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Trend analysis and future prospects of floriculture in India

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Abstract
The study pursued to examine India's growth trend and future projections in the area, production and productivity of floriculture in India. The study was based on secondary data. The data was collected from the official website of Department of Agriculture & Farmers Welfare, India from 2005-06 to 2020-21. Simple Linear Regression Model was used to calculate growth trend. Simple growth rate was calculated. The Adequacy of the ` model was resolved by using MAD, RMSE, MAPE, R^2 and Theil's Inequality coefficient. Out of three error measurements, the small MAPE value (4.45) indicated in production (Cut) 96.55 percent accuracy predicted by the independent variable. MAPE gave the best accurate and fair comparison of predictions method. Factors included the area of farming, production of both loose and cut flowers and the overall productivity. Linear association between the regression components and their respective independent variables were found. R^2 calculates indicated that model enlightened 95% of the variance in Area, 96% of the variance in Production (Loose), 96% of the variance in Production (Cut), and 82% of the variance in Productivity. Increasing trend had been found regarding area, production and yield per hectare of flowers cultivation in India over time. The models for Area, Production (Loose and Cut) and Productivity demonstrated a strong match, as seen by the high R^2 values.

Keywords: Floriculture, India, Theil's Inequality coefficient, area, production, productivity, growth rate

Introduction

The global flower production industry has undergone significant transformations in recent decades, evolving from localized cultivation to a complex, interconnected global market. Industrial liberalization and shifting trade policies have been key factors in facilitating the export-driven growth of flower production and fostering international trade (Netam, 2021) [9].

Today, the floriculture industry has expanded to over 145 countries worldwide. According to Future Market Insights (FMI) (https://www.futuremarketinsights.com), floriculture production has been growing at a steady rate of 10% annually. Experts predict that by 2034, the floriculture market will reach an impressive valuation of $109.1 billion (Malhotra, 2024) [18].

The International Association of Horticultural Producers (AIPH) (https://aiph.org/) reported that in 2023-24, the total global area under flower production was 702,383 hectares. Among all of these, Europe accounted for 48,705 hectares, Asia led with 523,829 hectares and North America contributed 21,067 hectares. Additionally, floriculture is expanding across the Middle East, Africa, Central America, and South America, further driving industry growth (Malhotra, 2024) [18].

India holds a significant position in the global floriculture sector, occupying 35% of the total floriculture area. Among the traditional flower-producing countries, Japan, the USA, the Netherlands, Colombia, and Italy remain prominent. The Netherlands, in particular, serves as a major hub for the global cut flower trade, supplying both imported and locally grown flowers (Wani *et al*., 2018) [16].

Several Asian countries have also improved their floriculture production in recent years. India, China, Bangladesh, Thailand and Vietnam are emerging as key players in the region. Latin America and Africa are also witnessing rapid growth in flower production. Collectively, the USA, Western Europe, Germany, the UK, the Netherlands, France, and

Switzerland consume 80% of the world's total flower production (Malhotra, 2024) [18]. Advancements in production and post-harvest technologies have significantly boosted global flower sales. Marketing strategies have played a crucial role in expanding the industry. Specialized protected structures tailored for tropical climates have improved the quality and logistical management of international flower trade (Wainwright and Hart, 1999) [15].

Trade reforms and the launch of the National Horticulture Mission (NHM) in 2005-06 marked a pivotal shift in agricultural activity, steering it towards horticulture. The expansion of the floriculture trade presents immense global opportunities (Sinha and Sharma, 2024) [14].

Several Indian states are actively engaged in commercial floriculture. Tamil Nadu leads with 21% of total flower production, followed by Karnataka (16%), Madhya Pradesh (14%), and West Bengal (12%). Floriculture is cultivated both in open fields and under protected environments such as greenhouses and playhouses (Malhotra, 2024) [18].

India has emerged as a major hub for flower production due to its favorable climatic conditions, high-quality soil, and abundant natural resources. The availability of inexpensive labor further enhances its competitiveness in the global market. Despite these advantages, the Indian floriculture industry faces challenges related to infrastructure, production, marketing, and exports (Pathak *et al*., 2022) [10].

