Original Research Article

Growth Dynamics of vegetable crops in Eastern Dry Zone of Karnataka, India:An Economic Analysis

Abstract: The present study was initiated in the Kolar and Chikkaballapur districts of Karnataka with the overall objective of assessing the growth in production and allocation of the area under vegetables in situations. The study was based on time series data collected from the Directorate of Economics and Statistics, Bangalore. Compound Annual Growth Rate and Triennium averages were worked out to examine the trend in area, production and productivity of major vegetable crops. Markov chain analysis was used to examine the dynamic shift in the area, production, and productivity of major vegetable crops for a decade from 2007-08 to 2017-18. The triennium end average of area major vegetable crops in Kolar district for the period TE 2010-11 was 2480.20 ha reduced to 1424.00 ha in TE 2017-18. The productivity of major vegetable crops is increasing to 15134.30 kg/ha from 8830.10 kg/ha (TE 2000-01). The triennium end average of area major vegetable crops in Chikkaballapur district for the period TE 2010-11 was 1085.20 ha increased to 1311.00 ha in TE 2017-18. The productivity of major vegetable crops is increasing to 14422.30 kg/ha from 12166.40 kg/ha (TE 2000-01). The overall growth in the area and productivity of vegetables in Kolar was -7.37 and 8.14 per cent, respectively whereas the overall growth in the area and productivity of vegetables in Chikkaballapur was 4.80 and 1.98 per cent, respectively. Implies growth in the area, production, and productivity showing a decline turn to negative. Whereas, the triennium end average of area for major vegetable crops for the period TE 2017-18 was 124765.7 ha growth of 3.1 per cent and a productivity average of 2165.7 kg/ha with a growth of -0.3 per cent. The tomato and cabbage were the highest retention capacity of 69 per cent equally in both districts. Beans, Brinjal, and Dry chilli have zero retention capacity in the Chikkaballapur district whereas onion, brinjal, and cabbage have zero retention capacity in the Kolar district. i.e these crops lost their 100 per cent area to the other crops. This will be projected by using Markov chain analysis.

Keywords: Compound Annual Growth Rate (CAGR), Triennium Average (TE), Transitional Probability matrix, Markov Chain Analysis.

Introduction

Population in developing countries increasing at an alarming rate. Feeding this population is a challenging task for the world's bodies. The Indian economy depends mainly on agriculture, about 42.39 per cent of India's population directly or indirectly depends on agriculture and allied activities for their livelihoods (Anon, 2018). The agriculture sector plays a vital role in economic development accounting for 17 per cent of the Gross Domestic Product (GDP) in 2017-18 which increased to 19.9 per cent in (2018-19) with a growth rate of 2.9 per cent.

In India, horticulture production has outpaced food grain production since 2012-13, with food grain and horticulture production of 281.37 m tonnes and 314.87m tonnes, respectively in 2018-19. Over the last few years, the contribution of vegetables remained significant to the whole horticulture production (about 59 to 61 %) **(**Anonymous, 2018). Birthal *et al.* (2007) presented evidence of the gradual diversification of Indian agriculture towards high-value crops. Further, the major percentage of the farmers growing fruits and vegetables were under the category of smallholders (Asati and Yadav, 2004; Dry et al., 1999; Nakuja et al., 2012). Agriculture diversification towards fruits and vegetables had consistently increased and the rate of increase was higher during the post-reform period (Belous et al., 2022). It was found that crop yield taken proxy for technology was the major source of growth in agriculture at the national level for the pre-reform period.

However, for the post-reform period output price was the major driver for augmented production (Anonymous, 2008). Rao and Joshi (2009) reported that expanding urbanization together with higher economic growth and changes in tastes and preferences are causing shifts in the food basket in favour of high-value food commodities like fruits, vegetables, milk, meat, egg and fish. This change in the food basket is driving the agricultural production portfolio away from food grains and towards high-valued food commodities. This process is likely to continue as the trends in the factors underlying this process have been quite strong in the recent past, and are unlikely to subside shortly.

