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Growth and instability in area, production and productivity of major fresh fruits and vegetables in India

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Abstract

India with a strong agricultural economy that gives a platform for economic growth and the significance of achieving increased growth in the agricultural sector, particularly in relation to fruits and vegetables, has garnered substantial attention from both policy makers and research experts. Given this context, the current research endeavours to assess the growth rate and volatility in the aspects of area, production, and productivity of fruits and vegetables within India. The present study is mainly based on the secondary data which is collected from various secondary sources for the period 2006-07 to 2021-22 by using analytical tools like CAGR and instability index. The results revealed for fresh fruits, that the other fresh fruits had the highest area with positive and significant growth rate at 12.33 percent, pomegranate showed the highest production growth rate at 12.27 percent and oranges showed the highest productivity growth rate at 5.52 percent. Instability indices, indicating the fluctuation in cultivation of area, production and productivity showed that other fresh fruits, pomegranate and grapes record the highest instability at 26.74, 26.74 and 23.60 for fresh fruits, respectively. For fresh vegetables like garlic had the highest area and production with positive and significant growth rate at 6.43 and 9.75 percent and green chilli showed the highest productivity growth rate at 4.21 percent, respectively. Instability indices for area of tomato (12.15), production and productivity of garlic record the highest instability at 16.79 and 14.49 for fresh vegetables.

Keywords: Compound annual growth rate, instability index, fresh fruits and vegetables, area, production, productivity

Introduction

India is a country with a strong agricultural economy specially horticultural sector that gives a platform for economic growth and provides employment opportunities to around 70 percent of its rural people (India at a glance, FAO). Indian economy is mainly based on agricultural trade as agriculture is the backbone of India and contributes to the global food basket. India produces a large amount of milk, legumes, fruits, vegetables, wheat, rice and other agricultural products. Fruits and vegetable farming is the best alternative for Indian agriculture because it increases land productivity, creates jobs and improves farmer's financial position because they can sell their produce with a better prices and makes a higher profit. Most importantly, though it gives the population access with healthy food.

India ranks second place in the production of fruits, vegetables, spices and plantation crops like tea and coffee after China. Fresh and processed fruits and vegetables are more and more in demand on the global market (Shinoj and Mathur, 2008; Saxena and Nath, 2012; Ramesh *et al.*, 2017) [10, 9, 8]. According to the Second Advance Estimates of the National Horticultural Database, released by the National Horticultural Board for the 2021-22 period, the fruit production in India amounted to 102.48 million metric tonnes, while vegetable production reached 200.45 million metric tonnes. The cultivation land area for fruits encompassed 9.60 million hectares, whereas vegetables were grown across 10.86 million hectares (India at a glance, FAO, 2021-22). Consumer tastes have changed from cereals to high-value agricultural produce as a result of rising incomes, urbanisation, shifting lifestyles and worldwide market integration. Farmers can thus profit from agricultural diversification by raising fruits and vegetables to satisfy the escalating demand.

Fruits and vegetables are vital components of the Indian food trade, playing a pivotal role. India's diverse climatic conditions ensure a consistent availability of a wide range of fruits and vegetables throughout the year.

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This holds particular importance in a country where 40 percent of the population follows a vegetarian diet, underscoring the essential role of fruits and vegetables in our nutrition.

A research study conducted on Assam unveiled intriguing insights. The analysis indicated that Assam contributed 18.08 percent to the overall value generated from pineapple, while also making contributions of 6.12 percent and 5.25 percent to the total output value of litchi and citrus, respectively. Notably, there had been substantial growth in the area, production and productivity of fruits in Assam. This transformation can be attributed to farmers recognizing the benefits of commercialization and the concurrent implementation of various government initiatives. The study findings also shed light on the trends in fruit cultivation in Assam. Major fruits like aonla, banana, and pineapple exhibited an upward trajectory in terms of cultivation area, while mandarin, sweet orange, guava, mango and papaya displayed a declining trend between the years 2012-13 and 2017-18. Considering the present pace of fruit production growth and the state's population, the projected demand-supply gap was found to be negative, indicating a surplus of fruit production in the region (Gogoi *et al.*, 2022)^[5].

In addition to fruits, vegetables also assume a significant role in the human diet. They serve as valuable sources of essential nutrients, including protein, minerals like phosphorus and iron, iodine, and various vitamins such as vitamin A, vitamin B, vitamin C, and vitamin K. These nutrient-rich components hold a crucial place in the daily dietary habits of the Indian populace. Fruits and vegetables collectively contribute to the overall well-being and disease prevention of individuals. They encompass valuable nutritional elements that can effectively contribute to the body's maintenance and repair processes (Dastagiri, 2015)^[3].

