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Assessing vegetable farming practices in a floodplain village of Kamrup District, Assam, India

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ABSTRACT
Farming practices in a floodplain environment hold immense ecological, economic, and social significance. The current study focuses on Choutara village, located in Kamrup District, Assam. The primary objective of the research is to evaluate the adaptive techniques employed by local vegetable farmers in response to recurring environmental stresses, including seasonal flooding, waterlogging, and soil erosion. The research aims to understand the long-term effects of these stressors on crop selection, land use decisions, and agricultural productivity. The study used a mixed-methods approach, integrating qualitative and quantitative methodologies. Primary data were collected via field surveys, oral interviews with aged farmers, and focused group discussions. Supplementary secondary data were examined to comprehend past trends. Descriptive statistics and comparative analysis were employed to investigate production patterns and discern changes in agricultural practices over different seasons and flood cycles. The findings indicate a dynamic adaptation process among farming households, which integrates indigenous agricultural knowledge with specific modern practices to address climate risks and market variation. Agriculturalists have diversified their planting schedules, chosen short-duration and flood-resistant vegetable cultivars, and adapted soil and water conservation techniques. The study highlights the need to enhance institutional assistance, encompassing infrastructural development, the availability of timely meteorological data, and agricultural extension services tailored to the specific requirements of floodplains. Policy-makers and development organizations can utilize these insights to formulate more adaptive and contextually relevant initiatives to improve the sustainability and productivity of floodplain agriculture.

Contribution/Originality: The study contributes to the existing literature on climate-resilient agriculture in the floodplains of Northeast India. It uses primary data and field-based insights to highlight adaptation practices. The paper's primary contribution is finding that traditional knowledge drives effective local adaptation.

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1. INTRODUCTION

Floodplains, subject to seasonal flooding, play a crucial role in agriculture. These areas are defined by their distinct hydrological dynamics, which promote a rich ecological network that supports various agricultural activities, particularly vegetable farming (Cook, 2010; Schilling, Jacobson, & Vogelgesang, 2015). Alluvial soils in floodplains are typically rich in nutrients due to sediment deposition during seasonal flood events (Appling, Bernhardt, & Stanford, 2014). This nutrient availability enhances soil fertility, which is essential for cultivating various vegetables, supporting local food security, and providing subsistence for farmers (Singh, Patel, Tiwari, & Singh, 2021). However, the dual nature of the floodplain environment presents both opportunities and risks (Tockner, Pusch, Borchardt, & Lorang, 2010). While predictable floods can replenish soil nutrients, they also pose significant challenges for farmers (Misra, Prasad, & De, 2023). Seasonal flooding disrupts agricultural productivity, resulting in economic instability for local farmers (Singha & Singha, 2025). Research indicates that adaptation strategies, such as employing varieties of flood-resistant crops and adjusting planting schedules, are essential for enhancing the resilience of agricultural livelihoods in floodplain regions (Kalita, Kumar, Hazarika, Baruah, & Borah, 2024).

In Choutara village, the annual flooding cycle significantly influences planting schedules, with farmers intentionally timing their sowing activities to coincide with the receding waters. They have adopted several strategies to reduce the negative impacts of flooding while reaping its benefits. These include selecting vegetables that thrive in damp conditions to exploit the nutrient-rich floodwaters and vegetable varieties that can be harvested before severe flooding occurs. Additionally, some farmers practice staggered planting, sowing crops at different times to ensure a portion of the harvest remains secure regardless of flood conditions. Adopting raised beds has also gained traction as a method for safeguarding plants against excess water, showcasing innovative land management practices specifically tailored to the challenges of the floodplain. The experiences of farmers in the village can be likened to the resilience strategies adopted globally, where communities have implemented various approaches to combat environmental challenges. For instance, regions in Southeast Asia prone to flooding have focused on enhancing water management systems and reducing community disaster risks (Kipgen & Pegu, 2018). Combining local knowledge with scientific methodologies has proven effective in fostering adaptive capabilities in vulnerable communities (Pradhan, Das, Gupta, & Shrestha, 2021).

With this rationale, the present research aims to evaluate current vegetable farming practices in Choutara Village, Kamrup District, to understand farmers' adaptation strategies in addressing flood-related challenges, and to explore opportunities for sustainable agricultural interventions in ecologically sensitive regions.

2. MATERIALS AND METHODS

2.1. Overview of the Study Area

For this study, Choutara village, located in the Goroimari development block of Kamrup District, was selected due to its heavy reliance on floodplain agriculture and frequent exposure to the annual flooding of the Brahmaputra River. Geographically, the village spans between 26° 6' 21" N to 26° 7' 7" N latitude and 91° 11' 37" E to 91° 12' 36" E longitude, covering a total area of 139.8 hectares (Figure 1). It borders Udalguri and Baksa districts to the north, Meghalaya state to the south, Darrang and Kamrup (M) to the east, and Goalpara to the west. Climatologically, the village lies in a monsoonal climatic zone with a subtropical humid climate characterized by hot, wet summers and cool, dry winters. The region's soils are generally rich in organic matter, supporting a variety of agricultural practices. According to the Census of India (Government of India, 2011) the village has a total population of 2,205 people and 435 households. Of the total population, 48.84% are male, and 51.16% are female. Children under the age of 6 make up 22.45% of the population. The average sex ratio is 1,047 females per 1,000 males, and the literacy rate stands at 46.37%.

