

## **Growth performance of area under forest in Gujarat state**

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### **Abstract**

*The forest area of Gujarat state is 11.14% of total geographical area of the state, it is much below the national average of 23.34%. Government of Gujarat has been launched different programmes to increase the forest cover in the state. Considering the importance of forestry sector in social and economic development of state the present investigation was done to study the growth and instability of forestry sector in respect of area under forest. For present study circle wise secondary data of area under forest by legal status collected for the period from 1990-91 to 2018-19 and divided in three periods. To study growth performance CAGR worked out whereas to study instability Cuddy Della Vella Instability indices worked out. From study it was found that during the period from 1990-91 to 2018-19, very less growth of 0.57 % per annum found in total area under forest in Gujarat state as a whole. The area under reserved and total forest declined with low variation in Surat, Junagadh, Gandhinagar, Valsad and Vadodara circle during the period-III and Overall period where as the area under protected and unclassed forest declined with high variation in Surat, Junagadh and Gandhinagar circle. The area under reserved, unclassed and total forest raised with low variability during the period-III and overall period.*

**Keywords:** Growth, trend, Instability, CAGR, Forest area

### **Introduction**

The uneven distribution of forest area is observed in Gujarat, mainly concentrated in Eastern and Southern region of Gujarat. During the year 1990-91 the area under forest under the different legal categories was 19379.20 sq. km. which was about 9.89% of total geographical area of Gujarat state. The forest area raised in the state up to 21859.22 Sq.km. during the year 2018-19 which was 11.14 % of total geographical area of the Gujarat state. Government of Gujarat has been launched different programmes to increase the forest cover in the state. The raise in area by 1.25% over the period is the result of all these programmes. Though the forest area of Gujarat state is 11.14% of total geographical area of the state, it is much below the national average of 23.34%. According to National Forest Policy 1988 and 2018,

there should be about one third of total land area under forest and tree cover. This target can be achieved through greening of cultivable wasteland, current fallows and other fallow land in the coming years (FAO, 2009). Considering these points in view and the importance of forestry sector in social and economic development of state it is necessary to study the growth performance of forestry sector in respect of area under forest is necessary. The present investigation was done with the following objectives

1. To study the trends in area under forest in Gujarat state
2. To study the instability in area under forest in Gujarat state

### **Methodology**

Present investigation covered forest area of whole Gujarat state. Secondary data pertaining to area under forest by legal status in Gujarat state collected circle wise/ zone wise from the available reports of 'Gujarat Forest Statistics' published by Principle Chief Conservator of Forest, Government of Gujarat for the period from 1990-91 to 2018-19. The forest area by legal status divided as reserved forest, protected forest

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and unclassified forest. Further, to study decadal growth the study period divided into three periods viz. Period-I: 1990-91 to 1999-2000, Period-II: 2000-2001 to 2009-2010, Period-III: 2010-11 to 2018-19 and Overall period: 1990-91 to 2018-19. Analysis pertaining to growth and instability was done circle wise/ zone wise.

#### Compound growth rate:

To study the growth in respect of area under forest, exponential trend equation was fitted and the compound annual growth rate (CAGR) was worked out for each period.

$$Y = ab^t$$

Where Y = area/ production / productivity

a = intercept, b = regression coefficient

t = time variable in year

Annual compound growth rate (CGR) were worked by the formulae

$$CGR = (\text{antilog } b - 1) * 100$$

The significance of CGR was tested with help of correlation coefficient (r) by using 't' test.

#### Cuddy and Della Velle Instability Index (CDVI)

To study the instability in area under forest the Cuddy and Della Velle Instability Index (CDVI) was used (Kolar *et.al.* 2020 and Sihmar, 2014), as it de-trend the given series of data and provide a clear direction of instability. This method is modification over the coefficient of variation.

$$CDVI (\%) = C.V. * \sqrt{(1 - R^2)}$$

Where C.V. = Coefficient of variation and

R<sup>2</sup> = Coefficient of multiple determination

The range of CDVI given as below

CDVI between 0 and 15 = Low instability

CDVI > 15 and < 30 = Medium instability

CDVI > 30 = High instability

## Results and Discussion

### Growth and Instability in area under forest:

From Table 1 it was observed that during the Period-I the area under protected forest and total forest

