

Study of Instability and Decomposition Analysis of Major Crops in Assam

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Abstract: This study takes into consideration instability and decomposition analysis of major crops cultivation in Assam. The important crops of Assam are Autumn Paddy, Winter Paddy, Summer Paddy, Total Paddy, Wheat, Tur, Rape & Mustard, Jute, Potato and Sugarcane. The instability analysis was examined by employing Cuddy-Della Valle Index and as well as decomposition analysis based on the secondary source of data. Paddy cultivation is one of the most widely grown crops. The findings of the study revealed positive yield growth rate and lower yield instability was recorded mostly for all the crops during all the periods with fewer crops under moderate and higher instability till period II. Generally lower level of respective instabilities with positive growth rate was recorded but this phenomenon was more prominent and stable after period II or post green revolution. The decomposition analysis revealed that area effect was more dominating factor at the initial period of study and at later stage yield effect had more role to play in increase of output.

Keywords: Area, Crops, Paddy, Instability, Decomposition analysis, Assam

I. INTRODUCTION

Assam being an agriculture-based economy produces different types of crops which comprises of food, non-food and horticultural crops. More than 70 percent of the state population resort to cultivation as their economic activity. So, it can be said to be as backbone for the population dependent on agriculture. Moreover, contribution of agriculture in terms of state domestic product (SDP) is on the declining trend as it had declined to 15.64 percent in the year 2017-18. Cultivation of paddy is one of the most important crops cultivated as autumn paddy, winter paddy and summer paddy are cultivated in different seasons of the year all round. Besides other crops such as wheat, jute, tur, rape & mustard, potato and sugarcane are also cultivated. In this paper an effort has been made to examine the instability in growth rate of area, production and yield of the above crops mentioned. Also, decomposition analysis has been attempted to examine which factors contribute more in output growth rate.

II. REVIEW OF LITERATURE

Sen (1967) examined a relationship between productivity growth rate and instability and found evidence that variability in production increases with cultivation being undertaken on marginal land along with increase in agricultural implements. However, growth rate in yield results in higher instability in production growth rate as yield instability is greater than area instability as found in the study conducted by Rao (1975). Chattopadhyay (2001) examined that wide variability in agriculture also depends upon the statistical techniques employed, choice of study period and the cut-off points of study period. Chand and Raju (2008) tried to examine instability in three major crops of the state of Andhra Pradesh for the period 1981 to 2004. In their study the effect of technology had stabilizing effect on yield variability across different districts. Instability was higher in farm income rather than area, production and prices.

Pattnaik and Shah (2015) aims to investigate the factors contributing to agricultural growth in Gujarat during 1990-2010 by undertaking a decomposition analysis with reference to price, area, cropping pattern and yield. The analysis demonstrated that high growth rate in agriculture was the result of shift in cropping pattern towards high valued crops such as cotton, fruits, horticultural crops, wheat and groundnut; shift in cropping area was also accompanied by increased yield of among the major crops. It was also noticed that crops with better growth performance is associated with high variability in yield and price variability. The decomposition analysis revealed that individual price effect has increased overtime with reduction of yield effect. The price-area interaction as well as yield-price interaction was found to be positive during 2000s than compared to 1990s; which further highlights the fact that substantial price increase shows favourable changes in yield and area during 2000s whereby importance of price effect is more than that of yield effect.

Sagolsem et al., (2017) tried to investigate growth rates and instability of major crops in North East India for the period 1990 to 2014. The study found that production of rice has increased manifold overtime leading to increase in productivity of rice. Potato and oilseeds production are also on the rise with decline in pulses, fibre and sugarcane. Thus, wide variability could be observed in terms of area, production and yield with dominant of area effect being more for increase in production of crop output.

III. MATERIALS AND METHODS

3.1 Data Source

The study is based on secondary source of data collected from Directorate of Economics and Statistics, Government of Assam for the period 1951 to 2018. According to the availability of data, the study period is divided into four sub-periods as Period I (1951-52 to 1970-71), Period II (1971-72 to 1990-91), Period III (1991-92 to 2010-11), and Period IV (2011-12 to 2018-19).

