Biological Forum – An International Journal **15(10): 1657-1667(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Instability and Decomposition Analysis of Apple Crop in Kashmir

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(Received: 27 August 2023; Revised: 25 September 2023; Accepted: 08 October 2023; Published: 15 October 2023)
(Published by Research Trend)

ABSTRACT: Assessing the trends in variability in agricultural production is crucial for comprehending the shifts in outputs over time. This study investigates the patterns of apple crop production in the Kashmir region, utilizing time-series data spanning from 2001-02 to 2019-20. The study's aim is to examine the volatility and breakdown of area, production, and productivity in apple crop cultivation. The results indicate significant instability in crop production in the region, with the greatest instability found in the yield aspect, followed by production and area. The extent of instability fluctuates between two time periods, implying shifts in production patterns. The breakdown analysis identifies shifts in average yield and average area as the primary contributors to variations in overall production. Furthermore, changes in yield variance, area variance, and shifts in average area significantly influence production instability in various districts. Notably, alterations in average area emerge as the dominant factor affecting overall production in the Kashmir division. This research provides valuable insights into the factors affecting production instability and underscores the importance of addressing yield variance, area variance, and changes in average area to improve the stability and productivity of apple crop cultivation in the region.

Keywords: Instability, Coefficient of variation, Coppock Instability index, Cuddy-Della Valle index, Decomposition Analysis.

INTRODUCTION

The apple is a significant fruit in temperate zones worldwide, featuring a diverse range of commercial cultivars. Classified under the genus Malus within the subfamily Pomoideae and family Rosaceae, apples possess a fundamental chromosome number of x = 17. Despite the existence of over 10,000 recognized apple cultivars globally, only 20 are acknowledged for their commercial importance (Janick *et al*., 1974; Devi *et al.*, 2021). The origin of the apple can be traced back to southwestern Asia, particularly the Caucasus area near Gilan in Turkistan. Over time, human intervention has facilitated its dissemination to nearly all corners of the globe. This widespread distribution is facilitated by the significant genetic variability inherent in the apple species, allowing for the development of adapted varieties suited to diverse environments (Juniper *et al.*, 2001). In India, the commercial cultivation of apples is predominantly concentrated in Jammu and Kashmir, Himachal Pradesh, Uttaranchal, and to a limited extent, in the North-Eastern states (Devi *et al.*, 2021).

The issue of agricultural growth and instability continues to be an enduring topic of discussions and debates given the overwhelming importance of agriculture in the Indian economy, notably since the mid-1960s when new agricultural technology was introduced. Numerous studies on various aspects of agricultural development are available in the literature, including those on the increase in area, production, and productivity of various crops, sources of growth, adjustments in cropping patterns, use of inputs, the degree of instability, sources of instability, etc. (Mehra, 1981; Hazell, 1982; Bhalla and Singh, 1997; Ahluwalia, 1991; Dev, 1987; Sawant and Achuthan, 1995). The need for increasing agricultural production is evident; however, the rise in production instability has negative implications (Chand and Raju, 2008). It increases risks in farm production, affects farmers' income, and influences their decisions regarding the adoption of high-paying technologies and farming investments (Chand, Ramesh, and Raju 2009). Production instability also impacts price stability, consumers, and further exposes low-income households to market vulnerability (Naylor and Falcon, 2010). Furthermore, the volatility in agricultural and food production plays a vital role in the management of food resources and maintaining macroeconomic stability (Chand and Raju 2009).

The implementation of modern technologies in India has been a significant event in the country's history, attracting the attention of researchers interested in its impact on farm output growth and instability (Chand *et al.*, 2011). Many acknowledge that these novel and improved technologies have significantly boosted food production in a brief span, propelling India closer to attaining food self-sufficiency by the early 1980s (Ghose, 2014). Nevertheless, the effect of these technologies on the volatility of agricultural and food production remains uncertain and worrisome (Parayil, 1992).

Most studies conducted over a 10 to 20-year period following the introduction of new technologies determined that agricultural output insecurity has been increasing (Mehra, 1981; Hazell, 1982; Ray, 1983; Rao *et al.,* 1988; Singh, 1989, 1998). In contrast, certain researchers hold the belief that the technologies associated with the Green Revolution, marked by the widespread adoption of a modern input package encompassing enhanced seed varieties, fertilizers, irrigation, and improved production methods, will mitigate the traditional instability of subsistence agriculture attributed to weather, pests and diseases (Hazell, 1982; Dev, 1987).

Recent research endeavors have expanded their investigations to encompass a more extended post-Green Revolution period or have included more contemporary years. Notably, a study conducted by Larson *et al.,* (2004) arrived at the conclusion that the Green Revolution had indeed led to a significant increase in food grain and crop production in India. However, this increase was accompanied by heightened production and yield instability.

Insecurity in agriculture can impede the growth of production, investment, employment, consumption, and equitable income distribution, hampering the overall economic development and progress of the nation (Abler *et al.*, 1994; Eicher and Staatz 1998).

The current study sought to analyze the impact of new technologies on production variability by comparing agricultural production instability from 2001-02 to 2019-20. It is important to keep in mind that this study did not differentiate between different stages of technological adoption, such as early and limited use versus widespread adoption.

The primary objective of this paper is to resolve the ambiguity regarding shifts in instability within agricultural production brought about by the adoption of new technology. It achieves this by assessing agricultural instability during the modern technology era, which is divided into two distinct periods: period I (2001-02 to 2009-10), representing the initial phase of improved technology, and period II (2010-11 to 2019-20), representing the post-technology implementation phase of wider technology dissemination.

This analysis would significantly contribute to resolving the question of whether the long-term adoption of modern-era improved technology ultimately increased or decreased production variability. Additionally, it could shed light on whether the short-term and long-term effects of improved technology on production instability differ. The specific objectives of this study are as follows:

1. To estimate the instability in the production of the Apple crop and to study its nature and extent.
2. To work out and examine the components of change in the mean and variance of the production of Apple crops.

