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Growth, Instability and Decomposition of Millets in Odisha: 1960-61 to 2017-18

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Growth, Instability and Decomposition of Millets in Odisha: 1960-61 to 2017-18[1]

Diptimayee Jena and Srijit Mishra[2]

Abstract

Purpose: Odisha started a programme to revive millets in 2017. Keeping this in the background, this paper proposes to examine growth and instability of production, area and yield, and decomposition of production of millets in Odisha in the last six decades.

Design/methodology/approach: The study period is split into six sub-periods, one for each decade, using triennium ending data from TE 1962-63 to TE2017-18, to analyse decadal changes. Boyce's kinked exponential has been used to estimate growth, instability is estimated after using Boyce's method of de-trending, and production is decomposed to area, yield and interaction effects of millets. In this, millets as a crop group is compared with other major crop groups and then one analyses these for four specific millet crops/categories – ragi, jowar, bajra and small millets.

Findings: In Odisha, the 1960s and 1970s indicate an increasing trend in area and production of millets. There is a reversal for millets with decadal growth since 1980s declining in area and production. The decline started first for small millets in the 1980s and subsequently since the 1990s for the three major millets – bajra, jowar and ragi. Decomposition of millets production indicates that that decline since 1980s is largely on account of area effect, but also because of yield effect in the 1990s and 2010s.

Originality/Value: It adds to the understanding of millets vis-à-vis other crop groups and not as a constitutive component of cereals, which has been dominated by paddy and wheat, and also for the four specific millet crops/categories. It provides a context to the ongoing action research on Odisha Millets Mission.

Key Words: Millets, Decomposition of Production, Growth, Instability.

JEL Classification: Q10, Q18, Q19

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1. Introduction

Millets are sturdier and hardier crops that can survive in rocky soils and in areas of scanty rainfall and with harsh climatic conditions (Nellithanam & Krishna, 2014; Naveena et al., 2016; Malathi et al., 2016 and Rao et al., 2007) and also occupy an essential role in the diet of people in many regions of the world (Anderson &Martin, 1949). Besides, compared to other cereals like rice and wheat, millets have better nutritional characteristics (FAO, 1995) and it contributes for the food and nutritional security of our country (Malathi et al., 2016 and Rao et al., 2007). Conventionally, it is often referred to as coarse cereals, but realizing the nutrient richness of the grains, it is now considered as nutri-cereals (The Gazette of India, 2018).

The Green Revolution (GR) ushered India onto a path of agricultural innovation and structural transformation through food self-sufficiency and technological advancement, which as (Kataki, 2002 and Pingali, 2012) among others point is largely the rice-wheat cropping system. This has, since 1970s, resulted in the crowding out of traditional micronutrient-rich food crops, such as millets and pulses from areas in which they were historically grown. Post green-revolution, in India, the area under foodgrains which comprise of millets, other cereals and pulses has increased from 124.32 million hectares in 1970-71 to 127.57 million hectares in 2017-18. However, the area under millets has been declining in India from 81.01 million hectares in 1970-71 to 37.17 million hectares in 2017-18; for the same period, the area under other cereals which includes the area under rice, wheat and maize has increased from 61.68 million hectares to 82.84 million hectares and that for the pulses also has increased from 22.54 million hectares to 29.99 million hectares (Government of India, 2018).

In Odisha where the green-revolution ushered in later (late 70s to early 80s) the area under foodgrains has declined from 7.02 million hectares in 1980-81 to 6.21 million hectares in 2017-18 (Government of Odisha, 2017-18). This was on account of decline in areaunder millets from 0.74 million hectares in 1980-81 to 0.15 million hectares in 2017-18, and decline in area under other cereals from 4.55 million hectares to 4.01 million hectares. At the same time, area under pulses increased from 1.72 million hectares to 2.04 million hectares.

There have been limited policies and schemes at the all India level that explicitly included millets. Among the available schemes, the most important ones are Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) (INSIMP budget, 2011-12), Rainfed Area Development Programme (RADP) as a sub-scheme of Rashtriya Krishi Vikas Yojana (RKVY) (Department of Agriculture and Cooperation, Guidelines for Rainfed Area Development Programme, 2011), and Integrated Cereals Development Programmes in Coarse Cereals based Cropping Systems Areas (ICDP-CC) under Macro Management of Agriculture (MMA).

INSIMP was an integrated scheme by combining different policy components like demonstration, inputs, seed, post-harvest technology, awareness raising, capacity building and research. It extended its targets to all millets: sorghum (jowar), pearl millet (bajra), finger millet (ragi) and small millets. In this, the focus was largely on input supply including that for micro-nutrients, fungicides, (bio) fertilizers, urea, potash, pesticides, herbicides, and seeds of improved and hybridised varieties. It ignored the traditional knowledge of the farming communities as it pushed for the extensive use of inputs (Sandeep, 2012) and little focus on consumption leading to nutritional security.

RADP put forward a holistic approach to rainfed area development through the promotion of rainfed farming systems and by focusing on the needs of small and marginal farmers through integrated farming practices, assistance to farmers in improving the productivity of existing cropping patterns and in diversifying production. Support to millets was only one component amongst its programme components. Similarly, millets through MMA under ICDP-CC being a sub-category had limited reach.

In recent years, keeping in perspective the nutritional potential of millets and its adaptability to harsh climatic conditions, the Government of Odisha launched a “Special Programme for Promotion of Millets in Tribal Areas of Odisha,” also referred to as Odisha Millets Mission (OMM) in 2016-17 which has been operating through four verticals – production, processing, marketing and consumption. Keeping this in the background, the present study proposes to examine growth and instability of production, area and yield, and decomposition of production of millets in Odisha in the last six decades.

The study period is split into six sub-periods, one for each decade, using triennium ending data from TE 1962-63 to TE2017-18, to analyse decadal changes. Boyce’s kinked exponential has been used to estimate growth, instability is estimated after using Boyce’s method of de-trending, and production is decomposed to area, yield and interaction effects of millets. In this, millets as a crop group is compared with other major crop groups and then analyses these for four specific millet crops/categories – ragi, jowar, bajra and small millets.

