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RESEARCH ARTICLE

Agricultural growth in Sikkim: Evidence from multiple break unit root test

Himanshu Narayan Prasad[1*], Soumitra Kundu[2]

Abstract

The agriculture sector of Sikkim has undergone a significant transformation especially in the last two decades. It serves as a key livelihood activity for about 46% of the state's population while contributing about nine percent to the gross state domestic product (GSDP) Our study attempts to estimate the growth performance of production and yield of total foodgrains, rice, wheat, maize, pulses, and oilseeds during the period 1981-82 to 2021-22 using modern time series methods allowing for endogenous structural breaks in the growth rates. We find evidences of significant slow-down in growth rates of productions of all of these crops in the decade of 1990s and in the first decade of new millennium, resulting from decline in area and decline in growth rate of yields of crops like rice, wheat and maize during the decade of 1990s. Area under crops declined further for all of the selected crops in the next two decades, but increase in yield have been observed in the first decade of new century, following the shift toward organic farming in the state, in the cases of maize, pulses and oilseeds.

Keywords: Agriculture, Sikkim, Food Grains, Unit root.

Introduction

Sikkim, the smallest northeastern state of India, has undergone a significant transformation in its agricultural sector especially since the early years of 2000s. Although the sector contributes a merely nine percent to the Gross State Domestic Product (GSDP) it serves as a key avenue of employment for about 46 percent of the state's population (NITI Aayog and NCAER 2025)—a characteristic common across developing regions where the share of workforce dependence on agriculture often exceeds its sectoral share in GSDP. Due to rugged mountainous terrain only about 11 percent of the state's geographical area is under active cultivation. The agrarian landscape is characterised by terrace cultivation which are mostly rainfed while farm mechanization is virtually non-existent making agriculture a manual labour-intensive activity. About 80 percent of the farm operators fall under the category of marginal and small cultivators and the average size of holdings is close to 1.25 hectares (Agricultural Census 2015).

Sikkim relied on traditional subsistence agriculture which gradually shifted towards the widely prevalent input intensive agriculture after its merger with India in 1975. The year 2003 marked a remarkable shift in favour of organic agriculture by systematically eliminating the use of chemical intensive practices and embracing traditional farming methods so as to conserve biodiversity, restore soil health, and protect its fragile ecosystems. After more than a decade of consistent policy intervention as well as grassroot support for the bold initiative, the state successfully achieved 'fully organic' status in the year 2016.

Although the shift towards organic agriculture promotes environmental conservation and healthy and safe food systems for the state's populace, the celebrated shift might be accompanied with a possible decline in production and productivity of several major foodgrains vis-a-vis the pre-organic period, severely impacting the state's food security, as has been experienced in other regions who have made a shift towards organic agriculture (de la Cruz et al. 2023; de Ponti, Rijk, and van Ittersum 2012; Seufert, Ramankutty, and Foley 2012). Therefore, our paper seeks to study

[1]Department of Economics, Vivekananda Satavarshiki Mahavidyalaya, Manikpara, Jhargram, West Bengal, India

[2]Department of Economics, Narasinha Dutt College, Howrah, West Bengal, India

***Corresponding Author:** Himanshu Narayan Prasad, Department of Economics, Vivekananda Satavarshiki Mahavidyalaya, Manikpara, Jhargram, West Bengal, India, E-Mail: hnprasad78@gmail.com

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the characteristics and pattern of growth of agricultural foodgrains in the Himalayan state employing modern time series methods.

The paper by Chettri and Pradhan (2020) attempted to examine the extent and nature of agricultural diversification in Sikkim from the years 2003 to 2016 which corresponds to the onset of the state's move towards organic farming and the attainment of full organic status respectively. Using the CAGR it was found that while both area and production of high value crops were positive; the same for traditional agricultural crops recorded a negative growth.

The paper by Gamoh et al. (2023) tries to investigate the structural changes in the area and yield of the crops after the launch of the 'organic mission' in the state of Sikkim in the year 2010. For this purpose, they have computed the annual growth rates of area and yield of selected crops during the period 1981-82 to 2016-17 and tested for a structural break in growth rate in 2010 using dummy. They found that the state's adherence to organic agriculture led to the decline in the area under different foodgrains, except maize, while the same under spices like ginger and turmeric and vegetables and fruits recorded an expansion. The total area under rape and mustard and oilseeds was also seen to decline. However, the policy was found to have a positive impact on the yield of all foodgrains as well as vegetables, rapeseed and mustard. There was an exception in case of pulses in which no structural break was visible. However, their methodology for testing structural break in growth rate using dummy variable is appropriate only when the underlying data generating process is stationary or trend stationary. Since many time series data are non-stationary in nature, in order to avoid erroneous conclusions, it is necessary to test for whether the underlying data generating process is trend stationary or difference stationary, which has not been attempted in this paper.

