

Indigenous Knowledge and Challenges of Sustainable Paddy Cultivation: A Cross-cultural Study on Uncovering Traditional Knowledge, Modern Challenges and Climate Resilience in Mymensingh

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Abstract: The traditional wisdom surrounding paddy cultivation has been deeply rooted in Bangladesh's agricultural practices since ancient times. This study delves into the intricate dynamics of sustainable paddy cultivation in Bangladesh, investigating the interplay among traditional farming practices, existing challenges, and the imperative for climate resilience. Data was collected from 150 participants recruited using stratified random sampling procedures for surveys, key informant interviews, case study analyses, and Participatory Rural Appraisal (PRA). Farmers are categorized based on land ownership and size, providing in-depth insights into the challenges and strengths associated with different groups. Seasonal analyses unravel the complexities of Aush, Aman, and Boro paddy cultivation, underscoring the significance of adaptive farming practices aligned with environmental conditions. Main findings underscore the substantial impact of scientific cultivation methods on paddy yield, advocating for a fusion of traditional wisdom and contemporary approaches. Furthermore, the study explores irrigation systems and paddy damage problems, offering important insights into crop protection and water management. The study investigates the effects of climate change on paddy cultivation through real-life case studies, spotlighting challenges such as escalating temperatures, erratic rainfall, and the migration of pests and diseases. Urgent attention and interventions are recommended to bolster climate resilience in agriculture. This research not only enriches the comprehension of sustainable paddy cultivation but also lays the groundwork for well-informed policy decisions and progress in agricultural practices. The ramifications of our findings extend to shaping the trajectory of agricultural development in Bangladesh, emphasizing the necessity of

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a comprehensive and adaptive approach to tackle the evolving challenges confronted by farmers.

Keywords: Indigenous knowledge systems, sustainable agriculture, paddy cultivation, climate change, Mymensingh.

1. Introduction

Agriculture plays a fundamental role in our country's economy, with paddy production holding a prominent position in this crucial sector. Culturing paddy in Bangladesh has been associated with using indigenous knowledge, a custom that has existed since ancient times (Smith & Rahman, 2023). Significantly, despite the progress in contemporary agricultural technology, traditional knowledge is a crucial component of paddy growing in Bangladesh. The continued dependence on indigenous methods highlights the importance and durability of ancient agricultural knowledge in modern farming techniques (Jones et al., 2016).

Indigenous knowledge referred by diverse terms such as 'local knowledge,' 'folk knowledge,' 'people's knowledge,' 'traditional knowledge,' or 'traditional science and technology,' is pivotal in shaping global societies. In Bangladesh, this knowledge is deeply ingrained in the cultural tapestry, transmitted across generations through oral traditions and cultural rituals. Serving as the foundation for myriad activities, including agriculture, food preparation, health care, education, and conservation, indigenous knowledge is the lifeblood of various communities in the country. This unique local knowledge mirrors the culture and defines all Bangladeshi societies.

With agriculture being the cornerstone of Bangladesh's majority population, this essay delves into the intricate relationship between indigenous knowledge and agriculture in the country. It explores the historical and traditional background of agriculture, the significance of agricultural biodiversity, the production of staple crops through traditional methods, evolving crop patterns, the development of agriculture, and various critical aspects contributing to this complex interplay. The study addresses crop varieties, challenges posed by pests and diseases, environmental concerns tied to agricultural practices, utilization of traditional technologies and tools, the impact of modern technologies and chemical fertilizers, and international influences and challenges affecting development.

This article seeks to demonstrate the role of indigenous knowledge in bolstering grassroots decision-making within Bangladesh, a nation characterized by its rural areas and reliant on a self-sustaining agricultural economy. This decision-making occurs at the community level through local

organizations and associations, where problems are identified, and solutions are collaboratively determined. Indigenous knowledge empowers these local communities to navigate the challenges and opportunities inherent in agriculture, significantly contributing to the country's overall development. The interplay of social and cultural factors, along with financial constraints, influences the agriculture-based practices of the marginal population in Bangladesh, making this topic a crucial area for research in the current social reality.

This study is based on small holder farmers' traditional knowledge in three different areas of Bangladesh, focusing on farming practices and agricultural risks. Conducted in Pakundia of Kishoreganj, Trishal of Mymensingh, and Atpara of Netrakona, the research gathers insights through interviews with marginal farmers. The research examines the obstacles encountered by small farming communities in attaining sustainable farming practices, encompassing their production methodologies and the vulnerabilities exacerbated by climate change. It endeavors to elucidate the convergence of indigenous knowledge with sustainable paddy cultivation in Mymensingh, thereby providing a holistic comprehension of the cultural, social, and traditional factors shaping agricultural approaches in Bangladesh.

2. Research Objectives

This research aims to thoroughly investigate the obstacles and possibilities linked to the sustainable cultivation of paddy in Bangladesh. This study specifically examines the influence of climate change on paddy farming, explores the importance of traditional methods, and discusses the incorporation of scientific knowledge for sustainable paddy cultivation, particularly emphasizing its effects on rural development. This mission aims to understand the complex interconnections of ancient traditions, environmental changes, and modern scientific breakthroughs in paddy agriculture. The study is conducted with specific objectives to address these broader goals.

- Investigate the present condition of paddy cultivation and production, examining its various aspects.
- Analyze and evaluate the difficulties associated with sustainable paddy agriculture in Bangladesh.
- Analyze the precise risks that climate change presents to the practice of paddy growing.
- Investigate and record the traditional methods utilized by communities involved in environmentally friendly rice farming.
- Examine the incorporation of scientific knowledge into sustainable paddy growing methods and assess its effect on agricultural sustainability.

3. Literature Review

Traditional indigenous knowledge is an interconnected network encompassing knowledge, beliefs, and traditions with the intent to preserve, communicate, and contextualize indigenous relationships with culture and landscape over time (Bruchac, 2014). The terms ‘knowledge,’ ‘belief,’ and ‘tradition’ are often used interchangeably, referring to factual data, religious concepts, and practices that define indigenous epistemologies. Indigenous knowledge is conveyed formally and informally within kin groups and communities through social encounters, oral traditions, ritual practices, and other activities (Sililtoe et al., 2006).

