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Factors Affecting Sustainability of Indigenous Farming Processes in South 24 Parganas District of West Bengal, India

Amirul Mir[1*] | Dr. Manas Naskar[2]

[1]Research Scholar, Department of Commerce, Raiganj University, India.
[2]Associate Professor, Department of Commerce, Raiganj University, India.

[*]Corresponding Author: amiamirmir@gmail.com

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ABSTRACT

Agriculture is the backbone of Indian economy. Its fertile plains and perennial rivers make India largely an agrarian nation. Nearly 70% of the population depends on agriculture as its main source of livelihood, and about 75% of the country's cropland is dedicated to food crop production. Staples that form the core of the human diet are cultivated in large part in India. West Bengal, one of the states in India which has played a prominent role in shaping the civil society of the country, is marked with a great deal of agricultural heterogeneity. Distinct regions of India have adopted different practices of farming since the oldest times, dependent upon regional demographic, geographic and climatic variables. Indigenous farming systems foster sustainability of the local biodiversity and ecosystems. West Bengal being rich in agricultural resources, the people of the state have come up with many original farming processes. These processes, however, are affected by a number of factors and agricultural practices in the area have evolved in the last decades. The present study aims to look at the factors determining sustainability for indigenous farming systems. A structured questionnaire is used for collecting primary data, and 100 valid responses collected from the farmers across the subdivisions of South 24 Parganas district of West Bengal have been used for the analysis. Reliability testing is used along with the use of factor analysis that helped to identify the key factors influencing sustainability of indigenous farming practices in the selected study area. Declining demand, storage problems, inaccessibility, credit facility and low technology penetration are the main hindrances to maintaining indigenous farming in South 24 Parganas district, West Bengal. Accordingly, policy makers should come up with effective measures to support the small and marginal farmers and hence help conserve indigenous agriculture in this district.

***Keywords**: Sustainability, Indigenous Farming Process, Agricultural Practice, Marginal Farmer.*

Introduction

Agriculture plays a central role in the social and economic structure of the country, and food security, livelihood generation and rural development form the basis for agriculture. Farming systems all over India have experienced transformation in varied historical periods under the influences of regional environmental scenario, cultural practices and climatic characteristics (Singh et al., 2019). Traditional farming has developed through the combination of indigenous growing methods with local resources in order to achieve long-term farming. These practices have produced different demographical profiles with varied geographical zones of India. In South 24 Parganas, wetland lands have predominance in rice cultivation, while arid lands have prevalence of rainfed agriculture and terrace system is followed in hilly lands. Traditional systems are based on the harmonious integration of ecological factors and biodiversity

present in certain domains to provide stability (Johns et al., 2013). Farmers integrate integrated pest management, use of bio-fertilizers and application of organic matter in crop production, thus maintaining cultural integrity as well as environmental sustainability. However, multi-component systems increasingly become vulnerable due to the convergence of economic changes and environmental transformations in the process of implementation of modern agricultural technology.

South 24 Parganas district has unique agro-ecological features which include coastal territories, deltaic soils and a mosaic of climatic regimes. Numerous plant species are living together with the adaptive characteristics, reinforced by a stable household income base from longstanding agricultural traditions. The traditional farming practices face manifold ecological and socio-economic threats that undermine soil quality, require labour migration and reduce governmental support.The study addresses the basic elements that make indigenous farming sustainable in South 24 Parganas district. Policymakers and stakeholders should be able to use these insights to develop interventions to encourage sustainable agriculture practices within the region. The research analysis delves into the methods through which the traditional agricultural systems can be integrated with the modern farming methods to bring up sustainable and productive outcomes.

Literature Review

Research on smallholder and indigenous farming has expanded significantly over recent years, particularly in the context of climate change adaptation, sustainability, and integration of indigenous knowledge systems with modern practices. Some of the prominent research works have been explored in order to grasp the theoretical underpinnings for this research.

Berkes et al. (2000) state that traditional farming practices are deeply entrenched in the culture of a region and therefore play a vital role in preserving cultural identity. The erosion of these practices can result in homogenization between communities and a loss of connection to indigenous wisdom systems.

Altieri (2004) argues that traditional farming knowledge is necessary to maintain ecological stability in agricultural frameworks and indigenous farming practices have been able to continue by drawing from the native ecosystem and reducing external inputs. Sustainable agriculture is therefore based on synergy between indigenous knowledge and modern science.

Adger et al. (2005) note extreme vulnerability of traditional agricultural systems to climate change and the need for adaptive measures such as climate resilient crop varieties and community level disaster preparedness.