MATERIALS AND METHODS

Source of data and the methodology for data utilization

This study analyzes time series secondary data of the apple crop's harvested area, production, and productivity from 2001 to 2020, taken from the Directorate of Horticulture, Kashmir's official website (Anonymous 2019–2020). The data were divided into two sub-periods, period I (from 2001-02 to 2009-10) and period II (from 2010-11 to 2019-20), and then submitted to instability and decomposition analysis. The current study was conducted using three different methods: district-level, zone-level, and Kashmir division of Jammu and Kashmir, UT, India.

Analytical framework

Instability analysis. For studying instability in the production of Apple crop, both the nature and extent of instability were estimated for both periods separately as well as for the overall period. The technique suggested by Sen (1967) and Bandyopadhyay (1989) was used to ascertain the type of instability. First, trend values were calculated by fitting the observed data points to the linear equation y = a + bx. The observed values that surpassed the associated trend values (indicating positive deviations or peaks) and those that dropped below the trend values (indicating negative deviations or troughs) were then separated, and variations around the trend were detected. A trend line was then fitted for each pair of observed values that were either greater or lower than the matching trend value.

As a result, on either side of the primary trend line, a comparable pair of trend lines was created, one indicating peaks and the other representing troughs. Each of these trend lines was independently fitted for peaks and troughs to determine where they diverged and converged.

The two trends were as follows:

Y" = a" + b" t (for peak),

Y' = a' + b ' t (for trough)

In order to find the convergence and divergence, a factor "t" was calculated.

Where, $\text{"t"} = \frac{(a''-a')}{(b'-b'')}$

When "t" > 0, it signifies that the "peak" and "trough" trend lines Converge in the positive quadrant, signifying reduced instability.

Conversely, if "t" < 0, it indicates that the "peak" and "trough" trend lines diverge in the negative quadrant, signifying an increase in instability.

To assess the level of instability in the domain of Apple crop production and yield, three distinct techniques were employed, namely, the Coefficient of variation, Cuddy-Della Valle index, and Coppock's Instability Index.

1. Coefficient of variation (CV). Karl Pearson introduced the coefficient of variation (CV) more than a century ago, and it has since become a crucial and extensively employed summary statistic based on moments. The Coefficient of Variation (CV) can be used as a valuable tool for instability analysis in various contexts, including financial markets, economic data, and other fields where instability or volatility is a concern. When applied to instability analysis, the CV can help assess the relative instability or variability of a dataset over a specific time period. Various studies have been conducted that indicate its value as a tool for assessing variability in time-series data (Sandeep *et al.*, 2016, and Ikuemonisan *et al.*, 2020).

$$CV = \frac{\sigma}{\bar{Y}} \times 100$$

Where,

σ = Standard deviation

$\bar{Y}$ = Mean of production/productivity/area

2. Cuddy-Della Valle index (CDI). The Cuddy-Della Valle index, introduced by Cuddy and Valle in 1978, aims to eliminate the influence of trends in the coefficient of variation (CV) by utilizing the coefficient of determination. It provides a more accurate indication of the direction of instability in data. While CV is commonly used to assess instability in time-series data, it has limitations. When applied to data with trends, CV can overstate variability; for example, areas experiencing steady production growth may show high production instability if CV is employed (Ravinder and Ajit, 2019). In contrast, the Cuddy-Della Valle index seeks to remove trend effects from CV by using the coefficient of determination (Wasem, 2001). Data on crop area and productivity were determined using linear relationships as detailed by Singh and Gangwar in 1991. Many researchers (Shaheen and Shiyani 2004; Bezabeh *et al.*, 2014; Kumar *et al.*, 2017; Bisht and Kumar, 2018; and Baviskar *et al.*, 2020) have applied the CDI method to measure variability in time-series data, considering it a superior approach for capturing instability in agricultural production. The estimable equation is presented as follows:

$$\mathrm{CDI} = \mathrm{CV}\sqrt{(1 - \mathrm{R}^2)}$$

In this context, the coefficient of variation (CV) is expressed as a percentage, and R^2 represents the coefficient of determination.

The levels of instability are categorized within the following ranges:

Low instability	=	(0-15)
Median instability	=	(15-30)
High instability	=	(>30)

3. Coppock's instability Index (CI). Coppock's instability index serves as a relatively accurate estimation of the annual percentage variation, accounting for the underlying trend. Its primary advantage lies in its ability to gauge the instability within price trends. A higher numerical value on the index signifies a more significant degree of instability (Coppock, 1962).

$$\mathrm{CI} = (\mathrm{Antilog})\sqrt{(\mathrm{logV} - 1)} \times 100$$

$$\mathrm{logV} = \frac{1}{N-1}\sum_{t=1}^{n}\left(log\frac{X_{t+1}}{X_t} - m\right)^2$$

$$\mathrm{m} = \frac{1}{N-1}\sum_{t=1}^{n}\mathrm{logX_{t+1}} - \mathrm{logX_t}$$

Where,

X_t	=	Area/Production/Yield
t	=	No. of years
log V	=	logarithmic variance of the series
m	=	Mean of difference between the log of X_{t+1}, X_t.

Decomposition Analysis. The fluctuations in the production of a specific crop in physical terms primarily depend on two key factors, namely changes in the harvested area dedicated to that crop and fluctuations in its average productivity. To investigate alterations in both the average production and the variability of production for individual horticultural crops, a decomposition analysis was conducted. This approach was recommended by Hazell (1982, 1984) and found support from various researchers (Srinivasa and Jalajakshi, 1994; Shyam, 2002; and Sathiadhas and Femeena 2002). Hazell (1982) introduced a unique method that utilized residuals to estimate instability, which differed somewhat from the approach developed by Mehra (1981).

