



## Research Article

# CHANGING DIRECTION IN AREA OF MAJOR FRUIT CROPS IN DHARWAD DISTRICT OF NORTHERN KARNATAKA

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**Abstract-** This study quantifies the direction of structural changes in area of major fruit crops. The markov chain analysis was attempted through linear programming method to assess the transition probabilities for major fruit crops. The results revealed that mango crop showed highest retention of area (99.23 %) in Dharwad taluk. In Hubli taluk also mango crop showed highest retention of area (86.44%). In Navalgund taluk, guava crop showed highest retention of area (93.69 %). In Kalghatagi taluk also guava crop showed highest retention of area (88.42%). In Kundgol taluk, sapota crop showed highest retention of area (86.95%).

**Keywords-** Markov chain analysis, retention

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## Introduction

mango belongs to the species *Mangifera indica* L., which is the most important member of the family Anacardiaceae. The mango is said to have originated in the Indo-Burma region.

According to the Horticultural Statistics at a Glance-2015[1], mango is now being produced commercially in a number of countries such as China, Thailand, Indonesia, Mexico, Pakistan, Brazil, Bangladesh, Nigeria and Egypt in addition to India. In India, mango is commercially grown in Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat, Tamil Nadu, Maharashtra, West Bengal, Orissa and Kerala.

Guava (*Psidium guajava*), belongs to family Myrtaceae. According to the Horticultural Statistics at a Glance-2015[2], guava is now being produced commercially in a number of countries such as China, Thailand, Indonesia, Mexico, Pakistan, Brazil, Bangladesh, Nigeria and Egypt in addition to India. In India, guava cultivated commercially in states like Uttar Pradesh, Maharashtra, Madhya Pradesh, Bihar, West Bengal, Punjab, Gujarat, Andhra Pradesh, Karnataka, Orissa and Tamil Nadu. Sapota belongs to the family Sapotaceae. Its botanical name is *Achras zapota*. According to the Horticultural Statistics at a Glance-2015 [3], Sapota is now being cultivated commercially in a number of countries such as Mexico, Central America, West Indies, Philippines and Malaysia in addition to India. In India, sapota is cultivated commercially in states like Karnataka, Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, West Bengal and Orissa.

This study attempts to quantify the direction of structural changes in area under major fruit crops in Dharwad district of Northern Karnataka so as to understand the dynamics of the changes.

## Materials and Methods

This study is based on secondary data. The time series data pertaining to the area of major fruit crops such as mango, guava and sapota for the period of 20 years. The Markov process was used to study the direction of structural change in area

under major fruit crops. The shifts in the shares of fruit crops thereby gain in understanding about the dynamics of the changes.

## The Markov probability model

A finite Markov process is a stochastic process whereby the outcome of a given trial  $t$  ( $t=1, 2, \dots, T$ ) depends only on the outcome of the preceding trial ( $t-1$ ) and this dependence is the same at all stage in the sequence of trials. Consistent with this definition, let  $S_i$  = be the  $i^{\text{th}}$  state of  $r$  possible outcomes;  $i=1, 2, \dots, r$ ,  $W_{it}$  = be the probability that state  $S_i$  occurs on trial  $t$  or the proportion observed in trial  $t$  in alternate outcome state  $l$  of the multinomial population based on a sample of size  $n$ , i.e.  $\Pr(S_{it})$ ,  $P_{ij}$  = Represent the transitional probability which denotes the probability that if for any time  $t$  the process is in state  $S_i$ , it moves on next trial to state  $S_j$ , i.e.,  $\Pr(S_{j,t+1}|S_{it}) = P_{ij}$   $P = (P_{ij})$  = Represent the transitional probability matrix which denotes the transitional probability for every pair of states ( $i, j=1, 2, \dots, r$ ), and has the following properties.

$$0 \leq P_{ij} \leq 1, \quad [1]$$

and

$$\sum_j P_{ij} = 1, \text{ for } i=1, 2, \dots, r \quad [2]$$

Given this set of notations and definitions for a first order Markov chain, the probability of a particular sequence  $S_i$  on trial  $t$  and  $S_j$  on trial  $t+1$  may be represented by

$$\Pr(S_{it}, S_{j,t+1}) = \Pr(S_{it}) \Pr(S_{j,t+1}|S_{it}) = W_{it} P_{ij} \quad [3]$$

and the probability of being in state  $j$  at trial  $t+1$  may be represented by,

$$\Pr(S_{j,t+1}) = \sum_i W_{it} = P_j \text{ or } W_j, t+1 = \sum_i W_{it} P_{ij} \quad [4]$$

The data for the study are the proportion of area under major fruit crops such as mango, guava and sapota. The proportions change from year to year as a result

of different factors. If these assumptions are acceptable, then the process of direction of structural change of major fruit crops such as mango, guava and sapota. Direction of structural change may describe in the form of a matrix P of first order transition probabilities. The element  $P_{ij}$  of the matrix indicates the probability of a farmer in fruit crop category  $i$  in one period will move to fruit crop category  $j$  during the following period. The diagonal element  $P_{ij}$  measures the probability that the proportion share of  $i^{th}$  category of fruit crop will be retained.