The paper by Gurung and Hannan (2021) titled 'Dynamics of Land Use and trends of Agriculture in Sikkim' attempts to study the changes in land use pattern, operational holdings, operated area, irrigation coverage, cropping pattern and cropping intensity in Sikkim from 2005-06 to 2010-11 using secondary sources of data and employing tabular analysis and statistical tools like measuring percentage of variations. They reported that the net sown area was almost constant across the two periods. Overall, the number of operational holdings increased while the size of operated area recorded a slight decline. There was a variation in cropping patterns over the years. The area under paddy and wheat displayed a declining trend while the same for maize remained fairly constant. Overall, the cropping intensity for the state as a whole was found to increase by more than four percentage points.

All of the above-mentioned papers have relied on analytical approaches like exponential growth framework and resorted to inspection of structural breaks in growth rate at a foreknown break date using dummy which is suitable only when the chosen variable is trend stationary.

It is needless to state that correct assessment of the data generating process is imperative in analysing time series data as employing popular frameworks like 'kinked exponential growth models' to a dataset that actually contains unit root can produce spurious inferences. In this context the seminal work by Nelson and Plosser (1982) revealed that many macroeconomic series follow difference stationarity instead of trend stationarity. However, subsequent advancements in the domain of time series econometrics underlined the critical case of structural breaks. More specifically, Perron (1989) illustrated that in cases where a deterministic trend is characterised by an exogenous break, standard testing frameworks like the 'Augmented' Dickey Fuller test are prone to be biased towards reporting the series to be non-stationary. However, the notion of treating the break date as a pre-determined exogenous event received numerous criticisms by subsequent studies on methodological grounds (Banerjee, Lumsdaine, and Stock 1992; Christiano 1992; Zivot and Andrews 1992). This methodical shortcoming was addressed by Zivot and Andrews (1992) who prescribed a framework where the break date is determined endogenously using formal testing methods.

Nevertheless, the methods prescribed by both Perron (1989) and Zivot and Andrews (1992) suffer from a common limitation. They identify only a single—the most prominent—structural break in the growth path of the chosen variable. As in actual practice a time series often experiences multiple shocks over a period, Lumsdaine and Papell (1997) generalized the framework provided by Zivot and Andrews (1992) to account for two endogenous breaks. By allowing for detection of two structural breaks, the framework provided by Lumsdaine and Papell (1997) is widely argued to offer a significantly greater statistical power vis-à-vis the single-break methods.

We have not found any existing study of agricultural growth rate of Sikkim taking into account time series property of underlying data generating process by incorporating testing of unit roots and endogenous structural breaks into the analysis. So present work seeks to measure growth rate of production and yield of selected crops in Sikkim using modern time series techniques allowing for endogenous structural breaks in the growth path of series under consideration. A few of such studies have been made in the context of some other states of India (Ghosh 2010; Kundu 2015), but none in the context of Sikkim so far.

Materials and Methods

The study is based on analyses of secondary data collected from Directorate of Economics and Statistics, Dept. of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture, Govt. of India and compiled by EPW Research Foundation. The data to be tested in this paper are yields and productions of total foodgrains, rice, wheat, maize, pulses and oilseeds during the period 1981-82 to 2021-22.

We begin our analysis with the standard procedure of examining the stationarity properties of all variables before conducting an estimation exercise. An assessment of the nature of the series is also essential for avoiding potential spurious regression outcomes due to non-stationarity of the series. Therefore, our study employs the 'Augmented' Dickey–Fuller (ADF) test developed by Said and Dickey (1985) which estimates the following equation:

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_i \dots\dots\dots\dots\dots\dots\dots (1)$$

Here y_t denotes the time series variable undergoing test for stationarity, *t* indicates a deterministic time trend variable and Δ is the first difference operator. To make certain that residuals are white noise, the model incorporates k number of lagged difference terms whose optimum number is selected using the Akaike's Information Criterion (AIC).