Components of Change in Average Production. If we use the variables P, Y, and A to represent production, yield, and area respectively, we can express the relationship among these three variables for each crop as follows

$$P = A\ Y$$

The average production, denoted as E(P), can be expressed as

$$E(P) = \bar{A}\,\bar{Y} + \mathrm{CoV}\,(A, Y) \quad (1)$$

$$\Delta E(P) = \bar{A}_1\Delta\bar{Y} + \bar{Y}_1\Delta\bar{A} + \Delta\bar{A}\,\Delta\bar{Y} + \Delta\mathrm{Cov}\,(A, Y) \quad (2)$$

where,

$\bar{A}$	=	Mean area in Over All Data
$\bar{A}_1$	=	Mean area in Period-I
$\bar{Y}$	=	Mean yield
$\bar{Y}_1$	=	Mean yield of Period-II
CoV (A, Y)	=	Covariance between area and yield
ΔCov (A, Y)	=	Change in covariance between area and yield

Components of Change in Variance of Production

In a similar manner, the variance of production can be broken down to identify the components of change in variance. Following the same relationship P = AY, Goodman (1960) and Bohrnstedt and Goldberger (1969) have formulated the variance of production, V(P), as

$$V(P) = \bar{A}^2 V(Y) + \bar{Y}^2 V(A) + 2\bar{A}\,\bar{Y}\mathrm{Cov}\,(A, Y) - \mathrm{Cov}^2(A, Y) + R$$

where

$\bar{A}$	=	Mean area
$\bar{Y}$	=	Mean yield
R	=	Residual term

It is clear that any modification in these elements will lead to a variation in V(P) between two time periods.

RESULTS AND DISCUSSION

A. Instability analysis

Nature of instability. The results of the instability analysis for area, production, and yield of Apple crop are presented in Table 1, showing the values of "t" computed at the point of intersection of peak and trough trend lines.

From Table 1, it can be observed that there is instability in the area under the Apple crop for district Srinagar, district Anantnag, district Pulwama, Central zone, South zone, and for the entire Kashmir region. During period I (2001-02 to 2009-10), the trend lines for "peak" and "trough" points converge in the positive quadrant, indicating decreasing instability. In period II (2010-11 to 2019-20), all districts, including South zone and Central zone, converge in the positive quadrant, indicating decreasing instability. However, in district Budgam, districts Baramulla, district Kupwara, and Central zone, the trend lines for "peak" and "trough" points diverge in the negative quadrant, indicating increasing instability. In period II, except for district Baramulla, in all districts, the trend lines for "peak" and "trough" points converge in the positive quadrant, indicating decreasing instability. In the overall period (2001-20), for districts Srinagar, Baramulla, and Pulwama, the trend lines for "trough" and "peak" diverge in the negative quadrant.

In period I (2001-02 to 2009-10), there is instability in production for all three zones and all districts, except district Pulwama, where the trend lines for "peak" and "trough" points converge in the positive quadrant. In period II (2010-11 to 2019-20), the trend lines for "peak" and "trough" points for all districts and the entire Kashmir region converge in the positive quadrant. However, over the entire period, for Baramulla and Pulwama, the trend lines for "peak" and "trough" points diverge in the negative quadrant. The instability analysis in yield during period I shows that for district Srinagar, district Budgam, district Anantnag, district Pulwama, Central zone, and North zone, as well as for the entire Kashmir region, the trend lines for "peak" and "trough" points converge in the positive quadrant. Meanwhile, for district Baramulla, district Kupwara, and South zone, the trend lines for "peak" and "trough" points diverge in the negative quadrant. In period II, the trend lines for "peak" and "trough" points converge in the positive quadrant for all districts of Kashmir and the Central and South zone.

Table 1: Assessment of instability in the area, production and yield of apple crop.

Districts	Period I (2001-02 to 2009-10)			Period II (2010-11 to 2019-20)			Overall (2001-02 to 2019-20)		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Srinagar	38.65	3.14	4.67	9.02	6.04	8.61	-3.14	3.98	-5.87
Budgam	-12.17	1.97	1.18	5.70	3.77	3.34	5.03	3.15	77.66
Baramulla	-1.01	19.22	-1.10	-7.10	15.13	16.40	-1.21	-1.63	-0.95
Kupwara	-5.47	3.92	-10.97	2.95	2.68	2.70	1.72	15.76	6.39
Anantnag	3.036	7.72	1.93	2.19	2.68	4.21	3.96	1.31	-8.57
Pulwama	264.31	-0.73	0.71	2.12	3.91	4.54	-16.40	-12.74	8.52
North zone	-0.16	1.93	4.31	16.35	4.89	-24.79	-2.99	1.03	-1.48
Central zone	1.91	2.00	4.28	-8.10	2.52	5.03	25.66	0.51	228.39
South zone	3.32	2.10	-1.47	2.21	2.94	4.61	-2.06	-2.30	-77.52
Kashmir Div.	2.57	2.49	6.96	2.34	4.02	4.18	0.01	0.54	1.44
Note: Data for years 2013-14 is missing. #FLOODS									

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Extent of instability. To estimate the degree of instability in the Area, Production, and Yield of Apple crop, the coefficient of variation (CV), Cuddy-Della Valle index (CDI), and Coppock's instability Index (CI) were computed from period-I to period II for all the three kinds of studies and are described below.

For District-wise study

Table 2 and Fig. 2 present the instability analysis in production for district Srinagar, which was found to be in the lower range (0-15) in all three periods with instability indices of 2.10, 13.74, and 13.52 in periods I, II, and III, respectively. For District Budgam, the instability index in period II and over the overall period was found to be in the medium range (15-30) with instability indices of 27.50 and 27.74, while in period I, it was found to be in the lower range (0-15) with an instability index of 3.12. For district Baramulla, the instability index was found to be in the lower range (0-15) in period I with an instability index of 2.40. While in period II and over the overall period, the instability was found to be in the medium range (15-30) with instability indices of 19.68 and 18.61, respectively. For district Kupwara, the instability was found to be in the lower range (0-15) in period I with an instability index of 8.55. While in period II and over the overall period, the instability was found to be in the medium range (15-30) with instability indices of 20.10 and 18.65, respectively. For district Anantnag, during period I, the instability was found to be in the lower range (0-15) with an instability index of 2.92. While in period II and over the overall period, the instability was found to be in the medium range (15-30) with instability indices of 15.36 and 17.36, respectively. For district Pulwama, the instability was found to be in the lower range (0-15) in all three periods with instability indices of 10.32, 13.19, and 13.41 for periods I, II, and III, respectively.

