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Growth and decomposition of wheat production in Vidarbha region of Maharashtra state

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Abstract
This study was aimed at investigating the "Growth and Decomposition of Wheat Production in Vidarbha". The study was based on secondary data of area, production and productivity of Wheat in Vidarbha region of Maharashtra. The complete data of Wheat available for all district of Vidarbha region from 1996-97to 2015-16 was split into two sub periods i.e. period-I 1996-97 to 2005-2006 and period -II 2006-07 to 2015-16. The growth rates were calculated by exponential function. The instability in area, production and productivity was measured through Coefficient of variation (CV) and Cuddy Della Valle's Instability index. The relative contribution of area and yield to change in output was estimated by using Minhas decomposition model. The district wise analysis was carried out for the period-I, Period-II and overall. The compound growth rate of area, production and productivity were positive in almost all the district except Buldhana district, during oveall period. Whereas, the compound growth rates for area were negative indicating decline in area in Vidarbha region during Period I and period II. The coefficient of variation estimated was in the range 35.16 to 62.70 per cent for area and 44.52 to 76.16 per cent for production. Thus, it indicates that the wheat is cultivated traditionally in the region during rabi season. Among the parametric models fitted to the area, production and productivity under Wheat crop, according to the goodness of fit cubic model was found to be best fitted for all the districts of Vidarbha. As regard to region as a whole the highest R^2 was recorded in area i.e. 61 per cent than production and productivity. The decomposition analysis for Vidarbha region was estimated the largest area effect on wheat production. It was also observed that for both the period area effect was more pronounce than yield effect and interaction effect. Hence There is need for policy maker to formulate development-oriented policy and researcher to design investigative research activity for promoting sustainable wheat production system in the region for expansion of area under wheat cultivation.

Keywords: Wheat, growth rate. instability, trend, decomposition

Introduction
Wheat (*Triticum aestivum*), is a self pollinated hexaploid (2n=6x=42) cereal of the family Gramineae, formerly known as common wheat. The three species of wheat namely, *Triticum aestivum* (bread wheat), *Triticum durum* (macaroni wheat) and *Triticum dicoccum* (Emmer or Khapli wheat) grown on commercial basis in the Indian subcontinent from pre-historic times with share of production in percent 95 per cent, 4 per cent and 1 per cent respectively, are being cultivated in the country**.** Wheat is a cereal grain, originally from the Levant region of the near east and Ethiopian Highlands, but now cultivated worldwide. It is grown in diversified environments. It is a staple food of millions of people. Approximately one-sixth of the total arable land in the world is cultivated with wheat. It supplies about 20 per cent of the food calories for the world's growing population. Carbohydrate and protein are two main constituents of wheat. On an average wheat contains 11-12 per cent protein. Wheat is cultivated mainly in temperate and sub temperate regions of the world. Wheat has a distinct place among the food grain crops.

Global wheat production touched 753.4 million tones in 2016-17. India is the second largest producer of wheat after China. Presently at global level, it occupies approximately 223 million hectares with production of approximately 753.9 million tones (2016-17). China, India and U.S.A. are first, second and third, respectively in wheat production. In addition to these, other countries are Canada, Argentina, Australia, France and Italy where wheat is cultivated at larger scale.

Wheat is grown in India in an area of about 30.71 Million ha. with a production of 97.44 Million tonnes. The normal national productivity is about 3.17 tones/ha (2016-17). The major Wheat producing States are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar and Maharashtra. These States contribute about 94.09 per cent of total Wheat production in the country.

Wheat is grown in Maharashtra (2016-17) in an area of about 12.72 lakh ha. with a production of 22.14 lakh tonnes, the normal productivity is about 1740 kg/ha. Maharashtra contributes about 1.51 per cent of the total wheat production of the country (area 3.06 per cent). Nagpur, Akola and Amravati districts of the black cotton soils are the main producers in Vidarbha region.

Methodology

The study has been undertaken to examine the growth pattern in Wheat area, production and yield also estimate the relative contribution of area and yield on production. The study further attempts to assess the direction of trend.