area in Gujarat state declined significantly by 13.23% per annum and 0.39% per annum, respectively whereas the area under unclassified forest raised significantly by 0.49% per annum. The area under reserved forest increased significantly by 0.18% per annum during the Period –II. During the period of last 29 years i.e. from 1990-91 to 2018-19, the CAGR of the total forest area of Gujarat state was worked out to 0.57 %, which was positive and significant at 1% level of probability implied that the total forest area in Gujarat state increased significantly by 0.57% per annum. The highest growth in area under protected forest (5.78% per annum) observed followed by the area under reserved forest (0.33% per annum) during the overall period under study. This may have attributed to the different schemes and programmes implemented by government to increase the forest cover in the state. According to Third Tree Counting- 2013 report of Forest Department, a forestation programme, and protection of the large forest areas under National Parks and Wildlife Sanctuaries contributed significantly to increase the tree populations. Directorate of Forest, Government of West Bengal also reported that the area under forest in West Bengal increased due to a forestation within forests and growth of commercial plantations and shade trees outside forest (Anonymous, 2016).

Table 1 further showed that during Period-I, Period-II, Period-III and overall period the instability index for the area under reserved forest and total forest was low implied that the area under reserved forest and total forest in Gujarat state was stable during the study period. In case of area under protected forest medium instability found during Period-I (24.26%) and Period-III (28.53%) whereas during period-II (1.66%) low instability was recorded. The medium instability during Period-I attributed to significant decline in area under protected forest during this period. The high instability in area under protected forest was worked

Table 1: Growth and instability in area under forest in Gujarat state (Values in %)

Forest	Period I (1990-91 to 1999-2000)		Period II (2000-01 to 2009-10)		Period III (2010-11 to 2018-19)		sOverall (1990-91 to 2018-19)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Reserved forest	-0.04	0.54	0.18***	0.21	-0.34	6.81	0.33***	3.87
Protected forest	-13.23***	24.26	0.16	1.66	14.78	28.53	5.78***	71.19
Unclassed forest	0.49***	1.23	-2.85	26.39	-0.18	2.61	-0.45	14.55
Total forest area	-0.39***	0.91	-0.30	5.86	0.61	6.65	0.57***	6.93

Note: \*\*\* indicate significant at 1% level of probability

out during overall period (71.19%), this attributed to the medium instability during the Period-I and Period-III.

*Growth and instability in area under reserved forest in Gujarat state*

Table 2 depicted that during the Period-I the area under reserved forest declined significantly in the Vadodara (-0.94% per annum) and Valsad (-0.04 per annum) circle. During period-II the highest positive growth in area under reserved forest worked out to 8.25% per annum in Valsad circle followed by Kuccha circle (1.44 % per annum) and Junagadh circle (0.87% per annum). Whereas during the same period the area under reserved forest significantly declined in Surat (-3.97% per annum), Vadodara (-0.56% per annum) and Ahmedabad Extension circle (-0.24% per annum). During Period-III, the highest significant decline in area under reserved forest reported in Surat circle (-8.25%) followed by Gandhinagar (-6.81%), Junagadh (-4.75%) and Valsad circle (-0.04%), whereas the area under reserved forest raised significantly in Jamnagar (3.41% per annum), Junagadh WL (2.22% per annum) and Kucchha circle (0.24% per annum).

From the table 2 it was observed that during the overall period the area under reserved forest declined significantly in the Gandhinagar (-2.40%), Junagadh (-1.21%), Surat (-2.91%) and Vadodara (-0.96%) circle. The negative growth in area under reserved forest in Gandhinagar, Juagadh and Surat circle attributed to significant decline in area under reserved forest during the period from 2010-11 to 2018-19. The area under reserved forest raised significantly in the Junagadh WL (0.93%), Kucchha (1.51%), Valsad (3.18%) and Jamnagar (2.15%) circle during

overall period. The positive growth in area under reserved forest in Kucchha and Valsad circle attributed to significant raise in area under reserved forest during the period-II i.e. from 2000-01 to 2009-10

From the table 2 it was found that, the instability index of area under reserved forest worked out for all the circle during the Period-I, II, III and overall period were less than 15%, indicated that there was low instability in area under reserved forest in all the circles and all the period except the Ahmedabad Ext. circle recorded high instability (101.45%).

