A Study on Trends and Instability of Finger Millets in India

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Abstract

The present study aims to analyze the trends and instability in the area, production, and yield of finger millet (Eleusine coracana) cultivation in India during the period 1994–95 to 2023–24. It examines the effectiveness of government interventions and identifies patterns of growth and volatility that affect the sustainability of finger millet cultivation. Despite policy support, the area and production of millets particularly finger millet have shown a steady long-term decline. The study objective is to analyze the trends and assess the instability in the area, production, and yield of finger millet cultivation in India. The study is based on the secondary data source, collected from the Ministry of Agriculture and Farmers' Welfare (Government of India), and Agricultural Statistics at a Glance report. The study used statistical tools such as the Compound Annual Growth Rate (CAGR), trend linear regression, and the Cuddy-Della Valle Instability Index (CDVI) to examine growth dynamics and variability. The study results revealed that a declining trend in the area of cultivation (-27.17), production (-27.64) and also the yield of finger millet slightly increasing trend (8.51) at statistically 5 % level. The study also found both cultivated area (CAGR -1.23%) and total production (CAGR-1.12%), reflecting an inverse trend in finger millet cultivation over the years. Whereas yield rose slightly (CAGR 0.12%), the growth was small, reflecting the fact that productivity gains have flattened off over time. The production varied most of the three metrics (CDVI 15.01), followed by yield (11.39) and area of cultivation (8.83) finger millet in India. The results found a declining trend and growth patterns in area, significant variability in production and a slightly increasing level of finger millet yield, emphasizing the crop's weakness despite policy interventions. Hence, the study suggested that the government should promote and support policy reform towards region-specific policies, upgrade market access and support for resilient millet farming structures in India. The present study also recommended that the provision of a minimum of one kg of millets per household through the Public Distribution System (PDS), along with institutional procurement and value chain enhancement, can significantly strengthen finger millet's contribution, crop insurance scheme for millet crops and sustainable agriculture. The study pointed out the necessity for future studies to conduct field-level analysis and state-wise comparisons, along with analyses of environmental, economic, and farmer-level factors and market conditions, to develop targeted strategies for enhancing the resilience and sustainability of millet cultivation in rainfed and marginal areas.

Keywords: Finger millet, Trends, Growth rate, CDVI, Agricultural Policy, Climatic condition, PDS

Introduction

Millets have historically constituted a fundamental component of food systems in Africa, European and Asia countries. Millet crops have inherent resilience, it's cultivation in resource-limited environments such as drought-prone and flood-affected areas, nutrient-deficient soils, regions with soil erosion and acidity, and areas inclined to pest infestations. In addition to contributing to food security, millet crops are crucial for the environment because they maintain soil cover, boost biodiversity, and encourage sustainable land management in

arid and semi-arid areas. The crops are especially well-suited for low-input agricultural systems and environmentally delicate landscapes because of these qualities. Millets serve as an essential layer of security during times of food scarcity, giving people with disabilities both dietary sustenance and support for their livelihood.

India is the largest millet producer in the world, about 38.4% of the world's millet production (KSDA, ICAR-IIMR; FAO). In India, there are cultivates various millet crops including Sorghum (Jowar), Finger millet (Ragi), Pearl millet (Bajra), Kodo millet, Barnyard millet, Proso millet, and Foxtail millet etc. Millet crops cultivation is an important because of its high nutritional density, particularly its iron and calcium content, which helps to address the widespread micronutrient deficiencies in rural and tribal communities. Millet crops perform a vital role in the agricultural economic system, in particular in semi-arid, rainfed, and marginal regions in India. It is a vital livelihood crop for millions of marginal and small farmers and makes a significant contribution to food and nutritional security particularly in regions where there are protein and micronutrient deficiencies in India due to its ability to flourish in rainfed, marginal lands with low input requirements. Although, millets have been grown in rainfed and marginal areas for a long time, but their cultivation area and output have been steadily decreasing for the past six to seven decades. This decline is a part of broader trends within Indian agriculture, including the intensification of irrigated agriculture and increased demand for high-yielding crops like wheat and rice, facilitated by government procurement, distribution schemes, changes in people's consumption habits, rapid urbanisation, and a lack of effective policy incentives.

