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Application of Hazell Decomposition Model in Ragi Production - A Case Study of Karnataka

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Abstract

Ragi, also known as finger millet, is one of the most important components in Karnataka's staple food diet. Finger millet is a gluten-free food that is high in calcium, iron, protein, fiber and other minerals. The cereal is low in fat and mostly made up of unsaturated fat. It is regarded as one of the healthiest cereals available. In the year 2019-20, the area covered by the ragi crop in India is 9.66 lakh acres. The present research is based on 18 years of data on ragi area, production and productivity in Karnataka (from 2000-01 to 2017-18). To determine the growth and stability of the data over the years, the exponential growth rate, the instability index and Hazel's decomposition analysis were utilised. During the study period, the area under ragi crop expanded by 1.79 per cent, while production climbed by 2.23 per cent. In the case of production, the variation around the trend (instability index 21.89) and the variance around the mean (CV 24.48 per cent) was greater than area and productivity. The increase in mean area was responsible for 87.49 per cent of the increase in production. The variation in ragi production was primarily related to changes in the area variance.

Keywords : Trend, Production, Productivity, Area, Decomposition analysis, Instability index

Ragi (*Eleusine coracana)* familiarly known as ragi or finger millet or madua is a very important minor-millet which is substantially grown in India and Africa as a staple food for a certain population (Devi *et al.,* 2014). It is grown as a staple food grain in over 25 nations across Africa (both eastern and southern) and Asia (from the Near East to the Far East). Uganda, India, Nepal and China are the biggest producers. The quantity of nutrients found in these small deep crimson pearls makes them unique. Finger millet is a gluten-free grain that is high in calcium, iron, protein, fiber and other minerals. It is considered to be a model nutraceutical crop owing to its health benefits to humans (Gupta *et al.,* 2017). The cereal is low in fat and mostly made up of unsaturated fat. Finger millet is easy to digest and does not contain gluten, making it suitable for gluten-free diets. It is regarded as one of the healthiest cereals available. In 2019-20, India's ragi area had covered 9.66 lakh ha. Karnataka (5.80 lakh ha.), Orissa (1.11 lakh ha.), Uttarakhand (1.10 lakh ha), Tamil Nadu (0.50 lakh ha.), Andhra Pradesh (0.24 lakh ha.) and Maharashtra (0.78 lakh ha.) are the biggest ragi producing states in India (Anonymous, 2019). Ragi output was estimated at 1.22 million tonnes in 2018-19, down from 1.99 million tonnes in 2017-18, according to the 4thAdvance Estimates of Production of Food Grains. In the year 2019, 527 thousand hectares of ragi were planted in Karnataka, yielding 677 thousand tonnes at productivity of 1285 kg per hectare. The biggest producing districts are Tumakuru, Kolar, Bengaluru, Chitradurga, Hassan and Mysore, which together account for 85 per cent of the total area and 80 per cent of the state's output.

In recent years, the area under ragi has grown significantly in the country, resulting in a number of concerns that require the attention of all parties involved. It offers nutritional value because its seeds are high in ethionine, calcium and iron and contain 11.7 per cent protein (Sankaran, 2017). Ragi is mostly used in savoury dishes, sathumavu, traditional foods such as roti (unleavened breads), biscuits and the feed industry. Some of the most critical challenges concern the replacement of land with other crops and greater production variability.

According to Hazell (1984), increase in cereal production in India and the United States are accompanied by a more than corresponding increase in the standard deviation of cereal production.

METHODOLOGY

The research is based on secondary data and time series data on ragi production, area and productivity in Karnataka from 2000-01 to 2016-17. The required secondary data is collected from Directorate of economics and statistics. Furthermore, the data was divided into two nine-year periods to know the factors contributed to increase ragi production.

Analytical Tools and Techniques Employed

The analytical tools employed in the present study are elaborated under the following headings.

Exponential Growth Model

From 2000-01 to 2017-18, growth rates for area, production, and productivity of ragi were calculated in Karnataka. The growth rates of the relevant economic variables were estimated using Exponential Growth Model. Finally, for the analysis, an exponential growth model was used, which takes the form below.

