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Sustainability of Banana Cultivation in Vaishali District, Bihar

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Abstract: *Horticulture is one of the important agricultural activities that provide large-scale production of fruits, woods, and medicines. Banana cultivation comes under horticultural cultivation. Bananas need a unique geographical location and cultivation. Vaishali has favorable geographical conditions for banana cultivation. Production of bananas is increasing, but the area of banana cultivation is declining, especially after 2020. In this research, researchers tried to investigate the sustainability of banana cultivation areas with the help of primary surveys and satellite data (Landsat 8 and MODIS).*

Keywords: *Sustainability, Banana Cultivation, Agriculture*

I. INTRODUCTION

Natural resources and their sustainability are highly significant for the local economy and also for its development. Every community has different levels of skill to (re)use resources, depending upon their level of development and technologies. Developing countries are using traditional methods because they do not have much efficiency or advance knowledge about the use of resource while developed countries are using advanced methods. Resources their value and significance change through time as the level of development increases. Thus, the natural resources and their sustainable development are very important for at the global as well as local level.

In this article researcher has tried to investigate very important plants which has been used for food, medicines, cloths and fertilizer. Banana needs a unique geographical location and cultivated land. In Bihar banana cultivation is found along the river Ganga and near other river basins. Vaishali, Samastipur, Khagariya, Katihar, and Purina districts are main districts which are engaged in growing banana and related activities. In case of Bihar, the state has very less production and ranked seventh after Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, and Madhya Pradesh. Banana is known as "Apple of the Poor", because it is highly nutritious fruit and, comparatively, available in low prices. Unfortunately, the production of banana has declined and therefore, price per kilogram of banana, is continuously increasing in Bihar.

It is affecting the huge population of Bihar, who has less income and engaged in the cultivation of banana. The shortage of banana has a direct relation between production and the cropped area which is continuously declining. Farmers are not able to fight against the weather's calamity and its impact. Thus, the sustainability of banana growers is in question. The present research will try to find the causes and consequences of this. Now the question is about the long-term maintenance of banana and its productivity, with least environmental impacts, minimized chemical inputs, and adequate returns to farmers.

In Vaishali district, the production of banana is very low when we compare with national average production of banana. In Vaishali district, the average productivity of banana is 20 tons per ha and average national production is 34.1 tons per ha., which is more than the production in Vaishali. According to Singh (2017) "Banana production and productivity in Bihar declined because of various reasons such unscientific cultivation, lack of proper irrigation, non-cultivation of other crops at regular interval of two to three years, impact of weather and climate change, lack of availability of good plants is also one of the reasons". Another problem is, that farmers are also not interested to cultivate banana while Vaishali farmers have unique banana "*Chinia (Hajpuria Kela)* and *Malbhog*" and it is good for health because it has medicinal value and 27 percent carbohydrates, a rich nutrient for human health. Therefore, it has higher significance in the regional and local economy of Vaishali district.

Thus, it is quite important to focus immediately on the sustainability of banana cultivation, Bihar in general and Vaishali in particular. Also there is a need to rethink about the development of agriculture and its impact on farmers' local economy. It should be sustainable with modern competitiveness in agriculture sector.

II. CONCEPTUAL FRAMEWORK

A. Banana Cultivation

Banana is an important fruit in India. It has varied significance. Banana is very useful to control heavy bleeding during menstruation, decreases acidity, controlled sickness, and helps to improve concentration, controlling blood pressure and production of banana not only beneficial to farmers, other people also getting fit and healthy. A stem of the plant used to remove kidney stones. Nowadays stems of banana plants used to make clothes and bags with help of fiber content. It comes under the horticulture (in India) and grown near to the tropical climate. Banana cultivation is a cash crop where the maximum amounts of profit are received. Banana cultivation is practiced in the southern part of India and also in eastern states like Bihar, West Bengal, and Asom. These states are also major contributor in banana production of India. In this cultivation, people have been using bio-fertilizer so it is more sustainable cash crop than others crop like tobacco. It gives us healthy environment, green landscape and many other benefits. Promoting banana cultivation is like going sustainability for local farmers in Vaishali, with a rich tradition of growing bananas. It has economic potential, negligible environmental degradation and gives economic benefits to the society.