The present study is organised into five sections, including the current section 1 of introduction. Section 2 provides a brief review of various issues on growth, instability and decomposition in the context of Indian agriculture in general and Odisha agriculture in particular with a focus on millets leading to the objectives of the current study. Data and methods are presented in section 3, and results and discussions are in section 4. Conclusions are in section 5.

2. Review of Issues

The review of issues has discussed the relevance of millets in the context of Indian agriculture and also presents a methodological review and, wherever possible, also contextualises these to their application on Indian agriculture, in general, and on millets, in particular. From a methodological perspective, as Chattopadhyay (2001) opines, unstable fluctuations in agriculture as also other factors such as the statistical techniques employed, choice of period and cut-off points make growth analysis in agriculture a complicated area. The study further points out that measurement of instability has evolved as a related issue to that of agricultural growth. The changes in agricultural production have also been decomposed into area, yield and interaction effects. We elaborate on some of these.

2.1 Relevance of Millets

It is discussed that to achieve an improved food and nutritional security, millets would be a good option for the farmers in semiarid regions of India (Food and Agriculture Organisation, 1995; DHAN Foundation and WASSAN, 2012; Nellithanam & Krishna, 2014; Shukla et al., 2015 and Naveena et al., 2016). Millets are rich in micronutrients, which are helpful in combat various nutritional disorders and will provide very economical food for a large proportion of people. They are of great value in poor or rocky soils and in areas of low or inconsistent rainfall, because of its strong and deep rooting system and efficient use of available moisture, some millet can survive in areas with harsh climatic conditions (Nellithanam & Krishna, 2014; Naveena et al., 2016). As India's agriculture suffers hugely from the vagaries of monsoon, millets, which are also known as "famine reserves" for their prolonged and easy storability, are of great relevance (Passi & Jain, 2014). The benefit-cost ratio indicates its feasibility of cultivation in the rainfed areas. The study also states that in spite of all its goodness, the area under millets shows a declining trend over time (Kusuma et al., 2014). Due to a lack of awareness of its importance and properties, its utilization is restricted in the regions where it is grown (Patel et al., 2014). Their production and good agronomic practices need to be promoted in location-specific and in a regional development framework for sustaining the livelihood of producers and food security of consumers (Meenakshi, 2009). In order to enhance productivity of nutritious millets and income from their cultivation the major interventions on improved agronomic practices are (i) use of farmer preferred millet varieties, (ii) use of quality seed produced in participation with farmers, (iii) planting in rows instead of broadcast sowing, (iv) use of scientifically recommended seed rate, (v) effective use of row ratios for millet-based intercrops, (vi) encouraging application of farmyard manure and fertilizers, (vii) thinning to regulate plant population, and (viii) inter-cultivation and need-based top dressing with fertilizers (Ravi et al., 2010). In addition to the agronomic practices, Ravi et al. (2010) and Patel et al. (2014) have observed that the unavailability of processed products of millet is the major reason contributing to the decreasing popularity of these grains even among people who had been its traditional consumers.

2.2 Measuring Agricultural Growth

A simple measure of estimating agricultural growth is the annual average growth rate or a simple linear average over the years (Pattnaik & Shah, 2015; Laitonjam et al., 2018). An alternative approach is to estimate agricultural growth using the compound growth rate with the implicit understanding that growth is exponential (Kalamkar et al. 2002Kalamkar, 2003; Pattanaik & Mohanty, 2016; Bellundagi, 2016; Malathi et al., 2016 and Devi et al. 2017), but a limitation of this is that it makes use of the base and final years only. T; o address this, linear trend growth rate of logarithmic values has been used by (Mishra, 2009; Kannan, 2011; and Ashwini et al., 2019), but then these assume that the entire period follows a similar pattern ignoring breaks in intercept and slope or imposing discontinuity between two sub-periods, which could result in anomalous results in estimation of growth rates. Boyce (1986), in a seminal work on kinked-exponential growth brings in break-points such that the trend lines between two sub-periods need not be discontinuous. This has been applied in the context of Odisha by Paltasingh & Goyari (2013) and Senapati & Goyari (2019) and for India by Dev et al. (2019).

2.3 Measuring Agricultural Instability

A simple method of measuring instability in foodgrains production was estimated by using standard deviation (Dev, 1987). On the other hand, (Sharma et al., 2006) estimated the instability in the production and yield of different foodgrains by using coefficient of variation method. An alternative method of estimation of instability in the area, production and yield is agriculture instability index (Chand & Raju, 2009 and Bellundagi, 2016). However, another method of measuring instability is Cuddy-Della Valle index (Sihmar, 2014; Samal et al., 2017; Senapati & Goyari, 2019 and Ashwini et al., 2019). Besides all the above methods, (Paltasingh & Goyari, 2013) analysed instability in crops for the area, yield and production using Boyce (1987).

The instability of millets in most of the states for production became more stable during the 1990s compared to 1980s (Sharma et. al, 2006). In Karnataka, instability in area, production and yield of finger millets was higher after introduction of targeted public distribution system (Bellundagi, 2016). The analysis on millets for Odisha by Paltasingh & Goyari (2013) indicates that instability in area, production, and yield for bajra and jowar was negative in the pre-reform period and was positive in the post reform period.

2.4 Decomposing Agricultural Production

A review of decomposition measurement is available in Kumar (2007). In a simple additive approach, the change in production can be decomposed into area, yield and interaction effects, which has been applied by Kalamkar (2003), Mishra (2009), Pattnaik & Shah (2015), Malathi et al. (2016), Devi et al. (2017) and Laitonjam et al. (2018) among others. The decomposition of millets production at the all India level is largely on account of yield effect (Malathiet al., 2016). This does not seem to be the case for Odisha when comparing the triennium ending 2004-05 over 1993-94 (Mishra, 2009).

2.5 Inter-year Fluctuations and Smoothening

In order to minimise the inter-year fluctuations, Laitonjam et al. (2018) used biennial averages whereas Mishra (2009), Kannan (2011) and Malathi et al. (2016) used three-year averages i.e., triennium ending (TE) of different variables. To address year-to-year fluctuation on account of vagaries of weather leading to floods and drought that could affect agriculture, a three-year average may be preferable.