Vegetables are one of the important aspects of the horticulture sector of India and the agricultural sector of India in general. Vegetables are considered in dietary guidelines of the human diet, due to their nutritional value. The regular use of vegetables provides dietary fibre,

micronutrients such as vitamins and minerals, electrolytes and phytochemicals especially antioxidants. According to the Dietary guidelines of the National Institute of Nutrition, the daily requirement of other vegetables is 200g. To uplift the quality of the diet of people and to ensure availability, it is essential to increase the production of vegetables in the country. This objective can be overcome by increasing the yield per unit area by using new and advanced production technology.

Vanitha *et al.* (2013) reported a phenomenal increase in vegetable area by about 3 folds, production by 9 folds and productivity by 3 folds in the country for the past 6 decades. Un-even growth between the states was observed for the vegetable areas as well as production. Increases in per capita income, urbanization, health consciousness, complimentary income elasticity for vegetables and diversification of agriculture production towards high-value crops were some of the contributing factors to increased vegetable growth in the country.

Karnataka is one of the major vegetable-growing State contributes about five per cent to the total country's production. As the state is the epitome of the diversified agro-climatic zones of India, it has diversity in the range of vegetables grown and the disparity between the districts in their production. Some vegetables are occupying more areas than others. However, for better nutritional status and agricultural growth, it is crucial to balance the production of different vegetables. Hence predicting the area change of different vegetables is needed to design the required policies. Hence the study was carried out to understand the pattern of change in area under different vegetables in Karnataka.

In Karnataka, Kolar district though termed a backward industrial district, has made considerable progress in the horticultural sector. The District comprise five taluks namely, Bangarpet, Kolar, Malur, Mulbagal, and Srinivasapura. The total horticulture area is 1,06,262 hectares which comprises 46.07 per cent of the total cultivable area of the district. It has great potential for vegetable cultivation due to its proximity to the metropolitan city of Bangalore since it provides an international market for vegetables. Demand is always high due to the higher population density in urban areas and the high income of the people residing in these areas

Materials and Methods

The study was undertaken to examine dynamic changes in the area under major vegetable crops in Kolar and Chikkaballapur districts. Secondary data on the production area of major vegetable crops ranging from 1997-98 to 2017-18 was utilized to analyze dynamic changes in the

area. The data was collected from the Directorate of Economics and Statistics. The principal crops under the present study were potato, onion, tomato, beans, brinjal, cabbage, and dry chill. The data was segregated into decades to examine the dynamic changes in the production of vegetable crops. Compound annual growth rate and triennium average were employed to examine the basic statistical properties of the data. The dynamics of production in the area of major principal major vegetable crops under study were analyzed using Markov chain analysis to examine the retention capacity of these major vegetable crops over the years. The detailed expression of the statistical methodology adopted for the study is given in the next section

Analytical tools

(a) Compound Annual Growth Rate

Compound growth rates of production areas were estimated to study the growth in vegetable crop groups under study. Growth rates of production area were obtained from exponential function as follows:

$Y = ab^t$

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

CAGR (%) = (Antilog b – 1) *100

where, CAGR = Compound growth rate; t = Time period in year; y =Area/ production / productivity; a & b =Regression parameters

(b) Triennium Average: a specified period of three years average. Calculated for the major vegetable crops using simple tabular calculations.

(c) Markov Chain Technique:

Markov chain analysis was used to examine the dynamic shift in production area under major vegetable crops in the Kolar and Chikkaballapur districts of Karnataka. The Markov chain approach is based on less stringent assumptions and provides more information than the regression approach (Matis, 1985). If the probability distribution of assigning agriculture land to one of the food grain crops in any period depends on distribution in the previous period and the dependencies are more or less the same for all periods, the process of structural change could be represented by a stationary first-order Markov chain. It should be noted that this technique assumes the Markov property to forecast the area distribution. Since the predictions are not constrained by any *prior* specification of distribution, this procedure is non-parametric (Matis, 1985).