The central and state governments have implemented various policies and schemes particularly the National Food Security Mission (NFSM), the National Mission for Sustainable Agriculture (NMSA), The Pradhan Mantri Krishi Sinchai Yojana (PMKSY), the Rashtriya Krishi Vikas Yojana (RKVY), the National Millet Mission, and the Initiative for Nutritional Security through Intensive Millets Promotion to promoting high-yielding millet varieties, developing irrigational facilities, raising farmer awareness, and providing credit facilities and support to boost productivity level of millet crop among the farmers in India across the state. In addition, the state governments particularly Karnataka, Odisha, and Tamil Nadu have initiative schemes to support and encourage farmers to grow millets. The governments have established several schemes to conduct awareness programme for millet consumption, marketing channel, and value-added programmes. Therefore, the Government of India was celebrated 2018 as a "National Year of Millets" (NYM), to encourage people to grow and eat millets by calling them Nutri-Cereals and the "International Year of Millets" (IYM) in 2023 announced by the United Nations. This declaration has highlighted the crucial role that millets can play in tackling issues like malnutrition, climate change, and the loss of agrobiodiversity (FAO). However, these efforts have yet to fully arrest the decline, particularly in finger millet cultivation. The objective of study aims to analyse the trends and growth patterns in the area, production, and yield of finger millet and to estimate the instability index in finger millet in selected time periods to influence of policy interventions aimed at supporting the millet crops in India.

Notwithstanding its long-term significance and recent policy attention to the cultivation of millet crops has been seen fluctuating trends on different time periods in India. While the previous studies have explored the trends and growth dynamics of millets in general, few studies have comprehensively focused on finger millet over a long-term timeframe using robust statistical tools such as CAGR and CDVI. Some studies have deliberated broader category of millets cultivation particularly finger millet crop's area, production and yield. Some studies have comparative anlysed of the multi crop such as rice and millet crops. Past studies have mixed results revealed on the area and production level of millets particularly finger (ragi), sorghum (jowar), and pearl millet (bajra) have decline trends but yield of millets slightly increasing. Moreover, many studies overlook the time-based impact of government policy interventions, particularly post-2000, on crop performance. In this framework, this study addresses research gap for study long-term, in-depth analysis particularly focused on finger millet

(ragi) by analysing three decades (1994-95 to 2023-24), which hugs significant importance in India's rainfed, marginal farming regions and Indian food system.

Thus, this study fills the empirical gap by conducting a three-decade-long national-level analysis (1994–95 to 2023–24) of finger millet's area, production, and yield using systematic trend and instability tools. To address the research gap, the study finds to answer the following research questions:

1. What are the trends and growth pattern in the area, production, and yield of finger millet in India from 1994–95 to 2023–24?
2. To what extent has finger millet cultivation exhibited instability, as measured by the Cuddy-Della Valle Index?

Review of Literatures

(Painkra et al.) analyzed ragi and kodo millet cultivation in Chhattisgarh's Jashpur district with regard to farmer profile, intensity of cropping, and return from farming. The study reported that though the smaller-sized farms had increased intensity of cropping, profitability was higher in case of large farms. Their study identified that area under millets dropped considerably, though productivity nearly doubled during the periods of 2014–15 to 2022–23. As much as farmers were economically viable particularly on large farms, they had certain challenges including poor irrigation, limited quality seed access, and weak market access. The study suggested that to improved infrastructure, input support, and more robust market associations to enhance millet farming yields.

(Kashid et al.) investigated the trend of finger millet (ragi) and rice cultivation growth in Maharashtra's Konkan belt from 2011 to 2023, analyzing government statistics and Compound Annual Growth Rate (CAGR). The research indicated that ragi output enhanced appreciably in Sindhudurg growing at 4.31% annually indicating improved farming practices adoption. However, overall ragi production dropped because there was a decline in cultivable land. Although a few districts such as Raigad and Sindhudurg showed positive growth in area as well as yield, others such as Thane witnessed a drastic decline, primarily due to urban growth and soil degradation.