*Growth and instability in area under protected forest in Gujarat state*

Table 3 showed that the area under protected forest raised significantly in Gandhinagar (1.12%) and Vadodara (0.41%) circle where as it was declined significantly in Valsad (-0.47%) circle during the Period-I. During period-II the area under protected forest declined significantly in Surat circle (-40.21% per annum) whereas it was raised significantly in Valsad circle (42.65% per annum). This may have attributed to transfer of area under protected forest in Surat circle to the Valsad circle during the year 2004-05, which cause decline in area in Surat circle and raise in area in Valsad circle (Anonymous, 2005). During period-III the highest decline in area under protected forest recorded in Gandhinagar circle (-31.21% per annum) followed by Surat circle (-7.78% per annum). This may have attributed to the transfer of area under protected forest to the other heads during this period in these circles.

It was observed that, the highest growth in area under protected forest was recorded in Kucchha circle (82.62% per annum) during the period form 2000-01

Table 2: Circle wise growth and instability in area under reserved forest in Gujarat state (Values in %)

Circle	Period-I		Period II		Period-III		Overall	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Gandhinagar	0.11	0.60	-1.10	10.87	-6.81***	12.89	-2.40***	11.28
Junagadh	0.31	0.68	0.87***	1.11	-4.75***	9.29	-1.21***	9.07
Junagadh WL	0.24	0.55	0.24***	0.52	2.22***	4.35	0.93***	3.91
Kucchha	0.47	1.07	1.44*	6.31	0.24***	0.36	1.51***	7.42
Surat	-0.04	0.50	-3.97***	8.18	-8.25***	13.85	-2.91***	11.86
Vadodara	-0.93**	1.04	-0.56***	1.37	-2.20	9.37	-0.96***	5.26
Valsad	-0.04**	0.05	8.25***	14.29	-0.04**	0.08	3.18***	13.60
Jamnagar	5.98	15.98	0.00	0.00	3.41***	7.05	2.15***	10.45
Ahmedabad Ext.	-	-	-0.24*	1.03	-1.51	118.25	1.86	101.45

Note: \*\*\*, \*\* and \* indicate significant at 1%, 5% and 10% level of probability, respectively

Period-I: 1994-95 to 1999-2000, Period-II: 2000-01 to 2009-10, Period-III: 2010-11 to 2018-19 and Overall period: 1994-95 to 2018-19

Table 3: Circle wise growth and instability in area under protected forest in Gujarat state (Values in %)

Circle	Period-I		Period II		Period-III		Overall	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Gandhinagar	1.12**	1.41	-2.91	226.51	-31.21***	61.27	-8.04***	240.12
Junagadh	0.09	0.22	0.26***	0.43	-3.72	248.33	-8.11*	280.28
Junagadh WL	0.05	0.11	0.00	0.00	0.22***	0.44	0.08***	0.40
Kucchha	-	-	41.65	34.27	49.17	33.46	82.62***	84.61
Surat	-17.49	66.62	-40.21**	48.46	-7.78***	13.08	-23.71***	102.84
Vadodara	0.41***	0.34	1.17*	4.42	-11.55	33.62	-1.23	21.76
Valsad	-0.47**	0.67	42.65***	41.06	0.01**	0.03	14.98***	38.66
Jamnagar	-	-	0.04	1.81	0.00	0.00	-0.03	1.43
Ahmedabad Ext	-	-	-	-	29.70	183.08	21.69	203.93

Note: \*\*\*, \*\* and \* indicate significant at 1%, 5% and 10% level of probability, respectively

Period-I: 1994-95 to 1999-2000, Period-II: 2000-01 to 2009-10, Period-III: 2010-11 to 2018-19 and Overall period: 1994-95 to 2018-19

Overall period for Kucchha & Jamnagar Circle: 2000-01 to 2018-19 and for Ahmedabad circle: 2007-08 to 2018-19

to 2018-19. This growth may attribute to addition of 2497 sq. km area in the protected forest area of Kucchha circle during the year 2011-12 (Anonymous, 2013). During the overall period i.e. from 1994-95 to 2018-19, the positive and significant growth in area under protected forest observed for Valsad (14.98%) and Junagadh WL circle (0.08%). The highest decline in area under protected forest recorded in Surat circle (-23.71% per annum) followed by Junagadh (-8.11% per annum) and Gandhinagr (-8.04% per annum) during the overall period. The highest decline in area under protected forest in Surat circle attributed to higher decline in area during the period-II.

Table 3 further depicted that, the highest instability in area under protected forest was recorded in Surat Circle (66.62%) during Period-I, in Gandhinagar (226.51%), Surat (48.46%) Valsad (42.65%) and Kacchha (34.27%) circle during period-II and in Junagadh (248.33%), Ahmedbad Ext. (183.08%), Gandhinagar (61.27%), Vadodara (33.62%) and Kucchha (33.46%) during Period-III. This indicated that there was large variation in the area under protected forests in these circles in different periods of study. During the overall period the instability index worked out to highest in most of the circles under the study except Junagadh WL, Vadodara and Jamnagar circle which recorded low instability in area under protected forest. The higher instability in area under protected forest may attribute to addition or transfer of area in or from these circles.