In addition, the transition probabilities have been estimated with the assumption of constancy, *i.e.*, all the forces which influenced agricultural structural change in the past will continue to do so in the future (Gaffney, 1992).

A stochastic matrix with the probability, A_{ij} of movement of the area under a given food grain i in period t to another food gain group j in period $t + 1$ is called transition probability matrix (TPM). The TPM is expressed as

$$P = \begin{bmatrix} A_{ij} & \cdots & A_{is} \\ \vdots & \ddots & \vdots \\ A_{ij} & \cdots & A_{ss} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $\sum_j A_{ij} \geq 0$ and $\sum_j A_{ij} = 1$

Here P is a square matrix ($n \times n$), with n being the total number of grains which is a total number of individual crops. Each element (A_{ij}) represents the probability of moving from one crop i another j.

Let F denotes the final probability matrix for each state through finite Markov chain theory

$$F = \begin{bmatrix} \prod_{i=1}^{s-1} A_{i,i+1} \\ \prod_{i=2}^{s-1} A_{i,i+1} \\ \prod_{i=3}^{s-1} A_{i,i+1} \\ \vdots \\ A_{ss} \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In addition, the transition probabilities have been estimated with the assumption of constancy, *i.e.*, all the forces which influenced agricultural structural change in the past will continue to do so in the future (Gaffney, 1992).

A stochastic matrix with the probability, A_{ij} of movement of the area under a given food grain i in period t to another food gain group j in period $t + 1$ is called a transition probability matrix (TPM). The TPM is expressed as

Finally, this matrix may be reduced as below: The F matrix can be used to protect the area under selected food grain crops. Since the single value projections are less realistic and do

not reveal the uncertainty of projections, the complete distribution of projected value is more appropriate. Hence, a Markov chain simulation of the transition probability on the assumption ta hat a 100 per cent probability shifts in the transitional matrix. Thereby, a Projection for the area of selected major vegetable crops in the next five years has been made by forecasting the transitional probabilities.

Results and Discussion

The triennium end average of area, production and productivity of vegetable crops in the Kolar district (Table.1) was calculated for a decade from (2008-09 to 2017-18). The average area, production and productivity of vegetable crops during TE 2010-11 was 2480.19 ha, 23269.05 tonnes, and 8830.14 kgs/ha which is reduced by 1423.95 ha, 22016.43 tonnes and 15134.33 kgs/ha in (TE 2017-18). This revealed that a negative trend in the production of vegetable crops was found in the study area.

The triennium end average of area, production and productivity of vegetable crops in the Chikkaballapur district (Table 1) was calculated for a decade from (2007-08 to 2017-18). The average area, production and productivity of vegetable crops during TE 2010-11 was 1085.62 ha, 12800.43 tonnes, and 12166.38 kgs/ha which is increased by 1310.95 ha, 20538.24 tonnes and 14423.95 kgs/ha in (TE 2017-18). This revealed that a positive trend in the production of vegetable crops was found in the study area.

This is mainly due to the bifurcation of Chikkaballapur from the Kolar district withdrawn area under vegetable crops. This might be due to vegetable crops losing their area for other crops like horticulture and commercial crops as farmers moved out from consumption-oriented towards market-oriented mainly to undertake income-generating operations. Which led to an increase in their per capita income by shifting the traditional form of self-sufficiency in the production of food grains to the production of modern market-oriented commodities. One more reason for the decline in the area under food grain is before 2007 Chikkaballapur taluk was under the Kolar district which was bifurcated as a separate district on 7th August 2007, therefore, the area under vegetable crops declined drastically.