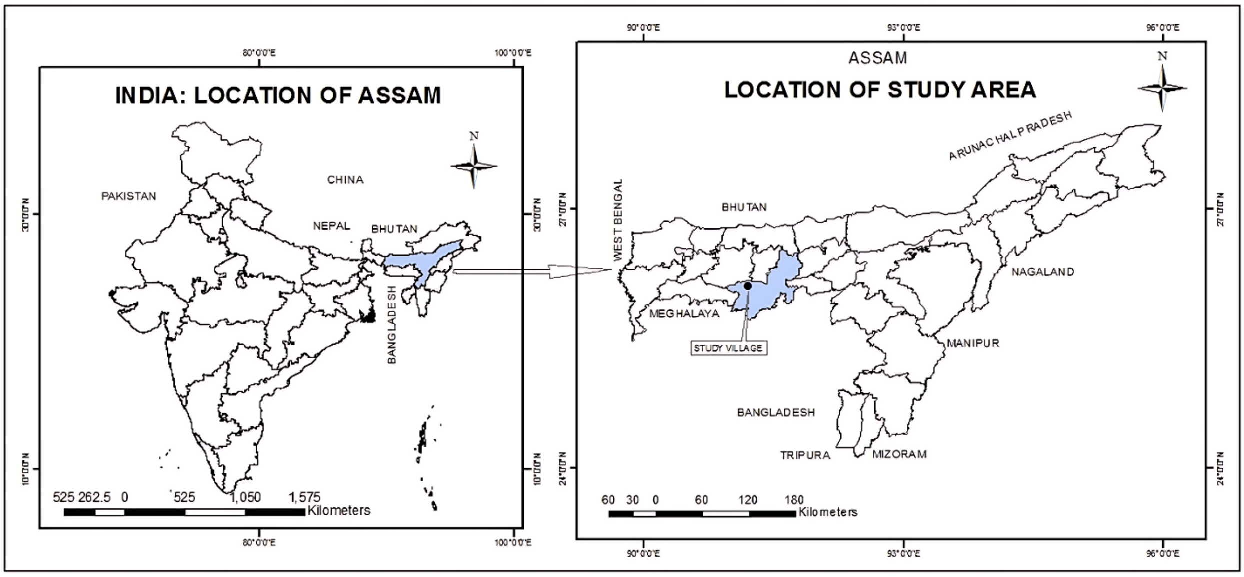

Figure 1. Location of the study area.

2.2. Data Collection and Sample Survey

The study is based on both primary and secondary data. Primary data were collected from field investigations in Choutara village following a stratified random sampling procedure. To fulfill the study's objectives, a structured questionnaire was prepared, encompassing demographic details, types of vegetables grown, seasonal cropping patterns, flood-related challenges, and adaptive strategies. All research ethics were strictly followed, and informed consent was obtained from all participants prior to data collection. Ethical approval for the study was obtained from the Institutional Ethics Committee of Gauhati University, Assam, India. All procedures involving human participants were conducted in accordance with institutional and national ethical standards. The Ethical Committee of Gauhati University, Assam, India, approved this study via application no. GUIEC-09/24, date 12/3/24. Forty percent of the households in the village, comprising 174 vegetable farmers, were interviewed across the village. Special care was taken to ensure that the socio-economic inequalities of the farmers were accurately reflected. In addition, focused group discussions were organized in the village with a group of 10-15 farmers to gather collective experiences and explore community-based responses to flooding through farming. Oral interviews were conducted with experienced farmers to gain insights into changes in farming practices over time. Key informant interviews were also conducted with Agricultural Development Officers, local leaders, and market intermediaries to gain insight into institutional perspectives and support mechanisms. Finally, direct field observations were made to assess the farm conditions, irrigation methods, and visible adaptation techniques employed by vegetable farmers, including raised beds and drainage channeling.

Secondary data on population characteristics and district-level agricultural statistics are collected from various government offices, such as the Directorate of Census Operations, Assam State Disaster Management Authority (ASDMA), the District Agricultural Office, and the Block Development Office, to cross-verify the field data and depict a district-level scenario of crop production, flood incidence, and infrastructural facilities.

All the collected data were processed in a computer environment using Microsoft Excel. Data were tabulated to categorize information under key parameters, including the type of vegetables grown, adopted farming practices, seasonal variations, and significant challenges faced by the farmers. A simple descriptive analysis was conducted by calculating the percentage of each response category to understand the distribution pattern and draw inferences related to the study's objective.

Crop concentration has been adapted using the Location Quotient Index to understand crop preferences, market trends, and dependency on specific crops, which is expressed as

$$LQ = \frac{Area\ of\ crop\ 'x'\ in\ the\ village}{Area\ of\ all\ crops\ in\ the\ village} \div \frac{Area\ of\ crop\ 'x'\ in\ the\ district}{Area\ of\ all\ crops\ in\ the\ district}$$

To ensure grammatical accuracy and clarity of expression, the final manuscript was reviewed using Grammarly, an AI-based writing assistant. This helped refine sentence structure, correct typographical errors, and improve overall language quality without altering the original content. Finally, the location map of the study area was created using ArcGIS 10.2 (Environmental Systems Research Institute, Redlands, CA, USA).

3. RESULTS

3.1. Demographic Profile of the Vegetable Farmers

Evaluating the demographic characteristics of vegetable farmers is crucial for understanding their agricultural decision-making, resilience strategies, and adaptability to recurring environmental challenges, such as seasonal floods (Joshi & Piya, 2021; Rai et al., 2019). The age structure is vital, as younger farmers can adapt to innovative practices more readily than older ones, who often rely on traditional practices (Hussain & Guha, 2023).