The transition probability matrix was estimated using the Minimum Absolute Deviation (MAD) estimator. The elements  $P_{ij}$  of the matrix are the conditional probabilities of the area under a particular fruit crop category in time  $t$  given its share in time  $t-1$ . The diagonal elements  $P_{ij}$  ( $i=j$ ) indicate the extent of stability of fruit crop categories. Hence, as the diagonal elements approach zero, area under a particular fruit crop become less and less stable, and as they approach one, the fruit crop categories tend to exhibit more and more stability over time. The off-diagonal elements  $P_{ij}$  ( $i \neq j$ ) are the probabilities of switching over between different fruit crop categories. If  $P_{ij}$  is the diagonal element corresponding to the  $i^{th}$  fruit crop category, the other elements in the  $i^{th}$  row give the proportions of previous period's area of  $i^{th}$  fruit crop category it is likely to loose to other categories in the current period. The elements of the  $i^{th}$  column gives the proportions of areas of other fruit crop categories in the previous period the  $i^{th}$  fruit crop category is likely to gain in the current period.

**Estimation of transition probability matrix**

Equation (4) can be used as a base for specifying the statistical model for estimation the transition probabilities. If errors are incorporated in equation (4) to account for the difference between the actual and estimated occurrence of  $W_{jt(t+1)}$ , the sample observations may be assumed to be generated by the following linear statistical model

$$W_{jt} = \sum_j W_{jt} W_{t-1} P_{ij} + U_{jt} \tag{5}$$

Or in matrix form it can be written as

$$Y_j = X_j P_j + U_j \tag{6}$$

Where,  $Y_j$  is a  $(T \times 1)$  vectors of observations reflecting the proportion in fruit crop in time  $t$ ,  $X_j$  is a  $(T \times r)$  matrix of realized values of the proportion in fruit crop  $l$  in time  $t-1$ ,  $P_j$  is a  $(r \times 1)$  vector of unknown transition parameters to be estimated and  $U_j$  is a vector of random disturbances.

**The minimum absolute deviations estimator**

A method to derive parameter estimates when equality or inequality restrictions are present is to make use of Minimum Absolute Deviations (MAD) estimator. If we employ this method in obtaining estimates of the transition probabilities, our problem may be specified as follows:

To find a vector P which minimizes

$$|Y - XP| \leq E \tag{7}$$

Subject to  
 $Y = XP + u; \tag{8}$

$$RP = e; \tag{9}$$

$$P \geq 0 \tag{10}$$

Where E is a unit vector of order  $(r \times 1)$ . In order to solve the above LP problem, non-negative variables are introduced for u such that

$$U = \theta - p \tag{11}$$

Where,

$$\theta = [\theta]_t = [\theta_{11}, \theta_{12}, \dots, \theta_{1r}, \theta_{21}, \dots, \theta_{r1}] \geq 0 \tag{12}$$

and

$$p = [p]_t = [p_{11}, p_{12}, \dots, p_{1r}, p_{21}, \dots, p_{r1}] \geq 0 \tag{13}$$

By redefining u in this way, the LP problem may be transformed to the following form.

To minimize:

$$(\theta + p)' E \tag{14}$$

Subject to

$$Y = XP + u = \begin{bmatrix} XP \\ u \end{bmatrix} = [I, -I] \tag{15}$$

$$RP = e \text{ and} \tag{16}$$

$$P, \theta, p \geq 0 \tag{17}$$

**Projections**

After estimating transition probability matrix (P), proportion of area under fruit crop categories can be predicted using the following equation:

$$Y'_{(t)} = Y'_{(0)} P^t \tag{18}$$

Where,

$Y_t = (r \times 1)$  vector of proportion of area under fruit crop categories in year  $t$ ,

$Y_0 = (r \times 1)$  vector of proportion of area under fruit crop categories in year 0,

$P^t = (r \times r)$  transition probability matrix to the power of time (t) and  $Y'_{(t)}$  and  $Y'_{(0)}$  are transpose of vector  $Y_{(t)}$  and  $Y_{(0)}$  respectively.