The instability analysis in Area (Fig. 1) for district Srinagar was found to be in the lower range (0-15) in period II and overall period, with instability indices of 8.87 and 12.25, respectively. On the other hand, in period I, the instability was found to be in the medium range (15-30) with an instability index of 16.82.

For district Budgam, the instability was found to be in the lower range (0-15) in all periods with instability indices of 5.80, 4.97, and 11.12 in periods I, II, and III, respectively. For district Baramulla, the instability was found to be in the lower range (0-15) in all periods with instability indices of 2.04, 1.63, and 3.74 in periods I, II, and III, respectively. For district Kupwara, the instability was found to be in the lower range (0-15) in all periods with instability indices of 1.48, 0.82, and 3.89, respectively. For district Anantnag, the instability in all three periods was found to be in the lower range (0-15) with instability indices of 2.49, 4.22, and 4.55, respectively. For district Pulwama, the instability was found to be in the lower range (0-15) with instability indices of 6.55, 2.90, and 5.83 in periods I, II, and III, respectively.

Instability analysis in yield (Fig. 3) for district Srinagar shows that the instability index in period I was found to be in the lower range (0-15) with an instability index of 11.62. In period II and overall period, the instability index was found to be in the medium range (15-30) with instability indices of 18.66 and 16.84, respectively. For district Budgam, the instability was found to be in the lower range (0-15) with an instability index of 6.50. In period II, the instability was found to be in the medium range (15-30) with an instability index of 29.89, while in the overall period, the instability was found to be in the higher range (>30) with an instability index of 31.73. For district Baramulla, the instability was found to be in the lower range (0-15) with an instability index of 1.11 in period I, while in period II and overall period, the instability was found to be in the medium range (15-30) with instability indices of 19.30 and 15.57, respectively. For district Kupwara, the instability was found to be in the lower range (0-15) with an instability index of 10.80, while in period II and overall period, the instability index was found to be in the medium range (15-30) with instability indices of 20.47 and 18.35, respectively. For district Anantnag, the instability was found to be in the lower range (0-15) in period I with an instability index of 6.00. While in period II and overall period, the instability was found to be in the medium range (15-30) with instability indices of 17.15 and 16.97, respectively. For district Pulwama, the instability was found to be in the lower range (0-15) in period I and overall period, with instability indices of 6.61 and 12.66, respectively, while in period II, instability was found to be in the medium range (15-30) with an instability index of 15.89.

For Zone-wise study

Table 3 shows the instability analysis in production (Fig. 5). For the Central zone, the instability index was found to be in the lower instability range (0-15) in period I with an instability index of 2.08. In period II and overall period, the instability was found to be in the medium range (15-30) with instability indices of 18.07 and 18.52, respectively. For the North zone, the instability index was found to be in the lower range (0-15) in all three periods with instability indices of 2.91, 13.48, and 13.76 in periods I, II, and overall period, respectively. For the South zone, the instability index in all three periods was found to be in the lower range (0-15) with instability indices of 5.97, 13.68, and 12.76, respectively.

The instability in the area (Fig. 4) for the Central zone in all periods was found to be in the lower range (0-15) with instability indices of 6.80, 5.52, and 9.50, respectively. For the North zone, the instability index was found to be in the lower range (0-15) with instability indices of 1.43, 1.15, and 3.67 in periods I, II, and overall period, respectively. The same is the case with the South zone; the instability index in all three periods was found to be in the lower range (0-15) with instability indices of 3.27, 3.53, and 4.72, respectively.

In yield (Fig. 6), for the Central zone, the instability was found to be in the lower range (0-15) in period I with an instability index of 7.73, while in period II and overall period, the instability was found to be in the medium range (15-30) with instability indices of 19.88 and 19.71, respectively. For the North zone, the instability in all three periods was found to be in the lower range (0-15) with instability indices of 3.56, 12.23, and 10.51 in periods I, II, and overall period, respectively. For the South zone, the instability was found to be in the lower range (0-15) during period I and overall period, with instability indices of 3.09 and 12.34, respectively, while in period II, the instability was found to be in the medium range (15-30) with an instability index of 16.02.

For Kashmir Division

The instability analysis for the Kashmir division is presented in Table 3. Examining the data, it is evident that the instability in production (Fig. 7) during all three periods remained within the lower range (0-15), with instability indices of 1.50, 11.54, and 10.12 for periods I, II, and the overall period, respectively. Similarly, the instability in area, across the same periods, was also situated in the lower range (0-15), displaying instability indices of 1.59, 2.40, and 4.46 for periods I, II, and the overall period, respectively. Regarding the instability analysis of yield, the highest instability was observed in period II, with an instability index of 13.56, while the lowest was recorded in period I, with an instability index of 1.65. These findings provide a comprehensive overview of the stability dynamics in production, area, and yield across the examined periods in the Kashmir division.

Table 2: District-wise extent of instability in area, production, and yield of apple crop.