India exports fresh-cut flowers to the USA, Europe, Japan, Australia, and the Middle East. Cut foliage is primarily shipped to Europe, while loose flowers are exported to Gulf countries. Additionally, dried flowers are exported to Russia, the Far East, Japan, Australia, Europe, and the United States (Malhotra, 2024) [18].

The Government of India has taken significant steps to develop the horticulture sector. The Mission for Integrated Development of Horticulture (MIDH) is one of the key initiatives supporting floriculture. The National Bank for Agriculture and Rural Development (NABARD) has provided financial assistance to farmers for implementing protected cultivation and precision farming. Research institutions such as the Indian Council of Agricultural Research (ICAR) and the Council of Scientific and Industrial Research (CSIR) have contributed extensively to floriculture research. State and central agricultural universities also conduct research under the All-India Coordinated Floriculture Improvement Project (Malhotra, 2024) [18].

Bobde *et al*. (2023) [2] highlighted those initiatives like MIDH have a significant impact on the growth of India's floriculture industry. The floriculture industry has experienced rapid expansion. Innovations in farming methods have introduced new flower seed varieties, advanced technology, and increased flower production. While fresh products and technological advancements have boosted the industry, challenges related to infrastructure, production, marketing, and exports persist (Kumar *et al*., 2023) [5].

Many seed companies have established production units in major flower-growing states, responding to the rising demand for flower seeds driven by the sector's expansion. To further support the industry, the Government of India has introduced various training programs and incentives, including subsidies on seeds, planting materials, equipment, and airfreight for exports. Improved policies have played a crucial role in strengthening India's floriculture sector (Malhotra, 2024) [18].

The floriculture industry is rapidly expanding, driven by advancements in cultivation techniques, trade policies and government support. Despite this growth, challenges related to infrastructure, production, marketing and export persist, requiring a comprehensive understanding of industry trends and future opportunities. This study was conducted to analyze the current landscape of floriculture, assess emerging trends and evaluate future prospects, particularly in India. By examining market growth, technological advancements and policy interventions, this research aims to provide insights into the sector's potential for sustainable expansion and global competitiveness. The findings can guide policymakers, researchers, and stakeholders in making informed decisions to enhance productivity, improve market access, and strengthen India's position in the global floriculture trade.

Materials and Methods

Data collection: This study was primarily based on secondary data collected from the official website of the Department of Agriculture & Farmers Welfare for the years 2005-06 to 2020-21 (https://agriwelfare.gov.in/). Data related to production was revealed in first two figures i.e., Production of loose flowers (figure:1) and production of cut flowers (figure :2) Data related to productivity (figure:3) was and area (figure:4) was shown in next two figures. The objective was to analyse trends in the area, production, and productivity of floriculture in India. Until 2011-12, production data included only loose flowers measured in metric tons, while cut flower production was recorded in numbers (Figure: 2). From 2012-13 onwards, cut flower production figures (converted into metric tons) were incorporated into the flower production data, as shown in (Figure: 1).

Data Analysis: To examine the growth trend in the floriculture future trends predictions of area production and productivity (Table :2 /Figure 1,2,3 and 4) a time series regression model (Table:1) was employed for data analysis, using the Ordinary Least Squares method as described by (Lakshmanarao *et al*., 2023) [6]. The analysis was conducted using QM for Windows v5.2 software. The model used was:

Linear Regression Model: (Results shown in Table: 1)

$y=b_0 + b_1x+e$

Where:

y = Estimated value of the dependent variable

b_0 = Intercept

b_1 = Regression coefficient

x= Time variable

e= Error term

To test the regression coefficient, the following formula was applied:

$t = b_1/S.E\ b_1$ with n-2 degree of freedom

Where:

b_1= Estimated regression coefficient/ Estimated value of b_1,

S.E. =Standard error of b_1

n= number of observations

Simple Growth Rate: (Results shown in table:1)

The simple growth rate was calculated using the formula proposed by (Raut and Sarawgi, 2019) [13]:

$SGR = b_1/\bar{y} * 100$

Where:
b_1= Regression coefficient
$\bar{y}$ = Mean of y
$\bar{y} = \sum y/n$

Adequacy and Inequality Coefficient Calculation: (Results shown in table:3)
The adequacy of the selected model was assessed using Mean Absolute Deviation (MAD), Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), R-squared (R^2), and Theil's Inequality Coefficient (U). Theil's Inequality Coefficient was calculated as follows:

$$U = +\sqrt{\frac{\frac{\sum(Pi-Ai)^2}{N}}{\frac{\sum(Ai)^2}{N}}}$$

Where:
P_i-=Forecasted change in the dependent variable
A_i= Actual change in the dependent variable
The values of Inequality Coefficient lie between 0 & ∞

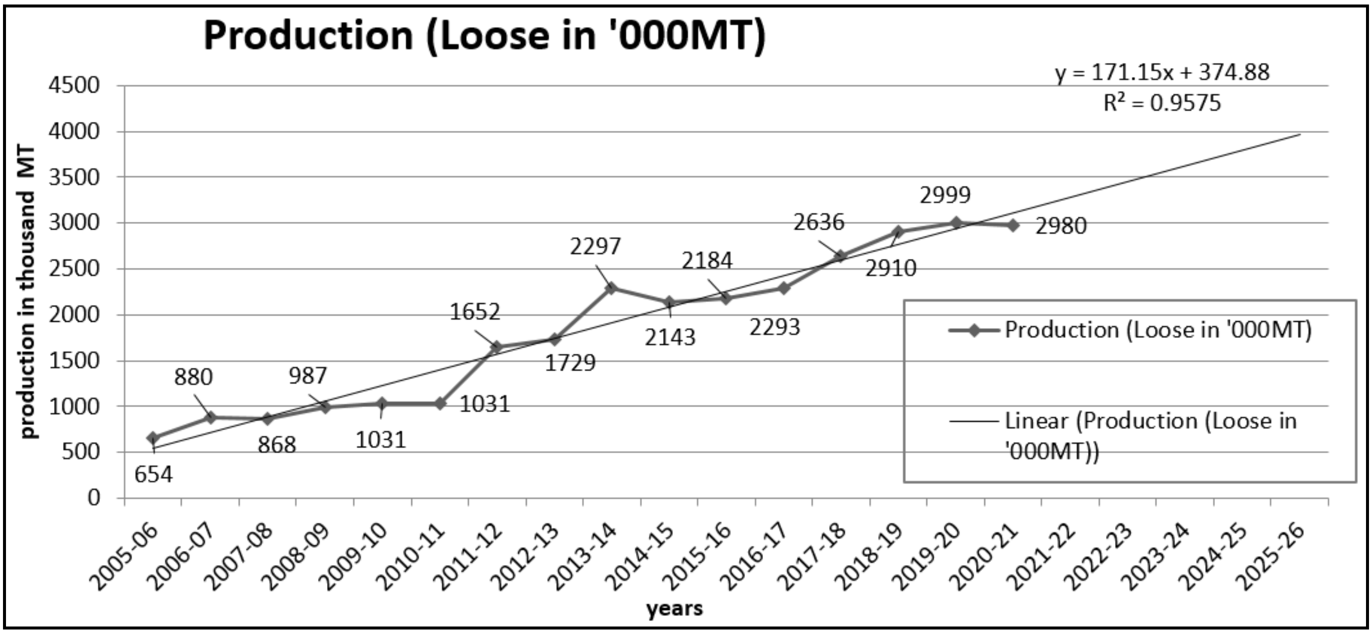
$0<U<\infty$

The inequality coefficient (U) values ranged between 0 and ∞ ($0 < U < \infty$). A value of $U = 0$ indicated an optimal model fit, whereas $U = 1$ represented the worst predictive power. Value of U between 0 and 1 suggested a good predictive model, with values closer to 0 signifying better model performance. If U exceeded 1, the predictive capability of the model was considered poor.
The analysis provided a comprehensive evaluation of the "goodness of fit" (Table: 3) for statistical models related to various parameters in the floriculture sector in India, including area, production (loose and cut flowers), and productivity. The "goodness of fit" assessed the degree to which the statistical model accurately represented the given data set.