3.2 Instability Analysis

To measure the magnitude of instability for each crop area, production and yield, Cuddy Della Valle Instability index (Cuddy and Della Valle 1978) was used as a measure of variability. This index is superior to the scale dependent measure (standard deviation) which over-estimates the level of instability in time series data and modifies the coefficient of variation by accommodating trend present in time series data and showing the exact direction of the instability. The Cuddy Della Valle index (CDVI) is calculated as follows:

$$CDVI = I = CV\sqrt{X}$$

I = Instability index (in percent)

Where, $X = 1 - \bar{R}^2$

CV = coefficient of variation and

\bar{R}^2 is adjusted coefficient of determination.

The ranges of CDVI (Sihmar, 2014) are between 0 and 15 for low instability, greater than 15 but lower than 30 as moderate instability and higher instability above 30.

3.3 Decomposition Analysis

The decomposition of the growth of crops has been investigated to measure the relative contribution of area, yield and their combined effect to the total output change for the crops under consideration. The present study uses the decomposition analysis formula proposed by Sharma (1977) whereby several other researchers have used in their work to decompose the component of changes in output and the relative contribution of area, yield and their interaction effect. The decomposition analysis has been worked out as follows:

$$P = \frac{A_0 \times \Delta Y}{\Delta P} \times 100 + \frac{Y_0 \times \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \times \Delta A}{\Delta P} \times 100$$

Production = Area Effect + Yield Effect + Interaction Effect

Where,

$$\Delta A = A_n - A_0$$

$$\Delta P = P_n - P_0$$

$$\Delta Y = Y_n - Y_0$$

A_0, Y_0 and P_0 are the values of area, production and yield of the respective crops in the base year respectively and A_n, P_n and Y_n are values of area, production and yield of the respective crops in the current period respectively.

Thus, the total change in production can be decomposed into area effect; yield effect and their combined interaction i.e., change in production due to change in area and yield.

IV. RESULTS AND DISCUSSIONS

4.1 Instability Analysis

Growth rates explain only the rate of growth over the period but cannot ascertain whether the growth performance is stable or not for the period of that particular variable. Thus, to have better understanding of the magnitude and pattern of changes in the level of production, cultivation area and yield of the crops, instability of area, production and yield have been worked out by Cuddy - Della Valle instability index in Table 1. In period I (i.e., pre-green revolution) low level of instability for crops such as winter paddy (1.60), autumn paddy (2.93), rape & mustard (2.96), sugarcane (3.59), potato (4.50) and jute (6.74) in terms of area under cultivation can be seen except for tur (19.67) of moderate instability, summer paddy (33.07) and wheat (63.44) high instability. Low level of instability for production of crops was recorded for winter paddy (6.20), rape & mustard (12.76), jute (12.90) and autumn paddy (14.04) respectively. Moderate level of instability of production was recorded for tur (19.85), sugarcane (20.70) and potato (22.67) and high level of instability for summer paddy (40.07) and wheat (52.70). Pattern of yield instability is similar to that of production instability where low level of instability was recorded for winter paddy (6.03), jute (11.31), rape & mustard (12.20) and autumn paddy (14.96). Tur (16.66), summer paddy (18.77), wheat (19.43), potato (21.38) and sugarcane (21.68) recorded moderate level of yield instability.

During period II (i.e., green revolution) low level of instability in area was recorded for winter paddy (2.11), autumn paddy (5.14), potato (7.82), jute (11.10), rape & mustard (11.94) and sugarcane (12.45). Other crops such as wheat (24.74), tur (28.60) recorded moderate level of area instability and summer paddy recorded high level area instability of 31.40. During the same period production instability of low level was recorded for winter paddy (7.34), autumn paddy (12.46) and potato (14.37). Rape & mustard (15.44), tur (20.92) and wheat (26.22) recorded medium level of production instability. High level of production instability was recorded for jute (44.02), summer paddy (62.53) and sugarcane (110.12). Yield instability was low for winter paddy (6.35), tur (7.25), wheat (7.76), autumn paddy (9.84), rape & mustard (10.92) and potato (14.99); high yield instability was recorded for jute (46.67), summer paddy (60.52) and sugarcane (118.50).