The demographic analysis highlights (Table 1) the predominance of middle-aged vegetable farmers in the study area, as 40.23% of the farmers are in the age group of 35-50, followed by 31.61% in the 18-35 years age group, which indicates the presence of both experienced and relatively younger farmers. A small portion of farmers (3.45%) are above 60 years old, suggesting a generational shift in involvement in vegetable farming.

Table 1. Demographic profile of the vegetable farmers in Choutara village.

Age group	No. of respondents	Percentage
18-35	55	31.61
35-50	70	40.23
50-60	43	24.71
Above 60	6	3.45
Total	174	100
Gender		
Male	123	70.69
Female	51	29.31
Total	174	100
Land holdings		
Very small (<0.24)	119	68.39
Small (0.24-0.48)	32	18.39
Medium (0.48-0.96)	15	8.62
Large (>0.96)	8	4.6
Total	174	100
Education level		
Illiterate	62	35.63
Primary	75	43.1
HSLC	21	12.07
HS	16	9.2
Total	174	100
Years of Farming Experience		
0-5	21	12.07
5 to 10	36	20.69
10 to 20	55	31.61
Above 20	62	35.63

Gender dynamics are also fundamental in shaping farmers' adaptive strategies (Balayar & Mazur, 2022; Joshi & Kalauni, 2018). Studies have shown that women often engage in different adaptive practices from men, influenced by their unique socio-economic positions (Naz, Khan, Maan, & Shahbaz, 2020). In the study area, vegetable farming is predominantly a male-dominated activity, with 70.69% of the respondents being male, reflecting traditional gender roles in Assam (Bora, Mishra, & Das, 2023). Females also actively participate in vegetable farming, constituting 29.31% of the population through seed selection, weeding, and post-harvest management.

The size of landholdings directly influences the intensity and sustainability of vegetable farming practices in ecologically sensitive environments, such as floodplains (Husain & Sharma, 2022; Raleting & Obi, 2015). The size of the operational landholding also determines the farmers' ability to invest in innovative techniques. Small and marginal farmers often lack access to adequate capital, irrigation facilities, and crop insurance, making them more vulnerable to environmental uncertainties (Hazell, Poulton, Wiggins, & Dorward, 2007). The landholding structure of the farmers reveals a prevalence of fragmented holdings, as 68.39% of the farmers operate on small plots (less than 0.24 hectares), indicating a marginal level of vegetable farming. 18.39% of farmers own small-sized land (0.24 to 0.48 hectares), and 8.62% of farmers own medium-sized land (0.48 to 0.96 hectares). Only 4.6% have a landholding size greater than 0.96 hectares. Thus, the study found that the village has limited land resources for intensive vegetable farming.

Educational attainment enhances farmers' ability to implement effective adaptation strategies, thereby facilitating a more informed decision-making process regarding flood resilience (Singh et al., 2021). The study found that 43.1% of farmers have received only primary education, followed by high school (12.07 %) and higher secondary (9.2%) education. Notably, 35.63% of farmers in the study area are illiterate, which limits their awareness of adopting modern agricultural practices (Mittal & Mehar, 2015). Regarding farming experience, 35.63% of farmers have more than 20 years of experience, 31.61% have 10 to 20 years, and 20.69% have 5 to 10 years of experience in farming. Only 12.07% are new to vegetable farming and have less than 5 years of experience. Thus, the data on farming experience suggests a wealth of traditional knowledge within the farming community.

3.2. Major Vegetable Crops Grown in Choutara Village

Analyzing the seasonal dynamics and productivity of major vegetable crops is essential for developing adaptive strategies and policy interventions in the context of climatic uncertainty and recurring floods in Assam (Rao et al., 2019). The floodplain ecosystem of Choutara village supports a variety of vegetable crops grown during different seasons of the year. The nutrient-rich, fertile alluvial soils and the region's subtropical monsoon climate provide a conducive environment for cultivating different types of vegetables (Singh et al., 2021).

Table 2. Major vegetable crops grown in Choutara village.

Vegetable crops	Season grown	Duration (Days)	Flood sensitivity	Area under cultivation (Ha)	Production (MT)	Productivity (Q/Ha)
Potato	Post-monsoon	100-110	Moderate	10.8	58.6	54.3
Pumpkin	Pre-monsoon	100-120	Low	4.8	41.9	86.7
Radish	Post-monsoon	50-60	High	3.0	22.0	73.2
Cabbage	Post-monsoon	60-70	High	14.1	233.4	165.5
Cauliflower	Post-monsoon	90-95	High	13.5	201.8	149.5
Broccoli	Post-monsoon	90-100	High	11.8	83.0	70.3
Brinjal	Post-monsoon-winter	90-120	Moderate	3.7	39.2	106.0
Okra	Pre-monsoon-Monsoon	120-135	Low	4.9	55.2	112.6
Chayote	Pre-monsoon	120- 140	Low	5.0	50.2	101.2
French beans	Post-monsoon-winter	40-50	Moderate	3.3	24.0	72.6
Indian bean	Post-monsoon-winter	60-70	Moderate	3.5	14.3	40.6
Yardlong bean	Pre-monsoon	60-70	Moderate	0.5	2.4	47.3
Peas	Post-monsoon	110-120	High	7.2	28.0	38.9
Cucumber	Pre-monsoon	45-50	Low	1.2	11.5	95.8
Pointed gourd	Pre-monsoon	120-140	Low	0.6	4.8	80.0
Spine gourd	Pre-monsoon	115-125	Moderate	1.1	7.7	70.2
Ridge gourd	Pre-monsoon	60-70	Low	1.3	12.7	97.9
Bitter gourd	Pre-monsoon-Monsoon	50-55	Low	0.9	7.7	85.5
Bottle guard	Pre-monsoon	60-75	Low	0.7	8.7	123.6
Kohlrabi	Post-monsoon	60-70	High	3.2	35.2	110.6
Carrot	Post-monsoon	110-120	High	1.1	7.0	63.2
Tomato	Post-monsoon	55-60	Moderate	2.6	29.1	110.2
Chillies	Post-monsoon	60-120	Moderate	3.3	8.3	25.4
Coriander	Post-monsoon	100-120	High	1.5	1.8	12.0
Mint	Post-monsoon	120-140	High	1.3	3.4	25.4
Leafy greens	Post-monsoon-winter	45-60	High	5.5	30.4	55.3