Results and Discussion

Production Trends of Loose Flowers Cultivation

The scatter plot shown in Figure:1, including a linear trend line, illustrated the production of loose flowers in India. The output was measured in '000 metric tons (MT) from 2005-06 to 2025-26. The linear regression line had a slope of 171.15, implying that the output was predicted to increase by an average of 171.15 thousand metric tons annually. The coefficient of determination (R^2 = 0.9575) indicated that 95.75% of the variation in loose flower production was explained by the time.



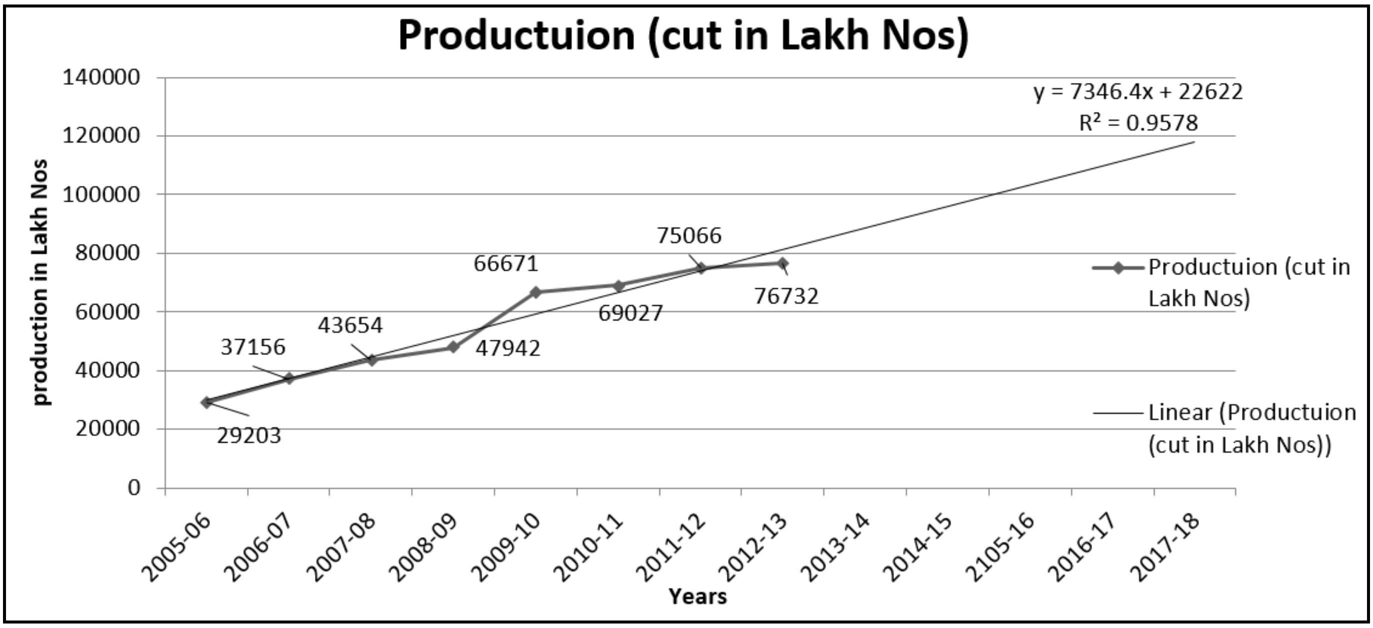
Source: Calculated by the researcher from the data collected from the Department of Agriculture & Farmers Welfare

Fig 1: Production of loose flowers in India

This robust association acknowledged that the production quantity could be predicted in great part by time. The upward trajectory of the regression line revealed a direct relationship between time and the quantity of loose flowers produced. The clustering of data points around the regression line suggested that the model provided a good fit for historical data and could serve as a reliable predictor of future production trends, assuming other influencing factors remained constant. So, increasing trend was found in the production of loose flowers. Data covered a decade from 2014-15 to 2023-24, exhibited a variable but typically rising trend in loose flower output. despite intermittent inclines and crests (Kumar *et al.*, 2024) [4]. Due to dynamics and traditional Practices, the demand for loose flowers was quite closely related with social and religious purposes. It was pointed to a steady market shaped by cultural practices (Malik *et al.*, 2021) [7].