$Y = ab^te$..................................(1)

Where,

Y = Dependent variable for which the growth rate is estimated (area, production and productivity of ragi).

a = Intercept

b = Regression coefficient

t = Time variable (2000-01 to 2017-18)

e = Error term

The compound growth rate was obtained from the logarithmic form of the equation (1) as below:

$\ln Y = \ln a + t \ln b$

The per cent compound growth rate (g) was derived using the relationship

g = (Anti ln of b – 1) x 100

Instability Analysis

The growth rates for ragi area, production and productivity in Karnataka were determined from 2000-01 to 2017-18. The growth rates of the relevant economic variables were estimated using Exponential Growth model.

Co-efficient of Variation

$$CV = \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \quad ....(2)$$

The original time series data was fitted with a linear trend for a period of 18 years, from 2000-01 to 2017-18. The significance of the trend coefficients was determined. When a series trend was found to be significant, the variation around the trend was utilised as an indication of instability rather than the variation around the mean. The Instability Index was calculated using the formula proposed by Cuddy and Della (1978), where the mean coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of multiple determination (R^2) in cases where R^2 was significant.

$$\text{Instability Index} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \times (1-R^2) \quad ....(3)$$

R^2 = Coefficient of Determination

A high degree of instability index signifies violent variations.

Hazell's Decomposition Analysis

The Model

Let Q-production, A-area and Y-yield per unit area.

Then Q = A * Y, Average production E (Q), can be expressed as

$$E(\mathbf{Q}) = \bar{A}\ \bar{Y}\ \text{Cov}(A, Y) .... (1)$$

Where, $\bar{A}$ and $\bar{Y}$ indicatesthe mean-area and mean-yield.

As a result, the covariance between area and yield, as well as variations in the mean area and mean yield have an impact on average production. The decomposition analysis goal is to divide the differences in average production between the first and second periods.

The average production in first period and in second period is given by,

$$E(Q_I) = \bar{A}_I \bar{Y}_I + CoV(A_I, Y_I) \text{........................} (2)$$

And production in the second period can be written as

$$E(Q_{II}) = \bar{A}_{II} \bar{Y}_{II} + CoV(A_{II}, Y_{II}) \text{........................} (3)$$

Each variable in the second period can be expressed as its counter part in the first plus the change in the variable between the two. For example,

$$\bar{A}_{II} = \bar{A}_I + \Delta \bar{A} \text{........................} (4)$$

Thus equation (3) can be written as

$$E(Q) = (\bar{A}_I + \Delta \bar{A})(\bar{Y} + \Delta \bar{Y}) + CoV(A_I, Y_I) + \Delta CoV(A\,Y)$$

The change in average production, $\Delta E(Q)$, is obtained by subtracting equation (2) from equation (3). Thus,

$$\Delta E(Q) = E(Q_{II}) - E(Q_I)$$

$$(Q) = \bar{A}_I \Delta \bar{Y} + \bar{Y}_I \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y}_I + \Delta CoV(A, Y) \text{.......} (5)$$

Thus, the average production is affected not only by two constituent parts, *i.e.,* mean area andmean yield but also by the covariance between them.The variance of production, V (Q), can be expressed as

$$V(Q) = \bar{A}^2 V(Y) + \bar{Y}^2 V(A) + 2\bar{A}\bar{Y} CoV(A,Y) - CoV(A_I, Y_I)^2 + R \text{...} (6)$$

R is a residual term that should be very small. V (Q) is a function of the variances of yield and area sown, as well as the mean area and yield and the covariance between area and yield, as shown in equation (6). Any change in one of these will result in a change in V(Q).

The basic goal of decomposition analysis is to break down changes in Q's predicted value and variability into their constituent elements, using the variables' values from the beginning as a starting point.

Components

TABLE 1

Components of change in average production

Source of Change	Symbol	Component of change
Change in mean yield	$\Delta \bar{Y}$	$\bar{A}_I \Delta \bar{Y}$
Change in mean area	$\Delta \bar{A}$	$\bar{Y}_I \Delta \bar{A}$
Interaction between change in mean area and mean yield	$\Delta \bar{Y}, \Delta \bar{A}$	$\Delta \bar{Y}, \Delta \bar{A}$
Change in area - yield Covariance	Δ Cov (A, Y)	Δ Cov (A, Y)

Source: Hazell, 1982

These components can be arranged as shown in Table 1 and there are four major sources of change which are grouped into pure effect, interaction effect and co-variance effect.