Table 2 shows that farmers in the region grow both short- and long-duration crops, which satisfy local demand and support regional food security. It also reveals a complex relationship between environmental conditions and farmers' crop choices. Most vegetable crops are grown during the post-monsoon season as floodwaters recede and fields become accessible. This season is also called the rabi crop season. Vegetables such as potatoes, brinjals, cabbage, cauliflower, tomatoes, carrots, radishes, and peas are cultivated during this period due to the moist, fertile soils left after seasonal floods. Brinjal, beans, and chilies are grown during the post-monsoon and winter seasons as they adapt to longer growing cycles. Bitter gourd, bottle gourd, pointed gourd, okra, and cucumber are planted from the pre-monsoon to the monsoon season, since these crops can tolerate waterlogging.

Flood sensitivity directly influences farmers' crop selection. During the early and peak flood months, farmers in the village prefer to cultivate low-flood-sensitive crops, such as bitter gourd, pointed gourd, okra, bottle gourd, and cucumber, on elevated or raised bed farms. On the other hand, crops such as cabbage, cauliflower, radish, and carrot are cultivated after the flood to minimize the risk of crop damage. Medium-sensitive crops, such as tomatoes, beans, and chilies, are cultivated when flood timing is more predictable.

Regarding the area under cultivation of major vegetable crops in the village, cabbage (14.1 ha) and cauliflower (13.5 ha) lead significantly, followed by broccoli (11.8 ha) and potato (10.8 ha). On the contrary, crops like yardlong bean (0.5 ha), pointed gourd (0.6 ha), and bottle gourd (0.7 ha) are grown on significantly smaller scales due to limited local markets.

In terms of total output, cabbage again leads with 233.4 metric tons (MT), followed by cauliflower (201.8 MT) and broccoli (83.0 MT), indicating that these vegetables not only occupy a larger area under cultivation but also yield a substantial harvest. Potato (58.6 MT) and okra (55.2 MT) also feature prominently in overall production, reflecting bulk production during the high-demand season; however, crops like coriander (1.8 MT), mint (3.4 MT), and yardlong bean (2.4 MT) show the least production due to limited cultivation area and shorter harvest cycles.

Regarding productivity, cabbage (165.5 q/ha) and cauliflower (149.5 q/ha) exhibit high yield efficiency, indicating effective land use and optimal inputs, such as improved seeds and better soil conditions. Bottle gourd (123.6 q/ha), brinjal (106.0 q/ha), and kohlrabi (110.6 q/ha) are the other notable crops with excellent productivity, reflecting good agricultural practices. Crops such as coriander (12.0 q/ha), chilies (25.4 q/ha), mint (25.4 q/ha), and peas (38.9 q/ha) exhibit lower productivity due to their high sensitivity to flooding and limited intensive input use. Thus, it has been observed that vegetable farmers balance seasonal uncertainties and maximize the utility of their land.

3.3. Input Used for Vegetable Farming Practices

The use of high-quality seeds, fertilizers, organic manure, pesticides, and adequate irrigation facilities significantly influences the efficiency of the vegetable farming system (Simonne, Gazula, Ozores-Hampton, DeValerio, & Hochmuth, 2017; Singh et al., 2020). However, several factors, including timely availability, affordability, technical knowledge, and environmental compatibility, influence the efficiency of the inputs (Akamin, Bidogeza, Minkoua, & Afari-Sefa, 2017; Ogunmodede & Awotide, 2020; Xu, Zhang, & Zhang, 2018).

Table 3 (Figure 2) highlights the various farming inputs used by vegetable farmers in the study area. Seeds are the primary inputs used in any farming system, and selecting appropriate seed types, whether indigenous or high-yielding varieties (HYV), is of utmost importance for successfully cultivating vegetable crops (Behera, Gupta, & Rai, 2025; George, 2009). From Table 3, it can be observed that 78.2% of vegetable farmers rely on high-yielding variety (HYV) seeds sourced through government and private channels to enhance productivity. In comparison, only 21.8% of farmers use indigenous seeds that they have preserved themselves. It has been observed that, despite the use of additional inputs such as fertilizers and pesticides and the increased cost of cultivation, farmers still rely on HYV seeds, as indigenous seeds have limited availability and do not offer the same yield potential as HYV seeds.

Table 3. Input used for farming practices.

