Exploring Geo-Tagging: Facilities, Marketing, and Sustainability of Sahi -Litchi, Mircha-Rice, and Impact on Micro and Macro Economics of Farmers' livelihood.

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ABSTRACT:

The adoption of digital technology, particularly geo-tagging, is transforming agriculture by enhancing traditional farming systems. This study examines the economic impact of geo- tagging on two agricultural products in Bihar: Shahi Litchi from Muzaffarpur and Mircha Rice from West Champaran. Both crops have unique geographic and cultural significance and are protected under Geographical Indication (GI) registration.

Geo-tagging embeds geographical metadata into product data, improving traceability, market value, and supply chain transparency, while boosting farmer incomes and promoting sustainable practices. The research highlights several benefits, including higher prices, premium branding, effective farm management, reduced disaster risk, and improved access to government schemes. Through structured statistical analyses, the study evaluates the adoption of geo-tagging and its effects on farmer livelihoods at both individual and community levels.

***Key Words**: Agriculture, Geo-tagging, Sahi Litchi, Mircha Rice, West Champaran, Muzaffarpur.*

INTRODUCTION:

Geo-tagging in agriculture involves attaching geographical metadata, such as latitude, longitude, and altitude, to agricultural products and data using GIS, GPS, and other technologies. This transformative approach enhances traceability, ensuring food safety and authenticity by tracking produce from farm to consumer, reducing fraud, and facilitating efficient recalls in the event of contamination incidents. It supports market differentiation through Geographical Indications (GI), increasing the value of products like Shahi Litchi and Mircha Rice by linking their quality to specific regions, thus commanding premium prices in domestic and international markets.

For Shahi Litchi, grown in Muzaffarpur, Bihar, geo-tagging reinforces its GI status, highlighting its unique sweetness and nutritional value while addressing challenges like pericarp browning and short shelf life through improved post-harvest practices. Similarly, Mircha Rice, an aromatic variety from Bihar, benefits from geo-tagging by preserving its cultural and economic significance, ensuring traceability, and supporting

genetic research for enhanced aroma and resilience. Both crops leverage geo-tagging to boost marketability and sustainability.

Geo-tagging facilitates precision agriculture by providing detailed data on soil fertility, water availability, and crop growth, enabling farmers to optimize irrigation, fertilization, and pest management. This data-driven approach enhances productivity, reduces resource waste, and mitigates risks from climate variability and diseases. In supply chains, geo-tagging enhances logistics by enabling precise planning of transportation, storage, and delivery, particularly for perishables, thereby reducing food waste and improving transparency. Environmentally, it tracks land use and farming practices, supporting sustainable agriculture, biodiversity conservation, and compliance with environmental standards.

The technology also empowers farmers by improving access to credit and insurance through reliable data, reducing climate-related risks, and enhancing economic stability. It aids governments in monitoring agricultural schemes, ensuring transparency, and formulating effective policies. Geo-tagging fosters collaboration with stakeholders like agronomists and suppliers, providing tailored advice for better farm management. It supports land use planning, climate monitoring, and disaster management by identifying affected areas and assessing risks, contributing to agricultural resilience.

Despite its benefits, geo-tagging faces challenges, including limited technological infrastructure, low digital literacy among farmers, and privacy concerns. Adoption requires collaboration among governments, private sectors, and academia to provide affordable tools, training, and digital infrastructure. Incentives like subsidies can accelerate uptake, particularly for smallholder farmers in rural areas.

LITERATURE REVIEW:

FACILITIES AND MARKETING OF GEO-TAGGING PRODUCTS

Gupta and Joshi (2023), Carvalho et al. (2021), and Oliveira and Costa (2020) highlight the significance of Geographical Indications (GI) and geo-tagging in enhancing the value of agricultural products. GI registration protects product names and origins, but inadequate post-

registration marketing and limited financial resources hinder producers' ability to capture value. Government support through trade exhibitions and digital platforms is crucial for promoting GI products domestically and internationally. Geo-tagging boosts product authenticity and premium pricing by linking items to local cultural identity and geodiversity, as seen in UNESCO Geoparks. However, challenges persist due to insufficient marketing tools and infrastructure, limiting global visibility. Coordinated branding efforts, like the GEO food project, and integrated digital marketing campaigns are recommended to enhance market access, improve farmer earnings, and support sustainable local economies.