2.6 Periodisation

The break-points identifying sub-periods can be on account of a structural change. The estimated production growth rates in Bangladesh and West Bengal by Boyce (1986) represented the sub-periods before the green revolution, 1949-64, and after the green revolution, 1965-80. For major crop groups in India, the sub-periods by Kannan (2011) are early green revolution, 1967-1968 to 1979-1980, mature green revolution, 1980-1981 to 1989-1990, early economic reforms, 1990-1991 to 1999-2000, and economic reforms, 2000-2001 to 2007-2008. In the same vein, growth estimates by Kalamkar (2003) for crop groups in Maharashtra could be referred to as pre-green revolution, 1961-62 to 1970-71, early green revolution, 1971-72 to 1980-81, and mature green revolution, 1981-82 to 1997-98, and that by Pattnaik & Shah (2015) for crop groups in Gujarat could be referred to as early economic reforms, 1990-99, and economic reforms, 2000-10. In an analysis of ragi in Karnataka by Bellundagi (2016) the sub-periods of 1984-85 to 1997-98 and 1999-00 to 2014-15 refer to before and after targeted public distribution system, respectively.

Analysis of growth rate of pulses by Devi et al. (2017) has pre-green revolution, 1950-51 to 1964-65, post-green revolution, 1966-67 to 1994-95, and post-economic liberalisation, 1995-96 to 2014-15. The estimated growth rates of rice by Laitonjam et al. (2018) were for pre-liberalisation, 1980-82 to 1994-96, and post-liberalisation, 1996-98 to 2012-14. And, estimated growth rate of area, production and yield of millets in India by Malathi et al. (2016) is divided into two approximately 30-year sub-periods, 1950-51 to 1980-81 and 1980-81 to 2011-12.

Odisha's growth rate of major crop groups for area, yield and production by Mishra (2009) has two periods referred to as 1980s and 1990s of 12 years each that implicitly represent pre-liberalisation, 1981-82 to 1992-93, and post-liberalisation, 1993-94 to 2004-05, while that by Paltasingh & Goyari (2013) has two periods of 20-years each that is explicitly referred to as pre-liberalization, 1970-71 to 1990-91, and post-liberalization, 1991-92 to 2010-11. The exercise on Odisha by Pattanaik & Mohanty (2016) with 2003-04 as break point has two periods that can be referred to as early economic reforms, 1993-94 to 2003-04, and economic reforms, 2003-04 to 2010-11. Another estimate of growth on Odisha by Senapati & Goyari (2019) is divided into green revolution, 1967-68 to 1987-88, and post-green revolution, 1988-89 to 2014-15.

The literature on periodisation while estimating agricultural growth does not provide a clear break-point for important structural changes such as green revolution or economic reforms. Further, the implications for these important structural changes can differ from region-to-region, and within a region it can differ from crop-to-crop, and for a crop in a region it can differ for area, yield and production. Besides, there can be other important factors at play. It is for this that decadal sub-periods may be considered for comparison purposes.

The estimates of growth, instability and decomposition of a crop for a region would depend upon the measure used the method of smoothening inter-year fluctuations, and Periodisation. Keeping this in mind, the current exercise proposes to use a three-year moving average trend with a decadal Periodisation to estimate growth, instability and decomposition of millets and other crop groups as also for specific millet crops/categories in Odisha.

3. Data and Methodology

3.1 Data

The present study pertains to the period 1960-61 to 2017-18 based on data from Odisha Agricultural Statistics Reports. The data is first smoothened by a three-year moving average and then the triennium ending (TE) data is split into six decadal sub-periods. They are:

- 1960s, TE1962-63 to TE1970-71;
- 1970s, TE1970-71 to TE1980-81;
- 1980s, TE1980-81 to TE1990-91;
- 1990s, TE1990-91 to TE2000-2001;
- 2000s, TE2000-01 to TE2010-11; and
- 2010s, TE2010-11 to TE2017-18.

The 40 major crops grown in Odisha have been categorised into eight crop groups:

- Millets (comprising ragi, jowar, bajra and small millets), other cereals (comprising rice, wheat and maize),
- Pulses (comprising mung, biri, arhar, gram, fieldpea, lentil, cowpea, kulthi and other pulses),
- Oilseeds (comprising groundnuts, sesamum, castor, sunflower, safflower, niger, mustard,linseed andsoya bean),
- Fibres (comprising jute, mesta, sunhemp and cotton),
- Vegetables (comprising sweet potato, potato, onion and other vegetables),
- Condiments and spices (comprising chilly, coriander, garlic, turmeric, ginger, betel vine and other spices), and
- Sugarcane.

3.1 Estimation of Growth

In the present study, the growth rate estimation of production, area and yield of different crop groups employs kinked exponential model that eliminates discontinuity between sub-periods (Boyce, 1986). For$t = 1, \dots, T$triennium ending time points with$m$sub-periods and $m - 1$ kinks, a generalized kinked exponential model is formulated with $K_1, \dots, K_{m-1}$ kink points and $D_1, \dots, D_m$ dummy variables such that the joint estimation of the sub-period growth rates for an unrestricted model with no continuity requirement can be written as:

(1) $ln\, Z_t = (\propto_1 D_1 + \propto_2 D_2 + \cdots + \propto_m D_m) + (\beta_1 D_1 + \beta_2 D_2 + \cdots + \beta_m D_m) + \varepsilon_t$

and, by applying m-1linear restrictions,

$\propto_i + \beta_i k_i = \propto_{i+1} + \beta_{i+1} k_i$, for all $i = 1, \dots, m - 1$, we can estimate growth rate as follows:

(2) $$ln\, Z_t = \propto_1 + \beta_1\left(D_1 t + \sum_{j=2}^{m} D_j K_1\right) + \beta_2\left(D_2 t - \sum_{j=2}^{m} D_j\, K_1 + \sum_{j=3}^{m} D_j\, K_2\right) + \ldots + \beta_i(D_i t - \sum_{j=i}^{m} D_j\, K_{i-1} + \sum_{j=i+1}^{m} D_j\, K_i) + \cdots + \beta_m(D_m t - D_m K_{m-1}) + \varepsilon_t$$

where, Z_t is production, P_t, or area,A_t, or yield, $Y_t = P_t/A_t$, of crop groups.