Selection of area

Wheat crop is grown in the entire Vidarbha region of Maharashtra. In Vidarbha region Amravati and Nagpur division are included. From this region out of eleven districts five districts were selected namely Buldhana, Amravati, Yavatmal, Nagpur, Akola except Washim (Because Washim was announced as a separate district on 1st July 1998, respectively) and Gadchiroli (Gadchiroli district have no potential area of wheat crop).

Selection of period

Period I	: 1996-97 to 2005-06
Period II	: 2006-07 to 2015-16
Overall	: 1996-97 to 2015-16

The data were collected on area, production and productivity of Wheat grown in Vidarbha region pertaining to the period from 1996-97 to 2015-16 (20 years) For the analysis of growth and instability, the entire study period was split into two sub-periods and overall as follows.

Source of data

The district-wise time series data on area, production and productivity were collected from Government publication; website of government of Maharashtra.

Analytical tools

The present study was based on time series secondary data of Wheat growing districts in Vidarbha region. The analysis was done on the following aspects.

Growth rate

The compound growth rates of area, production and productivity of wheat were estimated for last 20 years. The district wise compound growth rates of area, production and productivity were estimated by using following exponential model.

$Y = a.b^t$ ..... (1)

Where,

Y = Depended variable for which growth rate is to be estimated

a = Intercept

b = Regression Coefficient

t = Time Variable

This equation was estimated after transforming (1) as follows

Log y = log a + t Log b..... (2)

Then the per cent compound growth rate (g) was computed using the relationship.

CGR (r) = [Antilog (log b) – 1] × 100.....(3)

The significance of the regression coefficient was tested using the student's' 't' test.

Instability

To measure the instability in area, production and productivity, an index of instability was used as a measure of variability through Coefficient of Variation (CV) and Cuddy Della Valle's instability indices.

Coefficient of variation (CV)

Coefficient of variation (CV) = $\frac{\sigma}{x} \times 100$

Where,

σ = Standard deviation

$\bar{X}$ = Arithmetic mean

The simple Coefficient of Variation (C.V) often contains the trend component and thus over estimates the level of instability in time series data characterized by long term trends and Cuddy Della Valle's instability was estimated as follows.

Cuddy Della Valle's Instability Indices (CDVI)

It was used to measure instability of wheat which was close to approximation of the average year to year per cent variation adjusted for trend. The algebraic form of it was;

Instability Index = $CV\sqrt{(1 - R^2)}$

Where,

CV = Simple Estimates of coefficient of variation in per cent and

R^2= Coefficient of determination from a time trend regression (linear) adjusted by the number of degree of freedom.

Trend Analysis

The trend in area, production and productivity of wheat was computed for the series data of last 20 years. To trace the path of process different parametric trend models as given in the table below were used.

Among the competitive trend models, the best function were selected based in their goodness of fit (measured in terms of R^2) value and significance of the coefficients.

Table 1: List of different parametric models with their equations

Sr. No.	Name of Model	Equation
I	Linear	$Y_t = a+bt$
II	Quadratic	$Y_t = a+b_1t+b_2t^2$
III	Cubic	$Y_t = a+b_1t+b_2t^2+b_3t^3$
IV	Exponential	$Y_t = a+Exp(bt)$
V	Logarithmic	$LogY_t = a+b\ Log(t)$

Where, a, b and t represent constant, coefficient and time respectively in the model.

Decomposition of output growth

To measure the relative contribution of area, yield to the total output of the wheat crop, Minhas (1964), Decomposition analysis model was used which is given below.

Po = Ao x Yo and
Pn = An x Yn ---------- (1)

Ao, Po and Yo are area, production and productivity in base year and An, Pn and Yn are values of the respective variable in n^{th} year item respectively.