(Kumudha) analyzed millet production trends in Tamil Nadu from 2011–12 to 2021–22, focusing on finger millet (Ragi), sorghum (Jowar), and pearl millet (Bajra). The study found significant growth in the area and production of Jowar and Bajra, and major yield improvements in Ragi and Bajra. It showed that yield was the main driver of production growth across all millet types, while area contributed less or even negatively in some cases. Instability in production was highest for Jowar and Ragi, and lowest for small millets. The study also noted a long-term decline in millet cultivation due to the rise of rice and wheat post-Green Revolution, but recent gains in yield and market demand have encouraged millet adoption through improved varieties and cropping practices.

(Yamuna et al.) examined long-term trends in millet cultivation across India from 1966–67 to 2019–20 using ICAR data and advanced trend analysis models (linear, polynomial, logarithmic, exponential, and power functions). The study found a significant decline in the area and production of major millets such as Sorghum and Finger millet, with negative compound annual growth rates (CAGR) in the areas (-2.51% for Finger millet, -1.84% for Sorghum) and production (-1.44% and -0.49% respectively). Despite this, yield trends showed resilience and slight improvement, reflecting the impact of improved cultivation technologies. The Cuddy-Della Valle index revealed varying degrees of instability (ranging from 5.90 to 21.11). It indicates to continued decline in area and production, with a possible reversal in yield gains for crops like Sorghum by 2030. The study emphasized the importance of nutritional awareness, improved varieties, and supportive policies to revive millet cultivation.

(Sathish Kumar et al.) examined trends in the area, production, and productivity of minor millets in India from 1990–91 to 2019–20 using descriptive statistics and CAGR analysis. The study found a sharp decline in both area and production, mainly due to a shift toward cereals and commercial crops. However, productivity improved at a CAGR of 1.92%, thanks to the adoption of high-yielding, pest-

resistant varieties and improved farming practices. The authors highlighted the importance of raising awareness and promoting millets, especially in regions with low consumption and high nutritional desires.

(Anbukkani et al.) analyzed structural shifts in the cultivation of minor and finger millets using NSSO consumption data and spatial-temporal trends. The study identified key structural breaks in the area under minor millet cultivation, particularly in 1998 and between 2000–2002. While Madhya Pradesh and Chhattisgarh have the largest cultivation areas, states like Uttarakhand and Tamil Nadu show higher productivity. Minor millet consumption remains relatively high in northeastern states such as Assam and Bihar, largely due to traditional food habits. The study also pointed out that varietal development for minor millets lags behind other crops, highlighting the need for greater investment and extension efforts to enhance production and awareness.

(Sangappa et al.), study based on time-series data from 1950 to 2022, highlights a persistent decline in the area and production of minor millets, with an annual reduction rate of 3.30% and 2.20%, respectively. Despite this, the productivity showed a marginal increase of 1.05% per annum, largely attributed to the adoption of high-yielding and disease-resistant varieties. The study notes that the expansion of cereal crops, supported by government policies, has led to a systematic displacement of millet cultivation.

(Prashanthi and Reddy) provide a macro-level perspective on millet cultivation, stating that India leads globally in the production of various millets, including pearl millet, finger millet, and minor millets like little millet and barnyard millet. Despite this leadership, their analysis revealed a long-term decline in cultivation area and production, with Crop Growth Rates (CGR) of -16.21% and -13.58%, respectively, between 1950 and 2019. The state of Telangana, for example, has seen shifts in millet production due to the Green Revolution's emphasis on rice and wheat, urbanization, changing consumer preferences, and the structural incentives favouring other crops.

(Sendhil et al.) examined both historical and current trends in millet cultivation, revealing a steady decline in the area and production of jowar, ragi, and other small millets from the triennium ending (TE) 1968–69 to TE 2022–23. The exception was bajra, which showed production gains driven by improved yields. Despite the overall downward trend, recent policy efforts such as declaring 2018 as the National Year of Millets and 2023 as the International Year of Millets have helped rekindle interest in millet cultivation and consumption. The study highlights the importance of involving multiple stakeholders, investing in capacity building, and running awareness campaigns to revive both the cultivation and consumption of millets.