Districts	Instability Index	Period I (2001-02 to 2009-10)			Period II (2010-11 to 2019-20)			Over-all (2001-02 to 2019-20)		
		Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Srinagar	CV (%)	24.65	15.38	11.84	10.90	20.67	20.21	26.50	37.40	20.05
	CDI	16.82	2.10	11.62	8.87	13.74	18.66	12.25	13.52	16.84
	CII	12.19	10.34	12.14	11.10	12.19	13.05	11.66	11.60	12.64
Budgam	CV (%)	19.80	13.83	9.43	5.72	37.25	40.25	16.43	48.24	42.37
	CDI	5.80	3.12	6.50	4.97	27.50	29.89	11.12	27.74	31.73
	CII	11.02	10.65	10.95	10.72	19.56	20.51	10.85	15.93	16.49
Baramulla	CV (%)	6.64	5.65	1.61	1.75	24.57	23.89	7.51	18.69	16.27
	CDI	2.04	2.40	1.11	1.63	19.68	19.30	3.74	18.61	15.57
	CII	10.35	10.40	10.13	10.27	14.07	13.88	10.30	12.78	12.66
Kupwara	CV (%)	10.46	32.15	24.50	1.75	25.27	24.63	12.46	42.72	34.19
	CDI	1.48	8.55	10.80	0.82	20.10	20.47	3.89	18.65	18.35
	CII	10.26	11.12	11.09	10.17	15.25	15.26	10.21	13.54	13.54
Anantnag	CV (%)	17.19	11.83	8.85	8.76	26.71	22.04	25.41	41.35	20.42
	CDI	2.49	2.92	6.00	4.22	15.36	17.15	4.55	17.36	16.97
	CII	10.59	18.05	10.77	10.57	18.77	13.28	10.56	18.18	12.35
Pulwama	CV (%)	24.27	31.66	10.12	8.23	16.41	16.01	29.16	35.25	13.75
	CDI	6.55	10.32	6.61	2.90	13.19	15.98	5.83	13.41	12.66
	CII	10.82	11.55	10.84	10.43	11.94	11.95	10.64	11.80	11.60

CV: Coefficient of variation, CDI: Cuddy-Della Valle index, CII: Coppock's instability index
Note: Data for year 2013-14 is missing. #FLOODS

Table 3: Extent of instability in area, production, and yield of apple crop for Zone and Kashmir Division.

Zones	Instability Index	Period I (2001-02 to 2009-10)			Period II (2010-11 to 2019-20)			Over-all (2001-02 to 2019-20)		
		Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Central-zone	CV (%)	19.83	14.40	8.69	5.56	27.60	25.69	18.78	41.76	26.70
	CDI	6.80	2.08	7.73	5.52	18.07	19.88	9.50	18.52	19.71
	CII	10.94	10.43	11.29	10.71	14.81	15.06	10.85	13.19	13.50
North-zone	CV (%)	7.90	10.50	6.63	1.17	14.69	12.56	9.26	17.53	12.68
	CDI	1.43	2.91	3.56	1.15	13.48	12.23	3.67	13.76	10.51
	CII	10.23	10.34	10.28	10.17	12.43	11.94	10.23	11.84	11.51
South-zone	CV (%)	20.38	22.21	3.31	8.46	20.80	17.62	27.19	37.21	14.82
	CDI	3.27	5.97	3.09	3.53	13.68	16.02	4.72	12.76	12.34
	CII	10.43	10.82	10.52	10.46	12.29	12.41	10.48	11.77	11.80
Kashmir Division	CV (%)	14. 82	14.47	2.60	4.61	13.13	14.53	18.67	25.21	14.60
	CDI	1.60	1.50	1.65	2.40	11.54	13.56	4.46	10.12	10.52
	CII	10.24	10.21	10.27	10.30	11.73	12.00	10.31	11.38	11.52

CV: Coefficient of variation, CDI: Cuddy-Della Valle index, CII: Coppock's instability index
Note: Data for year 2013-14 is missing. #FLOODS

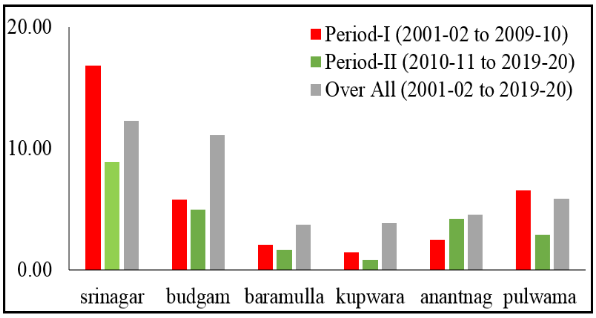

Fig. 1. Instability by Cuddy-Della Valle index for area.

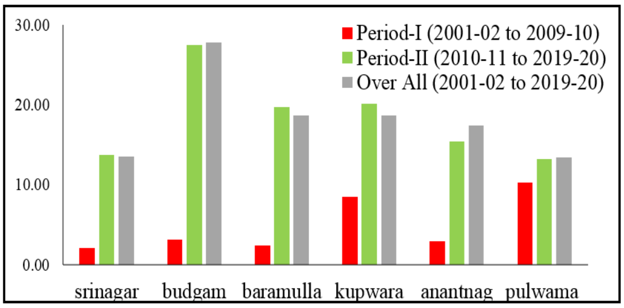

Fig. 2. Instability by Cuddy-Della Valle index for production.

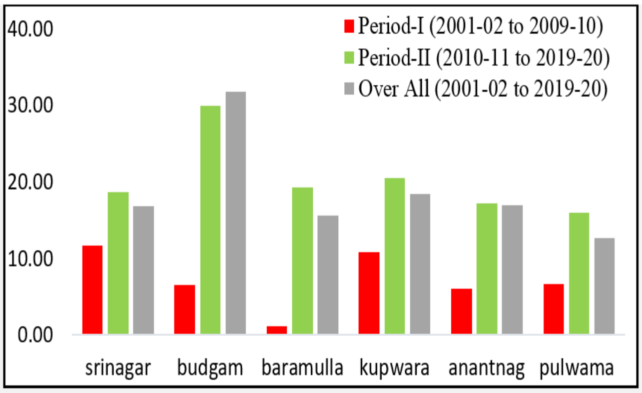

Fig. 3. Instability by Cuddy-Della Valle index for yield.

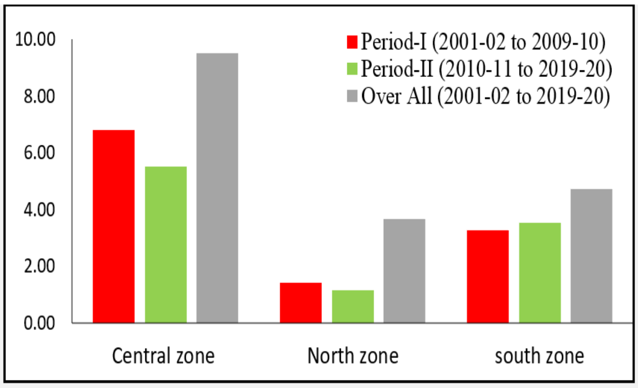

Fig. 4. Instability by Cuddy-Della Valle index for Area.