Table 1:

Triennium End Average on Area, Production and Yield of Vegetables in Chikkaballapur and Kolar districts

Particulars		Chikkaballapur		Kolar	
		TE 2010-11	TE 2017-18	TE 2010-11	TE 2017-18
Potato	Area (Ha)	1452.3	2519.3	5349.0	2935.7
	Production (Tones)	19691.7	42453.0	66832.7	46588.7
	Yield (Kg/Ha)	15365.0	17603.0	12812.3	16736.0
Onion	Area (Ha)	780.0	1256.3	402.0	249.0
	Production (Tones)	5220.0	12295.7	2590.3	2253.3
	Yield (Kg/Ha)	6956.7	10437.3	6582.3	9429.3
Tomato	Area (Ha)	3430.3	2789.7	7646.3	4871.0
	Production (Tones)	42071.7	53323.0	70512.7	83532.0
	Yield (Kg/Ha)	11049.7	20142.3	9076.0	17106.7
Beans	Area (Ha)	782.3	753.7	1635.0	735.0
	Production (Tones)	8612.3	7731.7	11366.0	8951.3
	Yield (Kg/Ha)	11204.3	10241.3	6975.7	12093.7
Brinjal	Area (Ha)	391.7	585.3	306.0	174.7
	Production (Tones)	8785.0	7980.3	2593.0	2194.0
	Yield (Kg/Ha)	22573.0	13630.3	8383.7	12573.3
Cabbage	Area (Ha)	243.0	653.0	391.0	252.3
	Production (Tones)	3923.3	18861.0	6383.7	9234.0
	Yield (Kg/Ha)	15856.3	27003.7	16293.7	36051.7
Dry Chilli	Area (Ha)	519.7	619.3	1632.0	750.0
	Production (Tones)	1299.0	1123.0	2605.0	1361.7
	Yield (Kg/Ha)	2159.7	1909.7	1687.3	1949.7

Average	Area (Ha)	1085.2	1311.0	2480.2	1424.0
	Production (Tones)	12800.3	20538.2	23269.1	22016.4
	Yield (Kg/Ha)	12166.4	14424.0	8830.1	15134.3

Note: TE – Triennium ending
Source: Directorate of Economics and Statistics

Table 2:

The trend in Area, Production and Yield of Vegetables in Chikkaballapur District from 2008-09 to 2017-18

Particulars		**Kolar**		**Chikkaballapur**		**'t' Test**	**CAGR (%)**	
		Mean	**SD**	**Mean**	**SD**		**Kolar**	**Chikkaballapur**
Potato	Area	3521	1548	2212	1143		-8.46	9.81
	Production	53318	23559	26385	13469		-5.01	12.58
	Yield	14880	6034	12455	5810		3.77	2.53
Onion	Area	276	120	1001	407		-6.30	7.99
	Production	1921	1012	7966	4570		-0.97	14.18
	Yield	6722	3195	7519	3622		5.68	5.73
Tomato	Area	5408	2107	2545	1460		-5.62	0.37
	Production	69673	25454	35350	24833		2.87	7.71
	Yield	12174	4970	12489	7093		8.99	7.31
Beans	Area	1105	503	840	409		-10.83	0.66
	Production	11013	4713	8377	3607		-3.49	-0.63
	Yield	9544	3883	9306	3279		8.23	-1.28
Brinjal	Area	223	91	479	176		-7.58	5.68
	Production	2665	1255	7576	2884		-1.93	-3.08
	Yield	11032	4660	15002	6598		6.11	-8.28

Cabbage	Area	298	111	441	226		-5.88	16.74
	Production	7375	3395	8648	8401		5.91	24.17
	Yield	23822	13074	16211	10043		12.53	6.36
Dry Chilli	Area	976	480	503	243		-10.20	2.40
	Production	1572	756	909	830		-7.95	8.32
	Yield	1569	559	1689	1154		2.51	5.78
Overall Growth rate	Area						-7.37	4.80
	Production						-0.75	9.07
	Yield						8.14	1.98