(Banerjee et al.) offered a holistic overview of millet production and trade dynamics. Their analysis of export data (2003–2020) indicated that sorghum is the most exported millet, while finger millet exports remain minimal. The study emphasized the resource efficiency of millet cultivation and its alignment with sustainable agricultural goals. The authors highlighted the urgent need for awareness and policy interventions to restore millet production and capitalize on their domestic and international market potential.

Methodology

This study is based on secondary data collected from the Ministry of Agriculture and Farmers' Welfare (Government of India), Agricultural Statistics at a Glance reports, the Food and Agriculture Organization (FAO), journals, and other relevant studies. The data for this study has been taken over a period of 30 years from 1994–95 to 2023–24 and has been used to analyze trends, growth rates, and volatility in the area, production, and productivity of finger millet in India. The study period from 1994-95 to 2023-24 was purposefully selected to examine long-term trends in the cultivation of finger millet in India. This timeframe has been selected to examine the impact of several government policies and initiative programmes envisioned at encouraging millet cultivation and the supportive of millet production and consumption among the farmers and people in India.

The central and state governments have implemented significant policies and programmes to promote of millets as Nutri-cereals. These include

the National Millet Mission (2007), the Initiative for Nutritional Security through Intensive Millets Promotion (2011–12), and the integration of millet crops into public welfare schemes such as the PDS and ICDS programme introduce to provide millet crops in mid-day-meals. Additionally, the government of India celebrate the National Year of Millets in 2018 and the International Year of Millets (IYM) in 2023, declared by the United Nation (FAO), were motivated of creating awareness, increasing production and productivity, and establishment the millet value chain to enhance millet consumption. These milestones have brought significant and attention to millets during the selected study period. The policies interventions justify the selection of this period for analyzing the structural and policy enhancements in the area, production, and yield of finger millet in India.

Tools for Analysis

The present study employs the statistical techniques, such as mean, coefficient of variance, compound annual growth rate (CAGR), linear trends analysis and instability index, to analyze trends in the cultivation of finger millet. The collected data were analyzed by Microsoft Excel 2019 and SPSS Version 25. The following statistical tools were used to comprehensive analysis of finger millet in this study.

1. Descriptive statistical measures, including mean, standard deviation (SD), minimum, maximum, and coefficient of variation (CV%), were also used to summarize the central tendency and dispersion of area, production, and yield.

2. Compound Annual Growth Rate (CAGR): The Compound Annual Growth Rate was calculated to estimate the average annual growth rate over the study period as follows: $CAGR = (v_f/v_i)^{(1/n)} - 1$

Where; v_f = Final value of the variable

v_i = Initial value of the variable

n = Number of years

3. Trend Analysis using Linear Regression: Linear regression was used to evaluate trends in area, production, and yield. The general form of the model is: $Yt=a+bt+\varepsilon t$

Where Yt is the dependent variable (area, production, or yield)

t = Time index (year)

a = Intercept

b = Slope coefficient representing the trend

εt = Random error term and the coefficient of determination (R^2) was used to evaluate the goodness of fit of the regression model.

4. Cuddy-Della Valle Instability Index (CDVI): To assess the variability over time, the instability index developed by Cuddy and Della Valle was employed. The Cuddy-Della Valle instability index was used to measure variability while adjusting for trend effects, which adjusts the coefficient of variation for the trend component:

$CDVI = CV \times \sqrt{(1-R^2)}$

Where CV = Coefficient of Variation (%)

R^2 = Coefficient of determination from the trend analysis

The results of the study reveal trends and instability in the area of cultivation (hectors), production (tonnes) and yield (ka/ha) of finger millet during the period 1994-95 to 2023–24, within the Indian agricultural context.

Result and Discussions

The study employed descriptive statistics to summarize trends in area, production, and yield of finger millet. Compound Annual Growth Rate (CAGR) was used to measure growth over time, while the Cuddy-Della Valle Index (CDVI) assessed instability. Linear regression analysis further identified long-term patterns and trend significance across the study period. The results and analysis section presents the findings and offers meaningful inferences and interpretations of the data concerning the area, production, yield of finger millet in India.

