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# Integrating Indigenous Technical Knowledge into Digital Farming Systems of Bangladesh

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## ABSTRACT

Agriculture today faces the dual challenge of increasing food production for a growing global population while protecting the environment. The country's rich indigenous traditions encompass ecologically balanced practices such as organic fertilization, crop rotation, pest management using natural repellents, and adaptive techniques like floating gardens in flood-prone regions. However, the increasing dominance of Western-oriented digital and mechanized farming models has often marginalized these context-specific systems of knowledge. Through an extensive review of literature, case studies, and policy documents, this study highlights how blending ITK with digital innovations—such as mobile-based advisory services, artificial intelligence (AI) pest detection, smart irrigation systems, and GIS-based soil mapping—can enhance productivity while safeguarding biodiversity and cultural heritage. The analysis underscores that ITK provides a foundation for ecological sustainability, while digital tools strengthen precision, documentation and scalability. Nevertheless, challenges including digital illiteracy, poor rural connectivity and inadequate institutional support continue to constrain effective integration. The study emphasizes the need for inclusive and participatory frameworks that recognize cognitive justice and ensure community ownership of indigenous knowledge. Key recommendations include establishing decentralized ITK documentation centres, developing multilingual digital platforms and creating participatory extension models that bridge the gap between traditional and scientific knowledge systems. Integrating ITK and digital farming is not merely a technological advancement but a pathway to achieving food security, environmental sustainability and cultural preservation in Bangladesh's agricultural transformation journey.

## INTRODUCTION

Bangladesh has a total population of around 169.8 million, with a tribal population of approximately 2 million. The country's digital transformation in agriculture often follows Western models that emphasize technology and economic efficiency. However, these approaches frequently overlook Bangladesh's rich Indigenous Knowledge Systems (IKS), which are deeply rooted in local ecology and culture. These systems include sustainable farming practices such as mixed cropping, organic fertilization, indigenous seed conservation, and the use of floating gardens (baira) in flood-prone areas

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(Islam & Hassan, 2018).

The Green Revolution, while increasing food production, also led to an overreliance on chemical inputs, reduced biodiversity, and the marginalization of traditional agricultural wisdom (Hossain, 1988; Shiva, 1991). Post-harvest storage losses can be minimised by Traditional Knowledge (Gupta et al., 2024). Modern development trajectories continue to prioritize external technologies over community-driven, ecologically balanced solutions (Altieri, 2004).

To ensure sustainable progress, it is essential to pursue cognitive justice, as Boaventura de Sousa Santos (2014) advocates—recognizing and integrating diverse ways of knowing. By combining digital tools with IKS, Bangladesh can build an agricultural future that is innovative, inclusive, and environmentally resilient (Ahmed, 2015). There is a need to strike a balance between preserving valuable traditional knowledge and integrating modern science-based approaches for more effective and sustainable grain management (Gupta, 2023).

**Objectives of the Study**

1. To identify key Indigenous Technical Knowledge (ITK) practices used in farming, livestock, and fisheries in Bangladesh.
2. To explore how digital tools (like mobile apps and AI) can support and improve ITK practices.
3. To examine the benefits and challenges of combining ITK with digital farming through case studies and literature.
4. To suggest ways to promote ITK-digital integration through farmer participation and policy support.


# CONCEPTUAL FRAMEWORK

## Indigenous Technical Knowledge (ITK)

Indigenous Technical Knowledge (ITK) is a dynamic, experience-based system of knowledge, belief, and practice rooted in centuries of interaction with local ecosystems. It is passed down through oral traditions and is adapted to specific ecological conditions and socio-cultural contexts. Gadgil (2000) defines ITK as "a cumulative body of knowledge and beliefs handed down through generations about the relationships of living beings with one another and their environment." Ferrington and Martin (1991) emphasize its logical and internally consistent structure, which enables ITK to guide sustainable practices such as water conservation, pest control, and biodiversity protection.