Singh and Swaminathan (2006) examined the role of public policies and institutional structures in preserving traditional practices, and call for more government support and extension services for the smallholders, who are facing systemic threats.

Hodges et al (2011) point out poor storage facilities as one of the causes of post-harvest losses in traditional farming; improving storage infrastructure and post-harvest management training increases the economic value of indigenous practices.

Pretty et al. (2011) show how the latest technology can be integrated into more traditional systems to increase productivity and maintain environmental balance; precision farming tools for example can accommodate the requirements of the small holder, and improve efficiency without abandoning traditional methods.

Thapa and Rattanasuteerakul (2011) suggest economic performance-based programs where farmers are rewarded for practicing sustainability and suggest governmental incentives to farmers sustaining their indigenous methods.

Conway (2012) states that in traditional agriculture, there is an outbreak of pests and diseases that are affordable to address through biological control and integrated pest management strategies.

Pingali (2012) observes how market globalization may marginalize smallholder farmers by giving preference to high-yield variety possibly of domestic but lesser cultural significance over resilient local varieties, although the latter have superior cultural value.

Binswanger-Mkhize and Savastano (2017) investigated the significance of credit access, land fragmentation and labour migration patterns on farming sustainability, and argued that targeted policy interventions are needed to meet the specific needs of marginal farmers.

Mukerjee et al. (2018) emphasized the importance of biocultural innovation to adapt the Indian Himalaya smallholder farming systems based on traditional practices, biodiversity and local knowledge highlighting the resilience inherent in the indigenous systems to climatic and socioeconomic stressors.

Lincoln (2019) explained that indigenous agriculture is a sophisticated ecological knowledge system that the current sustainability science needs to learn, but not to supplant. In agreement with this perspective, Maru et al. (2019) showed the role of indigenous soil and tree-management systems in Ethiopia in terms of conserving the ecosystem and resilience to climatic change, which supports the necessity to incorporate traditional knowledge into the policy of agricultural development.

Gebru et al. (2020) found socio-economic, institutional and environmental aspects that affect the adaptation decision-making in Ethiopia and demonstrated that the indigenous strategies of farmers are important in coping with climate uncertainty.

Swiderska et al. (2022) emphasized the importance of indigenous food systems and biocultural heritage as the key to sustainability that is underestimated in the mainstream policy. The research supported the causes of decolonial studies, increased institutionalization and protection of the native rights.

Lin et al. (2023) demonstrated the way that indigenous Rukai agricultural practices in Taiwan maintain agrobiodiversity by ensuring robust cultural and institutional ethics. Melash et al. (2023) recorded indigenous pest, seed and soil practices in Ethiopia and the researchers came to a conclusion that the knowledge systems were very effective in making the practices sustainable by minimizing the reliance on chemical inputs.

Research Gap

The current body of research has mainly focused on the environmental benefits related to traditional agriculture and studies on the extent to which traditional agriculture is sustainable, with respect to both social and economic factors, have been relatively scarce. Most empirical studies of indigenous farming concentrate on the ecological nature of farming, but they overlook the economic and social problems faced by the marginal farmers. Although scholars have carefully documented the effects of climate change on agricultural landscapes, but the adoption of sustainable agriculture process by indigenous farmers is very limited. Farmers in South 24 Parganas need to get benefit from specialized information on adaptive farming methods and traditional practices to overcome their local environmental constraints, especially water salinity and variability in rainfall. Moreover, the literature on supportive structures to indigenous farming strategies has received inadequate scholarly attention. Research looking at how modern technology can be integrated into traditional agricultural frameworks which is also limited. Conventionally, studies on cultural significance and preservation of traditional knowledge in indigenous agriculture are seen as marginal areas of study. Therefore, this study focuses on region specific farming situations faced by indigenous communities in South 24 Parganas. Such initiatives will help increase knowledge on traditional agricultural preservation techniques in the light of modern technological innovations.

Objectives of the Study

In order to address the overall objective of this study, following specific objectives have been finalised:

- To analyse the socio-economic and environmental factors for sustainability of indigenous farming processes in South 24 Parganas.
- To identify the challenges faced by marginal farmers in adapting the modern agricultural practices.
- To recommend policy interventions and support mechanisms for promoting sustainable agriculture.

Methodology

The study uses a mixed-method approach combining quantitative data analysis and qualitative intuitions to determine the factors of the sustainability of indigenous farming.