*Growth and instability in area under unclassified forest in Gujarat state*

By observing the table 4 it was found that

during the Period-I, significant positive growth in area under unclassified forest recorded in Jamnagar circle (8.19% per annum) whereas the area declined by -3.98%, -2.57%, -0.63% and -0.03% per annum in Vadodara, Junagadh, Gandhinagar and Valsad circle, respectively. During period-II, the area under unclassified forest raised significantly in Valsad circle (33.96%), which attributed to addition of more area during the year 2004-05 in Valsad circle. The area under unclassified forest declined significantly in Junagadh WL (-3.71% per annum), Vadodara (-2.28% per annum) and Junagadh (-1.59% per annum) circle during the period-II under study. During the period-III the area under unclassified forest declined in Surat (-13.61% per annum), Junagadh (-13.10% per annum), Gandhinagar (-12.63% per annum), Kucchha (-0.74% per annum) and Junagadh WL (-0.60% per annum) circle. This was due to the reduction or transfer of area under unclassified forest to the other heads during study period.

From the table 4 it was observed that, during the overall period i.e. from 1994-95 to 2018-19, the area under unclassified forest increased significantly in Valsad (10.76% per annum), Jamnagar (2.11% per annum), Ahmedabad ext (2.34% per annum) and Kucchha (0.39% per annum) circle, whereas it was declined significantly in Surat (-9.32% per annum), Vadodara (-5.10% per annum), Junagadh (-3.93% per annum), Gandhinagar (-3.18% per annum) and JunagadhWL (-2.13% per annum) circle. The increase in area under unclassified forest may attributed to dependency of local population on forest trees (TERI, 2015).

From table 4 it was observed that during Period-I medium instability index recorded for Surat (27.32%)

Table 4: Circle wise growth and instability in area under unclassified forest in Gujarat state (Values in %)

Circle	Period-I		Period II		Period-III		Overall	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Gandhinagar	-0.63***	0.55	-0.52	8.77	-12.63***	19.13	-3.18***	16.19
Junagadh	-2.57*	4.58	-1.59***	2.67	-13.10*	26.16	-3.93***	14.71
Junagadh WL	-5.83	15.19	-3.71***	9.14	-0.60**	1.39	-2.13***	12.84
Kucchha	-0.52	1.78	0.02	1.08	-0.74**	2.00	0.39**	5.12
Surat	-9.24	27.32	-9.12	52.09	-13.61***	21.71	-9.32***	77.08
Vadodara	-3.98**	5.69	-2.28***	3.58	-7.92	37.89	-5.10***	28.11
Valsad	-0.03**	0.05	33.96***	40.12	-2.00	8.05	10.76***	38.69
Jamnagar	8.19*	10.80	0.11***	0.27	4.74***	7.66	2.11***	9.42
Ahmedabad Ext	-	-	0.30	1.73	-1.02	15.92	2.34*	19.88

Note: \*\*\*, \*\* and \* indicate significant at 1%, 5% and 10% level of probability, respectively

Period-I: 1994-95 to 1999-2000, Period-II: 2000-01 to 2009-10, Period-III: 2010-11 to 2018-19 and Overall period: 1994-95 to 2018-19

Overall period for Ahmedabad circle: 1999-2000 to 2018-19

and JunagadhWL (15.19%) circle whereas all other circle recorded low level of instability. During the period-II the highest instability index worked out in Surat (52.09%) and Valsad (4.12%) circle, implied that there was large variation in area under unclassified forest during the period 2010-11 to 2018-19. This may attribute to addition or transfer of area in or from these circles during this period. During Period-III high instability recorded in Vadodara (37.89%), medium instability recorded in Junagadh (26.16%), Surat (21.71%), Gandhinagar (19.13%) and Ahmedabad Ext (15.92%) circles. During the overall period the highest instability index worked out in Surat (77.08%) and Valsad (38.69%) circle, implied that there was large variation in area under unclassified forest during the period 1994-95 to 2018-19 in these circle. This may attribute to addition or transfer of area in or from these circles during this period.