Table 1 Descriptive Statistics of Finger Millet Cultivation (1994-95 to 2023-24)

Variables	Area (000 Hectares)	Production (000 Tonnes)	Yield (Kg/Ha)
Minimum	890.94	1238.7	929.82
Maximum	1784.2	2731.7	1747.27
Average	1371.73	1995.08	1465.36
SD	268.12091	385.93104	183.08245
CV	19.55	19.34	12.49

Source: Calculated by Author

Table 1 provides a summary of the descriptive statistics for the area, production, and yield of finger millet in India over the period 1994-95 to 2023–24. These statistics provided into the central tendency and variability associated with finger millet cultivation over the last three decades. The area under cultivation ranged from a minimum of 890.94 thousand hectares to a maximum of 1,784.20 thousand hectares, with a mean value of 1,371.74 thousand hectares. The standard deviation of 268.12 and a coefficient of variation (CV) of 19.55% suggest a moderate degree of fluctuation, reflecting shifts in crop preferences, land use patterns, and possibly agro-climatic factors influencing cultivation decisions. The production finger millet in India has seen considerable fluctuations over the years, ranging from 1,238.7 thousand tonnes to 2,731.7 thousand tonnes, with an average of approximately 1,995.09 thousand tonnes. The standard deviation of 385.93 and a coefficient of variation (CV) of 19.34% highlight the extent of this variability. These changes closely mirror shifts in the area under cultivation, suggesting that production trends have been largely influenced by how much land is devoted to the crop, while yield has had a comparatively smaller impact on overall output.

Although finger millet cultivation in India has seen significant increasing and decreasing in terms of area and total production, the yield has remained relatively steady over the years. The yields ranged from 929.82 kg/ha to 1,747.27 kg/ha, with an average of about 1,465.36 kg/ha. A standard deviation of 183.08 and a coefficient of variation (CV) of 12.49% suggest that productivity levels have not fluctuated dramatically. This stability, despite the declining area under cultivation, may be attributed to improvements in seed quality, better farming practices, and advances in agricultural technology. The findings revealed that while both the area under cultivation and total production have experienced significant changes, the yield has remained relatively stable. it's important to use improved methods that help increase yield and also take action to stop the decline in the land used for its cultivation. This can be achieved through effective policies and proper support for farmers.

Compound Annual Growth Rate (CAGR)

The Compound Annual Growth Rate (CAGR) is a useful tool for measuring how finger millet farming in India has grown on average each year between 1994–95 and 2023–24. It helps show the overall trend by smoothing out year-to-year changes, making it easier to understand long-term patterns in the area cultivated, total production, and yield.

Table 2 Growth Rate of Finger Millet Cultivation

Year	Area (000 Hectares)	Production (000 Tonnes)	Yield (Kg/Ha)
1994-95	-	-	-
1995-96	0.57	6.81	6.20
1996-97	0.59	-6.45	-7.00
1997-98	-7.15	-10.82	-3.96
1998-99	6.13	24.98	17.76
1999-00	-7.04	-12.22	-5.57
2000-01	7.63	19.31	10.86
2001-02	-6.39	-13.07	-7.14
2002-03	-14.07	-44.59	-35.52
2003-04	17.77	49.40	26.86
2004-05	-6.82	23.74	32.80
2005-06	-1.21	-3.24	-2.05
2006-07	-23.24	-38.66	-20.09
2007-08	17.81	49.09	26.55
2008-09	-0.41	-5.22	-4.83
2009-10	-8.21	-7.42	0.85
2010-11	1.43	16.15	14.51
2011-12	-8.58	-12.05	-3.79
2012-13	-3.81	-18.39	-15.16
2013-14	5.53	25.95	19.34
2014-15	1.21	3.93	2.69
2015-16	-5.79	-11.60	-6.17
2016-17	-10.73	-23.97	-14.84
2017-18	17.54	43.33	21.94
2018-19	-25.40	-37.60	-16.36
2019-20	12.74	41.69	25.67
2020-21	15.39	13.84	-1.33
2021-22	5.09	-14.86	-19.03
2022-23	-4.52	-0.59	4.15
2023-24	4.47	-1.24	-5.43
CAGR (%)	-1.23436	-1.12094	0.116075