Where,
Ao and An = Area
Yo and Yn = yield in the base year and n^{th} year respectively.
Pn - Po = ΔP
An - Ao = ΔA
Yn - Yo = ΔY ---------- (2)

For equation (1) and (2) we can write
Po + ΔP = (Ao + ΔA) (Yo + ΔY)

Hence,

$$P = \frac{Ao\,\Delta Y}{\Delta P} \times 100 + \frac{Yo\,\Delta A}{\Delta P} \times 100 + \frac{\Delta Y\,\Delta A}{\Delta P} \times 100$$

Production = Yield effect + area effect + interaction effect
Thus, the total change in production can be decomposed into yield effect area effect and the interaction effect due to change in yield and area.

Results and Discussion

Growth rate of wheat in Vidarbha Region

The district wise compound growth rates of area, production and productivity of wheat in Vidarbha region for period I, period II and overall were worked out and presented in Table 2.

It could be seen from the Table 2 that, during period I, almost all districts in Vidarbha region registered negative growth including the region as whole, except area of Buldhana and productivity of Amravati Yavatmal and Nagpur district but statistically not significant. On the other hand, region as whole estimated less than one per cent per annum growth rate for productivity i.e. 0.44 per cent, while area and production were negative and statistically not significant.

During period II, almost all district in Vidarbha region registered negative growth including region as whole, except area of Buldhana, Amravati and Nagpur. The growth rates of area were highest in Nagpur district i.e. (6.31 per cent) and positively significant at 5 per cent level. Whereas, highest decline in growth rate of production and productivity were registered in Akola district i.e. -10.65 per cent and -5.91 per cent, respectively and found to be significant at 5 per cent level. On the other hand, region as whole estimated less than one per cent per annum growth rate for area, while production and productivity were negative and statistically not significant.

Table 2: District wise compound growth rate of wheat in Vidarbha Region

Sr. No	Name of District	Particular	Period-I	Period-II	Overall
1	Buldhana	Area	1.68	1.15	5.66**
		Production	-1.01	-4.71	4.70*
		Yield	-4.30	-5.79*	-0.88
2	Akola	Area	-5.50	-4.07	5.54**
		Production	-6.08	-10.65*	6.51*
		Yield	-0.22	-5.91*	0.71
3	Amravati	Area	-4.20	5.29	9.19**
		Production	-4.17	1.21	10.83**
		Yield	0.03	-0.03	0.30
4	Yavatmal	Area	-7.67	-0.66	4.43*
		Production	-7.93	-3.48	5.21*
		Yield	0.67	-2.85	1.12
5	Nagpur	Area	-5.32	6.31*	4.06**
		Production	-0.95	4.59	6.39**
		Yield	4.60	-1.61	2.24
Vidarbha Region		Area	-3.34	0.67	3.89**
		Production	-1.92	-2.78	5.80**
		Yield	0.44	-2.56	1.23

Note: **Significant at 1% level, * Significant at 5% level,

Whereas, at the overall period, the compound growth rate of area, production and productivity were positive in almost all districts in the region except for productivity (-0.88 per cent) in Buldhana district but it was not significant statistically. The highest growth rates were recorded in Amravati district for area and production i.e. 9.19 and 10.83 per cent per annum, respectively and found statistically significant at 1 per cent level. The growth rate of productivity was highest in Nagpur i.e. 2.24 per cent and Statistically not significant. The growth rates for area, and production of region as whole were 3.89 per cent and 5.80 per cent, respectively and found to be significant at 1 per cent level. The growth rate of productivity was highest in Nagpur i.e. 2.24 per cent and Statistically not significant. The growth rates for area, and production of region as whole were 3.89 per cent and 5.80 per cent, respectively and found to be significant at 1 per cent level.

The results of this study leads to the conclusion that, the compound growth rate of area, production and productivity were positive in almost all the district except Buldhana district, during oveall period. Whereas, the compound growth rates for area were negative indicating decline in area in Vidarbha region during Period I and period II.