Input type	Sources	No. of farmers using	Farmers using (%)	Application method	Issue faced
Seeds				Manual sowing	
HYV	Govt/Private	136	78.2		High Input requirement
Indigenous	Own	38	21.8		Limited availability
Fertilizer					
Combination of chemical fertilizer and organic manure	Private	118	67.8	Broadcasting	High Cost
Purely organic manure	Own	56	32.18	Soil incorporation	Insufficient
Crop protection measures					
Pesticides	Private	136	78.2	Spraying	Resistance
Local crop protection	Own	38	21.83	Dusting	Limited availability
Irrigation					
Shallow tube well	Govt	112	64.4	Pumping	Limited Coverage
Surface flow	Own	62	35.6	Channeling	Climate dependence

Managing soil fertility is crucial for successful vegetable farming, particularly in the dynamic agroecological environment of floodplains (Mandal, Banerjee, Purbey, & Kumar, 2024). Farmers in the study area use chemical fertilizers and organic manure to manage soil nutrients. Chemical fertilizers offer immediate nutrients and boost short-term productivity; however, their high costs and long-term effects on soil health and environmental sustainability raise significant concerns (Abobatta & Abd Alla, 2023; Pahalvi, Rafiya, Rashid, Nisar, & Kamili, 2021). In terms of fertilizer use, 67.8% of farmers apply a combination of chemical fertilizer and organic manure. While this approach enhances crop productivity, it also presents challenges, including increased costs and dependency on external inputs. In contrast, organic manure is valued for its ability to improve soil structure, enhance microbial activity, and support long-term soil health (Pinto, Brito, & Coutinho, 2017). It is employed by 32.18% of farmers in the study area. Nevertheless, due to its limited availability and slow nutrient release, organic manure is less effective as a standalone option.

To protect their vegetable crops from various pests and diseases, 78.2% of farmers depend on pesticides. However, the repeated use of the same chemical compounds has led to pests developing resistance, diminishing their effectiveness over time (Mamun & Goswami, 2024). In contrast, local crop protection measures, such as ash dusting, are used by only 21.83%, hindered by limited availability and declining traditional knowledge.

Proper irrigation facilities, especially during dry periods, ensure consistent moisture availability for optimal growth of vegetable crops (Shock, Pereira, Hanson, & Cahn, 2007). In the study area, farmers predominantly use shallow tubewells (64.4%) and surface flow irrigation (35.6%). The shallow tubewells are supported by government schemes and operated through a pumping system. They offer a sufficient amount of water supply but with limited area coverage, especially in remotely located, fragmented plots. Surface flow irrigation is highly dependent on seasonal rainfall and is unreliable during the dry season.

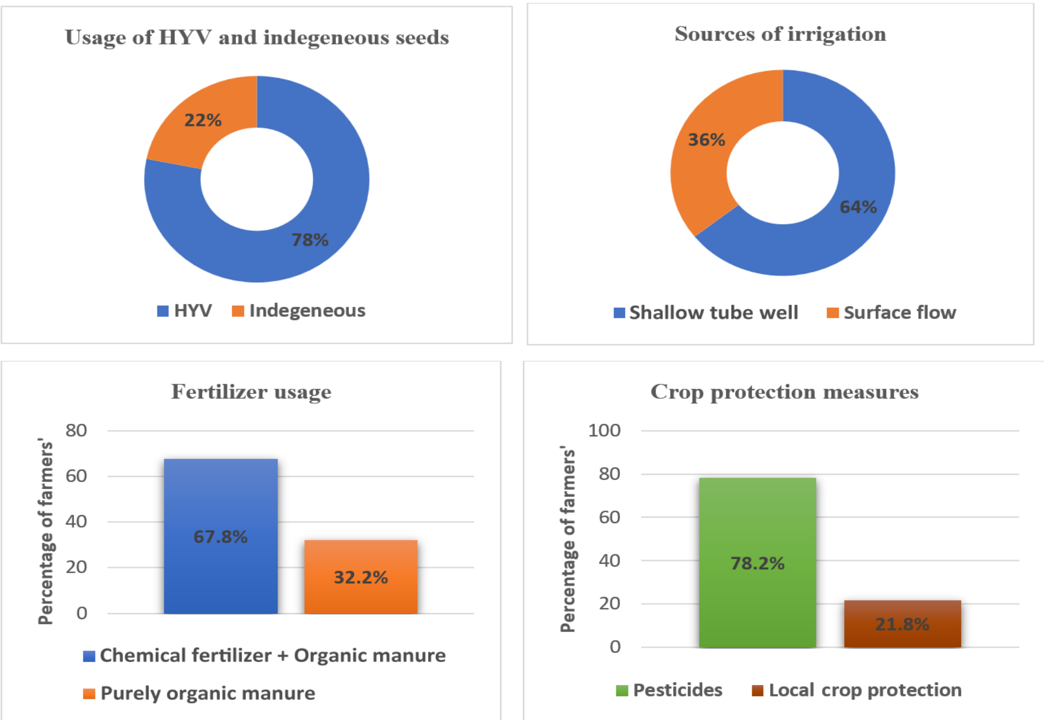

Figure 2. Graphical representation of input usage for vegetable farming practices in Choutara village, Kamrup District.

3.4. Adaptive Practices Adapted by Vegetable Farmers

Adaptive practices, such as raised bed farming, organic mulching, seed preservation techniques, and an adjusted crop calendar, are essential for sustaining productivity and mitigating risks (Elnesr & Alazba, 2016; Miernicki, Lovell, & Wortman, 2018; Morel & Cartau, 2023; Naik, Singh, & Ranjan, 2017; Ranjan, Patle, Prem, & Solanke, 2017). These practices help maximize crop yield, reduce dependency on external inputs, and improve the overall farming system. Table 4 highlights the different adaptive strategies prevalent in the study area, where 67.2% of the farmers use the raised bed farming method, in which the root zone of the vegetable crop is elevated and protected from temporary waterlogging. Farmers rated this method 4.2 out of 5 for its effectiveness. Similarly, organic mulching is adopted by 73% of farmers, in which the surface layer of the soil around the plant is covered with biodegradable materials, such as leaves and straw, to improve soil health, retain moisture, control weeds, and regulate temperature. The seed preservation technique is adopted by 21.8% of the farmers and is rated 3.9. This method involves saving seeds of vegetables like brinjal, pumpkin, bottle gourd, cucumber, and okra by drying them in the sun and using them in the next planting cycle. 71.8% of the vegetable farmers have adopted the adjusted crop calendar method. To avoid peak flood periods, the farmers have scheduled their sowing and harvesting practices in a more favorable window, and they have received the highest effectiveness rating (4.7), describing their central role in mitigating risk.