Source: Directorate of Economics and Statistics

The group of seven vegetable crops which are Potato, Onion, Tomato, Beans, Brinjal, Cabbage, and Dry chilli were mainly growing in the study area Table 3. Among these, cabbages had the highest retention capacity (69 %) followed by potato (36 %), tomato (27 %), onion (13 %), and Dry chill and Brinjal (0 %), respectively. This is mainly due to the shifting of area for the production of horticulture and commercial crops to enhance the income of the farmers in dryland areas. Therefore, farmers are undertaking allied activities with agriculture operations mainly to increase their income. The crops with zero retention capacity are dry chilli and brinjal since these crops lost 100 per cent area to tomato crops because Kolar and Chikkaballapur districts are having the highest area under tomato particularly because of the adaptability of that crop in the study area. Since potato is traditionally cultivated based on market demand in the study area, it gained area from crops like an onion (62 %), beans (36 %) and tomato (24 %), respectively. As like onion gained area from potato (20 %) and tomato (19 %), tomato gained 100 cent area from brinjal and dry chilli, beans (47 %), and onion (23 %), and beans gained from potato (27 %), respectively. Whereas other crops gained meagerly. Since others, vegetables are brinjal, cabbage and dry chilli crops, which are highly not suitable under dryland conditions. Thereby over the years, the retention capacity of irrigated vegetables is decreasing as those crops need much water for their cultivation. In the study area due to a trend of shortage of water sources and receiving

less rainfall all farmers are moving towards water-use efficiency technologies as well as shifting their cultivation methods from traditional agriculture to commercial or modern agriculture.

Table 3:

Transitional Probability matrix of Vegetable crops from 2008 to 2017 in Chikkaballapur

Crops	Potato	Onion	Tomato	Beans	Brinjal	Cabbage	Dry Chilli
Potato	0.36	0.20	0.00	0.27	0.14	0.04	0.00
Onion	0.62	0.13	0.23	0.00	0.02	0.00	0.00
Tomato	0.24	0.19	0.27	0.08	0.06	0.05	0.11
Beans	0.36	0.00	0.47	0.00	0.00	0.00	0.17
Brinjal	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Cabbage	0.00	0.00	0.00	0.00	0.00	0.69	0.31
Dry Chilli	0.00	0.00	1.00	0.00	0.00	0.00	0.00

Source: Directorate of Economics and Statistics

The projected average area and growth rate of vegetable crops in the Chikkaballapur district for the period from 2022-23 to 2025-26 is depicted in Table 4. The projected average area under vegetable crops in 2022 is 1857.77 ha with a growth rate of 5.87 % and it is likely to increase to 1883.31 ha with a growth rate of 5.90 % in 2026. Since onion has the highest average area and growth rate with 1904.06 ha (5.72 %) followed by potato with 1897.46 ha (5.82 %), Beans with 1888.31 ha (5.73 %), brinjal and dry chilli constituted equally with 1879.70 ha (5.73 %), tomato with 1870.57 (5.79 %) and cabbage with 1684.60 (6.57 %), respectively in the year 2022 and the projected average area under vegetables and growth rate, the potato has the highest average area and growth rate with 1909.27 ha (5.94 %) followed by onion with 1898.08 ha (5.89 %), Beans with 1887.59 ha (5.85 %), tomato with 1887.36 (5.88 %) brinjal and dry chilli constituted equally with 1883.23 ha (5.86 %), and cabbage with 1834.29 (5.99 %), respectively in the year 2026. These projections gave a clear picture that vegetables have more scope to gain area

for cultivation. This revealed that vegetable crops will gain area from the other crops, indicating that vegetable crops will have more scope in production in near future. Thereby, it should be noted that the production of vegetable crops is equally important as the production of other crops. Therefore, these projections may help the farmers in taking the production of vegetable crops.