This knowledge encompasses oral narratives detailing human histories, cosmological observations, reckoning time, symbolic communication, planting and harvesting techniques, hunting and gathering skills, specialized understandings of local ecosystems, and the craftsmanship of tools and technologies (e.g., flint-knapping, hide tanning, pottery making, and medicinal remedies).

Traditional aboriginal knowledge transcends mere survival tactics; it constitutes a system of awareness that provides moral guidelines and practical advice. Local practitioners engage in activities such as plant medicine, shelter construction, hunting, and craft manufacture using natural materials, relying on intimate understandings of local flora and fauna. Traditional ecological knowledge evolves from environmental understandings shaped over time through incremental learning, crossing scientific disciplines like biology, botany, geography, and cosmology (Augustine, 1997; Berkes, 2012).

The possible influence of indigenous technological knowledge (ITK) in shaping the future agenda of science and technology (Taher, 2003). The term ‘indigenous knowledge’ gained prominence in development literature in the 1970s, as it became apparent that new scientific knowledge alone was insufficient in alleviating mass poverty and environmental damage caused by capital-intensive production inputs. E.F. Schumacher's seminal work, “Small is Beautiful,” highlights the importance of indigenous knowledge, particularly in technology. This seminal study represents an early systematic inquiry into the field. Subsequently, anthropologists have conducted extensive research on indigenous knowledge, thereby establishing it as a distinct discipline. Indigenous Technological Knowledge (ITK) underscores the inherent compatibility of marginalized communities with nature and serves as a vehicle for empowerment, acknowledging and honoring their enduring struggles (Brokensha et al, 1980).

This scholarly exploration aims to expound upon the concept of knowledge translation in conjunction with indigenous knowledge, delineating indigenous knowledge systems as characterized by their ecological, holistic, relational, pluralistic, experiential, timeless, infinite, communal, oral, and narrative-based attributes. Organizing information in Indigenous and Scientific knowledge systems condenses experience and beliefs into "knowledge." Indigenous knowledge systems start with 'stories,' progress to 'knowledge,' integrating values and processes, and culminate in 'wisdom,' an experiential distillation of knowledge (Smylie et al., 2004)

Academicians, development planners, and proponents of alternative development approaches are actively examining indigenous knowledge systems (IKS) (World Bank, 1989). Implementing indigenous knowledge systems in agricultural education to advance sustainable agriculture, specifically targeting areas such as sustainable agriculture and environmental management that have been overlooked in agricultural education (Williams & Muchena, 1991)

The focus is on scientific advancements in labor-intensive agriculture, with an emphasis on ensuring fair access to resources through reforms related to land and water (Pauline et al., 1978)) The potentials of indigenous knowledge and ethno-biotechnology in sustainable agriculture in sub-Saharan Africa, underlining the importance of appropriate biotechnology and indigenous knowledge for cheap, low-tech disease and pest control (Yongabi1 & DeLuca, 2003). The role of indigenous technology knowledge in adapting to climate change impacts in Dolpa district, Nepal, emphasizing traditional farming methods and seed exchange within the community as adaptive measures (Parajuli & Maharjan, 2017).

The literature study examines indigenous knowledge but needs to elucidate its impact on sustainable agriculture, highlighting a significant research deficiency. The research acknowledges the change in context and recognizes the similarities in the importance of gaining a more profound comprehension of indigenous knowledge and practice. This study aims to provide fresh insights into the current understanding of sustainable rice farming in Mymensingh's unique cultural and socio-economic context.

The study aims to reveal a multifaceted and varied situation regarding indigenous knowledge and sustainable paddy cultivation by comparing it to prior literature on rice cultivation and the utilization of indigenous knowledge. The impact of cultural, economic, and family factors is expected to be significant, demonstrating the diverse effects observed in the setting of rice farming. Moreover, this study aims to clarify the difficulties encountered

by communities participating in rice farming and investigate solutions that might be applied or introduced to enhance the sustainability and welfare of the individuals involved.

To summarize, the aims to address the gaps in the current literature by performing an ethnographic study that explicitly examines indigenous knowledge and sustainable paddy growing in Mymensingh. By doing this, it aims to enhance the comprehension of agricultural methods and contribute to the broader discourse on the interconnection between culture, socio-economic elements, and sustainable development in the distinct setting of Mymensingh, Bangladesh. This project aims to enhance the current knowledge base and facilitate the development of well-informed policies and interventions that promote sustainable and culturally sensitive farming practices. Given Bangladesh's significant role in global paddy production and its vulnerability to climate change, there is a compelling need for further investigation into the indigenous knowledge of Bangladeshi peasants who contribute substantially to global paddy production.

The study endeavors to illuminate the multifaceted and diverse landscape surrounding indigenous knowledge and sustainable paddy cultivation, achieved through a comparative analysis with existing literature on rice cultivation and the utilization of indigenous knowledge. The anticipated significant impact of cultural, economic, and familial factors underscores the varied effects observed within the realm of rice farming. Furthermore, the study seeks to elucidate the challenges faced by communities engaged in rice farming and explore potential solutions aimed at enhancing sustainability and the well-being of involved individuals.

4. Theoretical Framework

This Framework section provides an overview of the Small Peasant Community Theory, initially formulated by anthropologists Eric Wolf (1966, 1969) and Alexander Chayanov (1966). This theory is the foundation for examining how small farming communities have historically adapted their agricultural practices in response to climate change. Central to this framework is Chayanov's theory of the peasant economy, which offers valuable insights into the social and economic dynamics inherent in peasant agriculture.

Chayanov's thesis emphasizes the family unit, emphasizing how economic decisions within small peasant households prioritize familial well-being over profit maximization. The distribution of labor within these households is carefully influenced by expertise, gender, and age, highlighting the

significant role of family members as essential contributors to labor. Chayanov's analysis further underscores the labor-intensive nature of peasant agriculture, characterized by substantial investments during planting and harvest seasons followed by periods of reduced activity.

Moreover, Chayanov underscores the localized focus of peasant farmers, prioritizing consumption for local sustenance rather than profit-driven motives. The theory also emphasizes the inclination of farm households towards risk aversion, often opting for techniques that ensure essential needs are met, even at the expense of potential income. Additionally, Chayanov highlights the inherent constraints on expanding peasant agriculture due to labor and property capacity limitations within family units.