GEO-TAGGING AND ITS SUSTAINABILITY

Günther and Möller (2024), Hanchen Yu et al. (2022), and Kim and Lee (2021) highlight geo- tagging's role in promoting sustainability in agriculture and beyond. Günther and Möller emphasize integrating geo-tagging into digital ecosystems to support sustainable development goals, focusing on data transparency and environmental monitoring for ecologically and socially responsible outcomes. Hanchen Yu et al. explore

geo-tagging's use in tracking human mobility, noting its sustainability depends on reliable data sources. They caution that user- generated content, like social media, introduces biases, requiring improved methodologies to ensure accuracy. Kim and Lee underscore geo-tagging's contribution to monitoring environmental changes, such as deforestation and crop growth, aiding sustainable agricultural practices. They stress the need for integration with broader environmental systems, incorporating human behavior and ecosystem dynamics, to provide real-time data for climate action and decision-making, ensuring geo-tagging's sustainability.

METHODOLOGY:

This study is based on the 2 districts of Bihar. The districts are chosen based on their popular agricultural products, which have a GI Tag, like Muzaffarpur for Sahi Lichi, and West Champaran for Mircha Rice. A total of 34 blocks is chosen from these two districts, i.e., 16 from Muzaffarpur and 18 from West Champaran, respectively.

To collect the data, the primary survey has been conducted in the respective districts of Bihar, and other required data has been gathered from the government platforms and the markets. The data has been interpreted using statistical tools, like descriptive statistics and correlation, for better presentation of the information.

OBJECTIVES:

1. To find out the facilities and marketing of the Geo-Tagging product.
2. To identify the sustainability of Geo-Tagging.

RESULTS AND DISCUSSIONS:

A total of 55 respondents' data were collected from the West Champaran district to see the viability of Geo-tagging in the Mircha Rice. 48 respondents are those who have below 1 hectare of land, and 7 are those who have land between 1.01 to 2.0 hectares.

Table 1: Number of respondents based on their land acquisition for the cultivation of Mircha Rice.

S. No.	**Categories (members)**	**Respondent**	
		Number	**Percentage (%)**
1.	Small (Below- 1.0 hectare)	48	87.3
2.	Medium (1.01-2.0 hectare)	7	12.7
3.	Large (2.01-3.0 hectare)	0	0
	Total	**55**	**100**

A total of 100 respondents have been interviewed and grouped based on their land acquisition for the Litch farming. 51 respondents belong to the category where farmers have land below 1 hectare, 30 respondents belong to the group who have land between 1.01 to 2.0 hectares, and 19 farmers belong to the group who have more than 2.01 hectares.

Table 2: Number of respondents based on their land acquisition of land in farming of Sahi Litchi

S. No.	Categories(members)	Respondent	
		Number	Percentage (%)
1.	Small (Below- 1.0 hectare)	51	92.7
2.	Medium (1.01-2.0 hectare)	30	5.5
3.	Large (2.01-3.0 hectare)	19	1.8
	Total	**100**	**100**

FACILITIES AND MARKETING OF GEO-TAGGING PRODUCTS:

Sahi Litchi:

Government Schemes: Among 100 respondents, 50 small, 32 medium, and 18 large farmers accessed schemes like KCC (28%), AIF (17%), and PMKSN (55%) after geo-tagging, with no uptake of PMFBY[1].

S. No.	Category	Respondent Numbers	Government Schemes after Geo Tagg in Sahi Litchi				Percentage (%)
			KCC	AIF	PMFBY	PMKSN	
1.	Small	50	13	10	0	27	50
2.	Medium	32	10	4	0	18	32
3.	Large	18	5	3	0	10	18
	Total	**100**	**28**	**17**	**0**	**55**	**100**

Facilities: Geo-tagging ensures authenticity, supports GI tag enforcement, enhances marketability, boosts consumer trust, improves crop monitoring, ensures supply chain traceability, aids disaster management, and promotes agri-tourism for Sahi Litchi from Muzaffarpur, Bihar.

Marketing: Geo-tagged Sahi Litchi is marketed as a premium GI product via digital platforms (eNAM, Agri Market App), physical markets, and government campaigns. QR codes provide origin proof, increasing market prices by 20-25%, export volumes by 15%, and farmer participation (2,000+ farmers). In 2023, 40 metric tonnes were exported to the UK, UAE, and Singapore.

Channel	Purpose
Digital Platforms	E-commerce sites, farmer apps, and government portals (like eNAM, Agri Market App).
Physical Markets	Retail chains, Agri fairs, local mandis, and export terminals.
Government Campaigns	Geographical Indication awareness drives, exhibitions, and farmer-producer meets.