The ADF test evaluates the null hypothesis (H_0: α=0) against the one-tailed alternative hypothesis (H1: α<0). Rejection of null hypothesis indicates that the series is stationary, while its non-rejection confirms the presence of unit root and consequent non-stationarity of the time series. The widely used ADF test, however, suffers from a limitation in cases where the selected series contains a structural break. In fact, the presence of structural breaks makes many macroeconomic series apparently appear non-stationary despite of them being stationary after accommodating for structural breaks (Perron, 1989)

Later Zivot and Andrews (1992) formulated a unit root test for identifying the presence of structural breaks endogenously from the data. The Zivot and Andrews (ZA) test for a structural break in intercept (Model A) and in both intercept and slope (Model C) can be illustrated by equations (2) and (3) respectively:

$$\Delta y_t = \mu + \beta t + \theta DU_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_i \dots\dots\dots\dots\dots\dots\dots (2)$$

$$\Delta y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_i \dots\dots\dots\dots\dots\dots (3)$$

In equation (2) and (3), DU_t denotes a level shift dummy variable such that DU_t=1 if t>T_B and zero otherwise; T_B indicates the break date. On the other hand, DT_t is a trend shift dummy such that DT_t=t–T_B when t>T_B, and zero otherwise. The selection of the optimal lag length (k) is accomplished following the criteria prescribed by Campbell and Perron (1991) and Ng and Perron (1995).

Despite making a remarkable contribution by endogenizing the structural break, the ZA test imposed rather a strict constraint by allowing for only one structural break. Lumsdaine and Papell (1997) highlighted that over long periods a time series variable is very likely to experience multiple shocks. Therefore, under such cases the ZA model which is capable to accommodate only a single break is less powerful and tends to be biased in favour of non-rejection of the unit-root null hypothesis. This limitation was addressed by Lumsdaine and Papell (1997) by extending the ZA methodology to account for two endogenous structural breaks. In effect, the Lumsdaine and Papell (LP) test augments the ADF test with two pairs of dummy variables to account for two breaks, which can be expressed in the following equation:

$$\Delta y_t = \mu + \beta t + \theta_1 DU1_t + \gamma_1 DT1_t + \theta_2 DU2_t + \gamma_2 DT2_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_i \dots (4)$$

Here DUi_t and DTi_t (i=1,2) are the break dummy variables which are defined as: DUit =1 and DTit = t – T_{Bi} if t >T_{Bi}, and zero otherwise. Also to ensure that the two break dates have an interval of at least two periods the restriction T_{B2} ≥ TB_1+2 is instituted. LP test for inspecting two breaks in the intercept only (Model AA) sets the restriction $\gamma_1 = \gamma_2$ = 0 in equation (4). No restrictions are imposed on the slope coefficients for evaluating the subsequent breaks in both the intercept and slope of the trend function (Model CC). The procedure for selecting the lag length *'k'* is the same as followed in the ZA test.

Results and Discussions

The area under the crops and crop groups under consideration is reported in the Table 1. From the table it may be observed that while net sown area in Sikkim have remained more or less constant during the periods under consideration (after increasing from around 81 thousand hectare during early 1980s to around 95 thousand hectares in early nineties, the net sown area declined to 78 thousand hectare in the new millennium and remains almost unchanged in the last two decades), the gross cropped area increased continuously from around 104 thousand hectares in early 1980s to around 148 thousand hectares in the recent 2019-22 (triennium) period, thanks to continuous increase in cropping intensity from 129.47 during the 1981-84 period to 191.27 in the 2019-22 period. From the table it may also be observed that area under foodgrain crops, which have remained more than sixty percent in 1980s and 1990s, declined significantly to around 47 percent in 2011-14 period and further to 37 percent in 2019-22 period.

We may also observe from the table that among the major foodgrain crops, percentage of gross cropped area under rice and wheat declined significantly , especially in the first two decades of the new millennium, while area (% of G.C.A) under maize, the main foodgrain crop grown in the state, showed a relatively moderate decline in the same period and area under pulses have also depicted moderate

Table 1: Percentage of Gross Cropped Area cultivated by the Crop/Crop Groups in Sikkim

Crops	*1981-82 to 1983-84*	*1991-92 to 1993-94*	*2001-02 to 2003-04*	*2011-12 to 2013-14*	*2019-20 to 2021-22*
Rice	14.42	13.07	12.47	8.21	5.87
Wheat	8.95	6.63	5.43	0.79	0.08
Maize	30.05	31.25	31.16	28.00	25.97
Pulses	6.78	5.79	5.71	4.48	3.54
Total Food grains	65.66	61.55	60.84	47.39	37.07
Oilseeds	8.18	7.57	8.19	5.95	4.12
Net Sown Area*	80.53	94.93	78.00	77.20	77.20
Gross Cropped Area*	104.27	127.27	120.87	142.68	147.66
Cropping Intensity	129.47	134.06	154.96	184.81	191.27

**in thousand hectares*

Source: Computed from data collected from EPW Research Foundation

decline in the last twenty years. Area under oilseeds, as % of G.C.A., also almost halved from 8.19 % in the 2001-04 (triennium) period to 4.12 % in the recent 2019 -22 period.