Table 4. Adaptive practices adopted by farmers in Choutara village.

Adaptive practice	No. of farmers	Adoption percent	Effectiveness (Farmer's rating 1-5)	Seasonal use
Raised-bed farming	117	67.2	4.2	Monsoon
Organic mulching	127	73.0	4.4	All Season
Seed preservation techniques	38	21.8	3.9	Post Flood
Adjusted crop calendar	125	71.8	4.7	All Season

3.5. Crop Concentration

Crop concentration refers to the spatial distribution and relative dominance of a particular crop in a specific region compared to other crops, and indicates agricultural specialization (Jasbir, 1976). Bhatia (1965) used the Location Quotient (LQ) method to delineate India's regional concentration of crops. The study involves 15 major crops to calculate the crop concentration in the village (Table 5). The results reveal that cauliflower is the dominant crop in the village, with the highest LQ value (2.6), followed by cabbage (1.9), okra (1.6), and bitter gourd (1.4), respectively, indicating their dominance in the village compared to the district-wide distribution. In contrast, crops such as potato (0.6), chilies (0.4), and bottle gourd (0.7) show lower LQ values compared to their distribution in the district. Meanwhile, crops such as cucumber, brinjal, pointed gourd, and carrot exhibit a balanced distribution with an LQ value of one. The overall data highlights a tendency towards specialized cropping patterns in the village, driven by local agroecological conditions, market demand, and farmers' preferences.

Table 5. Crop concentration in Choutara village.

Vegetable crop	Area in the village (Ha)	Area in Kamrup district (Ha)	Location quotient index
Potato	10.8	4302	0.6
Radish	3	893	0.8
Cabbage	14.1	1650	1.9
Cauliflower	13.5	1176	2.6
Brinjal	3.7	798	1.0
Okra	4.9	705	1.6
Yardlong bean	0.5	98	1.1
Peas	7.2	1934	0.8
Cucumber	1.2	265	1.0
Pointed gourd	0.6	132	1.0
Bitter gourd	0.9	143	1.4
Bottle guard	0.7	229	0.7
Carrot	1.1	250	1.0
Tomato	2.64	713	0.8
Chillies	3.26	1932	0.4

Figure 3 depicts the Crop Concentration Index in conjunction with the area (in hectares) allocated to various vegetable crops in the village. Cauliflower exhibits the highest concentration index, indicating a pronounced spatial preference, with cabbage and brinjal closely following. Cauliflower (14 hectares) and cabbage (13 hectares) are the predominant crops in terms of area cultivated. In contrast, crops such as bitter gourd, bottle gourd, and yardlong bean have both low concentration indices and restricted cultivation areas, indicating their marginal significance in the local agricultural system.

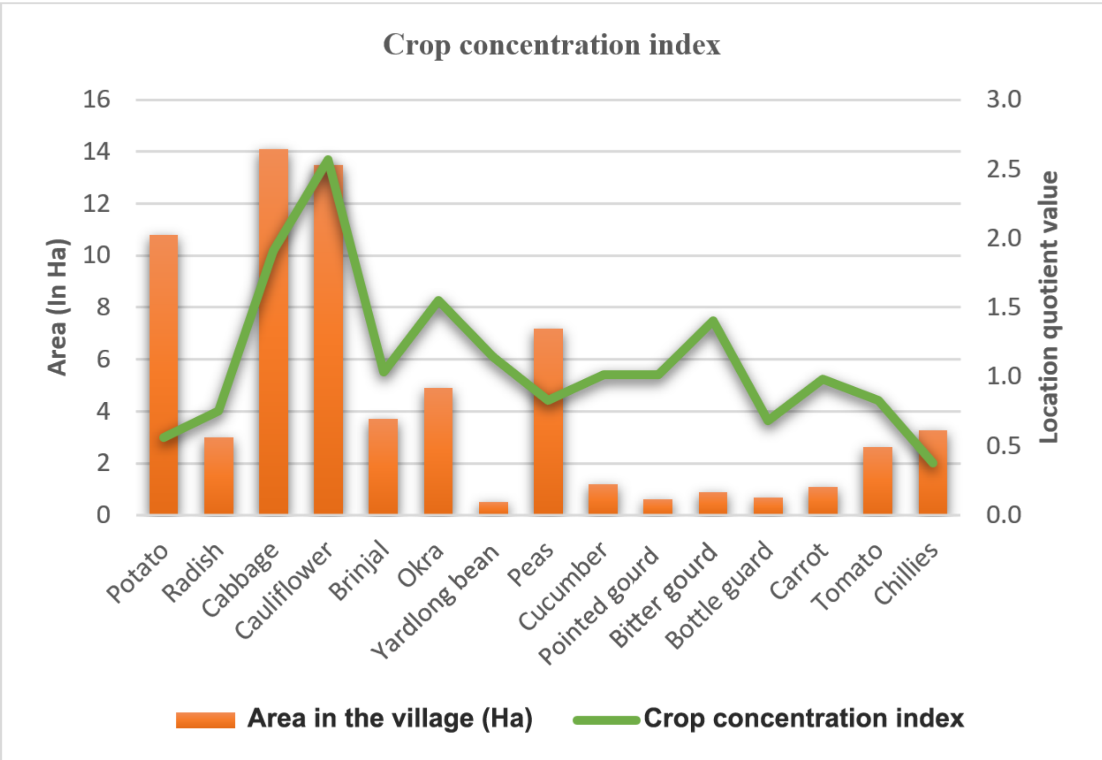

Figure 3. Graphical representation of crop concentration in Choutara Village, Kamrup District.