Production Trends of Cut Flowers Cultivation

In the illustration (Figure: 2), illustrated the output of cut flowers in India, measured in numbers from 2005-06 to 2012-13. The slope of 7346.4 indicated that production was projected to rise by an average of 7346.4 lakh numbers annually. The coefficient of determination ($R^2 = 0.9578$) demonstrated that approximately 95.78% of the variability in cut flower production was accounted for by the year. Post-2012-13, cut flower production data (converted into metric tons) was included in the overall flower production figures.



Source: Calculated by the researcher from the secondary data collected from the Department of Agriculture & Farmers Welfare

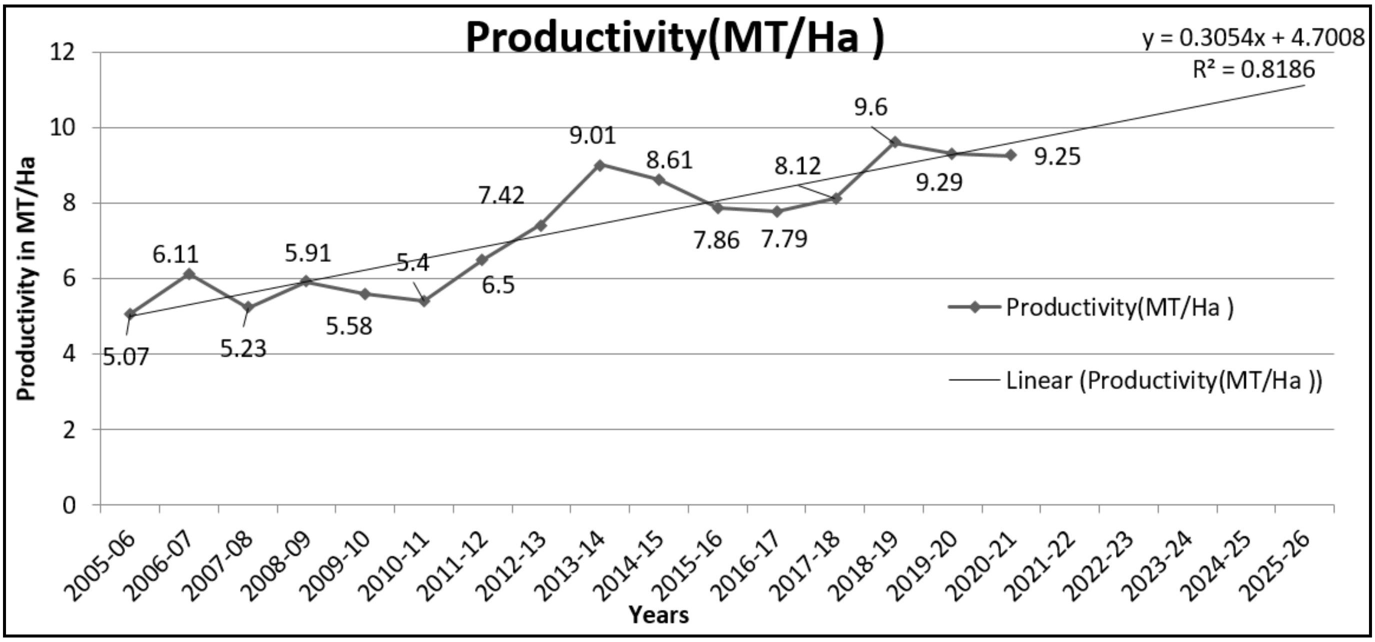
Fig 2: Production of cut flowers in India

The strong relationship suggested that time was a significant factor in predicting the output volume. The increasing trend indicated a direct correlation between time and cut flower production. The high R^2 value and close clustering of data points confirmed that the model provided a robust fit for historical data and could be a reliable tool for future projections, assuming other influencing variables remained unchanged.

Combining loose and cut flowers, India's floral output exhibited increasing trend. So, growing tendency was found in the production of loose flowers. This indicated a general rising market for flowers (Kumar *et al.*, 2024) [4].

Productivity Trends for Flower Cultivation

In Figure 3, trend line representing the productivity of floriculture in India, measured in metric tons per hectare (MT/Ha) from 2005-06 to 2025-26. The slope of 0.3054 indicated the annual rate of increase in productivity. The coefficient of determination ($R^2 = 0.8186$) suggested that 81.86% of the variability in productivity was explained by the linear model.