Source: Calculated by Author

Table 2 explores the annual and compound annual growth rates (CAGR) for the area, production, and yield of finger millet in India over the past 30 years. The area under finger millet cultivation has declined at a negative CAGR of around -1.23%, reflecting a steady reduction in the land dedicated to this crop (Yamuna et al.; Kumudha). This trend is consistent with the findings of (Prashanthi and Reddy) who point to factors such as the shift toward high-yielding crops like rice and wheat, urban expansion, and evolving farmer preferences. Sharp declines in specific years such as in 2006–07 (-23.24%) and 2018–19 (-25.40%) coincide with periods of drought and climate-related stress in major millet-growing regions, further highlighting the vulnerability of finger millet cultivation to environmental challenges.

Similarly, production registered a negative CAGR of about -1.12%, closely following the contraction in cultivated areas. The observed high interannual variability with production surging by nearly 49.40% in 2003-04 and dropping by -44.59% in 2002-03 reflects the crop's vulnerability to climatic fluctuations and pest outbreaks. The positive spike in 2017-18 (43.33%) correlates with favourable monsoon rainfall and enhanced input usage reported by the Ministry of Agriculture & Farmers' Welfare (MoA&FW, 2018). Conversely, the sharp decline in 2018-19 aligns with widespread drought conditions in key millet-producing states.

In contrast, yield exhibited a marginal positive CAGR of 0.12%, suggesting slight improvements in productivity. This modest increase is attributed to the adoption of improved high-yielding and pest-resistant varieties, better crop management practices, and targeted policy interventions promoting millet cultivation. However, yield fluctuations remain pronounced; significant increases, such as 32.80% in 2004-05, are frequently offset by steep declines (-35.52% in 2002-03 and -19.03% in 2021-22), highlighting the crop's sensitivity to abiotic stresses and inconsistent agronomic support. The relatively slow yield growth also reflects the limited research focus and extension outreach for finger millet compared to major cereals. While there has been a modest improvement in finger millet productivity, it hasn't been enough to offset the steady decline in the area under cultivation and total production. This ongoing trend highlights several persistent challenges such as weak market support, limited policy attention, and increasing climate-related risks that continue to hold back the revival of finger millet in India's farming system. The findings point to the urgent need for a more holistic approach that includes developing better crop varieties, promoting climate-resilient farming practices, and improving market access to make finger millet cultivation more sustainable and impactful for food and nutritional security.

Trend and Instability Analysis of Finger Millet

The linear regression analysis emphasized statistically significant trends in finger millet cultivation in India during the study period. The linear trend analysis supports to understand both the direction and extent of long-term changes in agricultural indicators of finger millet's area of cultivation, production and productivity in India. In this study, it was used to analysis trends in the area, production, and yield of finger millet from 1994-1995 to 2023–24. The study findings, based on the slope coefficients and the coefficient of determination (R^2), provide strong empirical evidence on whether the key indicators area, production, and yield have shown a statistically significant upward or downward trend over time.

Table 3 Trends Linear Analysis

Variable	Area (000 Hectares)	Production (000 Tonnes)	Yield (Kg/Ha)
Coefficient (β)	-27.170*	-27.647*	8.513**
Intercept	1792.871	2423.611	1333.406
R^2	.796	.398	.168

*1% level significant; **5% level significant

Table 3 shows the results of the linear regression analysis examining trends in the area, production, and yield of finger millet cultivation in India from 1994–95 to 2023–24. These findings offer valuable insights into how the crop's performance has changed over the past three decades. The statistical analysis noted a significant decline in the area under cultivation. The estimated coefficient value is –27,170 ($p < 0.001$), with a high coefficient of determination ($R^2 = 0.796$), indicating that, on average, the area under finger

millet has been decreasing by about 27,170 hectares each year. This strong negative trend explains nearly 80% of the variation in the cultivated area over time, underscoring a consistent and substantial reduction in the land allocated to finger millet farming. Such a contraction aligns with empirical evidence documented in recent agricultural surveys, where traditional millet-growing regions have increasingly shifted towards more lucrative crops like rice and maize due to changing market demands and government policies.