3.6. Challenges Faced by Vegetable Farmers

Vegetable farming in Choutara village faces numerous challenges, primarily due to environmental sensitivity and infrastructural deficiencies. Table 6 illustrates the challenges encountered by vegetable farmers in the study area. The frequent occurrence of floods has impacted 74.7% of farmers, causing significant damage to their crops. This challenge is ranked as the most severe (rank 1), as during the monsoon season, agricultural fields are inundated with floodwater annually, leading to crop destruction. Approximately 62.1% of farmers reported pest and disease infestations as a major issue, ranking second in severity. These infestations are facilitated by stagnant water, humidity, and temperature fluctuations, which create optimal conditions for pest proliferation. Soil erosion and sand deposition (Rank 4) have affected 48.3% of respondents. It has been observed that after each flood cycle, a substantial amount of sand and silt deposits in the fields, necessitating additional investment for reclamation, which is often prohibitively expensive for small and marginal farmers.

Ranked as moderately severe (rank 3), waterlogging has affected 56.9% of the farmers. It is recognized as a secondary consequence of floods, which reduces oxygen availability to roots, leading to root rot and wilting. This frequently affects crops with shallow roots, such as brinjal, chili, and tomato. Poor market access during floods is another severe challenge (rank 2) reported by 70.1% of the farmers. It was found that damaged and submerged roads during floods, as well as improper storage facilities, often hinder the timely movement of vegetables to the market, resulting in significant economic losses due to spoilage and reduced sales. Some farmers are unable to sell their produce at all. It is interesting to note that, although flooding is a significant challenge, 44.8% of the farmers reported limited irrigation access (rank 4) during dry spells, which restricts the cultivation of high-value winter crops and thus reduces cropping intensity. Limited access to agricultural training and extension services (rank 3) has been reported by 59.8% of the farmers, resulting in poor awareness among farmers about new technologies, adaptive practices, pest management, and market trends.

Table 6. Challenges faced by vegetable farmers.

Challenges	No. of farmers affected	Farmers affected (%)	Severity rank 1=High
Crop damage due to flood	130	74.7	1
Pest and disease infestation	108	62.1	2
Soil erosion/Sand deposition	84	48.3	4
Water logging	99	56.9	3
Poor market access during a flood	122	70.1	2
Limited irrigation access	78	44.8	4
Lack of training/Extension programme	104	59.8	3

3.7. Farmer Perspectives on Improvement

Understanding the preferences and priorities of local farmers is crucial for developing effective agricultural policies. Table 7 reveals that vegetable farmers in the study area support targeted measures to overcome recurring farming challenges. Around 85.1% of the farmers support improving market connectivity. According to them, there is an urgent need for uninterrupted access to the market during floods, as poor infrastructure often causes severe post-harvest loss. Similarly, 75.9% of farmers report the importance of flood-resilient farming practices. Access to quality seeds and inputs has been highlighted by 74.1% of the farmers, indicating that timely and cost-efficient agricultural inputs are the need of the hour in the study area. Crop insurance availability was mentioned by 67.8% of the farmers, reflecting the need for risk mitigation tools in response to frequent crop failures. Lastly, 63.2% of farmers support the construction of drainage channels to address waterlogging and flood-related loss.

Table 7. Farmers' suggestions for improvement.

Suggested intervention	No. of farmers supporting	Percentage (%)
Construction of drainage channels	110	63.2
Training of flood-resilient farming practices	132	75.9
Crop insurance availability	118	67.8
Access to quality seeds and inputs	129	74.1
Better market connectivity	148	85.1

4. DISCUSSION

The study reveals that the region exhibits a complex landscape of vegetable farming, shaped by access to inputs, adaptive practices, environmental challenges, and infrastructural constraints. The over-dependence on HYV seeds (78.2%), either purchased from private companies or distributed by government agents, has increased the productivity of vegetable crops but has also put a burden of high input costs on farmers. These findings align with those of Ogada, Mwabu, and Muchai (2014) who reported that while HYVs significantly enhance yield, their adoption is often hindered by the costs associated with them and their dependency on external inputs. On the other hand, the limited use of indigenous seeds (21.8%) due to limited availability matches the observations made by Hasan and Chaudhuri (2020) who reported the erosion of the traditional seed system in West Bengal. Regarding chemical fertilizers and pesticides, farmers have reported high costs and the development of resistance, which aligns with the findings of Mitra et al. (2022) who observed a decline in the efficiency of chemical inputs due to overuse and poor application practices. Although adapting organic manure is a sustainable alternative, farmers have reported an insufficient supply, reflecting a wider concern about the challenge of sourcing organic inputs in the study area (Singh et al., 2024). The irrigation methods reflect a clear dependence on government-assisted shallow tube wells (64.4%). However, the lack of comprehensive spatial coverage has limited their effectiveness. Deka (2023) highlights that in Assam, shallow tube wells and surface irrigation systems are often inadequate during peak demand periods due to climate dependence and uneven rainfall distribution. The surface flow irrigation method, adopted by fewer farmers (35.6%), is driven by climate, highlighting the weakness of conventional irrigation methods amid unpredictable monsoon cycles.