B. Sustainability

Brundtland Commission (1987) manifested the report "Our Common Future" and defined sustainable development as '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*' (World Commission on Environment and Development, 1987). Sustainability has been maintaining the sequence of sustainable development process. It is a thought process where we understand the management and maintaining well-being over the period of time, possibly even an imprecise period with inter-generational and intra-generational equity. Social Scientists have long been interested in the sustainability of the land, water, and forest resources for inclusive approach to handle both physical and human environment. In general, "sustainability" refers to the long-term ability to continue to engage in a particular activity, process, or use of natural resources (Benson and Craig, 2014). Sustainability is a progressive action where we learn to sustained ability, to use resources infinitely. Sustainability is the ultimate form of development to the people or resources. It has three dimensions: environmental, social inclusion and economic sustainability. With the help of sustainability, people can uphold resources for betterment of environment, society and economy for upcoming generation. Sustainability has main objective is to improve "the quality of human life" it means health of human being which is playing a significant role and supporting in increasing the carrying capacity of Ecosystem".

Sustainable agriculture is an operation, where farming adopts sustainable methods and maintained ecosystem services. It is very close to scientific actions where people awareness is very high about the physical/natural conditions of agricultural development and for sustaining their productivity and utility to society forever. Sustainable agriculture takes into consideration of conserving resources, healthy competition and environmentally sound development. Tilman et al (2002) suggested that agriculture not only significantly affects the environment, but is also effecting directly the environment. Consequently, farming activities involve recognizable environmental problems and agricultural development having a finite relationship with the development of an economy. For the development of agriculture, sustainable agriculture is able to tackle socio-economic and environmental issues with continuous development.

C. Sustainability of Banana Cultivation

Banana is a cash crop and its cultivation is related to agro-economic activity. The grower is benefited with cash and consumers use the product for better health. The product of banana and cultivation are very much eco-friendly. Waste materials of banana are used as bio-fertiliser. Banana is useful "*to maintain and increase long-term fertility and biological activity of soils using locally adapted cultural, biological and mechanical methods as opposed to reliance on inputs*" (Mattsson and Grolink, 2004). Growing period is quite long (6-7 months, one bunch of banana) and it provides a permanent job for labors because of fields are occupied by banana annually. Thus, we can say it is money oriented forestry. For developing countries or state's economy can improve after adopting banana cultivation. Therefore, it can help to improve situation of farmers to achieve equity (for the long time) in present technocratic society. Cultivation of banana makes healthy environment, create jobs and social security, stressless life/happiness and getting prosperity to the people. Also it will help to keep the spirit of the local traditions and culture which makes people happy and to live with sustainability.

III. REVIEW OF LITERATURE

Many Social Scientists and economists have worked on sustainable agriculture, ecological, social and economic benefits of sustainability. Also, Researchers have been work on contemporary issues related to agriculture like cropping pattern, trends, and productivity of crops, analyzed geographically. The proposed research is based on Banana cultivation and achieving sustainability, thus the literature has selected according to the nature of the problems and neutrality.

Through the scrutiny of literature on banana cultivation and significance of banana, some articles and books found are useful. In 2014 *Gonçalves and Kernaghan* has given the report on Banana production methods and discussed the process of banana harvesting, cultivation, and production. The study was based on three countries Brazil, Costa Rica, and the Dominican Republic. In this report, two types of production methods have identified, organic and conventional. *Santosh, Tiwari and Reddy (2017)* tried to found out the suitable techniques of protecting bunches of banana and suggested that covering the bunch of banana has beneficial to a physical protection of banana and improves the visual quality of fruit by promoting skin colouration and reducing blemishes. The whole study was conducted in West Bengal. *Kumar, Bhowmik, Duraivel, and Umadevi (2012)* described the traditional and medicinal uses of banana. The article discussed nutritional value of banana, medicinal properties, and other beneficial quality of banana for the human being because it has a rare combination of energy value, tissue-building elements, protein, vitamins, and minerals.

Some articles are useful for production and cultivation of banana in Vaishali districts and it will provide right direction to research on banana cultivation. *Singh and Singh (1990)* compared the dwarf banana and tall banana in Vaishali district of Bihar and found the income from banana cultivation seems to be highly affected by the choice of varieties and package of practices followed. *Maurya (1996)* examined the profitability of Banana in Hajipur, Bihar and accepted that the area has great potential to farming banana but farmers need a large amount of capital investment. *Rao (2000)* tried to focus on available resources and analysed the productivity of banana crop along the Tungabhadra river area of Karnataka. Rao found that non-availability of sufficient irrigation, higher prices of fertilizers, trouble in the availability of quality planting material, labour shortage in peak time, hazards of soil salinity, and hail storms of heavy winds these are the issues of banana production in Karnataka. *Thakur and Tanu (2007)* explained the spatial distributions of banana farming and identified the basic problem of farmers like high capital investment and low profits, lack of storage and proper markets. *Mohammad and Alam (2007)* stressed on fluctuation of foodgrain production per ha and measured carrying capacity of food. The level of food production and its categorisation was done by the authors. With the help of spatio-temporal analysis, trends and pattern of crop production were identified.