Instability in area, production and productivity of wheat

One should not obvious of instability by taking the growth rate only, because the growth rate will explain only the rate of growth over the period, whereas, instability judge, whether the growth performance is stable or unstable for the period for the pertinent variable. In order to know the instability in area, production and productivity of crop, the fluctuation measured with the help of coefficient of variation and mean. To facilitate better understanding of the magnitude and pattern of changes in the level of production, cropped area and

productivity of crop in the different wheat growing region, instability of production, area and productivity of wheat crop have been worked out as per the period discussed in methodology.

It is seen from the Table 3 that, during period I, the lowest coefficient of variation for area under wheat cultivation was observed in Buldhana (20.99 and 20.70 per cent for CV and CDVI, respectively). While, the highest CV was observed in Nagpur (30.14 per cent) and highest CDVI was observed in Akola district (26.28 per cent). The lowest coefficient of variation for production was in Akola (33.53 and 31.78 per cent for CV and CDVI, respectively) and the highest coefficient of variation was observed in Yavatmal district (46.53 and 40.19 per cent for CV and CDVI, respectively). The lowest coefficient of variation in yield was in Amravati district (19.06 and 19.00 per cent for CV and CDVI, respectively). Whereas, region as a whole recorded medium instability in area (19.27 and 16.56 per cent for CV and CDVI, respectively) and Productivity (19.18 and 19.17 per cent for CV and CDVI, respectively), while high instability in production (31.51 and 30.57 per cent for CV and CDVI, respectively).

During period II, the lowest coefficient of variation of area was observed in Buldhana district (20.49 per cent for CV) and Nagpur (12.80 per cent for CDVI), While the highest in Amravati district (29.44 and 25.18 per cent for CV and CDVI, respectively). The lowest coefficient of variation for production was observed in Nagpur district (25.90 per cent for CV) and Buldhana district (22.82 per cent for CDVI). While, the highest coefficient of variation was recorded in Akola district (51.42 and 38.63 per cent for CV and CDVI, respectively). The lowest coefficient of variation in yield was observed in Nagpur district (16.82 and 16.26 per cent for CV and CDVI, respectively). Whereas, Vidarbha Region recorded medium instability in production (24.46 and 22.53 per cent for CV and CDVI, respectively) and yield (16.64 and 14.99 per cent for CV and CDVI, respectively) while, low instability in area (12.71 and 12.58 per cent for CV and CDVI, respectively).

Table 3: District wise instability indices of wheat in Vidarbha Region

Sr. No	Name of District	Particular	Period-I			Period-II			Overall		
			A	P	Y	A	P	Y	A	P	Y
1	Buldhana	CV	20.99	39.48	30.61	20.49	26.56	24.02	39.91	44.52	26.73
		CDVI	20.70	39.21	28.22	19.98	22.82	17.93	24.64	38.06	26.17
2	Akola	CV	28.32	33.53	26.15	25.52	51.42	26.04	49.09	76.16	27.55
		CDVI	26.28	31.78	26.15	21.49	38.63	19.56	39.44	69.04	27.18
3	Amravati	CV	26.07	40.02	19.06	29.44	27.20	37.55	62.70	69.39	31.54
		CDVI	22.88	37.69	19.00	25.18	27.20	37.07	36.58	45.52	31.09
4	Yavatmal	CV	28.56	46.53	23.82	21.44	42.77	27.84	41.18	60.53	27.35
		CDVI	22.10	40.19	23.72	21.17	40.95	26.70	32.56	54.10	26.78
5	Nagpur	CV	30.14	38.29	23.53	21.92	25.90	16.82	35.16	46.52	22.27
		CDVI	25.08	37.59	21.93	12.80	23.12	16.26	25.48	31.92	19.75
Vidarbha Region		CV	19.27	31.51	19.18	12.71	24.46	16.64	30.90	47.32	19.88
		CDVI	16.56	30.57	19.17	12.58	22.53	14.99	21.35	37.04	18.82

Note: CV =Coefficient of variation (per cent per annum), CDVI = Cuddy Della Valle's Instability (per cent per annum) (A=Area, P=Production and Y=Yield)