#### *Growth and instability in total forest area in Gujarat state*

From Table 5 it was observed that during the Period-I the total forest area declined significantly in Vadodara (-1.07% per annum), Gandhinagar (-0.21% per annum) and Valsad (-0.04% per annum) where as it raised significantly in Jamnagar circle (8.22% per annum). During the period-II the highest positive significant CAGR worked out for Valsad circle (8.22%) implied that the total forest area in Valsad circle increased. This raise in total forest area in Valsad circle may attribute to addition of more area. Very less growth (Less than 1% per annum) in total forest area observed in Kucchh, Jamnagar and Ahmedabad circle during the period-II. The total forest area declined significantly

in Surat (-4.61% per annum) and Vadodara circle (-0.58% per annum) during period-II. During period-III, the highest decline in total forest area recorded in Gandhinagar (-9.39% per annum) followed by Surat (-8.42% per annum), Junagadh (-5.73% per annum) and Valsad circle (-0.06% per annum), which may be attributed to the reduction or transfer of area under different forest categories to the other heads during the period from 2010-11 to 2018-19. The area under total forest raised significantly in Jamnagar circle (4.67% per annum) which may due to addition of more area in this circle during the period-III.

From Table 5, it was found that the area under total forest increased significantly in Ahmedabad Ext. (5.22%), Kucchh (3.92%), Valsad (3.73%) and Jamnagar (2.13%) circle during the overall period which may attributed to addition of area under reserved, protected and unclassified forest during the different years under study. The total forest area found declined significantly in Surat (-3.75%), Gandhinagar (-2.75%), Junagadh (-1.80%) and Vadodara (-1.07%) circle during the overall period which may attributed to the reduction or transfer of area under different forest categories to the other heads during study period.

Table 5 further depicted that, there was low instability in all the circle in all the period under study in total forest area of Gujarat state. The instability index worked out for all the circles during the Period-I, II, III and overall period found less than 15% except the Ahmedabad circle implied that the variability in total forest area was minimum during the study period. Ahmedabad circle recorded high instability during

Table 5: Circle wise growth and instability in total forest area in Gujarat state (Values in %)

Circle	Period-I		Period II		Period-III		Overall	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Gandhinagar	-0.21*	0.33	-0.96	5.45	-9.39***	15.67	-2.75***	11.85
Junagadh	-0.70	1.71	0.04	0.48	-5.73***	10.91	-1.80***	9.16
Junagadh WL	-1.89	1.29	-4.09	0.01	-3.37	3.89	-7.78	3.77
Kucchha	0.08	0.30	0.88*	3.69	3.48	12.69	3.92***	14.49
Surat	-2.13	5.64	-4.61***	9.40	-8.42***	14.10	-3.75***	10.31
Vadodara	-1.07***	0.95	-0.58***	1.36	-2.25	9.92	-1.07***	5.54
Valsad	-0.04**	0.06	9.73***	18.87	-0.06***	0.13	3.73***	16.72
Jamnagar	8.22*	10.58	0.11***	0.24	4.67***	7.32	2.13***	9.22
Ahmedabad Ext	-	-	0.37***	1.00	10.39	89.44	5.22**	83.83

Note: \*\*\*, \*\* and \* indicate significant at 1%, 5% and 10% level of probability, respectively

Period-I: 1994-95 to 1999-2000, Period-II: 2000-01 to 2009-10, Period-III: 2010-11 to 2018-19 and Overall period: 1994-95 to 2018-19

Overall period for Ahmedabad circle: 1998-99 to 2018-19

period-III (89.44%) and overall period (83.83%) in total forest area. The significant positive CAGR accompanied by high instability index in Ahmedabad circle during the overall period indicated that the total forest area in Ahmedabad circle increased with large variation over the period of time.

### Conclusion

From the present investigation it was found that during the period from 1990-91 to 2018-19, very less growth of 0.57% per annum and 0.33% per annum recorded for the total forest area and reserved forest area in Gujarat state, respectively whereas the area under protected forest raised by 5.78% per annum. The area under reserved and total forest declined with low variation in Surat, Junagadh, Gandhinagar, Valsad and Vadodara circle during the period-III and Overall period where as the area under protected and unclassified forest declined with high variation in Surat, Junagadh and Gandhinagar circle. The area under reserved, unclassified and total forest raised with low variability during the period-III and overall period. The forest area of Gujarat state (11.14%) recorded much below the average area under forest at national level (23.34%). Therefore, there is need to give the attention to increase the forest area and tree cover in Surat, Gandhinagar, Junagadh, Valsad and Vadodara circles.

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