We have already mentioned that no earlier studies on agricultural growth in Sikkim have analysed the growth rates of production and productivity of major crops grown in the state using modern time series technique, seeking to determine whether the time series under consideration are trend stationary or difference stationary in nature and whether endogenous structural breaks are present in those series. The present paper seeks to do it, starting with the unit root (Augmented Dickey Fuller) test and then searching for endogenous structural breaks in the series using Lumsdaine and Papell test.

The data to be tested in this paper are yields and productions of total foodgrains, rice, wheat, maize, pulses and oilseeds over the period 1981-82 to 2021-22, expressed in natural logarithm. In order to examine the time series properties of the variables under consideration, we begin our analysis with the ADF test, the results of which are reported in the Table 2 (a) and (b). ADF test results have shown that the null hypothesis of a unit root cannot be rejected even at the 10% level of significance for the yields of foodgrains and oilseeds [Table 2 (a)] and for the productions of rice, wheat and pulses [Table 2 (b)].

From the tables it may be observed that unit root null can be rejected in favour of a stationary alternative for the yields of rice, wheat, maize and pulses and for the productions of foodgrains, maize and oilseeds. However, unit root null can't be rejected for five of the twelve series under consideration.

We have mentioned earlier that conventional unit root tests can have little power when the true data generating process contains structural break. In order to test for possible multiple structural breaks in the growth path of production

Table 2(a): Results from Augmented Dicky–Fuller (ADF) Test for stationarity in yield of major crop/crop groups

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \, \Delta y_{t-i} + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots . (1)$$

y_t	μ	β	α	k	*Nature of the series*
Ln of yield of foodgrains	4.2148 (2.42) *	0.0055 (2.49) *	-0.6002 (-2.42)	7	N
Ln of yield of Rice	5.0066 (4.15) **	0.0110 (3.28) **	-0.7193 (-4.09) *	1	S
Ln of yield of Wheat	5.1794 (3.49) **	-0.0095 (-2.95) **	-0.6923 (-3.48) #	1	S
Ln of yield of Maize	6.6507 (3.36) **	0.0098 (3.38) **	-0.9410 (-3.36) #	7	S
Ln of yield of Pulses	18.8491 (6.19) **	0.0055 (3.20) **	-2.7831 (-6.17) **	7	S
Ln of yield of Oilseeds	1.7872 (2.03) #	-0.0002 (-0.12)	-0.2637 (-2.00)	1	N

't' ratios are reported in parentheses; ** p<0.01, * p<0.05, # p<0.10
S: Stationary/Trend Stationary; N: Difference Stationary

Table 2(b): Results from Augmented Dicky–Fuller (ADF) Test for stationarity in production of major crop/crop groups

y_t	μ	β	α	k	*Nature of the series*
Ln of Prodn. of Foodgrains	4.8400 (3.97)**	-0.0017 (-1.23)	-1.0379 (-3.98)*	7	S
Ln of Prodn. of Rice	0.9009 (3.25)**	-0.0035 (-2.44)*	-0.2738 (-2.91)	1	N
Ln of Prodn. of Wheat	0.3292 (0.50)	-0.0289 (-1.60)	0.0148 (0.10)	8	N
Ln of Prodn. of Maize	2.9942 (3.94)**	0.0085 (4.05)**	-0.7850 (-3.96)*	7	S
Ln of Prodn. of Pulses	2.1830 (3.08) **	-0.0096 (-1.62)	-1.0029 (-3.08)	7	N
Ln of Prodn. of Oilseeds	1.8297 (3.39)**	-0.0091 (-2.22)*	-0.8038 (-3.54)#	6	S

't' ratios are reported in parentheses; ** $p<0.01$, * $p<0.05$, # $p<0.10$
S: Stationary/Trend Stationary; N: Difference Stationary

and yield of crops under consideration, we have employed the Lumsdaine and Papell (1997) test, allowing for two endogenous structural breaks in both intercept and slope of the trend function (model CC). This test enables us to examine structural breaks in the level as well as the growth rate.