During period III (i.e., economic reforms) low area instability and low level of yield instability was recorded for all the crops. However, production instability was low for all the crops except potato and summer paddy. Low level of area instability for crops is winter paddy (4.68), rape & mustard (4.85), autumn paddy (4.90), potato (5.75), tur (8.23), jute (9.75), sugarcane (9.77), wheat (10.81) and summer paddy (12.94) respectively. Low level of production instability was recorded for tur (8.69), rape & mustard (9.96), sugarcane (11.47), autumn paddy (11.66), winter paddy (12.53), wheat (13.11) and jute (14.82); however, crops such as potato (16.48) and summer paddy (17.78) recorded moderate level of instability. Low level of yield instability is recorded for tur (1.78), sugarcane (5.49), rape & mustard (8), winter paddy (8.48), summer paddy (8.52), wheat (9.52), jute (10.13), autumn paddy (10.66) and potato (12.72) respectively.

During period IV (i.e., post economic reforms) low level of area, production and yield instability was recorded for all the crops under consideration. Area instability was lowest for wheat (0.51), summer paddy (1.99), sugarcane (2.50), potato (2.63), rape & mustard (3.92), tur (4.57), autumn paddy (4.58), jute (5.77) and wheat (13.43). Low level of production instability was recorded for winter paddy (2.65), summer paddy (4.59), potato (4.63), sugarcane (4.65), autumn paddy (6.29), rape & mustard (9.49), jute and tur (10.06) and wheat (13.64) respectively. Low level of yield instability was recorded for winter paddy (2.91), summer paddy (3.78), potato (4.01), sugarcane (4.84), wheat (5.72), tur (6.30), jute (6.46), rape & mustard (6.79), and autumn paddy (8.19) respectively.

Table 1: Cuddy – Della Valle Instability Index of Area, Production and Yield of crops in Assam (1951-2019)

Crops	Area				Production				Yield			
	Period I	Period II	Period III	Period IV	Period I	Period II	Period III	Period IV	Period I	Period II	Period III	Period IV
Autumn Paddy	2.93	5.14	4.90	4.58	14.04	12.46	11.66	6.29	14.96	9.84	10.66	8.19
Winter Paddy	1.60	2.11	4.68	0.51	6.20	7.34	12.53	2.65	6.03	6.35	8.48	2.91
Summer Paddy	33.07	31.40	12.94	1.99	40.07	62.53	17.78	4.59	18.77	60.52	8.52	3.78
Total Paddy	1.71	2.50	4.03	0.60	5.49	7.57	11.20	2.59	5.43	5.98	7.58	2.86
Wheat	63.44	24.74	10.81	13.43	52.70	26.22	13.11	13.64	19.43	7.76	9.52	5.72
Tur	19.67	28.60	8.23	4.57	19.85	20.92	8.69	10.06	16.66	7.25	1.78	6.30
Rape & Mustard	2.96	11.94	4.85	3.92	12.76	15.44	9.96	9.49	12.20	10.92	8.00	6.79
Jute	6.74	11.10	9.75	5.77	12.90	44.02	14.82	10.06	11.31	46.67	10.13	6.46
Potato	4.50	7.82	5.75	2.63	22.67	14.37	16.48	4.63	21.38	14.99	12.72	4.01
Sugarcane	3.59	12.45	9.77	2.50	20.70	110.12	11.47	4.65	21.68	118.50	5.49	4.84

Source: Computed from data published by the Directorate of Economics and Statistics, Government of Assam, Statistical Handbook of Assam (Various Issues)

The association between yield of principal crops and relative variability is presented in table 2, four different types of association has been recorded: AA- increase in yield associated with lower instability, AB- increase in yield associated with moderate/higher instability, BA- decrease in yield associated with lower instability and BB- decrease in yield associated with moderate/higher instability. From the point of view of better growth and yield rate, crops placed under AA category indicate that the increase in yield is associated with lower instability whereas opposite is the case for BB category. AB category would be preferred to BA category.

