, but also strengthen the agricultural systems' overall resilience. The above findings are pivotal for ensuring regional food security by informing strategies to mitigate risks and maintain stable food production amidst climate uncertainties. With a focus on long-term sustainability, the result promotes agroforestry projects, sustainable land management techniques, and soil conservation efforts to create resilient agriculture systems that can endure upcoming climatic challenges in Batang Hari. This study also provides practical guidance to policymakers in developing efficient adaptation and mitigation initiatives, and eventually help in achieving the goals for sustainable food production and security in Batang Hari as well as other susceptible areas in Indonesia.

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