Some studies have also attempted to suggest some marketing strategies related to banana cultivation. *Senthilnathan and Srinivasan (1994)* identified a network of banana marketing in Tamilnadu. Through this work, it has categorized four channels, it shows different stakeholder's contribution to the marketing. Farmers, pre-harvest contractor, secondary wholesaler, commission agents, retailer and consumers these are the stakeholder contributed in banana marketing. Farmers- pre harvest contractor – secondary wholesaler and farmer- pre harvest contractor – commission agent –wholesaler – retailer – consumer is best combination. *Shivanad (2002)* studied the performance of Banana cultivation in northern Karnataka and found that the farmers suffered because of disease of banana *Musa Sercospora*, spreading over almost all districts of northern Karnataka and these diseases lead to heavy crop losses. Marketing of product is also one of the big issues in this area like delayed payments of sale proceeds, a high cost of transportation of produce, wide price fluctuations, and high commission charges there are the major problems, *Shivanad* explained. Also, *Begum and Raha (2002)* studied selected area of banana cultivation and focus on marketing of banana in Bangladesh (Areas of Bogra District). Study explained that marketing of banana is a profitable deal and price instability, lack of capital, inadequate facilities, and lack of adequate market information are the major problems.

Another crucial aspect social and community responsibility towards environment and agriculture have discussed by some researchers like *Goldstein (1981)* wrote about the transformation of land use; land grab, human participation in decision making also focused on natural resource utilization with respect to rural area. According to Goldstein people have both qualities of individual freedom and social responsibility; they have existed and interconnected with powerful structures in the society. In his book, he described historical changes, human adaptation of upcoming technology and conflict between farmers, state and local officials, federal agencies, politicians, legislator, conservationists and environmentalist. Through this book, tried to find out the clue about downward shift in social class participation as industrialization and suburban growth overtakes older agricultural systems and affects rural, agricultural societies within the region of pineland. *Bodin and Prell (2011)* in their work on social network and natural resource management described the linkages between people, available resources, strategies, and role of different stakeholder. Information that it gave, will be used in proposed research like social network analysis and stakeholder analysis, social communicational strategies.

For the achieving agricultural sustainability in Vaishali some article helps to search out the geo-psychology of locale. *Sajjad, Nasreen and Ansari (2014)* have tested the level of sustainability of Vaishali districts with the help of “Sustainable Livelihood Security Index” techniques. And calculated ecological security indicators, economic efficiency indicators and social equity indicators for finalizing the level of sustainability and achieved Sustainable livelihood security index. According to the results these three (ESI, EEI and SEI) is a powerful policy tool for identifying the necessary conditions for sustainable development.

IV. RESEARCH QUESTIONS

The present research will be an attempt to answer these pertinent questions.

- 1) Why area and production of banana cultivation is declining?
- 2) The banana of Hajipur called “Hajpuria Kela” is very famous in India but local farmers are refusing to grow, what are the reasons of it?
- 3) Which type of reasons play a role for declining interest among farmers?
- 4) How, the banana cultivation can be need more popular among farmer?