From the table 2, it is evident that during period I, prior to green revolution most of the crops were recorded under all the category but during green revolution phase no crops were recorded under BB category and only tur crops showed decrease in yield associated with lower instability; rest of the crops were recorded under AA and AB category. During the phase of economic reforms period and post economic reforms period, most of the crops were recorded under category AA; indicating higher yield rate associated with lower instability, wheat and rape & mustard during period III and summer paddy during Period IV was associated with decreasing yield and lower level of instability. It can be concluded that increasing yield rate of most of the crops was associated with lower instability which indicates the yield of growth rate has been stable over the period of time.

Table 2: Association between yield rate and relative instability

Types of Association	Crops under the category during different study period			
	Period I	Period II	Period III	Period IV
1. AA: Increase in yield associated with lower instability	AP, WP, TP, JUT	AP, WP, TP, WHT, R&M, POT	AP, SP, TP, WP, TR, JTE, POT, SGR	AP, WP, TP, JT, WHT, TUR, R&M, POT, SGR
2. AB: increase in yield associated with moderate/higher instability	TR, SP, SGR	SGR, SP, JT	–	–
3. BA: Decrease in yield associated with lower instability	R&M	TR	WHT, R&M	SP
4. BB: Decrease in yield associated with moderate/higher in instability	WHT, POT	–	–	–

Source: Computed from data published by the Directorate of Economics and Statistics, Government of Assam, Statistical Handbook of Assam (Various Issues)

Note: AP=Autumn Paddy, WP=Winter Paddy, SP=Summer Paddy, TP=Total Paddy, WHT=Wheat, TR=Tur, R&M=Rape & Mustard, JTE=Jute, POT=Potato, SGR=Sugarcane

4.2 Decomposition Analysis

Growth in production is the result of combined factors involving both the area growth, yield growth and their combined interaction. Thus, decomposition analysis is carried out to decompose the production growth rate into area effect, yield effect and the interaction effect which isolates the sources of growth in output and reveal the strength of forces behind the observed changes in production growth. Table 3 shows the period-wise decomposition of production growth into area effect, yield effect and interaction effect of both area and yield growth. During period I (i.e., pre- green revolution period) production growth of autumn paddy (3.12 per cent) was marked by the dominance of yield effect (79.04 per cent), area effect contributes (12.88 per cent) and interaction effect (8.08 per cent). Production growth of winter paddy (1.51 per cent) was contributed almost equally by yield effect (49.71 per cent) and area effect (43.2 per cent); and contribution of interaction effect (7.09 per cent). Summer paddy production growth (0.14 per cent) was mainly due to yield effect (70.1 per cent), interaction effect contribution was (26.48 per cent) and lesser due to area effect (3.42 per cent). Production growth of total paddy (1.87 per cent) combined was mostly due to yield effect (65.5 per cent), area effect (27.05 per cent) and interaction effect (7.45 per cent). Wheat production growth (10.75 per cent) was dominated only by yield effect (162.51 per cent) where interaction effect (-56.66 per cent) and area effect (-5.85 per cent) are negligible. Production growth of tur (5.16 per cent) was due to maximum contribution of area effect (74.14 per cent), lesser contribution of interaction effect (14.05 per cent) and yield effect (11.81 per cent) respectively. Production growth of rape & mustard (0.54 per cent) was dominated solely by yield effect (153.51 per cent); whereby area effect (-45.89 per cent) and interaction effect (-7.62 per cent) have negligible impact. Production growth of jute (1.17 per cent) was marked by the dominance of area effect (81.81 per cent), followed by yield effect (15.11 per cent) and interaction effect (3.08 per cent). Production growth of potato (1.14 per cent) was only due to yield effect (140.78 per cent) whereby area effect (-30.45 per cent) and interaction effect (-10.33 per cent) have negligible role. Production growth of sugarcane (3.45 per cent) was almost equally contributed by area effect (44.55 per cent) and yield effect (39.53 per cent); and also, interaction effect (15.92 per cent).