Table 4:

Predicated Area (Ha) and Growth rate (%) of vegetables in Chikkaballapur District from 2022 to 26

Crops/Ye	2022		2023		2024		2025		2026	
	Area	CAGR	Area	CAGR	Area	CAGR	Area	CAGR	Area	CAGR
Potato	1897.46	5.82	1904.11	5.86	1904.68	5.90	1907.68	5.91	1909.2	5.94
Onion	1904.06	5.72	1892.09	5.80	1896.03	5.83	1893.98	5.85	1898.0	5.89
Tomato	1870.57	5.79	1876.4	5.80	1879.98	5.84	1883.28	5.86	1887.3	5.88
Beans	1888.31	5.73	1880.6	5.79	1886.08	5.82	1887.05	5.85	1887.5	5.85
Brinjal	1879.70	5.73	1870.57	5.79	1876.4	5.8	1879.98	5.84	1883.2	5.86
Cabbage	1684.60	6.57	1746.68	6.31	1785.33	6.15	1812.73	6.04	1834.2	5.99
Dry Chilli	1879.70	5.73	1870.57	5.79	1876.4	5.80	1879.98	5.84	1883.2	5.86
Average	**1857.77**	**5.87**	**1863.00**	**5.88**	**1872.13**	**5.88**	**1877.81**	**5.88**	**1883.3**	**5.90**

Source: Directorate of Economics and Statistics

As Kolar and Chikkaballapur are highly diversified crops under cultivation. Vegetables occupy a significant share of the area under the production of vegetables. Among vegetables, a

group of seven vegetable crops which are Potato, Onion, Tomato, Beans, Brinjal, Cabbage, and Dry chilli were mainly growing in the Kolar district. The retention capacity of vegetables is depicted in Table 5. Among them, tomatoes had the highest retention capacity (69 %) followed by dry chilli (46 %), potato (43 %), and Beans (3 %), respectively. This is mainly due to the tomato having refacing area from other crops as this crop cultivation is highest in the study area. Thereby, farmers shift of area for the production of vegetables, horticulture as well as commercial crops to enhance their income of the farmer. The crops with zero retention capacity are cabbage and brinjal. Since the cabbage crop has lost 100 per cent of the area to potato crops because Kolar district is the hub of vegetable production, among all the vegetables potato and tomato had the highest area under production due to their adaptability and the brinjal crop lost its major area to beans (62 %), cabbage (36 %) and dry chilli (2 %), respectively. Since potato is traditionally a growing crop as it has more market demand due to their consumption all over the country. Hence, it gained 100 % area from cabbage followed by beans (94 %), dry chilli (54 %), and onion (39 %). In Kolar, Tomato has a typical composition having a large share of its area under cultivation and it gained area from potato (50 %), Beans gained from brinjal (62 %), onion (60 %) and tomato (15 %) and cabbage gained area from brinjal (36 %) and tomato (4 %). Other crops like onion, brinjal and dry chilli are losing their area for other crops but they gained meagerly from other crops. Since others, vegetables are brinjal, cabbage and dry chilli crops, which are highly not suitable under dryland conditions. Thereby over the years, the retention capacity of irrigated vegetables is decreasing as those crops need much water for their cultivation. In the study area due to a trend of shortage of water sources and receiving less rainfall all farmers are moving towards water-use efficiency technologies as well as shifting their cultivation methods from traditional agriculture to commercial or modern agriculture.

Table 5:

Transitional Probability matrix of Vegetable crops from 2008 to 2017 in Kolar

Crops	Potato	Onion	Tomato	Beans	Brinjal	Cabbage	Dry Chilli
Potato	0.43	0.00	0.50	0.00	0.00	0.00	0.07
Onion	0.39	0.00	0.00	0.60	0.01	0.00	0.00

Tomato	0.00	0.05	0.69	0.15	0.03	0.04	0.04
Beans	0.94	0.00	0.00	0.03	0.03	0.00	0.00
Brinjal	0.00	0.00	0.00	0.62	0.00	0.36	0.02
Cabbage	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry Chilli	0.54	0.00	0.00	0.00	0.00	0.00	0.46