ITK is not static—it evolves continuously, often shaped by experimentation, migration, and intercultural exchange. In Bangladesh, it is especially visible in tribal and rural communities, where farming systems are not just techniques but expressions of cultural identity and ecological stewardship.

## Significance of Preserving ITK

Improving Livelihoods: Traditional seed selection, crop rotation, and pest control methods enhance resilience and productivity without high input costs.

Eco-Based Economic Growth: ITK supports natural product industries such as herbal medicine, organic cosmetics, and bio-pesticides.

Safeguarding Biodiversity: Indigenous communities use natural resources in ways that preserve ecological balance.

Preventing Biopiracy: Proper documentation protects communities from exploitation by external actors.

Climate Adaptation: ITK offers proven, low-cost solutions to recurring climatic challenges like floods, droughts, and salinity.

## Digital Farming Solutions

Digital farming refers to the use of technologies such as sensors, satellite data, AI, and mobile applications to optimize farming decisions. In Bangladesh, digital innovations like Krishi Call Centres, soil testing apps, and drone surveillance are slowly gaining ground. However, many of these technologies are underutilized due to low digital literacy and poor rural connectivity.

## Integration Model: ITK and Digital Technologies

A hybrid approach that validates and enhances ITK

using digital tools can provide a sustainable and inclusive agricultural model. For instance, mobile apps can record and disseminate traditional pest control techniques; AI algorithms can help validate the effectiveness of indigenous crop rotation methods.

This integrative model ensures:

- Localization of farming recommendations
- Respect for traditional systems
- Enhanced innovation through data-driven adaptation of ITK

## Need for a Digital Database in ITK Procurement

Rapid advances in information and communication technologies (ICTs) allow large-scale collection, storage, and dissemination of data. Integrating ITK into digital databases is crucial for ensuring accessibility, intergenerational transfer, and protection from cultural erosion.

Benefits include:

Structured Storage: Systematic documentation of ITK related to seed preservation, pest management, and soil fertility.

Dynamic Accessibility: Enabling researchers, extension workers, and farmers to access localized knowledge.

Two-way Communication: Allowing farmers to contribute to and benefit from the database.

Cultural Preservation: Safeguarding oral traditions through digital archiving.

## Limitations of Traditional Dissemination Systems

The conventional agricultural extension system in Bangladesh operates in a top-down fashion, often failing to engage rural farmers adequately:

Limited Reach: Many farmers, especially in remote tribal regions, remain disconnected from extension services.

Lack of Responsiveness: Individual and contextual farming issues are not addressed adequately.

Generic Content: Information is often not tailored to local agroecological conditions.

A decentralized, IT-enabled knowledge-sharing platform can bridge these gaps and ensure more responsive, adaptive agricultural support.

## Case Studies and Indigenous Technical Knowledge (ITK) Practices in Bangladesh

Bangladesh, a country rich in traditional knowledge, hosts diverse Indigenous Technical Knowledge (ITK) practices across agriculture, fisheries, and livestock sectors. Rooted in experience, spirituality, and ecological awareness, these methods are adapted to local environmental conditions and available resources. This section highlights key practices documented in rural Bangladesh, complemented by relevant comparative examples from South Asia and Africa.

## Crop Protection and Pest Management

In rural Bangladesh, farmers use a range of ecologically sound pest management strategies passed down through generations:

Botanical repellents: Neem (Azadirachta indica), mint (Mentha spp.), chilies, and pyrethrum are commonly used. These plants emit odors or contain compounds that repel or kill insects such as caterpillars, aphids, ants, and flies (Anonymous, 1994). Mexican marigold is used to prevent fungal diseases in crops like potatoes and tomatoes.

Physical barriers and distractions: In Mymensingh district, farmers deter birds from brinjal fields by criss-crossing banana leaf threads overhead. Cutworm infestation is mitigated by digging deep rings around seedlings of cabbage and cauliflower, while sawdust is used to combat banana beetles (Hossain & Alam, 1993; Halim, 1992).