V. OBJECTIVES

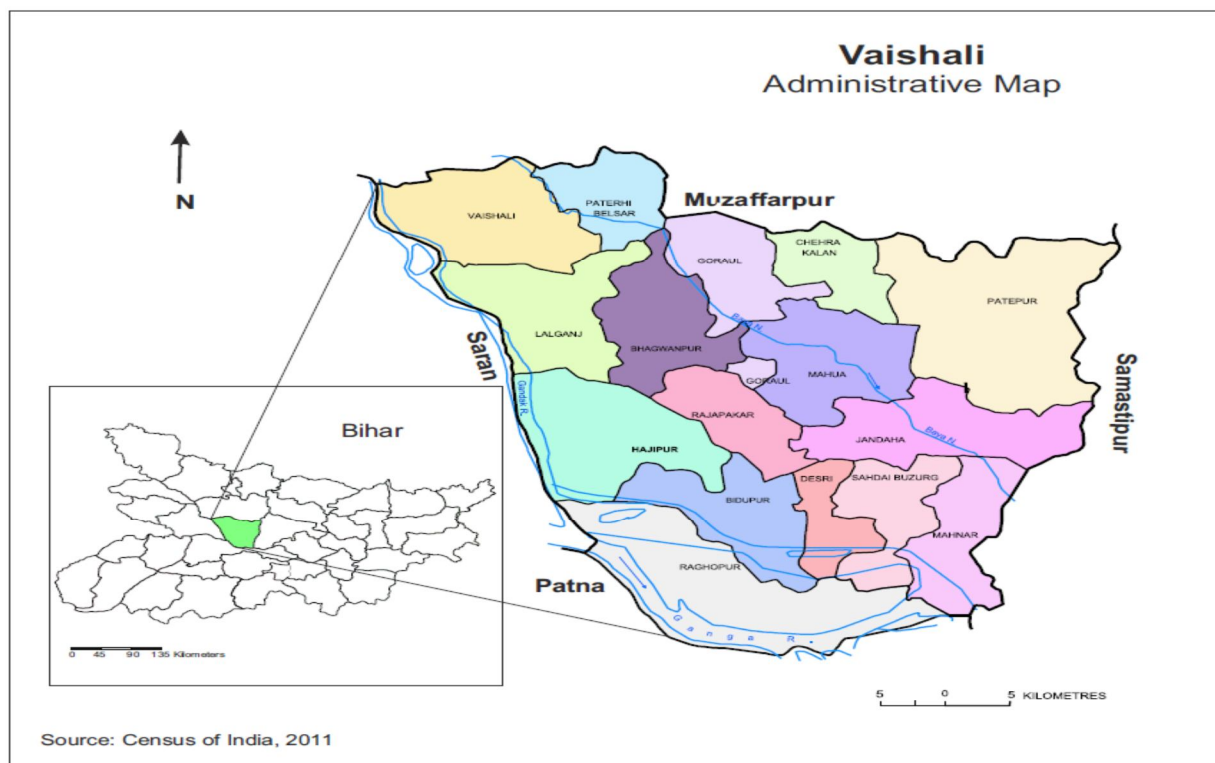
The objectives of the study are:-

- 1) to analyse the trends and patterns in area and production of banana cultivation
- 2) to find out the issues and challenges in sustainability of banana cultivation

VI. THE STUDY AREA: VAISHALI DISTRICT

Vaishali is one of the districts of Bihar. Before 1971 it was a part of Muzaffarpur district. 2nd October 1972 Vaishali had acquired the status of an independent district. Vaishali has consisted of 16 blocks and 1638 villages. Hajipur is the main town (Mahnar and Lalgaj is two other town and urban area has notified, census 2011) and identified as a district headquarter. Vaishali has several heritages to show the socio-cultural and political importance. It has been diluted after transformation of cities and land-use pattern. But socially it has still more sustain and proactive in terms of human and agro-economic utilization of manpower.

Map. 1, Study Area, Vaishali, Bihar



Geographical location of Vaishali, district lies between north latitude 25°28'0" to 26° 5'0" and east longitude 85°5'00" to 85°40'00". The area is very rich in terms of availability of primary resources and activities, 70 to 75 percent area under the agriculture. The total area of Vaishali is 2015.37 km² and the district is bounded in the north by Muzaffarpur, in the south by Patna, in the east by Samastipur, and in the west by Saran (Chapra) district.

Agriculture is prime activity in Vaishali District almost 70 percent people are engaged in cultivation and livestock activity. Vaishali has around 29 to 30 percent labor force participation rate. It means unemployment and less income groups exist. More than 70 percent household's monthly income is less than 5000. Only 6.28 percent (Rural) people have a salaried job.

Suitable potential can emerge with agriculture only in Bihar and Vaishali because it has a strong agricultural background. Agriculture land has rich fertility and hence farmers take 2 or 3 times an agricultural use of its land. In large scale, Wheat, maize, vegetables, tobacco and banana is cultivated in Vaishali. Vaishali is suitable for medium and small-scale industries in Food Processing Units. Especially Banana and its products, some other industries like Packaged drinking water units, Poultry units, and Bio-fertilizer units have potential to grow in this district.

VII. DATA SOURCE AND RESEARCH METHODOLOGY

To achieve the objectives of the present research work, both primary and secondary data have been used. The secondary data has collected from various government agencies and related organizations. The data on banana production like the area under the banana cultivation and other cash crops, productivity, and other economic factor's details collected from Annual Horticulture Report (India), Bihar Agricultural Task Force (Niti Aayog), Bihar Statistical Dictionary, Vaishali District Statistical Report, Hariharpur Krishi Kendra report and documents. For the analysis of data and collection of data, researchers used various tools related to GIS and Remote Sensing. Landset 5, Google Earth Engine (GEE) and MODIS are used. In this study the researcher analyse banana cultivation pattern of Vaishali District, Bihar (India) from 2000 to 2023(Which are suppose to be the latest data). The research utilized MODIS MOD13Q1 vegetation index data with 250-meter spatial resolution and 16-day temporal frequency. All processing was conducted within the Google Earth Engine (GEE) cloud computing platform to handle the extensive 24-year dataset efficiently. The Normalized Difference Vegetation Index (NDVI) was computed using the standard formula $(NIR-Red)/(NIR+Red)$ and scaled by 0.0001 to convert to the 0-1 range. Banana cultivation areas were identified using a specific NDVI threshold range of 0.2268 to 0.3519, derived from previous studies and validated for the region.