While the theoretical framework aligns effectively with the research's central focus on indigenous knowledge and sustainable paddy cultivation in Bangladesh, there exists an opportunity for further elaboration on the interaction between the chosen theory and specific elements of the research design and analysis. A more thorough discussion regarding how the small peasant community theory informs the study's approach to examining historical and economic underpinnings, along with its implications for understanding sustainable farming practices and climate resilience in Bangladesh, would bolster the theoretical underpinning of the research. Such an expanded discourse would deepen our comprehension of the intricate relationships among indigenous knowledge, agricultural strategies, and climate adaptation within the Bangladeshi context.

5. Study Area

This study investigates the peasant society in the Mymensingh, Kishoregonj, and Netrakona districts of Bangladesh, focusing on the traditional adaptation systems developed by small-scale farmers confronting recurrent natural calamities. Data were collected from Chalimpur of Trishal Union in Trishal Upazila (Mymensingh District), Duaz of Duaz Union in Atpara Upazila (Netrokona District), and Hossaindi village of Hossaindi Union in Pakundia Upazila (Kishoreganj District). These areas were chosen to represent diverse land classifications, including Haor and high land, reflecting the farmers' utilization of traditional farming methods amid geographical and positional differences. The research aims to uncover the stories behind rice cultivation in these regions, offering insights into the resilience and resourcefulness of the local peasantry. The findings contribute to understanding the intricate relationship between small-scale farmers and their agricultural landscapes, with implications for developing region-specific sustainable farming practices and policies.

6. Methodology

This study, conducted between June and September 2023, meticulously examined the unit of analysis, a foundational concept. Specifically, the study targeted 150 landless, marginal, small, and large farming communities across three distinct areas as the study unit. The study population encompassed the entire group under investigation, predominantly focusing on farming communities. Supplementary insights were gathered through interviews with local agricultural officials to enhance understanding of indigenous and traditional knowledge related to paddy cultivation.

The sampling strategy employed a combination of stratified random sampling, which aligns with the study's objectives and unit. Stratified random sampling involves dividing the population into non-overlapping strata, facilitating a more comprehensive cross-sectional representation. The research design was tailored to the study's objectives, incorporating qualitative and quantitative data collection methods. Primary data was gathered through a range of methods, including household surveys, Participatory Rural Appraisal (PRA), key-informant interviews (KII), observations, and a case study approach. In this study, 150 households were surveyed. During the household Survey conducted 17 key informant interviews with the entire farmer class possessing specialized skills relevant to the research objectives. Specifically, interviews were carried out with educated individuals and skilled informants engaged. In focus group discussions, information was collected through active discussions involving an average of 7 participants per group from the same farmer class. As well as four FGD conducted with landless, marginal, small, and large farmer's groups. Secondary data was sourced from government offices, research papers, articles, and statistical data. Data organization, preparation, and analysis were conducted thematically, with codes generated in the data analysis plan. The data management process included recording interviews, a transcription period spanning 72 hours, cross-matching with field notes, and resolving any points of ambiguity through participant communication. Data triangulation was employed for credibility, incorporating in-depth interviews and focus group discussions. Validity and reliability were addressed through diverse data collection methods and multiple sources. The research adhered to guidelines set by the American Anthropological Association (AAA), and pseudonyms were employed to protect informant identities. Acknowledging the researcher's outsider status in the field, power dynamics and knowledge control presented challenges. The study concludes by delving into fieldwork dilemmas and the coding process, facilitating categorizing themes in the interview findings. The comprehensive approach employed in this study contributes to the robustness and depth of the research findings.

7. Findings

Paddy production has long been a fundamental component of Bangladesh's agricultural landscape, intricately woven into the cultural and social fabric of the country. In the face of challenges posed by sustainable agriculture, the importance of indigenous knowledge systems has increased in promoting ecologically conscious and resilient farming methods. This study examines the traditional knowledge related to paddy production in Bangladesh, investigating the sustainable strategies utilized by local groups. Bangladesh possesses a diverse array of native knowledge that has been transmitted over generations among agricultural communities. This expertise involves a comprehensive approach to cultivating paddy, which includes ancient wisdom, local practices, and a deep awareness of the soil. Indigenous knowledge is crucial in ensuring sustainable and resilient paddy production, as it encompasses the selection of appropriate paddy cultivars and effective water management strategies.

7.1 Land Ownership Patterns

This diagram classifies farms into four distinct groups based on the average amount of land owned and the average amount of land operated. These categories provide vital insights into the scale and scope of agricultural activities. These farms do not own property ownership, but they effectively oversee an average of 1.25 acres of land. This implies that those who do not own property may participate in agricultural activities either as hired workers or by renting or sharecropping small parcels of land (Fieldwork, 2023).

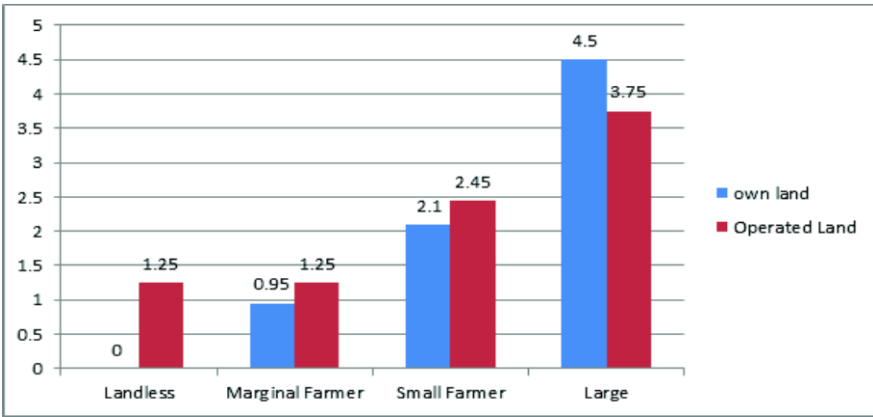


Figure 1: Distribution of sizes of land and operated land (Source: Field work, 2023)