3.2 Estimation of Instability in Production, Area and Yield

We use Boyce (1987) tofirst obtain detrend series,

(3) $$X_t = (Z_t - \hat{Z}_t)/\hat{Z}_t$$

where Z_t is actual and $\hat{Z}_t$is predicted from equation (2). And, then estimate

(4) $$|X_t| = a + bt$$

where statistically significant and positive (negative) $b$signifies increasing (decreasing) instability. A statistically insignificant b signifies constant or unchanged instability.

3.3 Estimation of Decomposition of Production

For any crop or crop group $\Delta Z_t = Z_t - Z_{k,t-\tau}$; $\tau = 1, \ldots, t-1$ denotes change at time t with respect to time, $t - \tau$, then decomposition of change in production can be computed as,

(5) $$\Delta P_t = \Delta A_t Y_{t-\tau} + \Delta Y_t A_{t-\tau} + \Delta A_t \Delta Y_t.$$

Or, change in production can be decomposed into area effect, yield effect and interaction effect. Now, at an aggregate crop group level with $k = 1, \ldots, K$ crops with $Z_{k,t}$ denoting production, $P_{k,t}$, or area,$A_{k,t}$, or yield, $Y_{k,t}$ of the k^{th} crop in time $t$and $\mathrm{a}_{k,t} = A_{k,t}/\sum A_{k,t}$denoting share of area under k^{th} crop in time t, then decomposition of the aggregate crop group can also be written as,

(6) $$\sum_{k=1}^{K} \Delta P_{k,t} = \sum_{k=1}^{K} \Delta A_{k,t} \sum_{k=1}^{K} Y_{k,t-\tau}\, \mathrm{a}_{k,t-\tau} + \sum_{k=1}^{K} \Delta Y_{k,t}\, \mathrm{a}_{k,t} \sum_{k=1}^{K} A_{k,t-\tau} + \sum_{k=1}^{K} \Delta A_{k,t} \sum_{k=1}^{K} \Delta Y_{k,t}\, \mathrm{a}_{k,t}.$$

This means that for a crop group with K crops there will be K^2 area effects, K^2 yield effects and K^2 interaction effects. Thus, overall, there will be $3K^2$ effects. The sum of all area effects, all yield effects and all interaction effects will be similar to what would be obtained from equation (5), but if one want details then one could use equation (6). We have independently computed the decomposition for millets, comprising ragi, jowar, bajra and small millets, using equation (6), but report for each crop and the aggregate one for millets – not the 48 effects.

4. Results and Discussion

4.1 Growth: Major Crop Groups

Decade-wise kinked exponential growth rate of crop groups in Odisha is given in Table 1. In the 1960s, all crop groups indicate a positive growth rate in production, except for sugarcane, in which growth rate is negative and significant and this is largely on account of a negative and significant growth in yield even though growth in area is positive. The positive growth rate in production is not significant for other cereals and pulses. In case of other cereals, this is because of a negative growth in yield and in case of pulses the growth in area and yield are both positive, but not significant.

Table 1: Kinked Exponential Growth of Crop Groups in Odisha (%)							
Item	*Crops*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
Production	Millets	14.99*	4.75*	-0.27	-7.42*	0.09	-9.80*
	Other Cereals	1.01	-0.36	4.38*	-0.57	3.20*	2.41*
	Pulses	1.40	4.67*	6.94*	-7.96*	3.31*	-4.89*
	Oilseeds	14.07*	6.15*	6.61*	-7.34*	1.76	-9.36*
	Vegetables	NA	11.95*	6.73*	-4.77	10.95*	-20.28*
	Fibres	4.05*	2.49*	0.50	-8.13*	2.65*	-0.22
	Condiments&Spices	NA	10.81*	6.69*	-1.87	5.38*	12.04*
	Sugarcane	-22.04*	-0.03	-5.83	17.08*	8.35*	-5.75
Area	Millets	13.40*	5.75*	-4.13*	-3.69*	-3.56*	-10.38*
	Other Cereals	0.91*	0.00	0.00	0.01*	-0.01	-0.01
	Pulses	1.98	4.76*	4.39*	-3.18*	1.02	-6.25*
	Oilseeds	5.19*	5.62*	6.82*	-3.95*	-1.98*	-10.34*
	Vegetables	NA	6.18*	5.15*	-5.00*	3.04*	0.58
	Fibres	3.37*	2.60*	-2.18*	-0.01	1.60*	3.18*
	Condiments & Spices	NA	8.93*	3.09	-0.40	-3.06	14.47*
	Sugarcane	61.79	307.49*	25.41	-318.18*	-6.15	-746.21*
Yield	Millets	2.00*	-1.00*	3.91*	-3.36*	3.18*	0.90
	Other Cereals	-0.20	-0.38	4.38*	-1.40*	3.96*	4.07*
	Pulses	0.75	-0.39	2.52*	-4.49*	1.96*	1.70
	Oilseeds	9.13*	0.89	-0.93	-2.70	3.21	0.66
	Vegetables	NA	5.91	1.45	0.51	7.87*	-22.52*
	Fibres	1.38	-0.45	3.07*	-8.50*	1.25	-3.18*
	Condiments & Spices	NA	2.24	3.71	-1.47	8.08*	-3.50
	Sugarcane	-22.57*	-3.13	-6.17	20.35*	9.00*	0.87

Note: * denotes that the growth rate for that period is significantly different from zero at 5% level of significance. NA is not available as vegetables data is from TE1973-74 and condiments & spices data is from TE1972-73.
Source: Authors' estimates based on data from Odisha Agriculture Statistics, Directorate of Agriculture and Food Production, Odisha.

In 1970s also, as in 1960s, production growth in most crop groups is positive and significant, except for other cereals and sugarcane. Other cereals continue to not have any growth in area and have a negative growth in yield. The area under sugarcane continues to have a positive growth, which is now significant while yield growth is negative.