At overall period, the lowest coefficient of variation for area was in Nagpur district (35.16 per cent for CV) and Buldhana district (25.48 per cent for CDVI) while, the highest in Amravati district (62.70 per cent for CV) and Akola (39.44 per cent for CDVI). The lowest coefficient of variation for production was observed in Buldhana district (44.52 and 38.06 per cent for CV and CDVI, respectively) and the highest coefficient of variation in Akola district (76.16 and 69.04 per cent for CV and CDVI, respectively). The lowest coefficient of variation in yield was in Nagpur (22.27 and 19.75 per cent for CV and CDVI, respectively). Whereas, Vidarbha region recorded medium instability in area (30.90 and 21.35 per cent for CV and CDVI, respectively) and productivity (19.88 and 18.82 per cent for CV and CDVI, respectively) and high instability in production (47.32 and 37.04 per cent for CV and CDVI, respectively).

The coefficient of variation estimated was in the range 35.16 to 62.70 per cent for area and 44.52 to 76.16 per cent for production. Thus, it indicates that the wheat is cultivated traditionally in the region during rabi season. Hence, there is a scope to increase the production of wheat, especially in Vidarbha by providing high yielding varieties and improve technology.

Trend in area production and productivity of wheat in Vidarbha Region

Trends in area, production and productivity of wheat in Vidarbha region is presented in the Table 4.

It could be observed from the Table 4 that, among the parametric models fitted to the area, production and productivity under wheat crop, the maximum R^2 was observed in case of cubic model in all the districts of Vidarbha region including region as a whole in comparison to that of other parametric models.

Table 4: Trend in area production and productivity of wheat in Vidarbha Region

Sr. No.	District	Particulars	Function	Constant	Coefficients			R^2
				a	b_1	b_2	b_3	(%)
1	Buldhana	Area	Cubic	220.39	7.54	0.98	-0.02	0.63
		Production	Cubic	492.86	-76.18	14.01	-0.50	0.38
		Yield	Cubic	1889.80	-189.71	24.20	-0.85	0.19
2	Akola	Area	Cubic	311.62	-63.17	10.49	-0.36	0.46
		Production	Cubic	607.07	-226.84	36.72	-1.31	0.45
		Yield	Cubic	1646.74	-207.66	33.22	-1.23	0.37
3	Amravati	Area	Cubic	236.15	-50.13	6.69	-0.16	0.73
		Production	Cubic	483.97	-183.50	25.88	-0.81	0.71
		Yield	Cubic	1532.14	-153.91	21.01	-0.70	0.10
4	Yavatmal	Area	Cubic	287.45	-56.81	7.46	-0.23	0.49
		Production	Cubic	431.53	-123.95	16.68	-0.54	0.37
		Yield	Cubic	1366.67	-172.84	24.00	-0.82	0.22
5	Nagpur	Area	Cubic	730.29	-115.18	11.21	-0.25	0.77
		Production	Cubic	784.65	-180.85	22.65	-0.65	0.66
		Yield	Cubic	1003.78	-58.04	13.13	-0.51	0.41
Vidarbha Region		Area	Cubic	2560.84	-339.29	44.37	-1.27	0.61
		Production	Cubic	3479.51	-901.76	132.38	-4.39	0.58
		Yield	Cubic	1268.76	-131.70	19.56	-0.68	0.36

As regard the trend in area and productivity the maximum R^2 was observed in Nagpur district i.e. 77 per cent and 41 per cent, respectively in comparison to that of other districts of Vidarbha region. Whereas, the trend in production the highest R^2 was observed in Amravati district i.e. 71 per cent. As regard to region as a whole the highest R^2 was recorded in area i.e. 61 per cent than production and productivity.

Decomposition analysis in wheat production

In this study attempt has been made to identify the contribution of area and productivity for change in production of wheat. This study period has been divided in two sub period and overall taking into consideration the important of each sub period as discussed in methodology.

Table 5: Per cent contribution of area, yield and their interaction for change in production of wheat in Vidarbha Region.