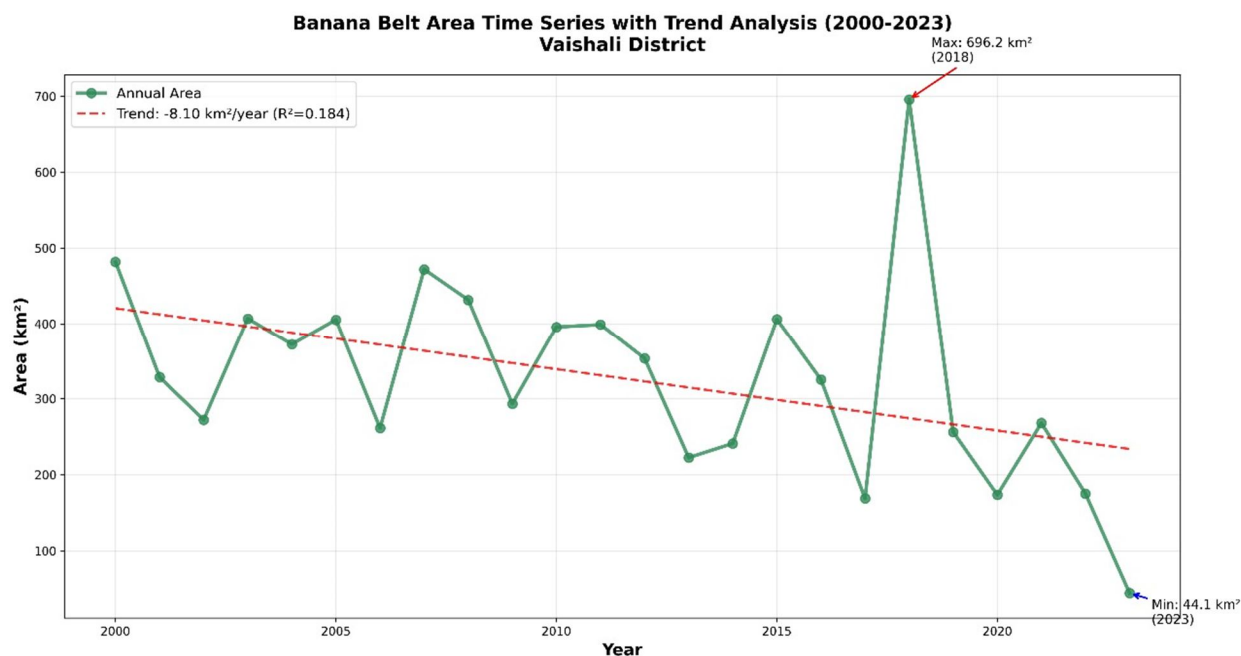
VIII. ANALYSIS AND RESULTS

According to Rajendra Prasad Central Agricultural University (2017), Banana cultivation has established an iconic presence among the local farmers; gradually they are interested in growing bananas. According to the Report of Banana Research Center (BRC), they are improving and developing disease-free banana varieties (Chiniya, Alpaan, Barhari and Malbhog) for the farmers. In August 2025, Krishi Vigyan Kendra, Vaishali, conducted training on various uses of Banana like chips, powder, and fibers, etc. It helps banana growers and diversifies income. But when researchers analyze the development of the banana belt, it shows the area expansion is unpredictable. It means the production and cultivation of bananas comes under threat.