Use of ashes and smoke: Wood ash is applied to seedlings to repel cutworms, and bamboo sticks or branches are inserted into rice fields to attract insectivorous birds (Chowdhury et al., 1996). Some farmers burn herbal mixtures or generate plant-based smoke (e.g., from cactus powder) to fumigate diseased crops (Prakash, 1996).

Sound-based bird control: In coastal Bangladesh, Rahman (ILEIA, 1991) observed the use of cassette tape ribbons stretched between posts. The wind passing through creates whistling noises that keep birds away.

Organic liquid treatments: Tobacco leaf extract, neem extract, and even hookah water are sprayed in rice fields to repel bugs (Chowdhury et al., 1996). Diluted cattle urine is used widely for disease prevention and powdery mildew control (Lohar, 1952; Prakash, 1996).

## Post-Harvest and Storage Practices

Grain storage innovations: Farmers in Mymensingh preserve husked rice with rice bran and use Nishinda (Vitex negundo) leaves to store pulses and prevent insect infestation (Hossain & Alam, 1993).

Oil-coating method: Though practiced widely in Mali, a similar logic of oil-impregnated grains may resonate with Bangladeshi ITK, as it provides effective pest protection during storage (Kone, 1993).

## Integration of Plants for Weed and Pest Control

Intercropping and botanical suppression: Haphazard planting

is practiced to minimize weed growth. In India and Nigeria, sesame (locally called 'Ramtal') is intercropped with millet to control striga weed, offering comparative insights into how Bangladeshi practices may relate to broader regional traditions (Anonymous, 1994).

Crop residue reuse: Some Indian farmers use cotton boll shells to suppress Cyperus rotundus weeds—this resonates with the Bangladeshi emphasis on recycling plant residues for soil and weed management (Koradia, 1996).

### Indigenous Knowledge in Livestock and Fishery

Though this section emphasizes agriculture, it is worth noting that many Bangladeshi farmers integrate livestock and aquaculture practices. For instance, poultry manure and cow dung are reused as fertilizers in rice fields and fish ponds (Chowdhury et al., 1996).

## Emerging Digital Farming Trends In Bangladesh

Bangladesh is witnessing a rapid transformation in agriculture through the integration of digital technologies aimed at increasing productivity, market access, and resilience to climate change. Several emerging trends highlight the country's progress in digital farming:

Mobile Applications: Tools like Krishoker Janala, Digital Krishi Sheba, and AgriBot are helping farmers access information on crop management, pest control, weather updates, and best farming practices. These mobile platforms are increasingly popular among smallholder farmers for their ease of use and real-time advisory services.

Weather Advisory Services: Digital platforms now deliver weather forecasts and agronomic tips via SMS and mobile apps. Tools like SHUFOLA, piloted in Barishal, provide tailored weather-based recommendations that enhance decision-making for activities like sowing, irrigation, and harvesting.

GIS and Satellite Imaging: Geographic Information Systems (GIS) and remote sensing technologies are being utilized to monitor crop health, assess soil conditions, and predict yields. These innovations enable more precise and data-driven agricultural planning.

e-Marketplaces: Digital marketing platforms are bridging the gap between farmers and consumers. Initiatives supported by public and private actors are helping farmers access fair market prices, bypass intermediaries, and sell their products directly through digital channels.

These trends not only modernize agricultural practices but also contribute to achieving the broader goals of food security, rural development, and climate-smart farming in Bangladesh.