Fruits and vegetables play a vital role in enhancing visual health, lowering the risk of gastrointestinal issues and mitigating the chances of conditions such as stroke, heart disease, diabetes and certain types of cancer within the human diet. Numerous phytochemicals found in these foods act as potent antioxidants, potentially reducing the vulnerability to chronic ailments. These antioxidants are believed to modify metabolic processes, counteract the detrimental effects of free radicals and aid in the detoxification of carcinogens, thus potentially lowering the risk of chronic diseases.

It's worth noting that a broad spectrum of fruits and vegetables might confer protective benefits against various chronic diseases for humans (Dias, 2012)^[4]. Consequently, the current research study aims to comprehensively analyze the growth patterns and fluctuations in this context.

1. To study area, production and productivity of fresh fruits and vegetables in India

Methodology

The study was conducted by utilising time series data on area, production and productivity of fresh fruits and vegetables in India were collected from publication of National Horticultural Board (NHB), APEDA (Agricultural Processed Food Products and Export Development Authority), Agricoop (Agriculture Co-operation and Farmers Welfare, agricoop.nic.in) Books, reports, Journal, periodicals and News Paper etc. for a period of fifteen years (2006-07 to 2021-22) of fresh fruits and vegetables.

Compound Growth Analysis

The present study involved the computation of growth rates pertaining to the cultivation of area, production output and productivity of key fresh fruits and vegetables in India. Growth rates serve as evaluative metrics for economic parameters, designed to portray trends in variables across time rather than predict future outcomes. Consequently, they serve as valuable indicators for gauging trends within time series data. The determination of compound growth rate was carried out utilizing the subsequent exponential model:

$$Y = a b t e$$

Where,

Y = Dependent variable for which growth rate is estimated.

a = Intercept.

b = Regression coefficient.

t = Time variable.

e = Error term.

The logarithmic form of the above equation estimated the compound growth rate

$$\log Y = \log a + t \log b$$

The compound growth rate (g) was estimated by using

$$g = [\text{Anti log of } (b) - 1] * 100$$

Measure of Instability index

“There are a number of techniques available to measure the index of instability. In this study the instability in area, production and productivity for major fresh fruit and vegetable crops were measured in relative terms by the Cuddy-Della Valle index which is used in recent years by a number of researchers as a measure of variability in time series data”

Cuddy-Della Valle Index (CDVI)

“The simple coefficient of variation over estimates the level of variability in time-series data characterized by long-term trends whereas the Cuddy-Della Valle index corrects the coefficient of variation. The instability index, is given by the expression”

$$CV = \frac{\text{Standard Deviation } (\sigma)}{\text{Mean } (X)} \times 100$$

A linear trend analysis was applied to the original data concerning the area, production and productivity of selected crops, covering a span of 15 years. The significance of the trend co-efficient was subjected to examination. In this case the time series exhibited a significant trend, emphasis was placed on assessing the variation around the trend as opposed to the variation around the mean. To quantify this instability, the formula advocated by Cuddy and Della (1978) was employed.

This involved multiplying the coefficient of variation by the square root of the disparity between unity and the coefficient of determination (r^2) whenever r^2 demonstrated significance. The result of this calculation yielded the Instability Index, which serves as a measure of the extent of variation around the trend.

$$\text{Instability index} = CV \times \sqrt{1-r^2}$$

Results and Discussion

The compound growth rates and instability indices for area, production and productivity of fresh fruits in India for the period from 2006-07 to 2021-22 are depicted in Table 1.

Table 1 presents the growth in area, production and productivity of fresh fruits in India for the study period. It could be observed from the table that average cultivation of area for mango and banana of higher order of 2,282.44 and 763.25 thousand hectares because mango and banana thrive in regions with warm tropical climates, where large areas are suitable for their cultivation. This could explain their extensive cultivation areas. On the other hand, fruits like lemon and pomegranate might require specific climatic conditions that limit their cultivation to smaller areas. Examining compound growth rates, other fresh fruits had highest growth rate with positive and significant growth rate at 12.33 percent because of substantial expansion in the cultivation area of miscellaneous fresh fruits. This could be due to the diversification of agriculture, introduction of new fruit varieties, changing dietary habits and increasing demand for exotic fruits. Pomegranate, oranges and grapes demonstrate the most robust growth 7.34, 6.02 and 5.96 percent due to increasing consumer awareness of nutritional value and rising demand for growth in the beverage industry. Watermelon, banana and mango exhibit the lowest growth rates at 5.26, 4.23 and 0.27 percent due to agro-climatic considerations. Instability indices, indicating the fluctuation in cultivation of area, showed that other fresh fruits record the highest instability at 26.74 followed by pomegranate at 17.33, lemon at 14.83, and banana at 11.29 due to variety of factors such as the introduction of new and experimental fruit varieties, changing consumer preferences, market volatility and varying success rates in cultivation due to factors like climatic conditions and disease outbreaks.