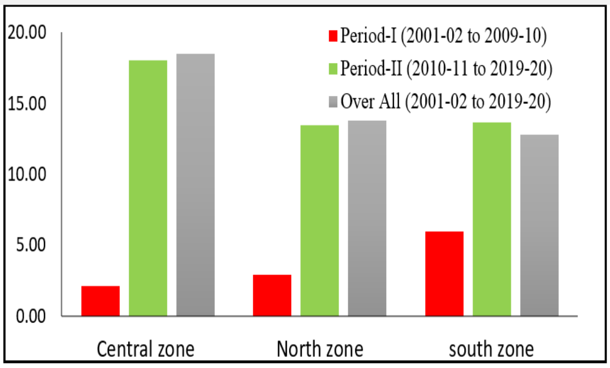

Fig. 5. Instability by Cuddy-Della Valle index for Production.

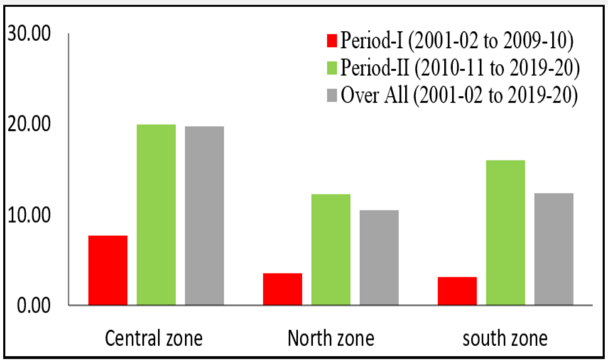

Fig. 6. Instability by Cuddy-Della Valle index for Yield.

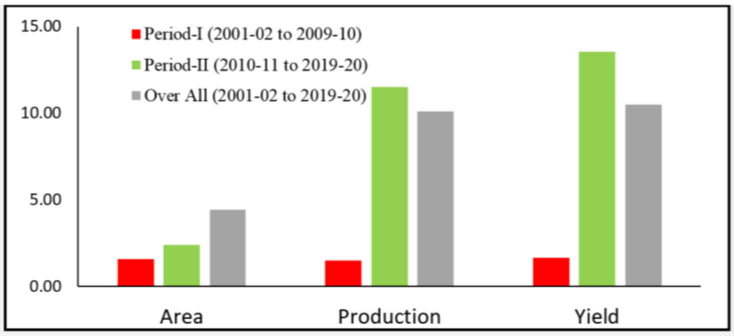

Fig. 7. Instability by Cuddy-Della Valle index for Yield in Kashmir.

Decomposition Analysis

For District-wise Study

Component of Change in Average Production

According to Table 4 and Fig. 8, the analysis reveals that the change in mean area was the dominant component contributing to the increase in the average production of the Apple Crop in several districts. Specifically, in district Srinagar, the change in mean area accounted for 58.86% of the increase. In Baramulla, it contributed 125.24%, in Anantnag, 59.84%, and in Pulwama, 85.86%. On the other hand, in districts Budgam and Kupwara, the main contributors to the increase in average production were changes in mean yield. In Budgam, the change in mean yield accounted for 65.23% of the increase, while in Kupwara, it contributed 63.27%.

Table 4: Components of change in Average Production (%) in Apple crop for different districts of Kashmir.

Components of change	Srinagar	Budgam	Baramulla	Kupwara	Anantnag	Pulwama
$\Delta\bar{Y}$	26.7	65.23	-24.38	63.27	24.2	10.11
$\Delta\,\bar{A}$	58.86	22.59	125.24	24.04	59.84	85.86
$\Delta\,\bar{A}\Delta\bar{Y}$	13.68	14.14	-3.04	14.52	13.56	6.61
$\Delta Cov\,(Y, A)$	0.76	-1.96	2.17	-1.83	2.4	-2.58

$\Delta\bar{Y}$: Change in Mean Yield, $\Delta\,\bar{A}$: Change in Mean Area, $\Delta\,\bar{A}\Delta\bar{Y}$: Interaction between Change in Mean Area and Mean Yield, Δcov (A, Y): Change in Area and Yield Covariance.

Note: data for year 2013-14 is missing. #FLOODS

Component of Change in Variance Production

Based on Table 5 and Fig. 9, the analysis indicates that the change in yield variance was the dominant component contributing to the increase in variance of production across all districts. In particular, the change in yield variance accounted for 170.16% in Srinagar, 117.24% in Budgam, 104.22% in Baramulla, 67.45% in Kupwara, and 52.31% in Anantnag. However, in the district of Pulwama, the main contributor to the increase in production variance was the change in mean area, which accounted for 106.07%.

Additionally, the interaction between the change in mean area and yield variance was observed to be influential in Srinagar (102.98%), Baramulla (3.14%), and Anantnag (30.75%). In Budgam and Kupwara, the change in mean yield was recorded as the second component contributing to the increase in the variance of production, with percentages of 12.30% and 30.90% respectively.

Decomposition analysis in Zone wise and Kashmir Division

Component of Change in Average Production. As Shown in Table 6 and Fig. 10, the analysis reveals that the change in mean area was the primary component contributing to the increase in average production across all three zones. Specifically, in the North-zone, the component change in mean area accounted for 62.35% of the increase, while in the Central and South-zones, it contributed 198.59% and 71.89% respectively. Similarly, in the overall Kashmir division, the change in mean area (79.55%) was the main factor leading to the increase in average production. On the other hand, the component change in area and yield covariance had a negligible effect in the North-zone, South-zone, and Kashmir division.