Table 1. Spatial-Temporal Distribution of Banana Cultivation Area -2000 to 2021

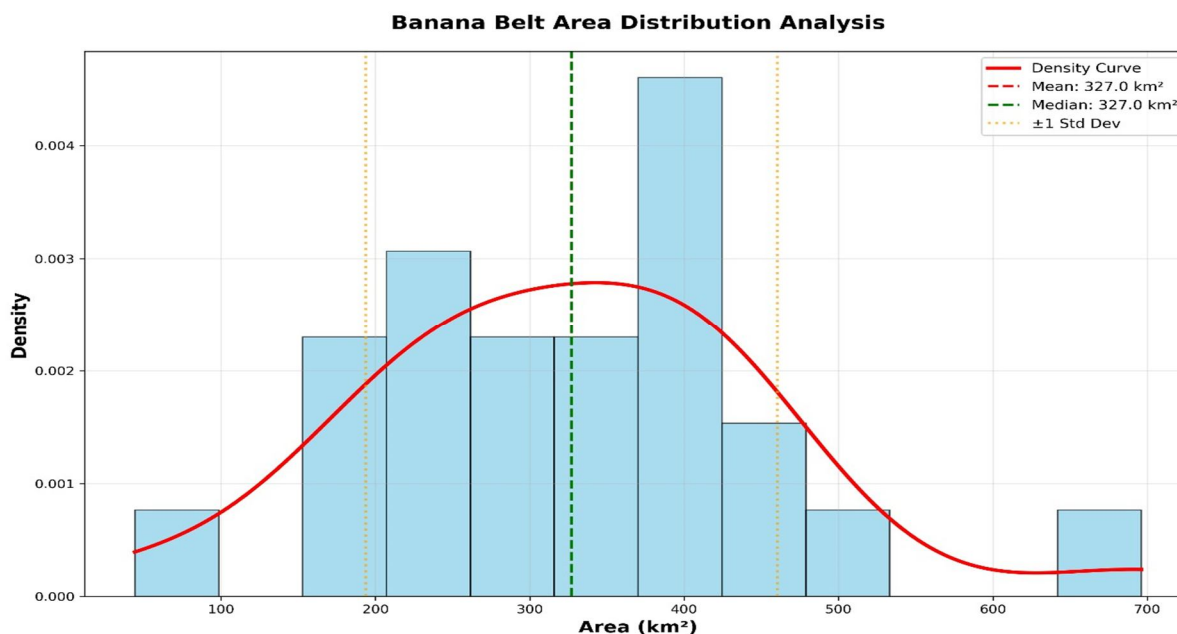
Year	Area (in Ha.)	Changes	Year	Area(in Ha.)	Changes
2000	48,172.42	00000	2012	35,342.45	-4,524.01
2001	32,859.11	-15,313.31	2013	22,251.84	-13,090.61
2002	27,223.99	-5,635.12	2014	24,120.86	1,869.02
2003	40,656.69	13,432.70	2015	40,568.89	16,448.03
2004	37,206.13	-3,450.56	2016	32,544.71	-8,024.18
2005	40,514.40	3,308.27	2017	16,864.31	-15,680.40
2006	26,146.00	-14,368.40	2018	69,620.70	52,756.39
2007	47,191.24	21,045.24	2019	25,619.78	-44,000.92
2008	43,149.61	-4,041.63	2020	17,354.59	-8,265.19
2009	29,353.33	-13,796.28	2021	26,803.21	9,448.62
2010	39,551.95	10,198.62	2022	17,502.58	-9,300.63
2011	39,866.46	314.51	2023	4,413.64	-13,088.94

Sources: Lanset8, MODIS and report of Banana Research Center, Gorowl, Bihar



Sources: Calculated by Researcher

When we analyse the growth of the Banana Belt with the help of trend analysis (2000 to 2023), it clearly shows that between 2000 and 2006, areas more or less declined. It means banana growers were not interested in growing the banana; they agreed that the banana price was not enough to sustain and run family expenditure that only depended on banana cultivation. One of the farmers accepted that they were not wanted to grow because banana fruits have a high rate of perishability, and they were not able to sell out of the Vaishali district. Above, the diagram shows considerable interannual fluctuation, with the highest amount of area recorded in 2018 (696.2 km²) and the lowest in 2023 (44.1 km²). When we calculate the decreasing rate of banana cultivation area per year, it is 8.10 km². It means the banana belt of Vaishali districts has been used for other purposes, like construction and transformational activities.