Sr. No.	Name of District	Particular	Period-I	Period-II	Overall
1	Buldhana	Area Effect	-98.27	-83.37	103.33
		Yield Effect	153.45	209.66	-1.32
		Interaction	44.82	-26.30	-2.01
2	Akola	Area Effect	-31.33	32.66	582.66
		Yield Effect	126.66	82.02	-235.37
		Interaction	4.67	-14.68	-247.30
3	Amravati	Area Effect	-206.92	264.87	183.78
		Yield Effect	279.84	-61.58	-19.10
		Interaction	27.08	-103.29	-64.69
4	Yavatmal	Area Effect	46.38	-370.00	301.24
		Yield Effect	68.80	353.72	-115.32
		Interaction	-15.18	267.28	-85.92
6	Nagpur	Area Effect	10.72	169.07	148.39
		Yield Effect	90.00	-47.66	-26.44
		Interaction	-0.71	-21.41	-21.95
Vidarbha Region		Area Effect	-2.10	-70.01	321.23
		Yield Effect	101.68	151.93	-123.20
		Interaction	0.42	18.08	-98.03

The Table 5 indicates that during period I and period II the yield effect was the most responsible factor for change in production of wheat in Vidarbha region. During period I, highest area effect was observed in Yavatmal district i.e. 46.38 per cent with 68.80 per cent yield effect. Whereas, in Amravati district, the Yield effect was the most responsible factor for change in production of wheat with magnitude 279.84 per cent and area effect was negative (-206.92per cent). As regard to region as whole yield effect was the most significant factor for change in production with 101.68 per cent in wheat whereas, area effect was -2.10 per cent.

During period II, highest area effect was observed in Amravati district i.e. 264.87 per cent while, highest yield and interaction effect were recorded in Yavatmal district i.e. 353.72 per cent and 169.07 per cent, respectively. Whereas in region as whole, yield effect was the most significant factor for change in production with 151.93 per cent in wheat while, area and interaction effect were -70.01 per cent and 18.08 per cent, respectively.

At overall period, it indicates that area effect was found the most responsible factor for change in production of wheat in almost all districts of Vidarbha region. However, it was the highest in Akola i.e. 582.66 per cent with negative yield effect i.e. -235.37 per cent. followed by Yavatmal district i.e. 301.24 per cent. Whereas in region as whole, area effect was the most significant factor for change in production with 321.23 per

cent in wheat whereas, yield and interaction effect were -123.20, -98.03 per cent, respectively.

Conclusions

The results of this study leads to the conclusion that, the compound growth rate of area, production and productivity were positive in almost all the district except Buldhana district, during oveall period. Whereas, the compound growth rates for area were negative indicating decline in area in Vidarbha region during Period I and period II. The coefficient of variation estimated was in the range 35.16 to 62.70 per cent for area and 44.52 to 76.16 per cent for production. Thus, it indicates that the wheat is cultivated traditionally in the region during rabi season. In Vidarbha region, among the parametric models fitted to the area, production and productivity under wheat crop, the maximum R^2 was observed in case of cubic model in all the districts of Vidarbha region including region as a whole in comparison to that of other parametric models. As regard to region as a whole the highest R^2 was recorded in area i.e. 61 per cent than production and productivity. The relative contribution of area and yield to change in output was estimated by using Minhans decomposition model. The decomposition analysis for Vidarbha region was estimated the largest area effect on wheat production. It was also observed that for both the period area effect was more pronounce than yield effect and interaction effect. Hence There is need for policy maker to formulate development-oriented policy and researcher to design investigative research activity for promoting sustainable wheat production system in the region for expansion of area under wheat cultivation. The efforts need to be made to increase the area under wheat. This can be done by making available the irrigation water either from existing cropping pattern or by increasing its potential. Insuring the remunerative prices to the farmer and supplying the significant amount of input especially fertilizer at the subsidized prices, has been the most important factor to promote the farmer to increase the production of wheat.

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