Study Area

South 24 Parganasis the largest district in West Bengal, that is based on traditional farming but has different sectors of agriculture. Local climatic and soil conditions due to its proximity to the Bay of

Bengal and the Sundarbans, leads to the formation of a unique agricultural hub. The region's agricultural industry consists of paddies and vegetable farms as well as aquaculture companies, which between them sustain the livelihoods of locals.

Data Collection

Primary data have been collected through 100 surveys using the structured questionnaires distributed to the marginal and small scale farmers working in different blocks of the district. The survey instruments covered four key areas: market exposure, resources access, institutional support and climate change effects. Direct interviews and focus group discussions provided the necessary qualitative information about the obstacles and opportunities for the farmers.

Data Analysis

Reliability and validity tests have been conducted for the dataset to check the reliability and validity of the dataset with the help of Cronbach alpha and Bartlett's test of sphericity. Factor analysis with varimax rotation identified major components that have influence to indigenous farming sustainability.

Results and Analysis

The findings give a reflection of the statistical consistency and assumption tests that were performed to verify the soundness and suitability of the data to undergo a sophisticated analytical processes. Reliability analysis helps to ensure internal consistency of the measurement scale and assumption testing helps to ensure that dataset meets the required statistical conditions necessary to factor analysis. The results reveal a good instrument reliability and a sufficient sampling adequacy thus confirming that the responses collected are statistically good and can be meaningfully interpreted. In addition, it is clear that diagnostic tests show enough inter-variable correlation which justifies the validity and scientific rigor of the consequent analytical procedures.

Reliability and Assumption Checks

Table 1 shows the reliability measures based on Cronbach alpha which is used to determine the internal consistency of the measurement scale. The alpha value of 0.703, as reported is an excellent indicator of reliability that is far much better than the minimum acceptable level of 0.70. The high coefficient indicates a high level of coherence of the items on the questionnaire and therefore indicates that the items measure the intended construct with little measurement error. As a result, the data collection device used has high levels of psychometric soundness and credibility.

Table 1: Reliability Test

	Cronbach's α
Scale	0.703

Source: Analyzed by the Researchers

The results of Bartletts Test of Sphericity are shown in Table 2, which is done to identify whether the correlation between the variables is strong enough to allow the multivariate analysis. The chi-square statistic ($\chi^2 = 2944$) with 66 degrees of freedom is highly significant at $p < 0.001$, indicating that the correlation matrix is not an identity matrix.This validates significant cross-relationships of variables, which makes the data suitable in a factor analysis. Based on this, the statistical data supports the appropriateness of the data set as an analytical subject of additional factor.

Table 2: Bartlett's Test of Sphericity

χ^2	**df**	**p**
2944	66	< .001

Source: Analyzed by the Researchers

The Kaiser-Meyer-Olkin (KMO) overall value of 0.955 implies the excellent sampling adequacy (Table 3). A value nearer to 1.0 indicates high shared variance and usefulness in the analysis of factors. Most of the variables have very high scores in the Measures of Sampling Adequacy (MSA) thus showing effective contributions towards the factor structure. However, the suitability of both the Institutional Support (0.438) and the Resource Availability (0.478) is less than the acceptable limit of 0.50 which implies the lack of suitability and shared variance between them and other variables. Although these are lower values, the overall KMO indicates strong adequacy of the data, which guarantees reliability in the identification of meaningful latent constructs.

Table 3: KMO Measure of Sampling Adequacy

	MSA
Overall	0.955
Demand	0.963
Storage	0.961
Capital	0.955
Access to Credit	0.955
Market Access	0.964
Institutional support	0.438
Climate Change	0.960
Labour Migration	0.840
Resource Availability	0.478
Pest and Dieses	0.962
Technological Penetration	0.720
Risk Management	0.951

Source: Analyzed by the Researchers

Key Findings from Factor Analysis

The results from the factor analysis showed that there were 3 main components, which explained 69.4% variance:

Component 1 (Socio-Economic Constraints)

- Decline in demand
- Limited storage facilities
- Insufficient capital
- Lack of access to credit
- Lack of access to market

Farmer welfare is affected negatively by different economic and social hindrances. Exclusion from monetary resources precludes farmers from other ways of improving agricultural methods or progressing their present ones. Inadequate storage infrastructure leads to an increase in post-harvest losses which adversely affects the profit of farmers and forces them into selling their produce at low price point.