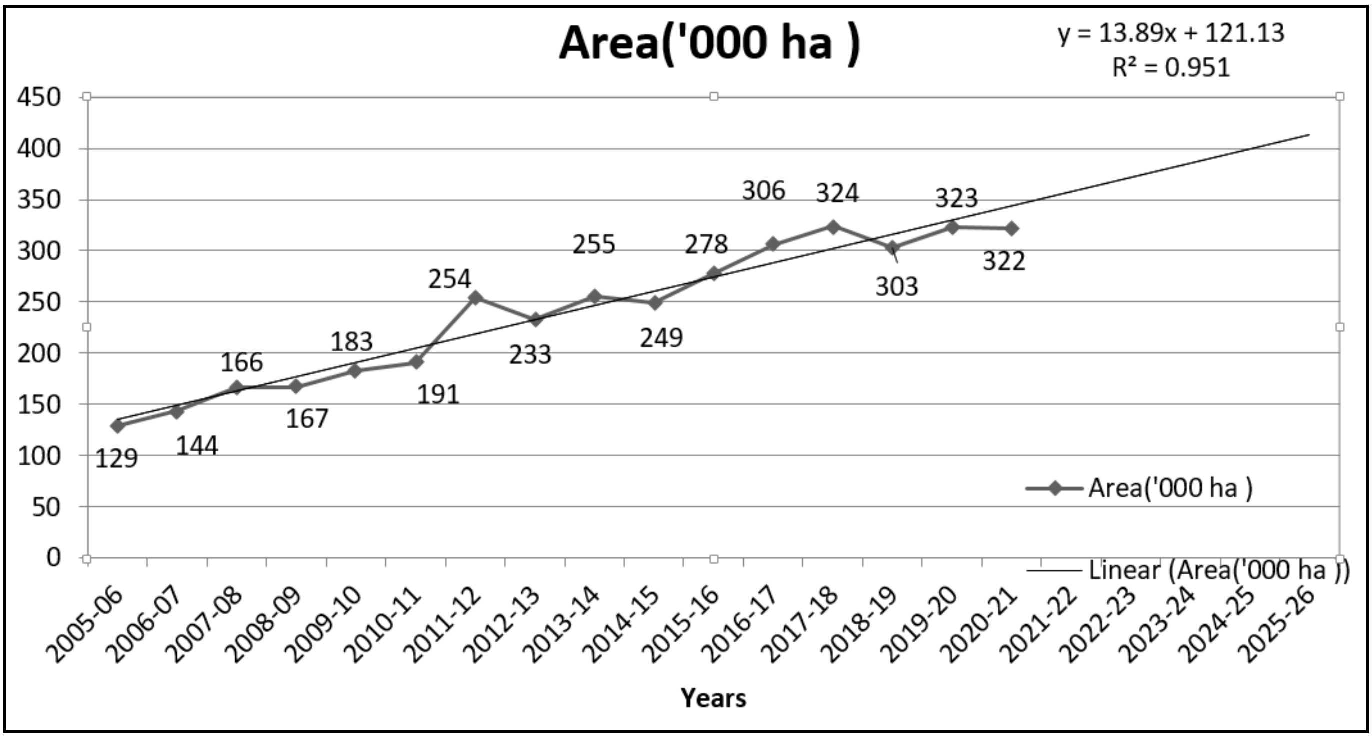


Source: Calculated by the researcher from the data collected from the Department of Agriculture & Farmers Welfare

Fig 3: Productivity of flower cultivation in India

While this association was strong, it was not as high as models with R^2 values nearing 1. The overall upward trajectory signified a consistent increase in productivity across the years. However, additional factors beyond the scope of this model likely influenced productivity, necessitating further research.
Furthermore, Investigating the application of improved technologies (fertilizers, insecticides, etc.) also improving output and export possibilities depends on overcoming obstacles in reaching international quality standards (Anumala and Kumar, 2021) [1].

Trends in area for flower cultivation in India
The allocation of land illustrated in Figure: 4 for floriculture in India, measured in thousands of hectares. The linear trend line, representing the best fit for the data points, had a slope of 13.89, indicating that the area allocated to floriculture increased by an average of 13.89 thousand hectares per year. The coefficient of determination (R^2 = 0.951) demonstrated that 95.1% of the variance in the area under floriculture was explained by time.