During period II (i.e., green revolution period) production growth of autumn paddy (2.71 per cent) was marked by the dominance of area effect (65.36 per cent), yield effect contributes (24.19 per cent) and interaction effect (10.45 per cent). Production growth of winter paddy (2.77 per cent) was contributed almost equally by area effect (45.67 per cent) and area effect (41.44 per cent); and contribution of interaction effect (12.89 per cent). Summer paddy production growth (7.38 per cent) was mainly due to yield effect (94.86 per cent), interaction effect contribution was (3.76 per cent) and lesser area effect (1.38 per cent) contribution. Production

growth of total paddy (2.94 per cent) combined was mostly due to area effect (47 per cent), yield effect (39.42 per cent) and interaction effect (13.58 per cent). Wheat production growth (4.25 per cent) was dominated by yield effect (93.17 per cent) where minimum contribution of interaction effect (3.61 per cent) and area effect (3.22 per cent) was recorded. Production growth of tur (0.66 per cent) was due to maximum contribution of yield effect (131.15 per cent), contribution of area effect (-26.55 per cent) and interaction effect (-4.6 per cent) have negligible impact. Production growth of rape & mustard (4.42 per cent) was dominated solely by yield effect (82.18 per cent); whereby lesser contribution of interaction effect (9.12 per cent) and area effect (8.7 per cent) are recorded. Production growth of jute (-1.08 per cent) i.e., decreased production was marked by the dominance of yield effect (154.14 per cent), followed by interaction effect (21.74 per cent) and area effect (-75.88 per cent) has recorded negligible impact. Production growth of potato (5.93 per cent) was due to yield effect (52.98 per cent) whereby area effect (22.89 per cent) and interaction effect (24.13 per cent) was recorded. Production growth of sugarcane (14.49 per cent) was mostly dominated by area effect (99.23 per cent); yield effect (0.06 per cent) and interaction effect (0.71 per cent) recorded negligible impact.

During period III (i.e., economic reforms period) production growth of autumn paddy (-1.71 per cent) i.e., decreased production was marked by the dominance of yield effect (182.17 per cent), interaction effect contributes (85.58 per cent) and area effect (-167.75 per cent) have negligible role. Production growth of winter paddy (2.04 per cent) was contributed mostly by area effect (90.6 per cent), lesser contribution of yield effect (6.6 per cent) and interaction effect (2.8 per cent). Summer paddy production growth (8.55 per cent) was the result of yield effect (56.1 per cent), interaction effect (29.76 per cent) and area effect (14.14 per cent) respectively. Production growth of total paddy (2.42 per cent) combined was dominated by area effect (99.9 per cent); yield effect (0.05 per cent) and interaction effect (0.05 per cent) have negligible impact. Wheat production growth (-3.52 per cent) was dominated by yield effect (83.95 per cent) where contribution of area effect (27.43 per cent) was minimum and interaction effect (-11.38 per cent) was recorded negligible. Production growth of tur (0.65 per cent) was due to almost equal contribution of yield effect (49.07 per cent), area effect (47.84 per cent) and interaction effect (3.09 per cent) have lesser impact. Production growth of rape & mustard (-1.15 per cent) i.e., decreased production was dominated solely by yield effect (99.52 per cent); whereby lesser contribution of area effect (0.6 per cent) and interaction effect (-0.12 per cent) have negligible impact. Production growth of jute (-1.71 per cent) i.e., decreased production was marked by the dominance of yield effect (138.82 per cent), followed by interaction effect (24.51 per cent) and area effect (-63.33 per cent) has recorded negligible impact. Production growth of potato (1.75 per cent) was mainly due to yield effect (96.87 per cent) whereby area effect (2.27 per cent) and interaction effect (0.86 per cent) was recorded. Production growth of sugarcane (-1.17 per cent) i.e., decreased production was mostly dominated by yield effect (106.24 per cent); interaction effect (1.69 per cent) and area effect (-7.93 per cent) recorded negligible impact.