The 1980s, as in the previous two decades, production growth is positive and significant for most crop groups. Sugarcane continues to have a negative growth in production largely on account of negative growth in yield while growth rate for area continues to be positive. An important reversal that happened in the 1980s is that production growth rate for millets is negative and this is on account of growth in area being negative and significant while yield growth is positive and significant. The positive growth in other cereals is on account of a positive and significant growth rate in yield while area growth continues to be near zero. In 1980s, the decline in area under millets is 233 thousand hectares while the increase in area under other cereals is by 131 thousand hectares. There is also an increase in area, during the 1980s, for other crop groups.

We see a substantive reversal in the 1990s with production growth in almost all crop groups being negative, except for sugarcane, which is now positive and significant. Besides, for sugarcane, the growth in area is now negative and in yield is positive. An increase in area with a decrease in yield or vice versa could be somewhat explained by an expansion to or a move away from marginal land, but this does not fit with the story of production growth and there could be other factors at play in production of sugarcane in Odisha. The negative growth in production for most crop groups is reflected in area and yield, but for the fact that for other cereals the area growth, while still quite low at 0.01 per cent per annum, is positive and significant. The growth in area for millets continues to be negative. In 1990s, the decline in area under millets is 108 thousand hectares while the increase in area under other cereals is by 118 thousand hectares. In fact, in the 1990s, there is a decline in area for all crop groups, except for other cereals.

In the first decade of 2000, we are back to production growth for crop groups being positive and this time it is for all of them, including for sugarcane. Sugarcane, as in the 1990s, has growth in area that is negative and that in yield that is positive. Growth in area under millets continues to be negative and significant while yield growth is positive and significant.

Now, in the current decade of 2010s, we again see that the production growth for most crop groups is negative, except for other cereals and condiments & spices. For other cereals, the positive growth in production is on account of a growth in yield, which is positive and significant, as growth in area is negative. With regard to condiments & spices the positive growth in production is on account of an increase in area. The negative growth in production is largely on account of growth in area being negative and significant for millets, pulses and oilseeds, and sugarcane and yield growth being negative and significant for vegetables and fibres.

In Odisha, the growth rates of production indicate that most crop groups behave in a similar manner. The growth rates being positive in the first three decades of our analysis, 1960s, 1970s and 1980s, and then again in the first decade of this millennia, 2000s. And, it has been negative in 1990s and 2010s. The decline in area under millets started since 1980s and has continued till date. In the 1980s there is a shift in area from millets to other cereals and other crops groups, and in 1990s there is a shift from millets and other crop groups to other cereals, in 2000s there is a shift in area towards pulses, vegetables and fibres, and in 2010s there is a shift to condiments & spices while the shift to vegetables and fibres continues. This means that in the last two decades there is a shift in area away from all cereals (millets and other cereals) and in the last decade there is a shift away from foodgrains to other crop groups.

4.2Instability: Major Crop Groups

The instability results across major crops groups in Odisha in Table 2. It indicates that the triennium ending trends have largely been stable. There are a few cases of instability being positive or increasing and a few where instability has been negative or decreasing.

Table 2: Instability in Crop Groups in Odisha (%)

Item	*Crops*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
Production	Millets	0.04	-0.09	-0.15	0.12	0.04	-0.35
	Other Cereals	0.03	0.04	0.06	0.00	0.07	0.05
	Pulses	-0.17	0.09	-0.12	-0.05	0.14	-0.34
	Oilseeds	0.53*	0.36	-0.13	0.00	0.17	-0.42
	Vegetables	NA	-0.67*	0.18*	0.06	0.25*	1.49*
	Fibres	-0.05	0.00	0.09	-0.14	-0.09	-0.21
	Condiments&Spices	NA	-0.08	-0.07	0.32*	0.12	-0.38
	Sugarcane	0.97	-0.68*	-1.51	0.43	-0.38	-0.16*
Area	Millets	0.08	-0.19*	-0.09	0.04	0.27*	-0.37
	Other Cereals	0.00	0.00	-0.02	0.01	-0.05*	0.02
	Pulses	-0.16	0.08	-0.16*	0.02	0.13*	-0.25
	Oilseeds	-0.02	-0.03	-0.16	-0.04	0.16*	-0.32
	Vegetables	NA	-0.67*	0.18*	0.06	0.25*	1.49*
	Fibres	-0.02	0.06	-0.06	-0.11	-0.19	-0.27
	Condiments & Spices	NA	0.02	-0.13	0.12	0.38*	1.34*
	Sugarcane	-0.48*	-0.25	0.13	0.32	-0.25	-0.35*
Yield	Millets	0.02	-0.01	-0.07	0.11	-0.10*	-0.05
	Other Cereals	0.06	0.06	0.07	-0.01	-0.03	0.05
	Pulses	0.02	0.02	0.02	-0.04	-0.01	-0.03
	Oilseeds	0.37*	0.76	-0.44*	-0.04	0.00	-0.05
	Vegetables	NA	-0.44*	-0.01	-0.01	0.40*	1.84*
	Fibres	0.05	0.03	0.10*	-0.10	-0.07	-0.09
	Condiments & Spices	NA	0.02	-0.11	0.21*	0.21	1.13*
	Sugarcane	0.73	-0.32*	-0.88	0.25	-0.32*	-0.20
Note and Source: As in Table 1							

In 1960s, instability is positive and significant in production and yield for oilseeds, whereas instability is negative and significant in area for sugarcane. In 1970s, instability is negative and significant in production, area and yield for vegetables, in area for millets, and in yield for sugarcane. In 1980s, instability is positive and significant in production and area for vegetables and in yield for fibres, whereas instability is negative and significant in area for pulses and in yield for oilseeds. In 1990s, instability is positive and significant in production and yield for condiments & spices. In the first decade of this millennia (2000s), instability is positive and significant in production, area and yield for vegetables and in area for millets, pulses, oilseeds, vegetables, and condiments & spices, whereas instability is negative and significant in area for other cereals and in yield for millets and sugarcane. In 2010s, instability is positive and significant in production, area and yield for vegetables and in area and yield for condiments & spices, whereas instability is negative in production and area for sugarcane.