The typical land ownership and operation of marginal farmers ranges from 0.95 to 1 acre. Their landholdings are rather small, often ranging from 1 to 1.50 acres, which they cultivate. Subsistence agriculture is often relied upon by marginal farmers, who may face challenges in generating surplus crops. Typically, small-scale farmers own and oversee between 1.50 to 2 acres of land. They have larger land holdings compared to marginal farmers and typically cultivate an area ranging from 1.5 to 2.50 acres. Small-scale farmers have a somewhat higher capacity to generate surplus agricultural products for both personal use and commercial purposes. The average land ownership of large farms varies between 4 and 4.60 acres, but their working area typically extends from 2.50 to 3 acres. These farms are larger in size and possess the capability for more substantial agricultural production. They may give equal importance to both subsistence farming and commercial farming. This categorization allows for a more thorough understanding of the range of farm sizes and the scale of agricultural operations. It is imperative to recognize that the categorizations of these groupings are established based on land ownership and the extent of agriculture, which might vary depending on the location and surroundings. The data provides valuable insights into the distribution of farms across many categories and their possible implications for agricultural practices, production, and livelihoods.

7.2 Paddy Farming Practice and Crop Season

The study was conducted on paddy farming in three local agricultural communities. However, most of the area in Atpara Upazila in Netrakona is dedicated exclusively to cultivating Boro paddy. Aush paddy is grown in a few areas of Trishal in the Mymensingh district and Pakundia upazila of Kishoreganj. The cultivation season for Aush paddy involves the preparation of seed beds and sowing seeds in the first week of April. Paddy cultivation commences from the latter part of April till the second week of May. The growth period of Aush rice spans from the second week of May to the second week of August. Harvesting Aush rice extends from the final week of August to the middle of September. Aman paddy is extensively cultivated in the Hossaindi Union of Pakundiya and the Trishal Union of Trishal Upazila.

Nevertheless, Aman paddy is cultivated in a limited area in the Duaz Union of Atpara Upazila in the Netrakona District. According to a seasonal analysis, the Aman paddy farming strategy involves the seedbed preparation and seeding of Aman paddy in mid-June. From late June until mid-July, the planting of paddy continues in addition to prepping Aman paddy fields. Aman paddy undergoes its growing phase from June/July until the initial

week of November. The harvesting of Aman paddy takes place from early November to mid-December.

Boro paddy is cultivated exclusively throughout the entire cultivated land of Hossaindi Union in Pakundia, Duaz Union in Atpara, and Trishal Union in Trishal Upazila. Nevertheless, the cultivation of Boro paddy is limited to a small area within the Hossaindi Union of Pakundia Upazila in the Netrakona District. The Boro paddy farming technique follows a seasonal pattern, with the seedbed preparation and sowing occurring between mid-December and the first week of January. From mid-January to late February, farmers are engaged in preparing Boro paddy fields and planting paddy. The growth period of Boro paddy spans from the last week of January to the second week of April. Boro paddy is harvested from the beginning of April to the middle of May.

7.3 Paddy Cropping pattern and Intensity

Table-1: Paddy cropping intensity (source: fieldwork, 2023)

Land Type	Kharip-1	Kharip-2	Robi	% of total cultivated land
Low land	Fallow	Fallow	Boro	15%
Middle low land	Fallow	Aman	Boro	28%
Middle high land	Fallow	Aman	Boro	45%
High land	Aush	Aman	Boro	12%
Very high land	Vegetables	Aman	Jute/fellow	10%

Note: Kharip-1 refers to the first season of the monsoon crop cultivation, typically starting around May and Lasting until August. Kharip-2 refers to the second season of monsoon crop cultivation, usually from August to November. Robi refers to the winter season crop cultivation, typically from November to April.

The data categorizes different land types according to their usage over different cropping seasons, providing insight into the percentage of total cultivated land allocated to each kind. The low-lying areas, which make about 15% of the entire land, are mostly used for Boro cultivation during the Rabi season. These areas may be left fallow during the Kharip season due to excessive water or for specific crop rotation practices. The middle lowland, which accounts for 28% of farmed areas, employs a crop rotation system. It mainly focuses on farming Aman and Boro crops, with fallow periods throughout Kharip due to reasons such as crop rotation or soil fertility management. The middle high land, which accounts for 45% of the total,

practices rotational cultivation of Aman and Boro crops, while keeping a substantial amount fallow during Kharip season. This approach helps maintain a balance between crops that are consumed locally and those that are grown for profit. The primary concentration in highland areas (12%) is on cultivating Aush paddy during the Kharip-1 season, followed by Aman and Boro paddy during the Kharip-2 and Rabi seasons, respectively. This selection is based on the elevation and appropriateness of the soil. Land at a high elevation (10%) displays a wide range of crops, indicating favorable conditions. The study highlights the variety of land types and the corresponding cultivation patterns, influenced by factors such as soil composition, water availability, and altitude. Comprehending these patterns is essential for directing agriculture, optimizing productivity, and guaranteeing environmental sustainability. This highlights the significance of crop rotation and fallow periods in preserving soil health and improving productivity.

7.4 Productivity of Paddy

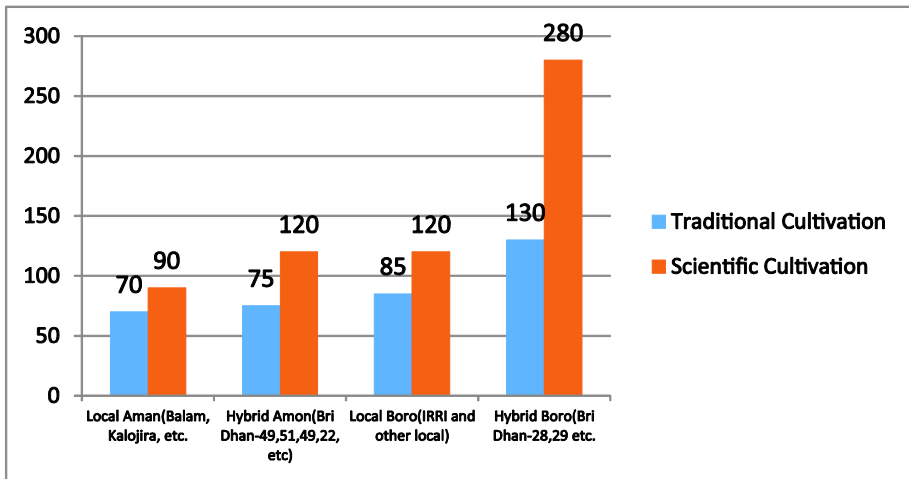


Figure 2: Production of paddy cultivation, per 10 decimal lands (Source: Fieldwork, 2023)

This diagram provides a comparative evaluation of paddy yield per 10-decimal area utilizing traditional and scientific cultivation techniques for different paddy cultivars. Significant observations encompass conventional approaches for cultivating native types such as Balam and Kalojira, which yield 70 kg. However, implementing scientific methodologies boosts the production to 90 kg, indicating a 28.57% augmentation. Traditional farming of Hybrid Amon types like Bri Dhan-49, 51, 49, and 22 yields 75 kilograms.