**Results**

The results of the transition probability matrix for major fruit crops in Dharwad district are presented in [Table-1 to 5]. The Taluks considered in the study were Dharwad, Hubli, Navalgund, Kalghatagi and Kundgol.

It can be inferred from the [Table-1] that in period 1991-2010, in Dharwad taluk, mango had retained 99.23 per cent of its previous years' share of area and lost about 0.05 per cent of its previous years' share to guava and 0.72 per cent to sapota. However, it gained about 4.78 per cent area from guava and 7.29 per cent from sapota. While guava retained 95.22 per cent of its previous years' share of area and it has lost 4.78 per cent to mango. But it gained its share of 0.05 per cent from mango. While sapota retained 92.71 per cent of its previous years' share of area and it has lost 7.29 per cent to mango. But it gained its share of 0.72 per cent from mango.

**Table-1** Transitional probability matrix for major fruit crops in Dharwad taluk (1991-2010)

Fruits	Mango	Guava	Sapota
Mango	0.9923	0.0005	0.0072
Guava	0.0478	0.9522	0.0000
Sapota	0.0729	0.0000	0.9271

It can be inferred from the [Table-2] that in period 1991-2010, in Hubli taluk, mango had retained 86.44 per cent of its previous years' share of area and lost about 2.47 per cent of its previous years' share of area to guava and 11.09 per cent to sapota. However, it gained about 15.6 per cent area from sapota. While guava retained 84.15 per cent of its previous years' share of area and it has lost 15.85 per cent to sapota. But it gained its share of 2.47 per cent from mango and 8.28 per cent from sapota. While sapota retained 76.12 per cent of its previous years' share of area and it has lost 15.6 per cent to mango and 8.28 per cent to

guava. But it gained its share of 11.09 per cent from mango and 15.85 per cent from guava.

It can be inferred from the [Table-3] that in period 1991-2010, in Navalgund taluk, mango had retained 83.81 per cent of its previous years' share of area and lost about 16.19 per cent of its previous years' share of area to guava. While guava retained 93.69 per cent of its previous years' share of area and it has lost 6.31 per cent to sapota. But it gained its share of 16.19 per cent from mango and 35.01 per cent from sapota. While sapota retained 64.99 per cent of its previous years' share of area and it has lost 35.01 per cent to guava. But it gained its share of 6.31 per cent from guava.

**Table-2** Transitional probability matrix for major fruit crops in Hubli taluk (1991-2010)

Fruits	Mango	Guava	Sapota
Mango	0.8644	0.0247	0.1109
Guava	0.0000	0.8415	0.1585
Sapota	0.1560	0.0828	0.7612

**Table-3** Transitional probability matrix for major fruit crops in Navalgund taluk(1991-2010)

Fruits	Mango	Guava	Sapota
Mango	<b>0.8381</b>	0.1619	0.0000
Guava	0.0000	<b>0.9369</b>	0.0631
Sapota	0.0000	0.3501	<b>0.6499</b>

It can be inferred from the [Table-4] that in period 1991-2010, in Kalghatagi taluk, mango had retained 87.41 per cent of its previous years' share of area and lost about 0.81 per cent of its previous years' share of area to guava and 11.78 per cent to sapota. However, it gained about 11.58 per cent area from guava and 18.69 per cent from sapota. While guava retained 88.42 per cent of its previous years' share of area and it has lost 11.58 per cent to mango. But it gained its share of 0.81 per cent from mango. While sapota retained 81.31 per cent of its previous years' share of area and it has lost 18.69 per cent of area to mango. But it gained its share of 11.78 per cent from mango.

**Table-4** Transitional probability matrix for major fruit crops in Kalghatagi taluk (1991-2010)

Fruits	Mango	Guava	Sapota
Mango	<b>0.8741</b>	0.0081	0.1178
Guava	0.1158	<b>0.8842</b>	0.0000
Sapota	0.1869	0.0000	<b>0.8131</b>

It can be inferred from the [Table-5] that in period 1991-2010, in Kundgol taluk, mango had retained 85.60 per cent of its previous years' share of area and lost about 2.61 per cent of its previous years' share to guava and 11.8 per cent to sapota. However, it gained about 44.35 per cent area from guava and 13.05 per cent from sapota. While guava retained 55.65 per cent of its previous years' share of area and it has lost 44.35 per cent to mango. But it gained its share of 2.61 per cent from mango. While sapota retained 86.95 per cent of its previous years' share and it has lost 13.05 per cent to mango. But it gained its share of 11.8 per cent from mango.