Source: Calculated by the researcher from the data collected from the Department of Agriculture & Farmers Welfare

Fig 4: Allocation of land for floriculture in India

The narrow dispersion of observed data points around the regression line suggested that the model effectively represented historical trends and could be used for future projections in the floriculture sector, provided other conditions remained stable. Expanding areas under flower cultivation also point to a deliberate attempt to boost output. With substantial increase seen for cut flowers including Gladiolus, Gerbera, Chrysanthemum, and Carnation between 2014 and 2024, his movement in cultivated area for different flower varieties demonstrates a tendency towards diversification (Kumar *et al.*, 2024) [4].

Analysis of Simple Growth Rates and Linear Regression for Entire Flower Area, Production and Productivity in India
Correlation demonstrated in Table 1 among the variables affect the overall growth the floriculture sector such as cultivated area, production of loose and cut flowers, and overall productivity. The regression coefficients indicated the expected changes in dependent variables per unit increase in time while controlling for other variables. Asterisks (*) denoted statistical significance at the 5% level, confirming the robustness of the findings. The regression coefficients for productivity and area were 0.31 and 13.89, respectively, while the coefficients for loose and cut flower production were 171.15 and 7346.4, respectively.
The calculated t-values for area, production (loose flowers), production (cut flowers), and productivity were 16.5, 17.7, 11.66, and 7.9, respectively, all significant at the 5% level. These values demonstrated the statistical relevance of the estimated coefficients. The simple growth rate analysis confirmed a positive trend in floriculture in India, aligning with similar studies (Patil *et al.*, 2020) [11].

Table 1: Regression analysis for area, Production and Productivity under floriculture in India

Regression Factor	Intercept	Regression Coefficients	S.E.	t cal.	SGR%
Area	121.13	13.89*	0.84	16.5	5.81
Production (Loose)	374.88	171.15*	9.63	17.7	9.35
Production (Cut)	22622	7346.4*	629.44	11.66	13.19
Productivity	4.7	0.31*	0.04	7.9	4.18

*Significance at 5 percent level
Source: Calculated by the researcher from the data collected from the Department of Agriculture & Farmers Welfare

The commercialization of floriculture expanded due to increased demand for flowers for various occasions. Advancements in technology enhanced commercial flower production and marketing strategies. Floriculture demonstrated strong potential for both domestic and international markets, particularly through the adoption of protected cultivation methods such as greenhouses and polyhouses (Prabhjit and Dubey, 2019) [12].

Rapid expansion in floriculture was facilitated by improved farming techniques, development of high-yielding seed varieties, and adoption of modern technology. However, challenges such as infrastructure limitations, production constraints, and market access continued to affect the sector (Kumar *et al*., 2023) [5]. Numerous seed companies established production units in major flower-growing states, responding to rising demand for flower seeds. The Government of India introduced training programs and financial incentives, including subsidies on seeds, planting materials, equipment, and airfreight for exports, further strengthening the floriculture sector (Malhotra, 2024) [18].

Future Projections of Flower Cultivation in India

Future projections for flower cultivation in India shown in table 2, from 2021-22 to 2025-26 suggested an overall increasing trend in cultivated area, production and productivity. The area under floriculture was projected to rise from 350.29 thousand hectares in 2021-22 to 412.79 thousand hectares in 2025-26. Loose flower production was estimated to grow from 3284.43 thousand metric tons in 2021-22 to 3969.03 thousand metric tons in 2025-26. Similarly, cut flower production was projected to increase from 88,736 lakh numbers in 2021-22 to 118,120 lakh numbers in 2025-26.

The estimated yield of floriculture, measured in metric tons per hectare, demonstrated a steady increase from 9.89 MT/Ha in 2021-22 to 11.11 MT/Ha in 2025-26. These projections indicated a positive growth trajectory for the floriculture sector in India.