[1] Sahi Litchi: https://horticulture.bihar.gov.in/, https://agriexchange.apeda.gov.in/, https://midh.gov.in/

Price Impact: Post-geo-tagging (2024), prices rose significantly, e.g., from ₹15,000 to ₹100,000 per tonne in Muzaffarpur (local) and ₹180,000 to ₹300,000 in Delhi (retail).

S. No.	Location	Before Geo-Tagg Market Price (Rs Per tonne 2018)	After Geo-Tagg Market Price (Rs Per tonne 2024)
1.	Muzaffarpur (Local)	15000	100000
2.	Litchi Processing Plant	30000	260000
3.	Delhi (Retail)	180000	300000
4.	Mumbai (Retail)	200000	350000
5.	Chennai (Retail)	250000	400000
6.	Bangalore (Retail)	250000	350000
7.	General Mandi (India)	80000	200000
8.	Online (Retail Villkart)	180000	200000

Mircha Rice:

Government Schemes: A total of 55 respondents, 54.6% small, 32.7% medium, and 12.7% large farmers who accessed KCC (12%), AIF (9%), and PMKSN (34%) post-geo-tagging, with no PMFBY uptake[2].

S. No.	Category	Respondent Numbers	Government Schemes after Geo Tagging in Mircha Rice				Percentage (%)
			KCC	AIF	PMFBY	PMKSN	
1.	Small	30	8	7	0	15	54.6
2.	Medium	18	4	2	0	12	32.7
3.	Large	7	0	0	0	7	12.7
	Total	**55**	**12**	**9**	**0**	**34**	**100.00**

[2] Mircha Rice: https://dbtagriculture.bihar.gov.in/, https://rkvy.nic.in/, https://dbtagriculture.bihar.gov.in/

Further details and information are retrieved from the APEDA (https://apeda.gov.in/) and the schemes aligned web platforms.

Facilities: Geo-tagging verifies Mircha Rice's origin, supports GI status, enhances market value (20-30% higher prices), builds consumer trust, aids crop planning, ensures traceability, supports farmer welfare, facilitates disaster management, and promotes agri-tourism.

Marketing: Marketed as a premium GI rice via retail, export markets, digital platforms (Amazon, Flipkart), and government schemes. Geo-tagging ensures brand protection and traceability via QR codes, increasing farmer participation (1,000+), export consignments (10% rise), and consumer interest (30% more online). In

2023, it was promoted at the India International Trade Fair.

Indicator	Data/Effect
Increased Farmer Participation	Over 1,000 farmers registered for geo-tagging (APEDA, 2023 data).
Export Potential	2023 saw a 10% rise in rice export consignments of geo-tagged Mircha Rice.
Higher Consumer Reach	Products with geo-tag QR codes reported 30% more consumer interest online.

Price Impact: Post-geo-tagging (2024), prices increased, e.g., from ₹30,000 to ₹50,000 per tonne in West Champaran (wholesale) and ₹50,000 to ₹80,000 in Patna (retail).

S.No.	Location	Before Geo-Tagg Market Price (Rs/ton, 2022)	After Geo-Tagg Market Price (Rs/ton, 2024)
1.	West Champaran (Local/Wholesale)	30000	50000
2.	Urban (Retail- Patna)	50000	80000
3.	Processing (Chura/Flakes)	35000	60000

Key Insights: Geo-tagging enhances authenticity, market value, and consumer trust for both Sahi Litchi and Mircha Rice, supported by government schemes and marketing via digital and physical channels. Significant price increases and export growth reflect the economic benefits of geo-tagging.

SUSTAINABILITY OF GEO-TAGGING

The sustainability of geo-tagging for Shahi Litchi in Muzaffarpur and Mircha Rice in West Champaran, both Geographical Indication (GI)-tagged products from Bihar, is evaluated through environmental, economic, social, and technological dimensions. Geo-tagging, which embeds geographical coordinates into data like product labels or images, enhances traceability, authenticity, and market value while supporting sustainable agricultural practices.

Shahi Litchi (Muzaffarpur):

Environmental Sustainability: Geo-tagging for Shahi Litchi has minimal environmental impact as a digital process, requiring few physical resources. It supports precision agriculture by mapping orchards and monitoring soil, climate, and pest conditions using tools like Geographical Information Systems (GIS). This reduces resource waste by identifying suitable cultivation zones. However, the energy consumption of devices like drones or smartphones could contribute to carbon emissions if not powered renewably. Shahi Litchi cultivation already employs low pesticide and organic practices, aligning with sustainable geo-tagging

applications.