4.3 Decomposition: Major Crop Groups

Decomposition of production of major crops groups in Odisha from 1960s to 2010s is given in Table 3. It shows area, yield and interaction effects of production change in each crop group.

For millets: in 1960s the increase in production is on account of all three effects – area, yield and interaction, in 1970s the increase in production is on account of area with the other two contributing to decline, in 1980s the decrease in production is on account of area and interaction with yield contributing to increase, in 1990s the decrease in production is on account of area and yield with interaction contribution to increase, in 2000s a marginal increase in production is on account of yield with area and interaction contributing to decline, and in 2010s the decrease in production is on account of area and yield with interaction contributing to increase.

For other cereals: in 1960s the increase in production like that for millets is on account of all three effects, in 1970s the decrease in production is on account of area and yield with interaction contributing to increase, in 1980s the increase in production is on account of all three effects, in 1990s the decrease in production is on account of yield and interaction with area contributing to increase, and in 2000s and 2010s the increase in production is on account of yield only with area and interaction contributing to decline.

For pulses: in 1960s the increase in production like that for millets and other cereals is on account of all three effects, in 1970s the increase in production like that for millets is on account of area only, in 1980s the increase in production like that for other cereals is on account of all three effects, in 1990s the decrease in production like that for millets is on account of area and yield, in 2000s the increase in production is on account of all three effects, and in 2010s the increase like that for other cereals is on account of yield only.

For oilseeds: in the first four decades under analysis (1960s, 1970s, 1980s and 1990s) the decomposition of production change is similar to that for pulses, in 2000s the increase is on account of yield only, and in 2010s this seems to have reversed and the decrease in production is also on account of yield only.

For vegetables: in 1970s and 1980s the increase in production is on account of all three effects, in 1990s the decrease in production is on account of area and interaction, in 2000s the increase in production like that for pulses is on account of all three effects, and in 2010s the increase in production like that for other cereals is on account of yield only.

Table 3: Decomposition in Crop Groups in Odisha (%)							
Crop	*Effect*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
Millets	Area	72.23	134.07	415.60	66.03	-88377.07	85.03
	Yield	12.06	-15.80	-516.54	48.11	108225.05	18.83
	Interaction	15.71	-18.27	200.94	-14.15	-19747.98	-3.85
	ΔP	122.13	163.67	-33.09	-142.67	0.04	-42.79
Other Cereals	Area	73.23	36.96	6.83	-25.84	-4.02	-129.42
	Yield	24.25	63.92	90.50	122.66	105.82	255.07
	Interaction	2.52	-0.89	2.68	3.18	-1.81	-25.65
	ΔP	529.61	-159.87	1778.16	-590.70	2249.61	585.98
Pulses	Area	64.11	138.13	46.40	52.74	52.13	-241.69
	Yield	28.39	-20.31	43.26	63.24	35.50	357.54
	Interaction	7.50	-17.81	10.34	-15.97	12.37	-15.85
	ΔP	133.57	290.53	385.34	-542.91	394.71	18.07
Oilseeds	Area	39.77	114.34	47.52	59.36	-2.56	145.12
	Yield	38.88	-7.03	32.94	56.76	103.63	-57.98
	Interaction	21.36	-7.30	19.54	-16.11	-1.07	12.86
	ΔP	120.64	188.90	495.34	-426.76	187.85	-99.85
Vege-tables	Area	NA	82.89	63.50	112.60	48.12	-208.19
	Yield	NA	11.18	25.86	-22.44	31.11	325.41
	Interaction	NA	5.93	10.63	9.84	20.77	-17.22
	ΔP	NA	1427.18	2368.01	-2346.29	5104.54	223.31
Fibres	Area	67.89	99.83	-185.19	-0.20	34.95	335.01
	Yield	25.52	0.13	325.16	100.09	58.68	-151.15
	Interaction	6.59	0.04	-39.97	0.10	6.37	-83.86
	ΔP	23.88	23.64	7.32	-61.24	17.51	12.23
Condim-ents& Spices	Area	NA	101.75	36.83	-7.34	-11.92	11.53
	Yield	NA	-0.84	48.08	107.97	121.41	82.39
	Interaction	NA	-0.91	15.09	-0.63	-9.48	6.08
	ΔP	NA	55.86	92.44	16.01	142.19	229.74
Sugar-cane	Area	-148.76	-51.85	10.71	-3.99	32.74	114.70
	Yield	193.18	113.64	87.80	136.27	63.69	-20.38
	Interaction	55.59	38.21	1.49	-32.28	3.57	5.68
	ΔP	-197.69	-534.55	46.04	1994.00	398.33	-662.70

Note: Area, Yield and Interaction effects are in per cent and for each crop group in each decade they will add up to 100.ΔP denotes change in production, which is in actual quantity, as per measuring unit of crop group. If ΔP is negative then a negative effect will be positive in actual values and a positive effect will be negative in actual values. NA is not available as vegetables data is from TE1973-74 and condiments & spices data is from TE1972-73.
Source: As in Table 1.

For fibres: in 1960s like that for millets, other cereals, pulses and oilseeds and in 1970s like that for vegetables the increase in production is on account of all three effects, in 1980s the increase in production is on account of yield only, in 1990s the decrease in production like that for other cereals is on account of yield and interaction effects, in 2000s the increase in production like that for pulses and vegetables is on account of all three effects, and in 2010s the increase in production is on account of area only (the introduction of Bt seeds for cotton have do not seem to so much impact on yield).

For condiments & spices: in 1970s the increase in production like that for pulses is on account of area only, 1980s the increase in production like that for other cereals, pulses, oilseeds and vegetables is on account of all three effects, in 1990s unlike other crop groups discussed so far this was the only crop group that showed an increase in production and this is on account of yield only, in 2000s the increase in production is a continuation of the previous decade as it is also on account of yield only (in this decade the increase is production on account of yield only is also observed for millets, other cereals and oilseeds), and in 2010s the increase in production is on account of all three effects.