Table 2: Projected Area, Production and Productivity under floriculture in India

Year	Area (‘000 ha)	Production (Loose in ‘000MT)	production (cut in Lakh Nos)	Productivity (MT/Ha)
2021-22	350.29	3284.43	88736	9.89
2022-23	366.95	3455.58	96082	10.19
2023-24	283.057	3626.73	103428	10.5
2024-25	398.9	3797.88	110774	10.81
2025-26	412.79	3969.03	118120	11.11

Source: Calculated by the researcher from the data collected from the Department of Agriculture & Farmers Welfare

Floriculture industry is probably going to increase in the next years, as the rising demand for flowers both locally and abroad. (Malviya *et al*., 2022) [8]. Rising disposable incomes, urbanization, and changing lifestyles elucidate this need, deeply rooted in religious and cultural customs. Loose flower farming is projected to continue be a major component of the industry (Malik *et al*., 2021) [7].

Even though scenario seems beneficial, the industry still has problems like supply chain inefficiencies, market instability, and the availability of trained workers. Changing customer preferences and global economic condition can also affect the direction of the sector. (Bhat, 2020) [3].

Adequacy of the Model and Inequality Coefficient Calculation for Flower Cultivation in India:

The Adequacy of the selected model was resolved by using MAD, RMSE, MAPE, R^2 and Theil’s Inequality coefficient**.** Test of goodness of fit evaluated the adequacy of the model. Table: 3 presented a comprehensive evaluation of the "goodness of fit" for statistical models pertaining to many parameters in the floriculture sector in India, including Area, Production (Loose and Cut), and Productivity. The term "goodness of fit" pertains to the degree to which a statistical model accurately corresponds to a given collection of facts.

Table 3: Test of Goodness of fit

Factor	MAPE	RMSE	MAD	R^2	U
Area	4.77	14.526	11.63419	0.95	0.03
Production (Loose)	9.17	166.216	127.5699	0.96	0.94
Production (Cut)	4.45	3533.265	2665.223	0.96	0.16
Productivity	7.35	0.663	0.523073529	0.82	0.27

Source: Calculated by researcher

The study used to three standard error measures MAD, RMSE and MAPE. Of three error measurements MAPE given the best accurate and fair comparison of predictions method. The numbers for area 4.77%, Production (Loose) 9.17%, Production (Cut) 4.45% and Productivity 7.35%. Given a small MAPE value of 4.45, production (Cut) 96.55 percent accuracy predicted by the independent variable demonstrated. The explanatory variable enables R2 to precisely estimate the fraction of the deviation in the dependent variable. The range was 0 to 1, where higher values indicated more suitable match. The model informed 95% of the variance in Area, 96% of the variance in Production (Loose), 96% of the variance in Production (Cut), and 82% of the variance in Productivity.

With their high R^2 values, the models for Area, Production (Loose and Cut), and Productivity showed a good fit overall. Still, there were differences in the degree of mistakes and fluctuations (MAPE, RMSE, MAD); Production (Cut) showed very high variability and oversights.

Conclusion

This study determined that the area under cultivation, yield per hectare, and overall production of floriculture in India have been expanding steadily over the study period. Although there were variations in specific years, the overall trend was upward, indicating consistent growth in flower cultivation, production, and yield per hectare. The findings revealed that the productivity of India's floriculture industry increased by an average of 0.3054 MT/Ha per year.

India's diverse agro-climatic conditions enable year-round flower cultivation across different regions. The winter season, from October to February, provides favourable conditions for high-quality cut flowers, aligning with peak demand during major festivals and international events. Additionally, India's strategic location benefits its exports to key markets, including Europe and East Asia. With great possibility for development, the future of flower farming in India seems bright overall. Realizing this potential, nevertheless, will depend on addressing current issues and adjusting to changing market dynamics and technology developments (Kumar *et al*., 2024) [4].

Recognizing the potential of floriculture, the Government of India has designated it as a 100% export-oriented sector. To further promote exports, the government should implement measures such as enhancing cold storage facilities at railway stations and airports, as well as developing refrigerated compartments and vans for road and rail transport. Strengthening the logistics infrastructure will be crucial in reducing post-harvest losses and boosting India's competitiveness in the global floriculture market. offer insightful information and analysis that can guide sector strategic planning and future forecasts. Although India's proportion in the worldwide floricultural export industry is little when compared to other key competitors. (Bhat, 2020) [3].

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