During period IV (i.e., economic reforms period) production growth of autumn paddy (-4.76 per cent) i.e., decreased production was marked by the dominance of yield effect (167.08 per cent), interaction effect contributes (78.72 per cent) and area effect (-145.8 per cent) have negligible role. Production growth of winter paddy (2.49 per cent) was contributed mostly by area effect (99.22 per cent), contribution of yield effect (0.64 per cent) and interaction effect (0.14 per cent) is almost negligible. Summer paddy production growth (-0.06 per cent) was the result of area effect (199.12 per cent), negligible interaction effect (0.96 per cent) and area effect (-100.08 per cent) respectively. Production growth of total paddy (1.52 per cent) combined was dominated by area effect (153.04 per cent); yield effect (-44.34 per cent) and interaction effect (-8.7 per cent) have negligible impact. Wheat production growth (-14.08 per cent) was dominated by yield effect (102.12 per cent) where contribution of interaction effect (5.38 per cent) was minimum and area effect (-7.5 per cent) was recorded negligible. Production growth of tur (1.52 per cent) was due to higher contribution of area effect (79.93 per cent), yield effect (18.2 per cent) and interaction effect (1.87 per cent) have lesser impact. Production growth of rape & mustard (3.11 per cent) production was equally contributed by area effect (47.65 per cent), yield effect (46.22 per cent) and interaction effect (6.13 per cent). Production growth of jute (3.25 per cent) was marked by the dominance of area effect (108.81 per cent), followed by negligible impact of interaction effect (-2.18 per cent) and yield effect (-6.63 per cent). Production growth of potato (1.28 per cent) was mainly due to yield effect (65.77 per cent) whereby area effect (31.97 per cent) and interaction effect (2.26 per cent) was recorded. Production growth of sugarcane (1.84 per cent) was dominated by area effect (67.83 per cent); yield effect (29.07 per cent) and interaction effect (3.1 per cent) were recorded.

Table 3: Decomposition of Production growth into percent contribution of area, yield and their interaction effect

Crops	Area Effect				Yield Effect				Interaction Effect			
	Period I	Period II	Period III	Period IV	Period I	Period II	Period III	Period IV	Period I	Period II	Period III	Period IV
Autumn Paddy	12.88	65.36	-167.75	-145.8	79.04	24.19	182.17	167.08	8.08	10.45	85.58	78.72
Winter Paddy	43.2	45.67	90.6	99.22	49.71	41.44	6.6	0.64	7.09	12.89	2.8	0.14
Summer Paddy	3.42	1.38	14.14	199.12	70.1	94.86	56.1	-100.08	26.48	3.76	29.76	0.96
Total Paddy	27.05	47	99.9	153.04	65.5	39.42	0.05	-44.34	7.45	13.58	0.05	-8.7
Wheat	-5.85	3.22	27.43	-7.5	162.51	93.17	83.95	102.12	56.66	3.61	11.38	5.38
Tur	74.14	26.55	47.84	79.93	11.81	131.15	49.07	18.2	14.05	-4.6	3.09	1.87
Rape & Mustard	45.89	8.7	0.6	47.65	153.51	82.18	99.52	46.22	-7.62	9.12	-0.12	6.13
Jute	81.81	75.88	-63.33	108.81	15.11	154.14	138.82	-6.63	3.08	21.74	24.51	-2.18
Potato	30.45	22.89	2.27	31.97	140.78	52.98	96.87	65.77	10.33	24.13	0.86	2.26
Sugarcane	44.55	99.23	-7.93	67.83	39.53	0.06	106.24	29.07	15.92	0.71	1.69	3.1

Source: Computed from data published by the Directorate of Economics and Statistics, Government of Assam, Statistical Handbook of Assam (Various Issues)

V. CONCLUSIONS

The study analysed the level of instability and decomposition of growth rate in area, production and yield of principal crops during four specific periods - Period I, Period II, Period III and Period IV. The study found that positive-area-growth with lower area instability was recorded mostly for the crops under consideration during all the periods of study, moderate and higher instability was also recorded during period I and II but for fewer crops. Positive production growth with lower production instability was also recorded mostly for crops under consideration during all the periods; fewer crops under moderate and higher instability of production with both positive and negative production growth rate was recorded mostly during period I, II and III. By taking into consideration of positive yield growth rate with lower yield instability was also recorded mostly for all the crops during all the periods with fewer crops under moderate and higher instability till period II. Generally lower level of respective instabilities with positive growth rate was recorded but this phenomenon was more prominent and stable after period II or post green revolution. Dominance of area effect was observed in output growth for crops such as winter paddy, tur, jute and sugarcane during all the periods of study and yield effect was observed for increased production of summer paddy, wheat, rape & mustard and potato. Interaction effect of both yield and area was observed in increased production of autumn paddy after period II. Both yield effect and area effect assume equally important role in output growth of respective crops during all the periods under study.

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