Table 4: Component Loadings

	Component			
	1	2	3	Uniqueness
Demand	0.883			0.218
Storage	0.877			0.222
Capital	0.884			0.219
Access to Credit	0.877			0.228
Market Access	0.862			0.248
Institutional support			0.731	0.399
Climate Change	0.876			0.231
Labour Migration		0.681		0.532
Resource Availability			-0.718	0.416
Pest and Dieses	0.870			0.234
Technological Penetration		0.701		0.506
Risk Management	0.881			0.214
Note. 'varimax' rotation was used				

Source: Analyzed by the Researchers

Component 2 (Environmental and Institutional Factors)

- Impact of climate change
- Resource availability
- Institutional support

Agricultural productivity is greatly affected by the variability in the climate because of erratic rainfall patterns and increasing temperatures. Institutional support systems are inadequate as farmers have not been provided the advice and support they need to overcome these challenges. Indigenous farming practices are consequently less resilient because there is no structured subsidies and extension services.

Component 3 (Technological and Risk Management Challenges):

- Technological penetration
- Pest and disease management
- Risk management practices

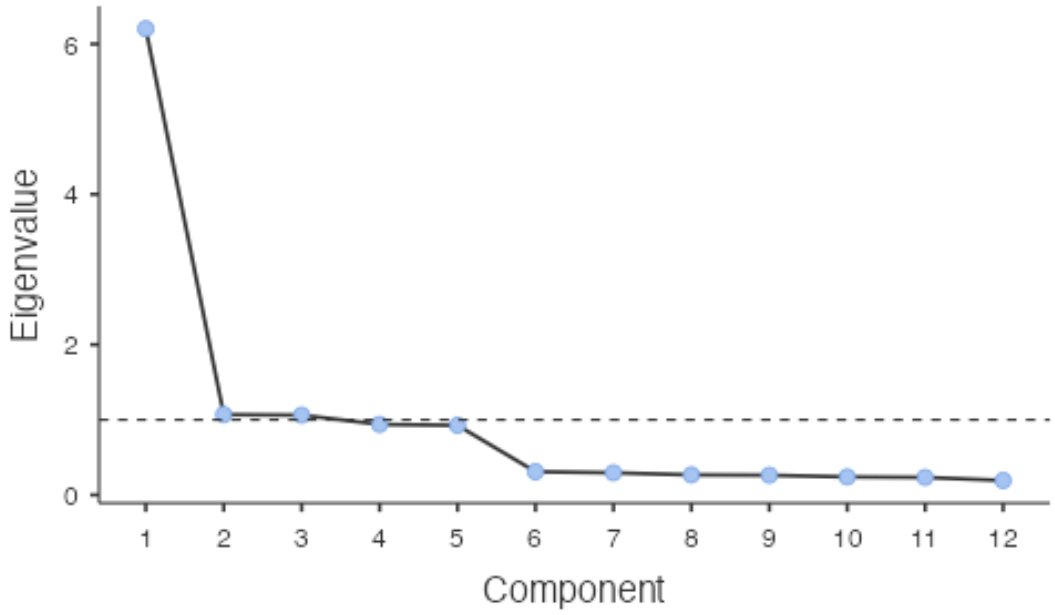
The possibilities of technological innovation to change agriculture are restricted as a result of limited adoption in rural South. 24 Parganas. Farmworkers are usually not well trained and do not have the resources to use modern tools and methodologies. Poor pest and disease management practices reduce agricultural productivity and make them vulnerable to complete crop destruction.

Table 5: Component Summary

Component	SS Loadings	% of Variance	Cumulative %
1	6.15	51.27	51.30
2	1.12	9.30	60.60
3	1.06	8.87	69.40

Source: Analyzed by the Researchers

Figure 1: Scree Plot



Source: Prepared by the Researchers

Discussion

The present study illustrates the negative consequences of a convergence of obstacles on the long-term viability of conventional farming systems in the South 24 Parganas region. Environmental crises, coupled with poor institutional support and socio-economic determinism, all combine to undermine traditional agricultural practices.

Marginalized farmers are limited in the adoption of sustainable practices due to financial constraints, which prevent them from investing in sustainable practices (Rodriguez et al., 2009). The decline of conventional crop markets adds to poverty and the lack of resilience of producers. Moreover,

the persistence of climate change is an environmental threat that destroys sustainable indigenous farming (Singh& Singh, 2017). Unpredictable rainfall patterns, growing temperatures and increasing salinity in the coastal sector are combined to reduce farm productivity and increase the vulnerability of the system.