The pure effect : Two parts $\bar{A}_I \Delta Y$ and $\bar{Y}_I \Delta A$ arise from changes in the mean yield and the mean area. Even if there are no other causes of change, these are 'pure' effects as they occur.

The interaction effect : The term $\Delta \bar{A} \Delta \bar{Y}$ arises from the simultaneous occurrence of changes in mean yield and mean area. If the mean yield or the mean area remain constant, it becomes zero.

The variability effect : The last term, Δ COV (A, Y), arises from changes in the variability of areas and yields. Since $COV(A,) = p[(A)(Y)]^{1/2}$ where ρ is the correlation co-efficient, then it can be seen that Δ COV (A,Y) arises from changes in the variances of areas and yields and from changes in the correlation between areas and yields.

Decomposition of Change in Variance of Production (Q)

The change in variance of production between two periods can be determined using the aforementioned formulae, with the first period serving as the basis, and the sources of change can be noted in Table 2. Changes in production variance V (Q) can be decomposed in an analogue approach. There are ten sources of variation in output that can be discovered.

TABLE 2

Components of change in the variance of production

Source of change	Symbol	Components of change
Change in mean yield	$\Delta \bar{Y}$	$2\ (\bar{A}_I\ \Delta\ \bar{Y}\ \ CoV(A_I,Y_I) + [2\ \bar{Y}_I\ \Delta\ \bar{Y} - \Delta\ \bar{Y})^2]\ V\ (A_I)$
Change in mean Area	$\Delta \bar{A}$	$2\ \bar{Y}_{11}\ \Delta\ \bar{A}\ \ CoV(A_I,Y_I) + [2\ \bar{A}_1\ \Delta\ \bar{A} - (\Delta\ \bar{A})^2]\ V\ (Y_I)$
Change in yield variance	$\Delta\ V(Y)$	$(\bar{A}_I)^2\ \Delta V(Y)$
Change in area variance	$\Delta\ V(A)$	$(\bar{Y}_I)^2\ \Delta\ V(A)$
Interaction between changes mean yield and meanarea	$\Delta\bar{Y}, \Delta\bar{A}$	$2\ \Delta\bar{Y}\Delta\bar{A}\ CoV(Y_I,A_I)$
Change in area-yield Covariance	$\Delta\ CoV(A,Y)$	$[2\ \bar{A}_1\ \bar{Y}_1 - 2CoV(Y_I, A_I)\ \Delta\ CoV - [\Delta\ CoV\ (A,Y)]^2$
Interaction between changes in mean area and yield variance	$\Delta\bar{A}, \Delta V(Y)$	$[2\ (\bar{A}_1\ \Delta\ \bar{A} + (\Delta\ \bar{A})^2]\ \ \Delta\ V(Y)$
Interaction between changes in mean yield and area Variance	$\Delta\bar{Y}, \Delta V(A)$	$[2\ \bar{Y}_1\ \Delta\ \bar{Y} + (\Delta\ \bar{Y})^2]\ \Delta\ V(A)$
Interaction between changes in mean area and yield and changes inarea yield covariance	$\Delta\bar{Y}\ \Delta\bar{A}\ \Delta\ CoV$	$[2\ \bar{Y}_1\ \Delta\ \bar{A} + 2\ \bar{A}_1\ \Delta\ \bar{Y} + 2\ \Delta\ \bar{A}\ \Delta\ \bar{Y}]\ \Delta\ CoV\ (A,Y)$
Change in residual	ΔR	$\Delta\ V\ (A,Y)$ - sum of the other components

Source: Hazell, 1982

As previously seen, components 1, 2, 5 and 6 reflect sources of change in mean output (Table 2). Change can also occur as a result of variations in area, yield and their interactions. The first four parts of change in variance of production in Table 2 indicate the pure effect and are quite important from the standpoint of variability. The fifth component contributes to the interaction effect, which is the result of a change in mean area and yield occurring at the same time. The sixth component represents variations in area and yield variability, as well as changes in the correlation between area and yield. The seventh and eighth components pertain to interactions at the second and third degrees between changes in mean area, mean yield and their variability. The last two sources of change aren't relevant in this case because they can't be directly controlled.