**Table-5** Transitional probability matrix for major fruit crops in Kundgol taluk (1991-2010)

Fruits	Mango	Guava	Sapota
Mango	<b>0.8560</b>	0.0261	0.1180
Guava	0.4435	<b>0.5565</b>	0.0000
Sapota	0.1305	0.0000	<b>0.8695</b>

It was evident from the [Table-6] that the area under Dharwad taluk in guava is

likely to lose its share in total area cultivated. Mango and sapota are likely to increase their share in total area cultivated.

It was evident from the [Table-7] that the area under guava in Hubli taluk is likely to lose its share in total area cultivated, while acreage in mango and sapota are likely to increase over the years.

It was evident from the [Table-8] that the area under mango and sapota in Navalgund taluk are likely to increase their share in total area cultivated. Guava is likely to lose its share in total area cultivated.

**Table-6** Projected shares of area under major fruit crops in Dharwad taluk (Per cent)

Crops Year	Mango	Guava	Sapota
2012-13	87.14	1.74	11.11
2017-18	87.29	1.00	11.71
2022-23	87.41	0.44	12.16
2027-28	87.50	0.56	12.52

**Table-7** Projected shares of area under major fruit crops in Hubli taluk (Per cent)

Crops Year	Mango	Guava	Sapota
2012-13	45.63	17.01	37.35
2017-18	49.28	12.76	37.96
2022-23	52.93	8.50	38.58
2027-28	56.58	4.24	39.19

**Table-8** Projected shares of area under major fruit crops in Navalgund taluk (Per cent)

Crops Year	Mango	Guava	Sapota
2012-13	0.41	81.52	18.07
2017-18	0.42	81.39	18.19
2022-23	0.42	81.31	18.27
2027-28	0.42	81.25	18.33

It was evident from the [Table-9] that the area under major fruit crops such as mango, guava and sapota in Kalghatagi taluk are likely to increase their share in total area cultivated.

**Table-9** Projected shares of area under major fruit crops in Kalghatagi taluk (Per cent)

Crops Year	Mango	Guava	Sapota
2012-13	64.25	4.44	43.29
2017-18	66.74	3.97	48.75
2022-23	69.22	5.07	54.20
2027-28	71.71	5.08	59.66

It was evident from the [Table-10] that the area under major fruit crops such as mango, guava and sapota in Kundgol taluk are likely to lose their share in total area cultivated.

**Table-10** Projected shares of area under major fruit crops in Kundgol taluk (Per cent)

Crops Year	Mango	Guava	Sapota
2012-13	47.12	2.35	50.53
2017-18	46.86	2.30	50.85
2022-23	46.68	2.26	51.06
2027-28	46.56	2.23	51.21

## Discussion

The results based on twenty year (1991-2010) time series data, Dharwad District has retained its all the major crops such as Mango, Guava and Sapota. Dharwad district comprising of five taluks, mango is largely cultivated because of ambient environmental conditions.

Guava has showed its higher retention in dharwad taluk, which is about 95.22 per cent followed by Navalgund (93.69%), Kalagatagi (88.42%), Hubli (84.15%) and Kundgol (55.65%). Guava crop being suitable for dry regions with protective irrigation so, it shows its higher retention in Navalgund taluk next to Dharwad Taluk. Whereas Kalghatagi taluk comes under malnad region and soil is red rocky soil because of this it retention percentage is low compared to other taluks.

Sapota also became stable in the period 1991-2010 by retaining most part of its previous years' share. It shows its higher retention in malanad regions of Dharwad District. Whereas Dharwad taluk (92.71 %), Kalagatagi (81.31%) and Hubli (76.12 %) showing higher retention percentage compared to dry regions of Navalagund taluk (64.99%).

The area in Dharwad taluk under guava is likely to loose its share in total area cultivated. Mango and sapota are likely to increase their share in total area cultivated. The area under guava in Hubli taluk is likely to loose its share in total area cultivated. While acreage in mango and sapota are likely to increase over the years. The area under mango and sapota in Navalgund taluk are likely to increase their share in total area cultivated. Guava is likely to loose its share in total area cultivated. The area under major fruit crops such as mango, guava and sapota in Kalghatagi taluk are likely to increase their share in total area cultivated. The area under major fruit crops such as mango, guava and sapota in Kundgol taluk are likely to loose their share in total area cultivated. These conclusions are similar with the observations of Mahendra Singh and Mathur (2008) while studying the structural changes in horticulture sector in India: Retrospect and Prospect for 11<sup>th</sup> Five Year Plan [4].

## Conclusion

The results of the markov chain analysis employed to study the direction of structural changes. The results revealed that the area under mango, guava and sapota in Dharwad district has showed stability over the years. Dharwad district comprises Malnad, Dry arid and Dry region, which shows diversification in horticultural crops cultivation.

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