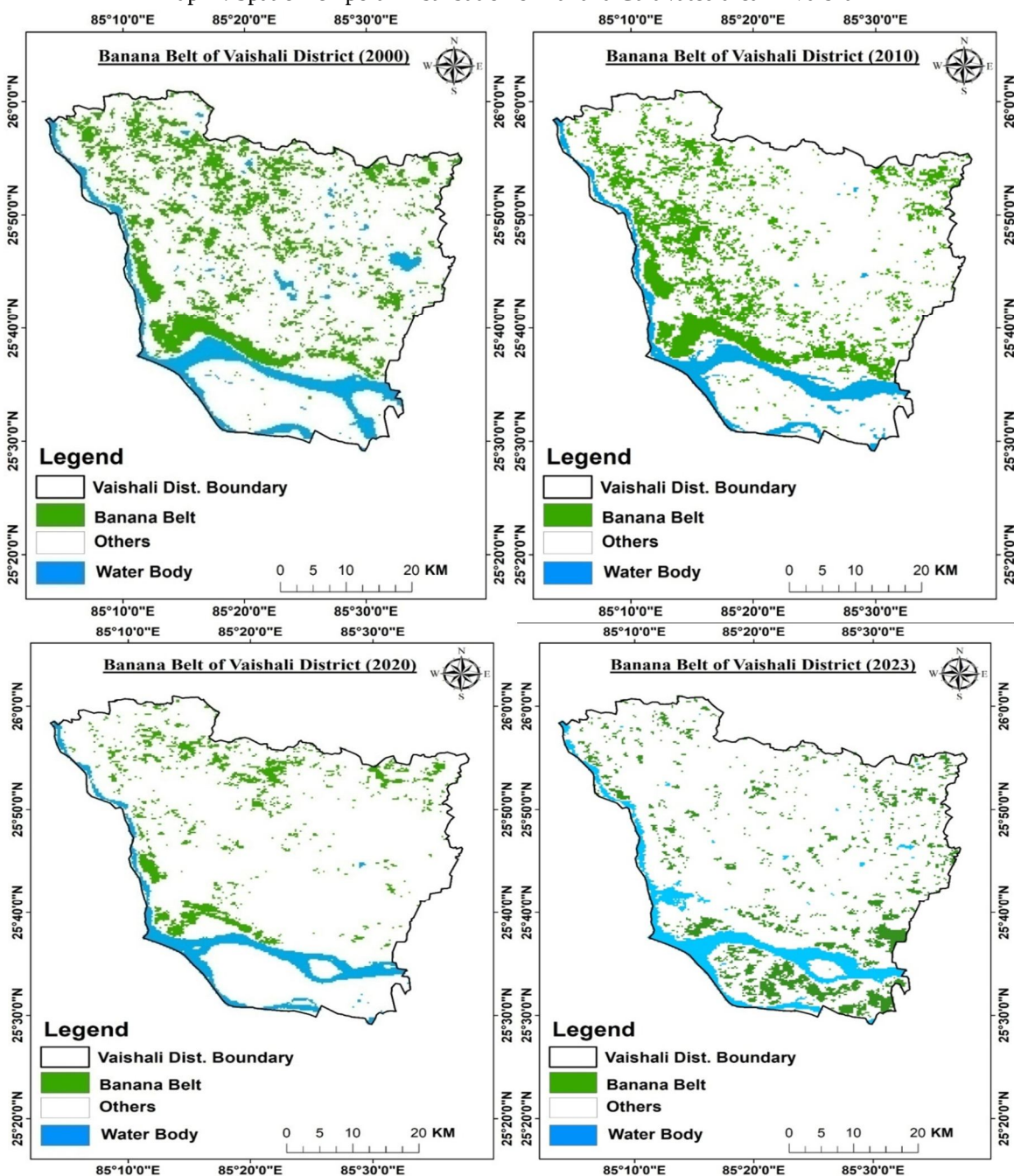
Sources: Calculated by Researcher

When we see the density of the banana cultivation area, the density curve shows a smoothed frequency distribution of area sizes, and the majority of the banana cultivated area comes under 200 km² to 450 km². Red line curves show normal (bell-shaped) distribution, which is moderate variation, as we can say it is not heavy skew. Also we can say that Vaishali's land use for banana cultivation is quite normal and a stable pattern of land allocation (influenced by agro-climatic uniformity and land availability of banana production) for bananas.

IX. MAPPING SPATIAL DISTRIBUTION OF BANANA IN VAISHALI DISTRICT, BIHAR

With the help of spatial-temporal distribution (2000 to 2023) of banana cultivation in Vaishali district, we can exhibit it. Map shows the distribution and transformation of the banana belt. We can see that in 2000, the concentration of bananas was mainly in the southern and eastern parts of Vaishali, along the rivers Gandak and Ganga.

Map 2 : Spatio-Temporal Distribution of Banana Cultivated area in Vaishali



Sources: Google Earth Engine (GEE), MODIS and GIS Tools

In the year 2010, banana areas increased and concentrated in Central Vaishali (Mahua–Lalganj area), the western part of the Gandak River, and the floodplain area of southern Vaishali (Ganga's flood-prone area). Overall, we can say it was the peak banana coverage among the decade. In the year 2020, the map shows a sharp decline in the banana belt of Vaishali. Banana cultivation becomes fragmented; the reason behind this is the expansion of built-up areas and flood events occurring many times (2016, 2019).