For sugarcane: in 1960s and 1970s the decrease in production is on account of yield and interaction, in 1980s the increase in production like that for other cereals, pulses, oilseeds, vegetables, and condiments & spices, is on account of all three effects, in 1990s the increase in production like that for condiments & spices is on account of yield only, in 2000s the increase in production like that for pulses, vegetables and fibres is on account of all three effects, and in 2010s the decrease in production like that for oilseed is on account of area and interaction effects.

A decomposition analysis, as adopted in this exercise will take into consideration the triennium ending base and final years in each decade and will not be based on the intervening years. Nevertheless, the patterns observed in our growth analysis along with other information of a shift in area away from millets to other cereals and other crop groups in the 1980s and from millets and other crop groups to other cereals in the 1990s is coming out. That there has been a decline in the area under millets since the 1980s is also holding out. We explore a bit more on the growth, instability and decomposition of each millet.

4.4 Growth: Millet Crops

In Odisha, the millets grown and reported are ragi (finger millet), jowar (sorghum), bajra (pearl millet) and small millets (which, of course, is a crop group within millets comprising suan/gurji (little millet), kangu (foxtail millet), kodo (kodo millet), proso millet and barnyard millet among others). From among this, ragi is the predominant crop with 76 per cent of the area under millets in 2017-18. The growth rates in production, area and yield for three major millet crops (ragi, jowar and bajra) and small millets is given in Table 4.

In 1960s, growth in production is positive and significant for all millet crops, except for bajra, where growth in production is negative and significant and this is largely on account of decline in area under bajra. The production growth for small millets is largely on account of area as growth in yield is negative and significant.

In 1970s, growth in production is positive and significant for each millet crop and also at the aggregate level for millets and this is also the case for growth in area, but growth in yield is negative and significant for ragi and this being the predominant millet crop one observes this at the aggregate level for millets also.

In 1980s, growth in production is positive and significant for ragi and bajra, but negative and significant for small millets. In fact, at the aggregate level the growth is negative, but not significant. Further, at the aggregate level, growth in area is negative and significant, which is also the case for small millets and other millet crops also show negative trends. Yield growth has been positive and significant at the aggregate level for millets as also for each millet crop.

Table 4: Kinked Exponential Growth of Millet crops in Odisha (%)

Item	*Crop*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
PSroduction	Ragi	17.59*	3.22*	2.32*	-6.02*	1.17	-8.00*
	Jowar	15.80*	7.83*	0.54	-11.93*	-5.27*	-15.59*
	Bajra	-6.05*	11.98*	5.27*	-13.91*	-4.26*	-18.77*
	Small Millets	12.78*	6.29*	-8.75*	-9.45*	-10.51*	-0.98
	Millets	14.99*	4.75*	-0.27	-7.42*	0.09	-9.80*
Area	Ragi	11.96*	5.63*	-0.91	-2.49*	-2.21*	-11.02*
	Jowar	14.80*	6.86*	-0.78	-7.61*	-6.62*	-13.69*
	Bajra	-8.41*	10.65*	-0.16	-7.25*	-6.11*	-18.01*
	Small Millets	16.97*	5.28*	-10.51*	-6.67*	-12.18*	0.99
	Millets	13.40*	5.75*	-4.13*	-3.69*	-3.56*	-10.38*
Yield	Ragi	5.59*	-2.02*	3.08*	-3.66*	3.37*	2.94*
	Jowar	1.15	0.67	1.50*	-4.13*	0.97	-1.01
	Bajra	2.06	1.53	5.26*	-6.56*	1.86	-2.15
	Small Millets	-4.99*	1.18*	2.22*	-3.13*	0.97	-1.17
	Millets	2.00*	-1.00*	3.91*	-3.36*	3.18*	0.90

Note: As in Table 1. Millets is aggregate of ragi, jowar, bajra and small millets.

In 1990s, growth in production is negative and significant for each millet crop and also at the aggregate level for millets. This is reflected in growth being negative and significant for area and yield also.

In 2000s, growth in production is negative and significant for jowar, bajra and small millets and positive but not significant for ragi as also at the aggregate level for millets. The decline in area continues to be significant for each crop and also at the aggregate level. Growth in yield is positive and significant for ragi and also at the aggregate level for millets and for the other millet crops it is positive but not significant.

In 2010s, growth in production is negative and significant for each millet crop (except for small millets where it is not significant) and also at the aggregate level for millets. The growth in area is also negative and significant for each millet crop and also at the aggregate level for millets, except for small millets that indicates a positive but not significant trend in area. Yield growth has been positive and significant for ragi, for other millet crops it is negative but not significant and at the aggregate level for millets it is positive but not significant.

4.5 Instability: Millet Crops

Instability in production, area and yield of each millet crop is given in Table 5. As in the case of major crop groups, it indicates that the triennium ending trends have largely been stable.

In 1960s, instability is positive and significant in area for small millets, whereas instability is negative and significant in production and area for jowar and in yield for small millets. In 1970s, instability is negative and significant in area for ragi and also at the aggregate level for millets. In 1980s, one does not observe any instability. In 1990s, instability is negative and significant in yield for small millets. In 2000s, instability is positive and significant in production for jowar, bajra and small millets and in area for each of the four millet crops and also at the aggregate level for millets, whereas instability is negative and significant in yield for ragi and also at the aggregate level for millets. In 2010s, instability is negative and significant in production for ragi and in area for jowar and small millets. The analysis for major crops groups (Table 2) and millet crops indicate that 2000s decade was a period of increasing instability in Odisha's agriculture.