Source: Directorate of Economics and Statistics

The projected average area and growth rate of vegetable crops in the Kolar district for the period from 2022-23 to 2025-26 is depicted in Table 6. The projected average area under vegetable crops in 2022 is 3098.24 ha with a growth rate of -7.36 % and it is likely to increase to 3102.99 ha with a growth rate of -7.36 % in 2026. Since brinjal has the highest average area and growth rate with 3149.10 ha (-7.3%) followed by tomato with 3124.00 ha (-7.3 %), onion with 3118.50 ha (-7.3 %), potato with 3084.80 (-7.4), beans with 3076.40 ha (-7.4), dry chilli with 3069.00 ha (-7.4 %), and cabbage with 3065.90 (-7.4 %), respectively in the year 2022 and the projected average area under vegetables and growth rate, the potato has the highest average area and growth rate with 3105.60 ha (-7.4 %) followed by onion with 3104.90 ha (-7.4 %), Brinjal with 3104.60 ha (-7.3 %), beans and cabbage constituted equally with 3102.80 ha (-7.3 %), dry chilli with 3100.30 (-7.4) and tomato with 3099.90 (-7.4 %), respectively in the year 2026. These projections gave a clear picture that vegetables have more scope to gain area for cultivation. This revealed that vegetable crops will gain area from the other crops, indicating that vegetable crops will have more scope in production in near future. Thereby, it should be noted that the production of vegetable crops is equally important as the production of other crops. Therefore, these projections may help the farmers in taking the production of vegetable crops**.**

Table 6: Predicated Area (Ha) and Growth rate (%) of vegetables in Kolar District from 2022 to 26

Crops/Year	2022		2023		2024		2025		2026	
	Area	CAGR	Area	CAGR	Area	CAGR	Area	CAGR	Area	CAGR
Potato	3084.8	-7.4	3100.4	-7.4	3109.6	-7.4	3102.8	-7.3	3105.6	-7.4
Onion	3118.5	-7.3	3078.9	-7.4	3094.0	-7.4	3104.0	-7.4	3104.9	-7.4
Tomato	3124.0	-7.3	3112.0	-7.3	3101.3	-7.3	3100.6	-7.4	3099.9	-7.4
Beans	3076.4	-7.4	3086.1	-7.4	3101.1	-7.4	3104.6	-7.3	3102.8	-7.3
Brinjal	3149.1	-7.3	3073.5	-7.4	3082.6	-7.4	3100.4	-7.4	3104.6	-7.3
Cabbage	3065.9	-7.4	3084.8	-7.4	3100.4	-7.4	3109.6	-7.4	3102.8	-7.3
Dry Chilli	3069.0	-7.4	3078.8	-7.4	3091.1	-7.4	3097.5	-7.4	3100.3	-7.4
Average	3098.24	-7.36	3087.79	-7.39	3097.16	-7.39	3102.79	-7.37	3102.99	-7.36

Source: Directorate of Economics and Statistics

Conclusion

Akin to other high-value crops, the area under production of vegetables is also increasing over time. Nevertheless, there exists inequality in growth rates within the vegetable group. Hence the objective of this study is to understand the pattern of area allocation for vegetables and project areas under different vegetables in future. Time series data of area for all vegetable crops, district-wise and state total was used for the analysis.

Markov chain approach produces the forecast of the target variable, *i.e., the* area under production of different vegetables, using historical data with an assumption of Markov property. To sum up, the area under all the vegetables is projected to have exhibited an increasing or constant trend except for potatoes and leafy vegetables. Potato would decline drastically, an increase in the area of one vegetable to the others indicates the unbalanced growth within the vegetable group.

This imbalance in area change could be detrimental to nutritional security which dampens the diversity in food consumption and increases import dependency on vegetables. To avoid imbalance in vegetable area and production, the government should intervene for the uniform production of all vegetables to achieve nutritional security and also to avoid the adverse effect on it the economy.

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