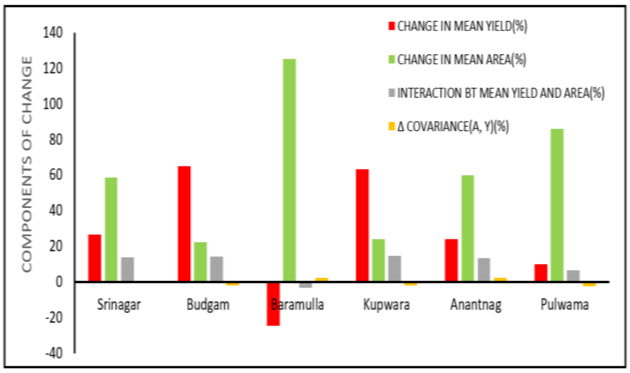

Fig. 8. Components of change in Average Production in Apple crop for different districts.

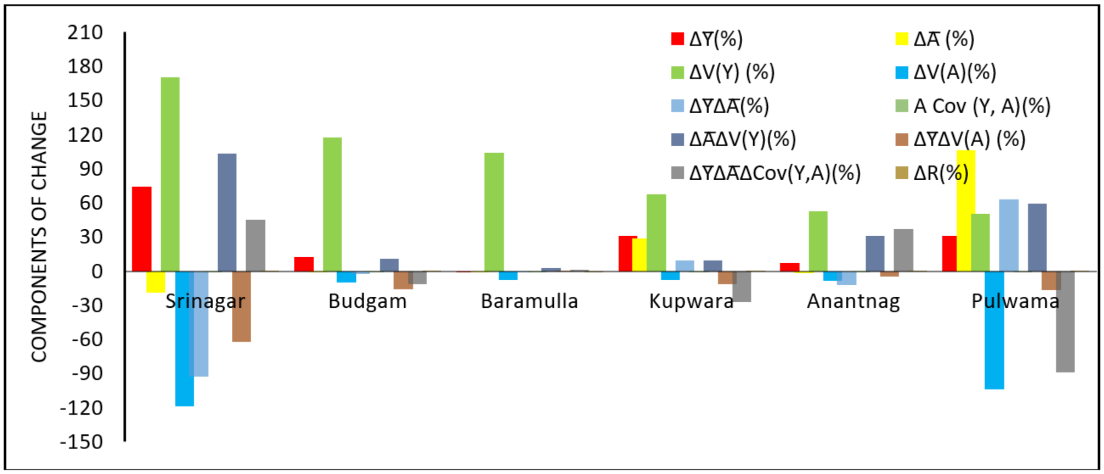

Fig. 9. Components of change in Variance of Production in Apple crop for different districts of Kashmir.

Component of Change in Variance Production. Based on Table 7 and Fig. 11, the findings indicate that in the North-zone and South-zone, the increase in the variance of production was primarily attributed to changes in yield variance, accounting for 112.44% and 60.89% respectively. On the other hand, in the central-zone and Kashmir division, the main component contributing to the increase in production variance was the interaction between changes in mean yield and area variance.

Table 5. Components of change in Variance of Production (%) of Apple crop for different districts of Kashmir.

Components of change	Srinagar	Budgam	Baramulla	Kupwara	Anantnag	Pulwama
$\Delta\bar{Y}$	73.95	12.30	-0.34	30.90	7.53	31.30
$\Delta\bar{A}$	-19.15	-0.78	-0.22	28.67	-1.93	106.07
ΔV(Y)	170.16	117.24	104.22	67.45	52.31	50.12
ΔV(A)	-118.92	-9.60	-7.75	-7.34	-8.71	-103.53
$\Delta\bar{Y}\Delta\bar{A}$	-92.68	-2.60	-0.34	9.32	-12.18	62.78
$ACov\,(Y,A)$	0.00	-0.10	0.00	-0.23	-0.45	-1.09
$\Delta\bar{A}\Delta V(Y)$	102.98	10.92	3.14	9.54	30.75	59.51
$\Delta\bar{Y}\Delta V(A)$	-61.70	-15.78	0.37	-11.55	-4.40	-16.56
$\Delta\bar{Y}\Delta\bar{A}\Delta Cov\,(Y,A)$	45.35	-11.60	0.91	-26.77	37.06	-88.60
ΔR	0.03	0.01	0.00	0.00	0.00	0.00

$\Delta\bar{Y}$: Change in Mean Yield, $\Delta\,\bar{A}$: Change in Mean Area, $\Delta\,\bar{A}\Delta\bar{Y}$: Interaction between Change in Mean Area and Mean Yield, Δcov (A, Y): Change in Area and Yield Covariance.
Note: data for year 2013-14 is missing. #FLOODS

Table 6: Components of change in Average Production (%) of Apple crop in zone wise and Kashmir division.

Components of change	North-zone	Central-zone	South-zone	Kashmir division
$\Delta\bar{Y}$	32.96	-85.45	17.46	15.25
$\Delta\,\bar{A}$	62.35	198.59	71.89	79.55
$\Delta\,\bar{A}\Delta\bar{Y}$	5.36	-26.91	10.58	5.69
$\Delta Cov\,(Y,A)$	-0.67	13.77	0.07	-0.49

$\Delta\bar{Y}$: Change in Mean Yield, $\Delta\,\bar{A}$: Change in Mean Area, $\Delta\,\bar{A}\Delta\bar{Y}$: Interaction between Change in Mean Area and Mean Yield, Δcov (A, Y): Change in Area and Yield Covariance.
Note: data for year 2013-14 is missing. #FLOODS

Table 7: Components of change in Variance of Production of Apple (%) crop in Zone wise and Kashmir. division.