Table 5: Instability in Millet crops in Odisha (%)

Item	*Crop*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
Production	Ragi	-0.02	-0.10	-0.29	0.22	-0.01	-0.38*
	Jowar	-4.54*	0.18	-0.29	-0.10	1.29*	-0.96
	Bajra	2.06	-1.67	-0.66	0.85	8.24*	102.72
	Small Millets	0.81*	-0.52	-0.15	-0.13	1.00*	-1.20
	Millets	0.04	-0.09	-0.15	0.12	0.04	-0.35
Area	Ragi	-0.07	-0.18*	-0.13	0.06	0.26*	-0.46
	Jowar	-2.14*	0.23	-0.05	-0.02	0.86*	-1.19*
	Bajra	2.76	-0.59	0.25	0.52	2.22*	-1.99
	Small Millets	0.52*	-0.41	-0.08	-0.04	0.73*	-0.94*
	Millets	0.08	-0.19*	-0.09	0.04	0.27*	-0.37
Yield	Ragi	0.10	0.03	0.01	0.12	-0.10*	0.00
	Jowar	-0.13	0.06	-0.07	0.00	0.03	0.08
	Bajra	-0.68	0.10	0.38	-0.16	0.11	-0.14
	Small Millets	-0.12*	0.04	-0.07	-0.08*	0.07	-0.01
	Millets	0.02	-0.01	-0.07	0.11	-0.10*	-0.05

Note and Source: As in Table 1

4.6 Decomposition: Millet Crops

Decomposition of production of millet crops in Odisha from 1960s to 2010s is given in Table 6. It shows area, yield and interaction effects of production change in each millet crop.

For Ragi: in 1960s the increase in production is on account of all three effects, in 1970s the increase in production is on account of area, in 1980s the increase in production is on account of yield, in 1990s the decrease in is on account of area and yield, in 2000s the increase in production is on account of yield, and in 2010s the decrease in production is on account of area and yield. Being the predominant millet crop, the overall change in production and its decomposition is similar to that for aggregate level for millets, except in 1980s when there was an increase in ragi production but a decrease in production at the aggregate level for millets.

For jowar: in the first four decades under analysis (1960s, 1970s, 1980s and 1990s) the decomposition of production change is similar to that for ragi, in 2000s and 2010s the decrease in production is on account of area and interaction effects.

For bajra: in 1960s the decrease in production is on account of area and interaction, in 1970s the increase in production is on account of all three effects, in 1980s the increase in production like that for ragi and jowar is on account of yield, in 1990s there is a reversal and the decrease in production like that for ragi and jowar is on account of both area and yield, in 2000s and 2010s the decrease continues and decrease in production like that for jowar is on account of area and interaction effects.

Table 6: Decomposition in Millet Crops in Odisha (%)

Crop	*Effect*	*1960s*	*1970s*	*1980s*	*1990s*	*2000s*	*2010s*
Ragi	Area	47.25	176.88	-70.31	52.33	-100.33	96.19
	Yield	23.93	-39.26	198.96	60.29	218.05	5.21
	Interaction	28.82	-37.62	-28.65	-12.62	-17.72	-1.41
	ΔP	96.39	72.71	42.38	-99.73	12.11	-45.32
Jowar	Area	96.26	108.97	-99.95	79.85	123.50	100.95
	Yield	1.71	-4.69	217.23	41.82	-35.87	-1.47
	Interaction	2.03	-4.28	-17.27	-21.67	12.37	0.52
	ΔP	6.14	9.31	1.63	-14.31	-2.16	-1.96
Bajra	Area	158.06	93.93	-60.89	73.92	153.77	100.89
	Yield	-116.14	1.77	192.24	50.31	-66.59	-1.42
	Interaction	58.08	4.30	-31.34	-24.23	12.82	0.53
	ΔP	-0.62	3.46	1.28	-3.96	-0.27	-0.68
Small Millets	Area	194.69	79.05	108.57	80.86	113.79	99.80
	Yield	-34.88	8.61	-28.69	35.72	-34.48	0.13
	Interaction	-59.81	12.33	20.12	-16.58	20.69	0.07
	ΔP	20.21	78.19	-78.38	-24.67	-9.65	5.17
Millets	Area	72.23	134.07	415.60	66.03	-88377.07	85.03
	Yield	12.06	-15.80	-516.54	48.11	108225.05	18.83
	Interaction	15.71	-18.27	200.94	-14.15	-19747.98	-3.85
	ΔP	122.13	163.67	-33.09	-142.67	0.04	-42.79

Note and Source: As in Table 3.

For small millets: in 1960s the increase in production is on account of area, in 1970s the increase in production like that for bajra is on account of all three effects, in 1980s the decrease in production is on account of area and interaction effects, in 1990s the decrease in production like that for all other millet crops is on account of area and yield effects, in 2000s the decrease in production like that for jowar and bajra is on account of area and interaction effects, in 2010s the increase in production is on account of all three effects. Our analysis of growth and decomposition is perhaps indicative that there is an unmet demand for small millets.

5. Conclusion

This has been an attempt to analyse and examine growth, instability and decomposition for millets vis-à-vis other major crop groups and for each millet crop (particularly, ragi, jowar, bajra and small millets) from 1960-61 to 2017-18. We have used three-year averages to smoothen year-to-year fluctuations and do a decadal analysis (as against linking breaks with green revolution, economic reforms or targeted public distribution system) to enable comparison across crops that might not have responded similarly to structural breaks. Besides, there is no clear agreement on the year for structural breaks.

Coinciding with the start of green-revolution in Odisha, the 1980s mark a reversal for millets with decline in area and decadal growth for production being significant and negative (except for1980s when it was not significant and negative and 2000s when it was not significant and positive). Our analysis shows that there has been a shift in area from millets around the 1980s, initially towards other cereals (which, is largely paddy) and other crop groups and then in the 1990s, primarily to other cereals, and then over the decades to other crop groups. In recent times, in Odisha, there seems to be a shift away from food grains. A silver lining is a slight revival towards small millets.

In this context, one may appreciate the fact that the Government of Odisha has started Odisha Millets Mission in Kharif 2017, the end year of our analysis. It is said that in the first year of its intervention, Mishra (2020), the yield has more than doubled and value of produce has more than trebled. The report also indicates that in the first year the focus was mostly on ragi. Our analysis provides an added context and while recognising the importance of support to any millet crop, including ragi, there is perhaps an unmet demand towards small millets (which, comprises of little millet, foxtail millet, kodo millet, proso millet and barnyard millet). Thus, the mission should focus on all millet crops. In addition, our analysis also suggests production decline in other major crop groups, particularly foodgrains and oilseeds. Hence, there is need for focus on complementarities of millets with other foodgrains rather than substitution.

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