In Table 1, the average production figures for various fresh fruits are highlighted. Among these, banana and mango exhibit the highest average production of 26,829.81 and 17,275.47 thousand metric tonnes. Bananas and mango are a staple in many diets due to their availability, affordability, nutritional content and large number of orchards. Considering the compound growth rate for pomegranate and oranges showed the highest growth rate with positive and significant growth rate at 12.27 and 11.90 percent attributed to increasing consumer awareness of the health benefits. Pomegranate and oranges are known for their antioxidant properties, common source of vitamin C and are often used in various food and beverage products, driving demand and cultivation. Examining instability indices, pomegranate and other fresh fruits holds the highest instability at 26.74 and 22.25 this could lead by fluctuating to different growth requirements, market trends and consumer preferences.

The data in Table 1 illustrates the average productivity levels of different fresh fruits. Among these, banana showed the highest average productivity at 34.91 metric tonnes per hectare due to their relatively shorter cultivation cycle, high yield per plant. The compound growth rate for oranges and pomegranate showed the highest growth rate with positive and significant growth rate at 5.52 and 4.57 percent due to staple fruits consumed widely, contributing to their steady growth rate. Looking at instability indices, grapes present the highest instability at 23.60 due to the diversity of grapes

varieties used for different purposes, such as table grapes, wine production and raisins. Variability in cultivation practices and demand for various grapes products could lead to fluctuations in productivity. It seems from the table that productivity was more stable during the study period, which also supports the above findings. Thus, scope for crop improvement studies are enormous in the crops. The scientists and research organizations need to be geared up in these lines to improve productivity of fresh fruits in the country to improve production in the coming years. Similar results were reported by Ramachandra *et al.* (2013) [7].

The compound growth rates and instability indices for area, production and productivity of fresh vegetables in India for the period from 2006-07 to 2021-22 are depicted in Table 2. It presents the average cultivation of area of various fresh vegetables. Among these, potato exhibit the most extensive cultivation area, accounting 1,938.68 thousand hectares due to potato where large areas are suitable for their cultivation, widely consumed and versatile in culinary applications. Examining compound growth rates, garlic, onion and other fresh vegetables demonstrate the most highest growth rate with positive and significant growth rate at 6.43, 5.73 and 3.46 percent, respectively. This indicates that increasing demand and diversification. But green chilli showed negative growth rate at -0.09 percent due to weather conditions affecting cultivation.

The Table 2, the average production figures for various fresh vegetables are highlighted. Among these, potato, other fresh vegetables and onion exhibit the highest average production levels, amounting to 42,194.89, 17,651.83 and 24,154.25 thousand metric tonnes. Thus, could reflect their essential role in diets used as a flavouring and staple ingredient in cooking. Considering the compound growth rate for garlic, onion showed the highest growth rate at 9.75 and 7.95 percent with positive and significant growth rate. This could be due to increasing demand for this flavour-rich and health-beneficial vegetables and often considered a natural remedy for certain health issues. Examining instability indices, garlic holds the highest instability at 16.79, garlic could be influenced by fluctuating consumer preferences and challenges in maintaining consistent production.

The data in Table 2 illustrates the average productivity levels of different fresh vegetables. Among these, tomato, potato and onion boast the highest average productivity rates, reaching 21.59, 21.56 and 15.88 metric tonnes per hectare due to their relatively short cultivation cycle, high yield per plant, efficient use of space in certain agricultural practices, ability to produce a significant amount of edible biomass per unit area. Compact growth habit and the ability to grow multiple bulbs in a single plant, increasing overall yield per hectare for onion. The compound growth rate for green chilli and garlic showed the highest growth rate at 4.21 and 3.12 percent with positive and significant growth rate due to increased use of spices in various cuisines, and the popularity of dishes, higher demand for this versatile ingredient. Looking at instability indices, garlic presents the highest instability at 14.49, due to factors such as its specific growth requirements, susceptibility to diseases and variations in market demand. Garlic cultivation could be influenced by fluctuating consumer preferences, challenges in maintaining consistent production, and potential disease outbreaks. Similar results were reported by Patil N A and Yeledhalli R A (2016) [6].