Table 2. Changing Pattern of Banana Cultivation

Year	Distribution Pattern	Key Changes
2000	Moderately Spread	Balance Distribution
2010	Maximised Concentration	Increase in Central and Western Part of Vaishali
2020	Highly Reduced	Fragmentation of Banana belts and shrinking due to increasing built-up area and water bodies
2023	Shifted to Southern Floodplain	Concentration increases in southern part of Vaishali(Bidupur, Hajipur, Mahnar and Rajapakar)

Sources: Primary Survey and Google Earth Engine (GEE)

Major changes can be seen after 2020, area has declined rapidly, the reason behind is lack of grower interest, increasing built up area and population pressure.

X. SWOT ANALYSIS OF BANANA CULTIVATION IN VAISHALI

With the help of SWOT analysis, we can identify the strengths, weakness, opportunity and threats for banana cultivation. Analysis is helped us to understand the internal and external forces for production of bananas.

1) Strengths of Banana Cultivation in Vaishali

- Production of banana in large scale due to favorable condition of Banana cultivation
- Greater participation in social activities
- Adaptation of improved technology
- Suitability of Soil for Banana Cultivation

2) Weakness of Banana Cultivation in Vaishali

- Unawareness about government policies
- Lack of Scientific Knowledge and scientific pattern of cultivation
- Unskilled marketing

3) Opportunities for Banana Cultivation

- Scope for high production of Banana
- Scope for increasing organic farming
- Scope for developing agro business and value addition
- High scope for enterprunrship development

4) Threat of Banana Cultivation in Vaihsali

- Uncertainty of Floods
- Indiscriminate use of fertilizer leads to soil degradation.

XI. ISSUES AND CHALLENGES FOR BANANA CULTIVATION IN VAISHALI

When we talk about the issues and challenges for banana cultivation, we find that they occur due to various factors related to environmental, agronomic and socio-economic issues.. These issues exist mainly, because of mismanagement of agricultural belts of bananas and a lack of marketing strategies for selling bananas.

A. Major Issues of Banana Cultivation

- 1) Traditional farming: The production and supply of bananas are affected very much because of traditional farming practices. Farmers are not able to identify diseases, and there is poor utility of scientific methods. It makes crops more vulnerable and affects the production of bananas, especially in the southern part of Vaishali.

- 2) Shortage of Skilled Labour for Banana Cultivation in Vaishali: After the establishment of the Banana Research Center, Gorowl, the variety of banana seeds improved, but the major issues that occur are a shortage of skilled labor and farmers.
- 3) Occurrence of Flood due increasing water level of River Ganaga and Gandak: Due to the high rate of flood occurrence in flood-prone areas, damaged banana crops also have a high risk of planting bananas after the floods.
- 4) Poor marketing strategies: Only a few marketing points are available in Vaishali, especially for banana fruits. A banana is a perishable item; therefore, it requires a good transportation facility and a quick sales facility outside of Vaishali.

B. Challenges for Banana Cultivation in Vaishali

- 1) Sustain geographical area of Banana Cultivation: Analysis of the spatio-temporal distribution indicates that the geographical extent of banana cultivation in Vaishali has reduced significantly after 2020. This decline is linked to factors like repeated disease outbreaks, high production costs, poor-quality planting material, unstable market prices, and increased climate vulnerability.
- 2) Develop Interest among the Farmers: Interest among the farmers to grow banana, has big issues especially Hajipur Block, most of the famers are agreed that they are not interested to plant Banana. The reasons behind works are following:-
 - a) Farmers in Hajipur view banana as a risk-prone crop, mainly due to:
 - Frequent wind damage, lodging, and cyclones
 - Waterlogging during monsoon in low-lying areas.
 - Past experiences where entire plantations were lost in 1–2 events. This makes farmers prefer safer, short-duration crops like vegetables
 - b) Long Crop Cycle(10 to 12 months) : Farmers in Hajipur Block generally prefer short-duration crops such as vegetables, paddy-wheat, and pulses because these crops provide quick and multiple returns within a year. In contrast, banana cultivation has a long crop cycle of 10–12 months, during which the land remains occupied by a single crop. This “land-blocking effect” creates hesitation among small and marginal farmers, who depend on frequent cropping and quick cash flow to meet household needs, repay loans, and manage seasonal expenses. As a result, many farmers perceive banana as a less flexible and high-commitment crop, discouraging them from adopting it despite its high potential profitability.
- 3) Develop friendly relationship between market and stockholder: Developing a friendly, cooperative relationship between the market and stakeholders—such as farmers, traders, wholesalers, retailers, FPOs, transporters, and government agencies—is essential for strengthening the banana value chain in Vaishali. A strong, trust-based relationship helps reduce market risks, ensures better price realization, and creates long-term sustainability for banana cultivation.

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