The lack of proper policy frameworks, combined with the absence of focused intervention programmes, makes it difficult for the peripheral farmers to use traditional techniques. Subsidization of high yielding varieties still goes to industrial agriculture and does not protect native ecosystems or traditional practices. Although penetration of technology is still limited, there is scope for scientific innovation to create context-specific tools to improve productivity while reducing safety risks. Mobile-based pest management apps, for example, give farmers important real-time meteorological forecasts.

The conservation of indigenous farming depends on a holistic evaluation of environmental variables and socio-economic determining factors together with the appropriate choice of technological solutions. Sustainable development of these practices requires collaborative research partnerships between governmental authorities and the farming community supported by policy-oriented institutions.

Recommendations

The following measures, based on empirical data, are proposed in order to increase agricultural output but retain traditional methods of farming.

- Reforms should be brought about to raise financial resources to bundle access to markets with subsidies specifically intended for traditional agricultural products.
- The construction and optimisation of storage facilities and irrigation systems should be prioritised as these reduce post- harvest loss and create more production capabilities.
- A structured training programme needs to be put in place to give farmers an education in sustainable agronomy and climate resilient techniques.
- Affordable technologies-such as mobile advisory platforms and low cost irrigation equipment-need to be available to farmers.
- Community based approaches should be strengthened through promotion initiatives that preserve traditional knowledge and practices.

Conclusion

The sustainability of indigenous farming in the South 24 Parganas district of West Bengal is dependent on a complex of social, economic, environmental, institutional and technological factors. The long list of challenges facing marginal farmers requires national level strategies in line with the results from this research. Smallholders in the region face numerous economic and social obstacles which sum up to negative outcomes. Farmers, who do not have proper financial resources or appropriate infrastructure for storage, are forced to rely on harmful modern agriculture practices as their traditional sources of income reduce. The lack of ability to obtain credit and capital is adding to the existing constraints in order to implement sustainable practices.

Climate change is an especially greater risk due to the location of the district adjacent to the Bay of Bengal and the Sundarbans estuaries. The combination of erratic rainfall, temperatures and increasing salinity has resulted in a decline in crop yields. The exhaustion of natural resources, which include the fertility of the ground and the availability of water, presents a large and significant obstacle to the survival of indigenous forms of agriculture.

Governmental institutions do not afford adequate support to traditional methods of farming. Farmers thus need full extension services, subsidies and technical advice to sustain these practices. Contemporary agricultural policies favor high yield industrial approaches over the benefits of traditional approaches weakening the resilience of traditional systems. Technological advancement is promising for changing the agricultural practices; however, there is hardly any adoption in rural South 24 Parganas. Many farmers lack proper training and resources for implementing modern tools/techniques. Lack of proper management of pests and diseases reduces the productivity of crops and makes farms susceptible to complete loss of crops.

Despite these challenges, the research finds some opportunity for the adoption of economically and geographically appropriate technologies to boost productivity; and reduce operational risks. Sustainable indigenous farming therefore requires diverse policy interventions as well as strong support

systems. Policymakers should design specific policies for supporting financial back-up and market entry programmes in conjunction with conventional crop subsidies. Investment in storage infrastructure and irrigation systems will help farmers to reduce the post-harvest waste and improve output. Education about strategies to adapt to climate change needs to be given in order to develop sustainable and resilient farming practices. The combination of low-cost mobile advisory tools with low-cost irrigation equipment provides a cost-efficient way of improving productivity while conserving the environment. Support for community led initiatives is critical in order to protect traditional practices and knowledge systems.

When farmers take part in decision-making processes, they will be more inclined to embrace sustainable practices because of the engagement. Therefore, every level of government needs to support researchers, decision makers, and members of the community in order to protect indigenous farming. Aligning the goals of sustainability and productivity through integration of technological solutions and participation of stakeholders will resolve the identified challenges. This research forms critical information regarding determinants of indigenous farming sustainability and also forms directions for promotion of sustainable agricultural practices in South 24 Parganas and other similar areas.

Limitations of the Study

The research presents useful results, but there are numerous limitations that restrict the level of insight, accuracy, and generalisability of the results:

- It is proposed to concentrate on South 24 Parganas only, limiting external validity; the findings will not be assured to be applicable to other indigenous farming situations with unique socio-environmental conditions.
- Heavy dependence on self-reported perceptions of farmers presents the threat of bias, exaggeration, or under-reporting, which could create the illusion of problems being worse than they actually are.
- The cross-sectional design does not allow tracking the long-term trends of sustainability, climate effects, and the effectiveness of the policy in the long run.
- Restricted access to official records and on-ground data on policy performance makes the capacity to critically assess the actual impact of institutional support mechanisms weak.

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