However, implementing scientific methods significantly increases productivity, with a yield of 120 kg, representing a substantial rise of 60%. The indigenous Boro varieties demonstrate a yield of 85 kg using traditional methods, which increases to 120 kg when employing scientific procedures, resulting in a significant productivity increase of 41.18%. The hybrid Boro variety, consisting of Bri Dhan-28 and 29, exhibits a conventional yield of 130 kg, which significantly rises to 350 kilograms with the implementation of contemporary techniques, resulting in an impressive increase of 169.23%. When traditional methods are used to cultivate Hybrid Aush, the yield is 75 kg. However, employing scientific methodologies increases the production to 115 kg, demonstrating a substantial productivity increase of 53.33% (Fieldwork, 2023).

In summary, the evidence highlights the significant influence of modern farming techniques on paddy production, continuously surpassing conventional methods. These findings highlight the possibility of increasing agricultural output and guaranteeing food security by implementing modern and scientifically based farming methods, focusing on growing hybrid paddy types.

7.5 Irrigation System

Irrigated soil is agricultural land that is provided with extra water to improve the yield of crops. Irrigation plays a vital role in agriculture in Bangladesh by providing the necessary water for farming various crops, especially Boro paddy and wheat, during the dry season. Furthermore, irrigation is essential during the Kharif season. Irrigation during the Kharip season is an additional strategy to cultivate Aman paddy. During the Kharip-1 season (March-June), irrigation is supplied to high-yielding Aush, high-yielding saplings, native saplings, jute, and other crops. Irrigation is provided to high-yielding Aman, locally enhanced variety Aman, local Aman, seedlings, and mixed Aman during the Kharip-II season (July-October). During the robi season, which spans from November to February, several crops like Boro paddy, wheat, round potato, sugarcane, kalai, and oilseed are provided with irrigation. The percentage of irrigated cultivated land rose from 1.52 million hectares in 1982-83 to 505 million hectares in 2006-07, out of a total cultivated area of approximately 13.53 million hectares (Smith & Rahman, 2023). The irrigated area in Bangladesh experienced a substantial increase of 72.72 lakh hectares in the fiscal year 2021-22, mostly in areas equipped with shallow tube wells (Bangladesh Bureau of Statistics, 2022).

After examining the study's primary data, all the participants are involved in irrigating the land. However, irrigation is required for 37% of the region during the alternate or dry season. During the early Kharip-1 or Aush paddy production phase, 55% of the area must be rinsed as a primary measure.

According to the information provided by the sources, irrigation is required to cultivate Boro paddy.

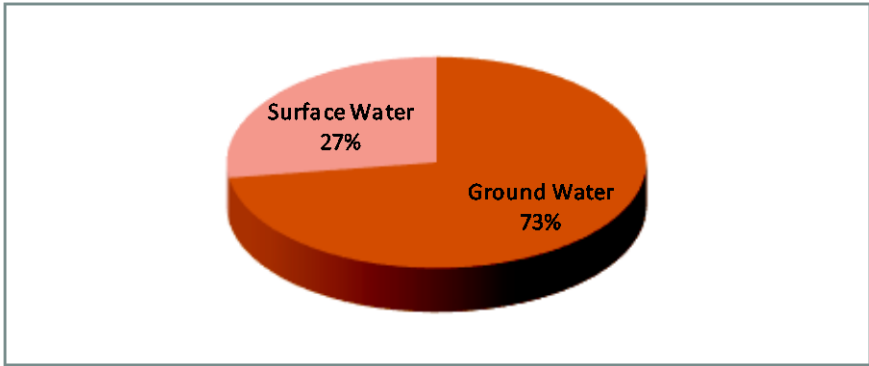


Figure 3: Water Source for Irrigation (Source: Fieldwork, 2023)

This study was conducted on paddy cultivation in three different areas. Among them, 100% underground water is used in boro paddy cultivation in Chalimpur village of Trishal upazila. Groundwater is used for irrigation in 96% of Hossaindi Namapara village of Pakundia upazila. Bill and local canal water irrigate the remaining 4% of the land. Local river water is used in 78% of the land of Atpara Upazila. The remaining 22% of the land is irrigated from underground sources. In other words, if we look at the water use in the combined irrigation system of the three areas, 72.66% of the land uses groundwater for irrigation, and the remaining 27.34% of the land is irrigated from surface water sources such as ponds, rivers, canals, and beals (Source: Fieldwork, 2023).

7.6 Paddy Damage Issues and Status (Last Three Years)

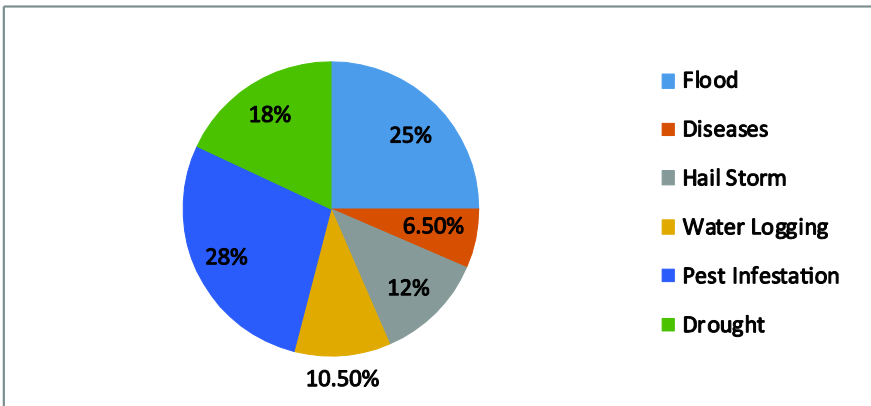


Figure 4: Paddy Damage issue (Source: Fieldwork, 2023)