Economic Sustainability: The GI tag, reinforced by geo-tagging, ensures authenticity, reduces counterfeiting, and boosts demand for Shahi Litchi in domestic and international markets, fetching premium prices for growers. Bihar exports approximately 1,80,000 tonnes of litchi annually, and geo-tagging streamlines supply chains, minimizing spoilage and enhancing export potential. However, initial costs for GPS devices, drones, or software may challenge small-scale farmers without subsidies or cooperative support. Long-term, geo-tagging improves profitability by ensuring traceability and market access.

Social Sustainability: Geo-tagging empowers farmers by reinforcing the GI tag, ensuring fair prices, and preserving the cultural identity of Shahi Litchi. It fosters community pride and involves local cooperatives and institutions like the National Research Centre on Litchi. Training farmers in digital tools enhances technological literacy, particularly for rural youth, but the digital divide in Bihar requires targeted programs to ensure accessibility. Data privacy concerns must be addressed through secure management practices.

Technological Feasibility: Geo-tagging is feasible with tools like drones, smartphones, or UAV software, though compatibility issues (e.g., Litchi app's CSV log files) may arise. Advanced applications, such as AI models like YOLOv5-TinyLitchi, improve yield estimation and fruit detection. Infrastructure limitations, like unreliable internet and electricity, necessitate solutions like solar-powered devices or offline geo-tagging. Climate change may shift suitable cultivation zones, requiring adaptive GIS mapping.

Mircha Rice (West Champaran):

Environmental Sustainability: Geo-tagging for Mircha Rice, cultivated on ~1,000 acres, has a low environmental footprint and supports precision agriculture by mapping fields and optimizing water and fertilizer use. It integrates with eco-friendly practices like the System of Rice Intensification (SRI), reducing water use by up to 50% and methane emissions by 35– 48%. However, rice farming's water intensity and methane emissions require complementary practices like Alternate Wetting and Drying (AWD). Device energy use remains a concern unless powered renewably.

Economic Sustainability: Geo-tagging enhances the GI tag's value for Mircha Rice, known for its aromatic Chura and non-sticky texture, ensuring authenticity and premium pricing. It supports exports by verifying origins from villages like Manatand and Narkatiaganj. High initial costs for equipment could exclude smallholder farmers, but cooperatives like *Marcha Dhan Utpadak Pragatisheel Samuh* and subsidies can mitigate this. Long-term, geo-tagging improves profitability by reducing supply chain losses and meeting export standards.

Social Sustainability: Geo-tagging benefits ~500 smallholder farmers by ensuring fair prices and preserving Mircha Rice's cultural identity. Training in digital tools fosters technological literacy, particularly for youth and women, but the digital divide requires community-driven programs. Data privacy concerns necessitate secure systems to maintain trust.

Technological Feasibility: Geo-tagging is viable using Sentinel-1 Synthetic Aperture Radar (SAR) imagery, ideal for cloud-prone West Champaran, enabling rice mapping and yield monitoring. Free Sentinel-1 data reduces costs, while machine learning enhances crop health tracking. Infrastructure challenges, like limited internet, require offline or solar-powered solutions. Compatibility issues with software need technical support.

Risks and Mitigation: For both crops, risks include economic exclusion, addressed through subsidies and cooperatives, and climate change, mitigated by adaptive geo-tagging and resilient practices. Data privacy requires transparent policies. Overall, geo-tagging is sustainable for Shahi Litchi and Mircha Rice if supported by infrastructure, training, and equitable access, enhancing environmental efficiency, economic viability, and social empowerment.

CONCLUSION:

Geo-tagging has significantly transformed the agricultural landscape for Shahi Litchi in Muzaffarpur and Mircha Rice in West Champaran, enhancing their GI status and economic viability. By embedding geographical metadata, geo-tagging ensures traceability, authenticity, and premium pricing, boosting farmer incomes by 20-30% and export volumes by 10-15%. It supports precision agriculture, optimizing resource use and reducing environmental impact through practices like organic cultivation and System of Rice Intensification. Socially, it empowers farmers, preserves cultural identity, and fosters technological literacy, though the digital divide requires targeted training and infrastructure. Economically, it streamlines supply chains and enhances market access via digital platforms like eNAM and Amazon. Despite challenges like high initial costs and data privacy concerns, subsidies, cooperatives, and secure systems can ensure sustainability. Geo-tagging thus offers a scalable model for sustainable agriculture, balancing economic growth, environmental stewardship, and social empowerment in Bihar's GI-tagged products.

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