The components of change in production variance can also be divided into four categories.

Average production components : These are same as that of the components of average production *i.e.,* components 1, 2, 5, 6 (Table 2).

Variance component : Includes change in yield and area variance *i.e.,* 3 and 4 (Table 2).

Interaction components : Components 7, 8, 9 may be included under this (Table 2).

Residual : This will be very small or zero as all other components completely explains the total variability (Table 2).

RESULTS AND DISCUSSION

Compound growth rates were calculated to understand the trends in ragi crop area, production and productivity in India from 2000 to 2018. Tables 3 and 4 show the findings of the estimated growth rates.

During the study period, the area under ragi crop rose dramatically with a growth rate of 1.79 per cent per year and output increased greatly by 2.23 per cent

TABLE 3

Compound growth rate and instability index of area, production and productivity of ragi in India (2000-2017)

Particulars	Area (1000 Ha)	Production (1000 Tonnes)	Productivity (kg/Ha)
CAGR(%)	1.79 ** (0.01)	2.23 ** (0.02)	0.451 (0.0043)
MEAN	772.61	1348.94	1724.11
CV(%)	16.25	24.48	11.30
Instability index	13.26	21.89	11.07

Note : figures in the parenthes is indicate b values
** denotes significance at 5 per cent level of significance

per year, but there was a modest increase in ragi productivity, but it was not significant. In the case of production, the variation around the trend (instability index 21.89) and the variance around the mean (CV 24.48 per cent) was greater than in the case of area and productivity.

Table 4 shows that an increase in mean area accounted for 87 per cent of the increase in production, while a change in area-yield co-variance accounted for 13.23 per cent. Changes in mean yield and the interaction between mean yield and change in mean area were 0.005 and -0.73 per cent respectively. It had a negligible impact on mean production.

Components of Change in Production Variability

The average production component, variance component and interaction component all

TABLE 4

Components of change in production in ragi

Description	Symbol	Percentage
Change in mean yield	$\Delta\bar{Y}$	0.0054
Change in mean area	$\Delta\bar{A}$	87.497
Interaction between change in mean area and mean yield	$\Delta\bar{A}, \Delta\bar{Y}$	-0.738
Change in area-yield co-variance	Δ CoV (A,Y)	13.23
Total change in mean production		100

contributed very little to the change in ragi production variability. It was fascinating to learn that, the change in area variance accounted for the majority of the change in production variability, accounting for 306 per cent and it was interesting to observe that, 207 per cent of decrease in the variance of production was due to residual factors (Table 5).

TABLE 5

Components of change in production variability

Description	Symbol	Percentage
Change in mean yields	$\Delta\bar{Y}$	0.00017
Change in mean areas	$\Delta\bar{A}$	2.802
Change in yield variance	ΔV(Y)	0.0003
Change in area variance	ΔV(A)	306.220
Interaction between changes in mean yield and mean area	$\Delta\bar{Y}, \Delta\bar{A}$	-0.0236
Change in area-yield covariance	Δ CoV (A,Y)	0.423988641
Interaction between changes in mean area and yield variance	$\Delta\bar{A}, \Delta$V(Y)	-0.054670581
Interaction between changes in mean yield and area variance	$\Delta\bar{Y}, \Delta$V(A)	-2.585862693
Interaction between changes in mean area and yield and change in area-yield covariance	$\Delta\bar{A}, \Delta\bar{Y}, \Delta$ CoV (A,Y)	0.489712115
Change in residual	Δ R	-207.2735525
Total		100

The area under ragi farming has increased dramatically over the years, possibly as a result of high yielding varieties and hybrids. This little millet, in particular, has a larger market demand. During the study period (2000-2018), the production of ragi increased in Karnataka. Ragi production showed more in consistency than area and productivity, indicating that the causes and cures for such in consistency in output should be investigated in order to improve the welfare of ragi farmers in the state. Overall, the area was the most important element determining the change in average production as well as the variability of production, according to the results of the investigation. There is a need to evolve appropriate strategies to maintain and sustain the growth trend in ragi production by shifting focus in finding alternatives. This helps in maintaining sustainable growth in ragi production to meet increasing demand.

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