Production of finger millet shown a significant negative trend, with an estimated coefficient value of -27.647 ($p < 0.001$), reflecting an average annual decline of about 27,647 tonnes. However, the R^2 value of 0.398 illustrations that only 39.8% of the variation in production is explained by the linear trend, suggesting other influencing factors such as climate variability and input use also impact output. Similarly, the production trend also shows a significant negative slope (-27.647) with high statistical significance ($p < 0.001$), reflecting a substantial reduction in total output over time. This reasonable descriptive power is consistent production volatility in finger millet is partly attributable to irregular rainfall patterns and pest incidences in millet-growing states like Karnataka, Tamil Nadu and Andhra Pradesh.

Inversely, finger millet yield shows a positive but modest increasing trend, with a slope coefficient of 8.513 ($p = 0.025$) and a lower R^2 of 0.168. Conversely, the yield exhibits a positive slope (8.513), which is statistically significant at the 5% level ($p = 0.025$). This suggests a modest but meaningful improvement in yield per hectare despite the overall decline in area and production. This suggests an average yield improvement of approximately 8.5 kg/ha per year, although the low explanatory power indicates variability in yield is driven by multiple factors beyond time trends alone. The past studies have linked such yield gains to gradual adoption of improved varieties and crop management practices. Hitherto, the yield growth has not been sufficient to offset declines in area and production, highlighting persistent structural challenges.

The empirical results found that the contraction in finger millet cultivation area and production in India is statistically significance, while gradual productivity gains suggest some technological or management improvements are partially offsetting these declines. Such patterns align with prior studies highlighting area decrease due to changing cropping patterns and socio-economic factors, alongside yield improvements driven by improved seed varieties and agronomic practices. The trend analysis shows in the area, production, and yield (APY) of finger millet in India for the period 1994–95 to 2023–24 is showed in Figures 1, 2, and 3.

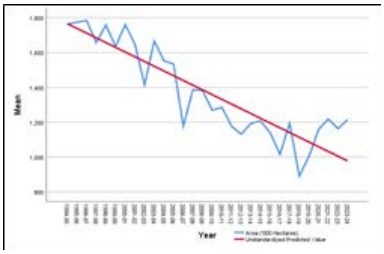

Figure 1 Trend Analysis of Finger Millet in Areas (000 Hectares)

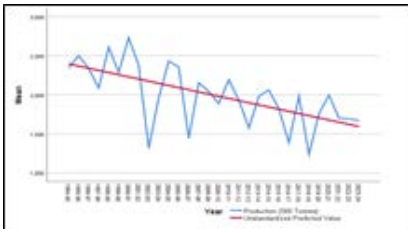

Figure 2 Trend Analysis of Finger Millet Productions (000 Tonnes)

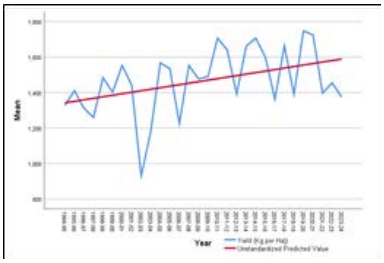

Figure 3 Trend Analysis of Finger Millet in Yield (Kg/Ha)

Instability Cuddy-Della Valle Index

The Cuddy-Della Valle Instability Index (CDVI) is a well-known technique used in agricultural research to determine whether a variable is stable or unstable over time. Unlike the classic coefficient of variation, which ignores long-term trends, the CDVI accounts for these patterns, resulting in a more

precise manner to represent genuine fluctuations. In this study, the CDVI was used to investigate how the acreage, production, and yield of finger millet in India changed between 1994-95 and 2023-24. By removing variations induced by continuous long-term trends, the index provides a more accurate view of how steady finger millet agriculture has been. It aids in determining where the crop is most prone to variability, providing significant insights into its overall consistency and resilience throughout time.