This figure showcases several crop damage issues and their corresponding percentages. Now, let us examine this data:

- **Flood:** Flooding is a substantial threat, impacting 25% of the instances of crop damage. Excessive precipitation can result in drowned fields, soggy soil, and agricultural damage.
- **Diseases:** Crop diseases are responsible for a relatively minor proportion of damage, representing 6.50% of instances. These diseases encompass fungal, bacterial, or viral infections that have a detrimental effect on the health and productivity of crops.
- **Hail Storm:** Hail storms present a significant danger, accounting for 12% of instances of crop damage. Hail has the potential to cause physical harm to crop, resulting in a decrease in output and financial losses.
- **Water logging:** It accounts for 10.50% of crop loss incidences. It happens when the soil gets excessively saturated with water, impeding the respiration of roots and resulting in harm to plants (Fieldwork, 2023).
- **Pest Infestation:** Pest infestations are the primary cause of crop damage, constituting 28% of reported instances. Crop pests, including insects, rodents, and birds, have the ability to consume or harm crops, resulting in decreased crop yields (Fieldwork, 2023)
- **Drought:** Drought is a major issue, accounting for 18% of crop damage incidents. Extended periods of inadequate precipitation or water accessibility can have a significant detrimental effect on crop development and yield (Fieldwork, 2023).

Crop damage problems, which include common pest infestations in more than 25% of instances, require effective management. Since floods and droughts make up 43% of extreme weather occurrences, water management and weather resilience are critical. Although they are confined to specific regions, hailstorms and flooding nevertheless play a role in the damage that occurs. Diseases contribute significantly to crop health even though they make up a smaller fraction of the total. Recognizing these issues is essential to creating strategies that safeguard agricultural productivity and ensure food supply.

7.7 Crop Damage (%) by Farm Category

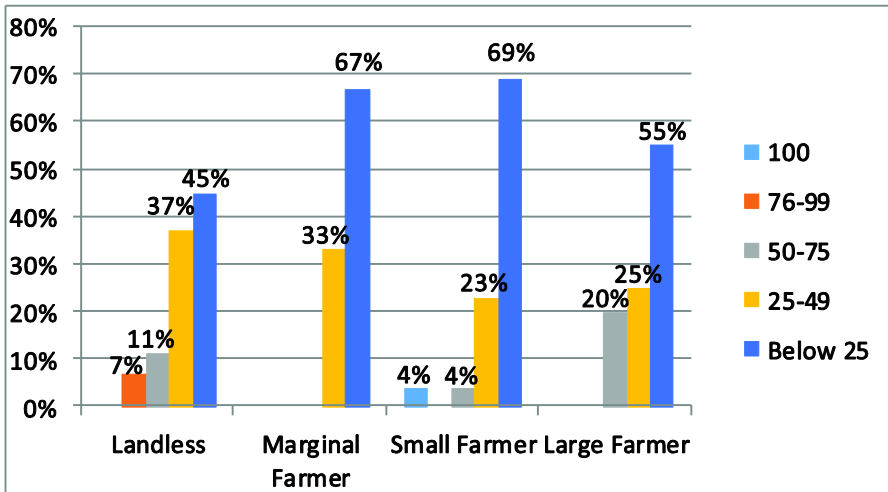


Figure 5: Paddy Damage (%) by Farm Category (Source: Fieldwork, 2023)

This diagram illustrates the following:

The extent of loss: The category with "Below-25% Damage" is the most common across all farm types, suggesting that a substantial fraction of farmers in each category encounter minor levels of crop loss.

Resilience of marginal farmers: Marginal farmers exhibit the highest proportion (67%) of undamaged farms. This implies their capacity to effectively handle and adjust to conditions that result in crop harm, potentially due to the scale of their farm and their management of resources.

Primary challenges faced by large farmers: Large-scale farmers experience the most significant proportion (20%) of farms with '25-49% damage.' This suggests that, even if they have more excellent operations, they still encounter significant difficulties in dealing with harm within this range.

Vulnerability of landless farmers: Approximately 37% of landless farmers' farms experience damage below 25%. Nevertheless, they encounter difficulties, as 7% of farms endure '50-75% damage' and 11% endure '25-49% damage' (Fieldwork, 2023).

Adaptation of small farmers: Small farmers demonstrate a high level of adaptability, as seen by the fact that 69% of farms experience damage below 25%. In addition, they have a lower proportion of 'complete damage' (4%) than other groups. The analysis highlights the variation in crop damage among various farm groups. Although 'below-25% damage' is frequently

observed, the capacity to handle and adjust to different degrees of damage differs among farms of different sizes. Marginally sized farmers demonstrate resilience, as a more significant proportion of their farms remain unaffected, whereas large-scale farmers have difficulties with a critical '25-49% damage' rate. Landless and small farmers demonstrate resilience and susceptibility to different levels of harm. Analyzing these trends can provide valuable insights for developing support and intervention methods to strengthen the resilience of farmers and minimize crop damage.

7.8 Return from Paddy Cultivation (Profit)

The High Yield Variety (HYV) Boro crop has the highest average production level is 45,357 BDT, indicating its superior yield. HYV Amon is notable for its impressive average production income 29,254 BDT, which demonstrates its high productivity. The HYV Aush variety has the lowest average production among the three types, with a production rate of 20,891 BDT (Source: Fieldwork, 2023).

Despite its relatively lower production, the high-yielding variety (HYV) Aush maintains a commendable gross value of 33,008 BDT, indicating favorable market prices. HYV Boro, with its superior production, achieves the greatest gross value of 55,336 BDT, highlighting its significant economic importance. HYV Amon also yields a significant gross value of 39,493 BDT (Fieldwork, 2023).