The high adoption rate of adaptive practices, such as organic mulching (73%), adjusted crop calendars (71.8%), and raised bed farming (67.2%), contributes significantly to agricultural productivity and sustainability, indicating an encouraging trend toward climate-smart agriculture (Chandra, McNamara, & Dargusch, 2017). The adjusted crop calendar, with an effectiveness rating of 4.7, emphasizes its potential to mitigate crop loss during extreme weather conditions. Verma et al. (2024) also highlighted the benefits of adaptive irrigation scheduling in the northeastern hill ecosystem, showing that precise irrigation intervals significantly enhance crop performance under climate stress. The relatively lower adoption of seed preservation techniques (21.8%) suggests that increasing awareness and comprehensive training can lead to more effective utilization. Similar findings were mentioned by Yadav and Ghosh (2023) emphasizing the importance of community seed banks and farmer training for improving post-flood recovery capacities. The high LQ value for cauliflower and cabbage suggests that these crops are preferentially cultivated in the village with an effective drainage system, which reflects farmers' adaptation to seasonal waterlogging. Similarly, the concentration of bitter gourd indicates a judicious focus on crops with low flood sensitivity, aligning with the findings of Mandal (2014) regarding the selection of flood-adaptive crops. The concentration index also highlights the prominence of niche crops, such as yard-long beans and pointed gourd, which are cultivated in relatively small areas for local markets, aligning with the findings of Barman, Saha, Patel, and Bera (2022) on local market-driven crop selection. Comparative analysis across farmer categories shows that larger landholders tend to cultivate a wide variety of vegetable crops and invest more in flood-resilient infrastructure, such as raised beds and tube wells. Small and marginal farmers, who constitute over 86% of the sample, often rely on low-cost, adaptive methods such as mulching and adjusted crop calendars. Similarly, farmers with higher education levels (HSLC and above) demonstrate greater engagement with adaptive techniques and market connectivity, whereas farmers with lower education levels (illiterate and those with primary-level education) are more reliant on traditional practices. Seasonal patterns further reveal that high-yield, high-sensitivity crops, such as cabbage and cauliflower, dominate post-monsoon cultivation. In contrast, pre-monsoon farming emphasizes flood-tolerant crops, including okra, chayote, and gourds, thereby optimizing resource use during less predictable flood conditions. Despite their efforts, the farmers of the study area face multiple challenges. Crop damage due to floods and market inaccessibility during floods was ranked highest in severity (rank 1), aligning with the findings of Baruah, Mili, Gogoi, and Chetia (2023) who noted similar disturbances in Assam during the Monsoon period. Pest and disease infestations have also affected more than half of the respondents, indicating an urgent need for plant protection services and an integrated pest management approach (IPM), as advocated by Singh et al. (2025). It is reported that waterlogging and soil erosion, particularly in the plots located adjacent to the river, continuously degrade the quality of land, aligning with the findings of (Singha & Singha, 2025) who mentioned that recurring floods in Assam lead to extensive crop losses and soil degradation.

The most commonly recommended suggestion was better market connectivity (85.1%), highlighting that structural barriers are as crucial as environmental ones. This aligns with the findings of Jain, Sheekha, and Mandal (2022) who demonstrated a correlation between market access and improved farm incomes and adaptive capacity in Northeast India. Training in flood-resilient practices (75.9%) and access to quality seeds (74.1%) highlight the importance of enhancing technical inputs, extension services, and infrastructure development. The demand for crop insurance availability (67.8%) highlights the financial risk faced by farmers. It validates the need for inclusive agricultural schemes, as Chatterjee (2024) mentioned, who found that low insurance penetration leaves farmers in Assam exposed to disaster-induced losses.

5. CONCLUSION

The foregoing discussion presents a complex picture of vegetable farming, characterized by ecological sensitivity and limited access to resources in the study area. The farming practice is male-dominated and operates on very small landholdings. The limited educational attainment of the farmers has restricted the adoption of new technologies. Despite this, the community retains deep-rooted traditional knowledge passed down through generations, which has helped them maintain seasonal cropping patterns and adapt to farming practices. Various vegetables are grown using both indigenous and hybrid seeds, depending on seasonal suitability and seed availability. Though chemical fertilizers and pesticides are increasingly used to increase productivity, organic manure is also applied to maintain soil health. Irrigation is primarily dependent on shallow tube wells. Innovative adaptive practices, such as raised bed farming, adjusted crop calendars, and organic mulching, are being adopted at promising rates to mitigate the risk of crop loss. Crop damage due to unpredictable floods, pest infestations, poor market connectivity, and limited access to reliable irrigation systems remains a significant challenge. The research suggests an urgent need for integrated, area-specific interventions to enhance the resilience of floodplain agriculture. Strong policy initiatives should be implemented, focusing on infrastructure development, community-based climate-smart farming practices, and enhancing extension services to support sustainable development. The findings of this study have significant implications for regional planning and climate-resilient agricultural policy. Policymakers must recognize the unique challenges of floodplain environments and prioritize resource allocation, education, and technology transfer to effectively address these issues. By aligning grassroots adaptation strategies with institutional support and regionally tailored frameworks, the sustainability and productivity of floodplain vegetable farming in the Kamrup district can be secured. The active involvement of local communities with institutional and government support will ensure a sustainable and productive vegetable farming system in the Kamrup district.

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