Components of change	North-zone	Central-zone	South-zone	Kashmir Division
$\Delta\bar{Y}$	6.70	-5.11	21.56	33.75
$\Delta\bar{A}$	5.02	-4.14	8.89	-5.35
$\Delta V(Y)$	112.44	-41.55	60.89	214.44
$\Delta V(A)$	-27.99	-73.21	-35.42	-193.19
$\Delta\bar{Y}\Delta\bar{A}$	3.02	-35.31	6.19	-6.90
$ACov\,(Y,A)$	0.00	-1.04	0.01	-0.04
$\Delta\bar{A}\Delta V(Y)$	10.58	227.39	47.29	112.21
$\Delta\bar{Y}\Delta V(A)$	-5.02	18.49	-11.20	-28.63
$\Delta\bar{Y}\Delta\bar{A}\Delta Cov\,(Y,A)$	-4.75	14.47	1.79	-26.29
ΔR	0.00	0.00	0.00	0.00

$\Delta\bar{Y}$: Change in mean yield, $\Delta\bar{A}$: Change in mean area, $\Delta V(Y)$: Change in yield variance, $\Delta V(A)$: Change in area variance, $\Delta\bar{Y}\Delta\bar{A}$:Interaction between change in mean yield and mean area, $ACov\,(Y,A)$: Change in area yield covariance, $\Delta\bar{A}\Delta V(Y)$:Interaction between change in mean area and yield variance, $\Delta\bar{Y}\Delta V(A)$:interaction between change in mean yield and area variance, $\Delta\bar{Y}\Delta\bar{A}\Delta Cov\,(Y,A)$: Interaction between changes in mean area and yield and change in area yield covariance, ΔR: Change in residuals.

Note: data for year 2013-14 is missing.

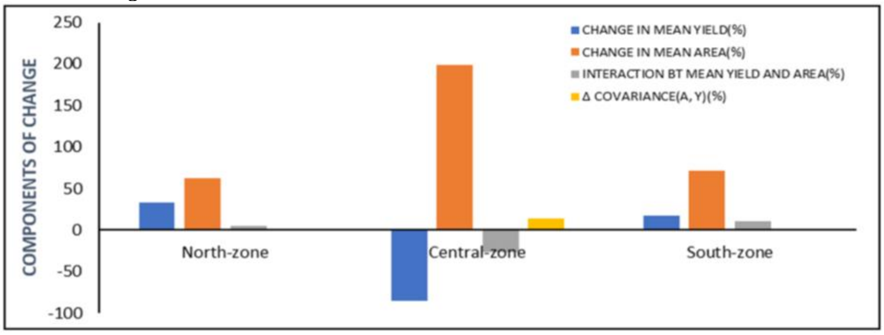

Fig. 10. Components of change in Average Production for Apple crop in different zones.

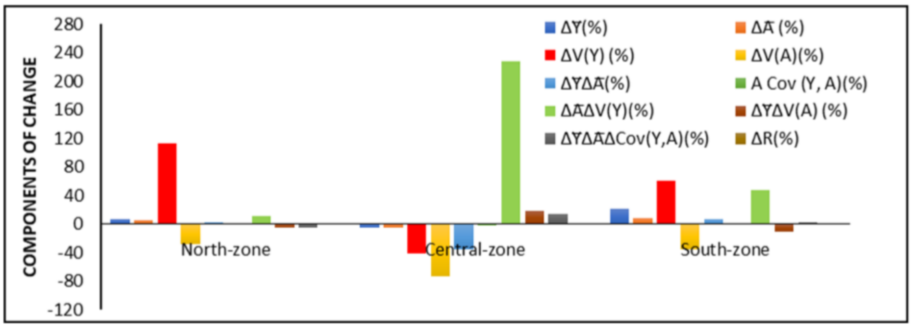

Fig. 11. Components of change in Variance of Production for Apple crop in different zones.

SUMMARY AND CONCLUSION

This study systematically assessed the instability and decomposition of the Apple crop in the districts of the Kashmir division in UT of Jammu and Kashmir. It aimed to provide valuable insights for policymakers in formulating effective policies to improve the Apple crop in the region. Data was collected from the official website of the Directorate of Horticulture, Kashmir, covering two periods (period-I: 2001-02 to 2009-10, period-II: 2010-11 to 2019-20) and an overall period (2001-02 to 2019-20).

Various indices, such as the Coefficient of Variation, Cuddy-Della Valle index, and Coppock's Instability Index, were employed to calculate district-wise instability in the area, production, and yield of the apple crop. The Hazell decomposition model was utilized to assess the relative contributions of area and yield to the total production. The study revealed that, across different districts in the Kashmir division, the area exhibited lower instability compared to production and yield. Specifically, District Budgam demonstrated the highest instability in yield, followed by production in the same district, and area in District Srinagar. Conversely, District Baramulla displayed the lowest instability in the area, followed by yield in District Pulwama, and production in District Srinagar and District Pulwama. Upon analyzing the zones, it was observed that all three zones exhibited lower instability in the area compared to production and yield. The Central zone had the highest instability in yield, followed by the North zone in production, and the South zone. Notably, the North zone displayed the lowest instability in the area. Overall, the study indicated that yield experienced the highest instability, followed by production, while the area had the lowest instability.

The district-level decomposition analysis underscored changes in mean yield, mean area, and yield variation as the primary factors contributing to the increase in the average output of the apple crop. Likewise, the analysis conducted at the zone level revealed the dominance of the change in mean yield in all three zones. However, the study places emphasis on the finding that the change in mean area was the dominant factor contributing to the rise in the average output of the apple crop in the Kashmir division.

In conclusion, this research has yielded valuable insights into the instability and decomposition analysis of the apple crop in the Kashmir division. It has illuminated the factors influencing production and proposed potential areas for improvement in agricultural policies and practices. Such studies play a crucial role in comprehending production fluctuations and provide guidance for scientific planning and the implementation of agricultural development programs. Further investigations into other important crops, including fruit crops, oilseeds, and cereals, at both the state and district levels, are recommended to augment our understanding of agricultural dynamics in the region.

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How to cite this article: Arif Bashir, Imran Khan, Bhagyashree Dhekale, M S Pukhta, Farhat A. Shaheen, A. H. Mughal and Bariz Aijaz Wani (2023). Instability and Decomposition Analysis of Apple Crop in Kashmir. *Biological Forum – An International Journal, 15*(10): 1657-1667.