The net return, which is the profit obtained by subtracting production costs, is highest for HYV Amon at 10,239 BDT, suggesting effective cost control. Despite a decrease in production, the High Yielding Variety (HYV) Aush still generates a positive net return of 9,811 BDT. Despite its significant production and gross value, HYV Boro exhibits a comparatively lower net return of 9,979 BDT, potentially attributed to elevated cultivation and input expenses (Fieldwork, 2023).

7.9 Fields of Using Traditional Knowledge in Paddy Cultivation

The scope of traditional knowledge in paddy agriculture is wide-ranging and has been determined through interviews with informants and case studies. Informants possess expertise in seed preservation, traditional methods of improving soil fertility, irrigation techniques, paddy threshing, conservation practices, and insect management.

The indigenous seed storage systems in Bangladesh possess invaluable traditional agricultural knowledge that is essential for maintaining crop diversity, ensuring food security, and adjusting to local conditions. Farmers utilize cost-effective techniques such as utilizing clay pots, bamboo, or

woven baskets, specifically designed for local conditions, to safeguard seedlings from dampness and pests. One aspect highlights the strong correlation between the preservation of indigenous seeds and the maintenance of traditional crop varieties, which is essential for ensuring long-term agricultural viability.

Abdul Khalek emphasized the cultivation of a specific paddy variety in water with minimal maintenance, while adhering to conventional methods of seed preservation.

Respondent Saiful Islam stressed the importance of gathering seed paddy before harvesting, utilizing conventional techniques for conservation.

Indigenous seed storage systems encounter difficulties due to alterations in agricultural techniques, the use of commercial seeds, and contemporary storage methods, despite their significance. By incorporating ancient methods into contemporary farming, it is possible to preserve a wide range of crops, enhance the reliability of food supply, and promote long-term ecological balance, thus connecting ancestral knowledge with cutting-edge scientific progress.

The preservation of native seeds in Bangladesh serves as a valuable repository of information crucial for maintaining crop variety, adapting to climatic change, and ensuring local food stability. It is essential to conserve and incorporate this expertise into contemporary methods to ensure long-lasting and adaptable agriculture in the area.

7.10 Traditional Harvesting

This research examines the long-lasting agricultural heritage, cultural importance, and environmentally friendly methods linked to paddy farming, surpassing current methods of collecting and separating grains as obtained from information provided by informants.

Paddy harvesting in traditional practices is closely linked to cultural ceremonies and festive occasions, symbolizing the significance of paddy harvesting in indigenous traditions. During the Aman season, Paddy threshing was a celebratory event that entailed morning chores, such as fetching cows from nearby sheds. Nevertheless, the implementation of evidence-based techniques has prompted communities to forsake the ancient practice of threshing with cows in favor of contemporary ways.

Traditional paddy harvesting aligns with seasonal fluctuations, with agricultural practitioners strategically planning cropping schedules to coincide with peak crop maturity. This scheduling forms the basis of the

social and cultural threshing structure. Many traditional paddy harvesting techniques rely on physical labor, fostering cooperation among community members, often extended families. This not only reduces workload but also cultivates a sense of camaraderie and solidarity. However, due to the current labor shortage, there is a shift toward technology-based threshing. Traditional methods prioritize environmental impact reduction, often employing manual harvesting to minimize crop damage and eschewing mechanical equipment that may harm the ecology.

Traditional paddy harvesting encompasses post-harvest practices, including grain separation from the stalk, impurity removal, and preparation for consumption. These practices are accompanied by individual customs and cultural traditions. The challenges in traditional paddy cultivation, as articulated by study informants, encompass labor shortages, time-consuming yet cost-effective farming methods, high labor costs, susceptibility to diseases, and low production. The provided data illuminates these challenges, providing analytical insights for a comprehensive research report. A primary hurdle in sustainable paddy cultivation is the scarcity of labor. This crisis significantly affects traditional paddy farming, prompting small and landless farming communities to shift to alternative professions. The migration of the younger generation to urban areas exacerbates the need for agricultural workers, potentially causing delays and reduced crop yields. Informants highlight the cost-effectiveness but time-intensive nature of traditional farming. Balancing cost reduction with maximum efficiency becomes crucial, as traditional methods, reliant on manual labor, may impact overall productivity.

Acknowledging the prolonged process inherent in traditional paddy cultivation, sources underscore that despite technological advancements, a shortage of labor or the necessity for skilled workers contributes to the considerable expenses faced by small-scale farmers. Conventional paddy farming, although it preserves soil fertility, is susceptible to pests and illnesses because conventional rice cultivars lack resistance to these ailments. Efficiently controlling pathogens is crucial to protect agricultural productivity.

Despite its environmentally beneficial nature, traditional paddy production is hindered by low productivity. The experiences of the interviewees highlight the reduced productivity in comparison to contemporary, high-yield varieties and techniques, which have significant consequences for both food security and economic sustainability. The concerns expressed by informants provide valuable insights for study reporting, highlighting the importance of tackling

labor shortages, optimizing the balance between cost and time, and developing efficient disease control measures.

7.11 Climate Change Threat for Paddy Cultivation

According to several sources, the primary hindrance to achieving sustainable paddy farming in Bangladesh is the occurrence of natural disasters resulting from climate change. Upon analyzing the gathered data, it becomes evident that climate change is giving rise to new hazard risks. Consequently, the small farming community is experiencing a significant decline in strength or transitioning to alternative professions. The places where climate change is hindering sustainable paddy agriculture include:

Temperature escalation: Climate change has led to a rise in the average temperature in Bangladesh, potentially resulting in heat stress on the rice crop. Elevated temperatures can impact the growth of crops, diminish their productivity, and facilitate the proliferation of heat-resistant pests and illnesses.

Case study-1: Hot air is burning rice

This case study is about Sirajul Islam of Pakundia Upazila. Sirajul Islam stated that after taking a loan last year, I planted Boro paddy on about one acre of land and Bri rice-28, an early variety, on 40 decimal land. But at the time of the emergence of paddy grains, a sudden hot wind destroyed all the crops. I had never been in such danger before. I would give up paddy cultivation if I fell into this situation for the second time.

This case study emphasizes the urgent and existential threat to the sustainability of rice cultivation due to climate change. Sirajul Islam's narrative serves as a poignant reminder of the vulnerability of farmers to the adverse effects of changing weather patterns and extreme weather events. The devastation of his crops by sudden warm winds highlights the fragility of agricultural livelihoods in the face of climate variability and emphasizes the pressing need for adaptation strategies to build resilience in farming communities.