Since testing for any change in the growth rate of the variables under consideration is one of our primary objectives, the model CC of Lumsdaine and Papell (1997) test is chosen for our analysis.

The results obtained from model CC of LP test (reported in Tables 3 (a) and 3 (b)) bears the evidence of rejection of unit root null in favour of stationarity around a broken trend for five of the six crop yield variables (viz., for yields of rice, wheat, maize, pulses and oilseeds) and all six crop production variables under considerations.

When structural breaks are accounted for, only yield of foodgrains have been found to be non-stationary [Table 3(a)]. From Table 3(a) a significantly positive time trend implying a significantly positive growth rate is discernible for yields of all the crops except in the yields of pulses and oilseeds. From the model CC of the LP test, a significantly negative downward shift in both level and growth rate is discernible for maize, the main foodgrain crop grown in Sikkim, from 1991-92, which was followed by a significantly positive shift in level and growth rate in the yield of maize from 2001-02. Growth rate of yield of rice also depicted a significant decline in growth rate from 1991-92, followed by a positive shift in yield level in 2006-07, but growth rate of rice yield has not shown any improvement in the last three decades. Among the other foodgrain crops, two significant downward shifts in the level (but not in the growth rate) are discernible for the yield of wheat, first in 1996-97 and then in 2006-07. Yield of pulses has also depicted a significant rise in level in 1993-94, followed by a significant increase in both level and growth rate from 2007-08. Yield of oilseeds, a non– foodgrain crop, has shown a statistically significant negative growth rate along with a significant drop in yield level but significant increase in growth rate from 1997-98, followed by a significant increase in both level and growth rate from 2007-08. Thus, there are some evidences of a rise in crop productivity in the latter half of first decade of the 21st century, following the shift towards organic farming, in the cases of yield of maize, the main foodgrain crop grown in the state, and in the yields of pulses and oilseeds.

From the Table 3(b) a significantly positive time trend is discernible only for productions of rice and maize while a significantly negative time trend is observed for productions of foodgrains, pulses and oilseeds. Growth rate of production of wheat also depicted a negative (but statistically insignificant) time trend. Growth rate of production of foodgrains, however, has depicted a significant rise in growth rate from 2001-02, only to be followed by a significant rise in level but slowdown in growth rate from 2008-09. Growth rates of productions of major foodgrain crops grown in the state, viz. rice, wheat and maize have also experienced statistically significant drop in the decade of 1990s [Table 3(b)]. Both level and growth rate of rice production.

dropped significantly in Sikkim from 1991-92. Growth rate of rice production further declined significantly again from 2008-09. Growth rates of productions of wheat and maize have also depicted a significant decline from 1991-92. Growth rate of wheat production also declined significantly again from 2008-09. Productions of maize and wheat, however, have depicted a significant rise in level in 2008-09. Production of pulses and oilseeds, on the other hand, have shown a significant rise in growth rates from 2001-02 followed by a significant decline in growth rates, from 2008-09 in the case of pulses production and from 2010-11 in the case of oilseeds production.

Table 3(a): Results from Model CC of Lumsdaine and Papell's (LP) test for stationarity in yield of major crop/crop groups

$$\Delta y_t = \mu + \beta t + \theta_1 DU1_t + \gamma_1 DT1_t + \theta_2 DU2_t + \gamma_2 DT2_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_i \ldots (4)$$

y_t	TB_1	TB_2	μ	β	θ_1	γ_1	θ_2	γ_2	α	K	Nature of the series
Ln of yield of foodgrains	1996	2008	6.8751 (6.44)**	0.0179 (4.13)**	-0.0920 (-3.22)**	-0.0119 (-2.56)*	0.0427 (1.69)	0.0064 (1.62)	-0.9850 (-6.36)	1	N
Ln of yield of Rice	1991	2006	7.6451 (6.78)**	0.0573 (4.49)**	-0.0421 (-0.66)	-0.0465 (-3.74)**	0.1010 (1.72)#	-0.0004 (-0.06)	-1.1424 (-6.72)#	0	S
Ln of yield of Wheat	1996	2006	9.1178 (8.29)**	0.0239 (3.17)**	-0.4035 (-3.91)**	-0.0162 (-1.08)	-0.3015 (-3.18)**	-0.0088 (-0.61)	-1.2620 (-8.27)**	0	S
Ln of yield of Maize	1991	2001	9.1543 (6.63)**	0.0466 (4.81)**	-0.0882 (-3.09)**	-0.0469 (-4.28)**	0.0818 (3.35)**	0.0145 (3.05)**	-1.3176 (-6.54)#	1	S
Ln of yield of Pulses	1993	2007	37.9958 (10.86)**	-0.0215 (-0.63)	0.3119 (4.93)**	0.0154 (0.45)	0.0735 (2.80)*	0.0201 (5.39)**	-5.5782 (-10.35)**	8	S
Ln of yield of Oilseeds	1997	2007	24.7943 (8.24)**	-0.0578 (-2.46)*	-0.4844 (-6.73)**	0.0605 (1.99)#	0.2161 (4.15)**	0.0433 (2.74)*	-3.5501 (-8.21)**	8	S