### Integrating Indigenous Knowledge with Digital Farming in Bangladesh

In Bangladesh, traditional agricultural wisdom—referred to as Indigenous Technical Knowledge (ITK)—has long supported environmentally sustainable and resource-efficient farming. With the rise of digital agriculture tools, blending ITK with modern technologies offers a promising path toward resilient and climate-smart farming practices. The following table illustrates how ITK is being effectively integrated with digital innovations:

| Domain | Traditional Practice (ITK) | Digital Integration | Resulting Benefits |
|---|---|---|---|
| Pest Management | Neem leaves and ash for pest deterrence | AI-based pest detection apps (e.g., Plantix) | Minimizes chemical use and enables early response |
| Soil Fertility | Crop rotation and composting | Soil health sensors, GIS nutrient mapping | Enables targeted nutrient management |
| Crop Calendar | Lunar-based sowing and harvesting schedules | Mobile weather forecasting tools (e.g., SHUFOLA) | Enhances preparedness and climate adaptability |
| Water Use | Canal and bamboo irrigation methods | IoT-enabled smart irrigation systems | Improves water-use efficiency and conservation |

## METHODOLOGY

This study employs a qualitative review and synthesis methodology to explore the intersection of Indigenous Technical Knowledge (ITK) and digital agriculture within the context of Bangladesh. Secondary data were gathered from various academic journal articles, policy documents, and ethnographic reports focused on traditional farming knowledge and digital innovation. By examining multiple case studies, the analysis sought to identify existing practices and evaluate opportunities for integrating traditional knowledge systems with emerging digital tools. Thematic analysis was applied to extract key themes and reveal patterns illustrating the convergence between indigenous agricultural

wisdom and modern technology (Creswell, 2013; Braun & Clarke, 2006).

## RESULT AND DISCUSSION

The analysis indicates that Indigenous Technical Knowledge (ITK) constitutes a context-specific and ecologically sustainable framework that effectively addresses agricultural challenges in Bangladesh. The integration of ITK with contemporary digital technologies enhances the scalability, precision, and adaptability of traditional practices. For instance, the application of AI-based pest detection systems improves the efficacy of neem-based pest management, thereby reducing reliance on synthetic chemicals. Similarly, the incorporation of smart irrigation technologies optimizes traditional water management practices, leading to improved resource use efficiency.

However, the implementation of such integrative approaches faces several challenges, including inadequate digital literacy among rural farmers, limited infrastructural support, and institutional constraints within existing agricultural extension services. Addressing these limitations necessitates participatory approaches that prioritize the involvement of local knowledge holders and ensure ethical stewardship of indigenous knowledge. This will facilitate the development of inclusive innovation pathways that respect cultural norms and promote sustainable agricultural development.

## CONCLUSION AND RECOMMENDATION

This study underscores the potential of integrating Indigenous Technical Knowledge with digital farming technologies to foster a resilient and sustainable agricultural sector in Bangladesh. ITK embodies a repository of empirical knowledge rooted in local ecological and cultural contexts, while digital innovations offer mechanisms to validate, disseminate, and enhance these traditional practices. The convergence of these knowledge systems enables a synergistic model that optimizes productivity while safeguarding environmental and cultural integrity. Adoption of digital platforms for documenting and sharing ITK not only facilitates intergenerational knowledge transfer but also mitigates risks related to cultural erosion and biopiracy. Effective implementation of this integrative framework requires inclusive policies and participatory governance to empower smallholder and indigenous farmers and ensure long-term sustainability.

1. Establish decentralized ITK Digital Documentation Centres at the Upazila level to systematically capture and preserve indigenous agricultural knowledge.
2. Develop multilingual, voice-enabled mobile applications tailored for Bangla and indigenous language speakers to increase accessibility for farmers with varying literacy levels.
3. Promote participatory extension models that engage local farmers, indigenous leaders, and stakeholders in the co-creation and dissemination of integrated ITK-digital farming practices.
4. Provide targeted subsidies and incentives to encourage the adoption of eco-friendly ITK practices enhanced by digital technologies, such as AI-assisted pest management and precision irrigation.
5. Initiate pilot projects in vulnerable geographic regions, including tribal areas and flood-prone zones, to demonstrate the efficacy of combined traditional and digital agricultural interventions.
6. Conduct continuous capacity-building and training programs for agricultural extension officers to bridge the gap between traditional knowledge systems and modern digital innovations.
7. Implement robust data governance frameworks to ensure the protection of indigenous knowledge, securing informed community consent and preventing unauthorized exploitation.

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