Integrating this case study into a larger analysis, it becomes clear that Sirajul Islam's experience serves as a microcosm of the challenges facing agricultural systems in an era of climate change. By illustrating the personal story of a farmer grappling with the consequences of environmental instability, the case study advances our understanding of the complex interplay between climate factors and agricultural sustainability. Furthermore, it emphasizes the imperative to incorporate local knowledge

and experience in formulating effective climate adaptation and mitigation policies.

Irregular rainfall: Climate change has disrupted traditional rainfall patterns. As a result, there is a lack of rain in paddy cultivation, sometimes even more severe irregular rainfall. This results in droughts in rice cultivation, early floods, and delayed floods, which affect sustainable rice cultivation. Inconsistent water availability can lead to yield reduction and crop damage.

Case study-2: No rain - no cultivation

This case study is narrated by Nurul Abshar (50) of Trishal Upazila. He stated that the cultivation of Aman paddy in our Trishal upazila entirely depends on rainwater. There is no profit if the amount of Aman rice production is added to the irrigation cost. That is why Aman paddy depends on rainwater. However, during the last two years, the people of this region are suffering from heatstroke while planting paddy. Due to the lack of rain, even after the scheduled time, paddy production is disrupted to a large extent due to the failure to grow rice seedlings. As a result, we cannot cultivate due to the lack of rain. Because there is no rain, there is no cultivation.

Case study -3: Water stole my dreams

This case study was narrated by an informant named Sohag Mia (45). Narrating this case study, the informant said, I have planted two acres of paddy this year. It cost me about 35,000 BDT to cultivate two acres of land. Seeing the growth of the crop, I thought that this year, I would get an excellent yield. But in the early part of the month of Kartik, the waterlogging and flood-like situation caused by this rain destroyed all the paddy in my land. Water has robbed me of my crop dreams.

Analyzing this case study, a change in rainfall is observed due to climate change, resulting in untimely rainfall creating challenges in sustainable paddy cultivation. Connecting these case studies to the broader analysis, it's evident that changes in rainfall patterns, attributed to climate change, pose a severe threat to sustainable paddy cultivation. Nurul Abshar's narrative underscores the vulnerability of agricultural systems to shifting weather patterns, emphasizing the urgent need for adaptation strategies to mitigate risks associated with rainfall variability. Sohag Mia's experience highlights the detrimental effects of changing rainfall patterns on agricultural livelihoods, illustrating the urgency of implementing adaptive measures to safeguard farmer well-being and ensure the resilience of agricultural systems in the face of climate change.

Migration of Pests and Diseases: Changing climate conditions facilitate the migration of new pests and diseases. Paddy fields previously free of certain pests may now be infested, leading to reduced yields and increased pesticide use. However, even after applying insecticides, they do not work in many cases. Therefore, this issue has created a challenge in sustainable paddy cultivation.

Case study-4: Pesticide efficacy in question: Shahabuddin's field observations

Informant Shahabuddin (55) said that if a little medicine (insecticide) was given to the land, all the insects and spiders would be killed or not found. But now there are so many insects that no medicine (insecticide) works on. Last year, during Aman, my land was attacked by maggots. In this situation, when there was no way to fix it, some benefit is obtained by planting the branches of trees and bushes on the ground.

By integrating this case study into the broader analysis, it becomes apparent that the rise of pesticide-resistant pests represents a pressing issue in agricultural sustainability. This narrative underscores the importance of exploring alternative pest management approaches and promoting integrated pest management practices to address the challenges posed by pesticide resistance. In doing so, we can enhance agricultural resilience while minimizing the environmental and economic impacts associated with pest infestations.

8. Conclusion

In conclusion, this extensive investigation into the challenges of sustainable paddy cultivation in Bangladesh provides a comprehensive understanding of the intricate web connecting traditional wisdom, modern challenges, and climate resilience. The findings underscore the enduring significance of indigenous knowledge in paddy agriculture, revealing the rich tapestry of practices embedded in Bangladesh's cultural and social fabric. From seed selection to water management, indigenous knowledge is pivotal in ensuring resilient and environmentally friendly paddy cultivation practices.

The study categorically explored the diversity in land sizes and farming practices across different categories of farmers, shedding light on each group's unique challenges and strengths. From landless farmers engaging in agricultural activities as labourers to large-scale farmers focusing on extensive production, the classification offers valuable insights into the farming landscape. This information is critical for guiding policy interventions and support systems tailored to the specific needs of each

farming category. The seasonal analysis of paddy cultivation in three distinct areas reveals the intricacies of Aush, Aman, and Boro paddy cultivation systems. Understanding the cultivation timelines, growth periods, and harvesting schedules is vital for optimizing agricultural productivity and ensuring food security. The cropping intensity table further emphasizes the diverse utilization of land types across different cropping seasons, showcasing farmers' adaptability to environmental conditions.

Productivity analysis, illustrated through comparative diagrams, highlights the substantial impact of scientific cultivation methods on paddy yield. This emphasizes the potential for elevating agricultural productivity and ensuring food security by adopting contemporary and scientifically informed farming practices. The study advocates for integrating traditional practices with modern approaches to maintain crop diversity, increase food security, and ensure sustainability.

Furthermore, examining the irrigation system and paddy damage issues offers critical insights into the challenges and opportunities associated with water management and crop protection. The data-driven analysis of various factors influencing paddy damage, including floods, diseases, hailstorms, waterlogging, pests, and droughts, sets the stage for devising effective strategies for mitigating these challenges.

The study delves into the impact of climate change on paddy cultivation, showcasing real-life case studies of farmers grappling with rising temperatures, irregular rainfall, and the migration of pests and diseases. These challenges necessitate urgent attention and interventions to enhance climate resilience in the agricultural sector. In conclusion, this research contributes to the understanding of sustainable paddy cultivation in Bangladesh and serves as a foundation for informed policy decisions, interventions, and advancements in agricultural practices. It has the potential to influence the region's agricultural development trajectory, emphasizing the need for a holistic and adaptive approach to address the evolving challenges farmers face.

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