Note: 't' ratios are reported in parentheses; ** p<0.01, * p<0.05, # p<0.10; S: Stationary/Trend Stationary; N: Difference Stationary

Table 3(b): Results from Model CC of Lumsdaine and Papell's (LP) Test for stationarity in production of major crop/crop groups

y_t	TB_1	TB_2	μ	β	θ_1	γ_1	θ_2	γ_2	α	K	Nature of the series
Ln of Prodn. of Foodgrains	2001	2008	10.2146 (10.59)**	-0.0185 (-3.90)**	-0.0432 (-1.25)	0.0389 (4.50)**	0.1628 (4.54)**	-0.0538 (-6.44)**	-2.1385 -(10.64)**	7	S
Ln of Prodn. of Rice	1991	2008	3.2479 (7.93)**	0.1042 (6.33)**	-0.2149 (-3.47)**	-0.1013 (-6.10)**	0.0707 (1.24)	-0.0451 (-5.17)**	-1.3340 (-7.75)**	0	S
Ln of Prodn. of Wheat	1997	2008	10.3518 (7.88)**	-0.0157 (-0.62)	-0.4531 (-2.61)*	-0.1686 (-4.31)**	1.1135 (3.78)**	-0.9519 (-7.78)**	-3.6682 (-8.10)**	7	S
Ln of Prodn. of Maize	1997	2008	8.5105 (8.75)**	0.0693 (5.15)**	-0.1304 (-5.61)**	-0.0564 (-4.09)**	0.1412 (6.76)**	0.0081 (1.73)	-2.3781 (-8.54)**	8	S
Ln of Prodn. of Pulses	2001	2008	7.7480 (8.19)**	-0.1345 (-6.84)**	-0.0821 (-0.48)	0.2614 (5.83)**	0.8263 (3.79)**	-0.2868 (-5.86)**	-2.9116 (-8.07)**	7	S
Ln of Prodn. of Oilseeds	2001	2010	10.4633 (6.30)**	-0.1680 (-5.46)**	0.0729 (0.64)	0.2109 (5.33)**	0.2607 (2.46)*	-0.1451 (-5.18)**	-3.7287 (-6.52)#	8	S

Note: 't' ratios are reported in parentheses; ** p<0.01, * p<0.05, # p<0.10; S: Stationary/Trend Stationary; N: Difference Stationary

Critical values for t_α at the 1%, 5%, and 10% level of significance are -7.19, -6.75 and -6.48, respectively (Ben-David, Lumsdaine, and Papell 2003).

Conclusion

Using the modern time series techniques for estimating the growth rate of production and yield of important foodgrain crops (total foodgrains, rice, wheat, maize and pulses) and oilseeds, grown in Sikkim, the present study found the presence of unit roots (difference stationary processes) in the yields of foodgrains and oilseeds and in the productions of rice, wheat and pulses, during the period 1981-82 to 2021-22. However, allowing for two endogenous structural breaks in both intercept and slope by applying LP test, present study have found that both productions and yields of all of these crops, i.e., rice, wheat, maize, pulses and oilseeds are stationary or trend stationary. Production of 'total foodgrains' also depicted a trend stationary process and a difference stationary process is observed only for yield of 'total foodgrains'. The present study also found evidences of significant slow-down in growth rates of productions of all of these crops in the decade of 1990s and / or in the first decade of new millennium, resulting from decline in area and decline in growth rate of yields of crops like rice, wheat and maize during the decade of 1990s. Area under crops declined further for all of the crops under consideration in the next two decades, but increase in yield have been observed in the first decade of new century, following the shift toward organic farming in the state, in the cases of maize, pulses and oilseeds.

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