Table 4 Instability Index (CDVI) of Finger Millet Cultivation

Variables	Area (000 Hectares)	Production (000 Tonnes)	Yield (Kg/Ha)
CV (%)	19.55	19.34	12.49
R^2	0.796	0.398	0.168
Instability Index	8.830023	15.00565	11.39263

Source: Calculated by Author

Table 4 shows the results of the Cuddy-Della Valle Instability Index (CDVI) analysis, which evaluates the level of variability in finger millet area, production, and yield in India from 1994-95 to 2023-24. The coefficients of variation (CV) of 19.55% for area, 19.34% for production, and 12.49% for yield indicate a reasonable value of distribution in all three variables. However, because the CV does not take into reason causal trends, the CDVI provides a more accurate estimate of long-term instability. After controlling for the strong downward trend (R^2 = 0.796), the CDVI for the area under agriculture was determined at 8.83%. This indicates relatively low instability in land use despite the long-term drop.

It shows that, while the area has been decrease, the variation around the trend line is modest, implying a generally constant reduction rather than confused fluctuations. In contrast, the production CDVI is 15.01%, indicating a higher level of instability caused primarily by external variables such as erratic rainfall patterns, price volatility, and inconsistency in policy support. The lower R^2 value of 0.398 for production suggests that much of the variation is not explained by linear trends and may be due to external shocks, such as climate variability or market fluctuations. The instability index for yield is 11.39%, despite a lower CV of 12.49%. The comparatively low R^2 of 0.168 indicates that yield fluctuations are not significantly trend-bound and could be influenced by occasional technology interventions, changes in agricultural practices, or input utilization. The slight yield volatility could also be attributed to regional disparities in extension services and adoption rates of better seed varieties. According to the study's findings, the biggest level of output variability is caused by factors other than variations in area and yield. This needs specific measures to encourage production stability, such as enhanced irrigation infrastructure, strong procurement systems, and climate-resilient agricultural methods. Furthermore, while the area under cultivation has remained reasonably consistent, the continued loss highlights the critical need for well-designed incentives and increased policy support to help reverse this trend and maintain farmer interest in finger millet farming.

Conclusion

The study presents a comprehensive analysis of finger millet (ragi) cultivation in India over three decades, focused on trends in area, production and yield and examining growth patterns and instability index. The results of the study showed a declining trend in the area of cultivation (-27.17), production (-27.64) and also the yield of finger millet slightly increasing trend (8.51) at statistically 5 % level. The study also found both cultivated area (CAGR -1.23%) and total production (CAGR-1.12%), reflecting an inverse trend in finger millet cultivation over the years. Whereas yield rose slightly (CAGR 0.12%), the growth was a little, reflecting the fact that productivity gains have flattened off over time. The production varied most of the three metrics (CDVI 15.01), followed by yield (11.39) and area of cultivation (8.83) finger millet in India. Despite the government policies, the area and production of finger millet are still decreasing trends. This is noticed that finger millet remains weak, and the policies have not been very effective. This indicates more serious issues in millet cultivation and market access. To address this issue, the study provides a national-level analysis of growth and instability in finger millet cultivation from 1994–95 to 2023–24. The present study provides empirical insights to

support policy reforms aimed at developing region-specific strategies, improving market access, and strengthening resilient millet farming systems in India.

Suggestions and Recommendations

The government both state and central levels create policies and schemes that support the regional climate and soil conditions. These plans should fix problems like poor soil and lack of access to markets.

The government provides millets in public distribution schemes, Mid-Day Meal Scheme, and ICDS. It is suggested that each household gets at least 1 kg of finger millet every month to improve nutrition and increase demand.

The government should be setup the purchase platforms, millets buying directly from farmers. Also, support Farmer Producer Organizations (FPOs).

The government should adopt millet crops in crop insurance schemes like PMFBY. This will help farmers manage risks and encourage them to keep growing the crop.

Limitations of the Study

The present study is based on secondary data sources, which don't have deliberation for environmental, soil, or socio-economic variables impact on millet farming systems. Furthermore, the study does not examine the price trends, input usage, and farmer perceptions.

Scope for Further Research

Nonetheless, the findings of the study offered openings for further study related to climate change, technology adoption, and millet economics. Additionally, researchers may conduct field-level studies, particularly at the state and regional levels, to further analyze and develop the findings in millet cultivation in rural India.

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