Table 1: Growth and instability in area, production and productivity of major fresh fruits in India (2006-07 to 2021-22)

Particulars	Area (000 Ha)	Production (000 MT)	Productivity (MT/Ha)
Banana			
Average	763.25	26,829.81	34.91
CV (%)	19.96	0.23	0.06
CAGR (%)	4.23**	4.87*	0.61*
CDVI	11.29	0.23	0.06
Grapes			
Average	113.28	2,324.02	20.81
CV (%)	26.15	31.68	22.84
CAGR (%)	5.96**	6.36**	0.37*
CDVI	9.67	20.46	23.60
Lemon			
Average	273.33	2,697.79	9.89
CV (%)	15.71	19.99	11.79
CAGR (%)	1.51	3.38**	1.87 **
CDVI	14.83	12.40	8.39
Mango			
Average	2,282.44	17,275.47	7.54
CV (%)	5.31	17.86	18.04
CAGR (%)	0.27*	3.75**	3.61**
CDVI	5.33	5.65	7.03
Oranges			
Average	336.63	3,531.14	9.88
CV (%)	27.73	49.21	25.69
CAGR (%)	6.02**	11.90**	5.52**
CDVI	7.91	11.25	8.65
Pomegranate			
Average	169.21	1,671.56	9.18
CV (%)	66.39	48.96	2.27
CAGR (%)	7.34**	12.27**	4.57**
CDVI	17.33	26.74	13.21
Watermelon			
Average	97.75	2,493.13	25.26
CV (%)	18.65	24.81	6.68
CAGR (%)	5.26**	6.98**	1.63**
CDVI	4.75	5.78	3.44
Other fresh fruits			
Average	711.01	4,893.36	7.58
CV (%)	57.80	50.41	20.45
CAGR (%)	12.33**	9.70**	3.05*
CDVI	26.74	22.25	15.16

Note: **Significant at 5 percent, *Significant at 10 percent

Table 2: Growth and instability in area, production and productivity of major fresh vegetables in India (2006-07 to 2021-22)

Particulars	Area (000 Ha)	Production (000 MT)	Productivity (MT/Ha)
Green Chilli			
Average	766.00	1,554.44	2.03
CV (%)	6.83	22.12	23.90
CAGR (%)	-0.09**	4.14**	4.21**
CDVI	7.06	10.53	11.87
Garlic			
Average	255.73	1,550.54	5.80
CV (%)	29.49	50.66	21.41
CAGR (%)	6.43**	9.75**	3.12*
CDVI	6.96	16.79	14.49
Onion			
Average	1,088.97	17,651.83	15.88
CV (%)	26.37	33.77	11.53
CAGR (%)	5.73**	7.95**	2.09**
CDVI	8.70	9.39	6.69
Potato			
Average	1,938.68	42,194.89	21.56
CV (%)	12.19	20.65	10.44
CAGR (%)	2.47**	4.49**	1.96**
CDVI	5.92	8.57	5.39

Tomato			
Average	752.53	16,447.59	21.59
CV (%)	16.30	25.60	14.33
CAGR (%)	2.55*	5.57**	2.94**
CDVI	12.15	11.54	4.15
Other fresh vegetables			
Average	1,824.93	24,154.25	13.35
CV (%)	21.10	17.74	8.49
CAGR (%)	3.46**	2.10**	1.41*
CDVI	11.64	14.65	5.47

Note: **Significant at 5 percent, *Significant at 10 percent

Conclusion

The results above highlight the varying trends in the growth of area, production and productivity for major fresh fruits and vegetables in India. These trends encompass both positive and negative changes, with a few being statistically significant. Notably, the compound growth rate of fruits productivity exhibited the highest positive trend. Additionally, the instability indices for most crop areas were found to be low, indicating favourable conditions for cultivation in India. To bolster yields of these crops, a targeted approach towards policy-making is necessary. Promoting the adoption of scientific cultivation methods for diverse crops and advocating for sustainable agricultural practices are imperative for enhancing productivity. It's crucial to establish research institutes dedicated to the prominent fruits and vegetables cultivated in India. These endeavours are pivotal for driving agricultural profitability through effective marketing, the incorporation and dissemination of innovative technologies and the facilitation of incentives for on-farm investments.

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