# AN OVERVIEW OF MILLETS PRODUCTION IN INDIA- GROWTH AND INSTABILITY


## ABSTRACT

The study investigates the growth and instability in area, production and productivity of major and minor millets in the World and India. Global millet production is predominantly in Asia, and India being the top producer of millets. Examination of compound annual growth rate (CAGR) of global millets production during 2000-2021 showed that area declined by 0.69 per cent, production increased by 0.48 per cent and productivity by 1.18 per cent. In India, millet farming witnessed a decline in cultivated area with CAGR of 1.92 per cent while productivity showed increasing growth rates by 0.77 per cent and 2.75 per cent respectively for the period 2000-2021. The improvement in productivity of millets is attributed to varietal improvement and ability of millets to withstand abiotic and biotic stress. Instability index used to assess variability in millet area, production and productivity both at the global and national level for the period 2000-2021 showed low instability. Theincrease in adoption of improved millet varieties which are drought resistant, adoption of sustainable agronomic practices were the factors attributed to low instability.



**Keywords:** Millets, Growth, Instability, Sorghum, Pearl Millet and Ragi

## 1. INTRODUCTION

As the International Year of Millets in 2023 unfolded, India found itself at the forefront of a global movement to promote these drought-resistant, nutritious, and climate-resilient crops. Millets, which include sorghum, pearl millet, finger millet, and minor millets like foxtail millet, proso millet, kodo millet, barnyard millet, little millet and two pseudo millets, i.e., buck-wheat and amaranthus have been staples in India for centuries (Nesari, 2023; Madhu et al 2024). In recent years, there has been a notable resurgence in millet production due to their numerous advantages, including low water requirements, adaptability to various agro-climatic zones, and high nutritional value. International Year of Millets, served as a global platform to raise awareness about the significance of millets in addressing food security, reducing malnutrition, and sustaining agricultural livelihoods. It also highlights India's efforts in promoting these remarkable grains and underscores the need for continued support and innovation to ensure their sustained growth and stability in the country's agricultural landscape (Glover et al 2019). Government of India's initiatives and programs like the National Food Security Mission, Initiative for Nutritional Security through Intensive Millet Promotion (INSIMP) under Rashtriya Krishi Vikas Yojana(RKVY), Rainfed Area Development Programme, National Food Security Mission(NFSM), National Nutrition Mission, The Integrated Child Development Services (ICDS), Odisha Millets Mission (OMM) and the Mid-Day Meal Scheme (MDMS) have encouraged millet cultivation and consumption leading to an increase in production (Anbukkani et al 2017; Pal et al 2023). Raitha Siri a programme launched by Government of Karnataka is aimed at providing financial assistance of Rs. 10,000 to the farmers to encourage millets cultivation and increase its production. Also, the state is encouraging organic farming and millet promotion through "Savayava Bhagya Yojana". Chhattisgarh is the only state in India where Kodo, Kutki and Ragi are being procured at Minimum Support Price (MSP).

Millets, also referred as dryland cereals are a group of small-seeded grasses that are typically grown in arid and semi-arid regions(Madhu et al 2024; Sri et al 2024). Millets were among the earliest crops cultivated by humans in Asia and Africa and have played a significant role in human civilization as a vital source of food. However, in the post-green revolution era in India, millets lost their prominence due to cultivation of high yielding varieties of rice and wheat to increase food production and policies favouring their cultivation. Further,these crops received research, extension, and market support (Amrutha, 2018). Thus, on the supply side, there was a shift in area under cultivation from coarse

cereals to rice and wheat even in rainfed areas (Nagaraj et al 2013). On the demand side, the distribution of rice and wheat through the public distribution system (PDS) at subsidised prices contributed to a decline in the consumption of millets especially sorghum, pearl millet and finger millet. Further, technology mission on oilseeds and pulses to promote pulses and oilseeds as development initiatives of governments further dampened farmers' interest in cultivating millet (Nagaraj et al 2013). Post green revolution, millet production was mostly confined to resource-limited farmers on marginal lands. However, in the recent years, agricultural institutions, governments and industry stakeholders worldwide are shifting their focus back to millets, recognizing their agro-ecological and nutritional importance.

Millets are commonly referred to as "Nutri-Cereals" due to their exceptional nutritional value. The term millet is derived from the French word "Mille" meaning "Thousand." This is because a single handful of millet can contain up to a thousand grains (Dayakar et al 2022; Madhu et al2023). Despite their nutritional importance, decline in cultivation and consumption was observed in many countries. Millets provide nutrition, resilience to climate change and yields sustainable income to farmers in developing countries (Parthasarathy Rao et al2006; Madhu et al2023). Whereas, in developed countries, millets can help to tackle health issues such as obesity, diabetes and lifestyle problems as they are free from gluten, have low glycemic index and are rich sources of micronutrients (Madhu et al2023). Millets are richest sources of nutrition, especially iron, calcium, and zinc, among cereals and can provide all the nutrients at the least cost to the poor compared to wheat and rice (Parthasarathy Rao et al2006; Sri et al 2024).

Millets are photo-insensitive and resilient to climate change. Millets are C4 crops having carbon fixing properties (that is, they are climate-change compliant). Millets are well suited to drought-prone regions and are the best alternatives for extreme weather conditions. They are hardy, resilient crops that have low carbon and water foot print. They only need 350-400 mm annual rainfall. In times of adverse climatic conditions, they are often last crops standing to survive, thereby providing a good risk management option particularly for resource poor small farmers. Millets are grown with minimal fertilizers and pesticides and survive with less water. Millets are unique because of their short growing season with crop duration as little as 60 to 65 days, putting less stress on environment (Amrutha 2018; Manojkumar Patil2021; Madhu et al 2024). Hence, millets are climate smart future food crops. In semi-arid tropics of the globe, millets are grown, as they form the staple diet of a

majority of poor smallholders and poor consumers. Despite these advantages, there is a declining trend in their consumption and has relegated them to the status of inferior crops.

The recent developments in health sector has increased emphasis on consumption of nutritious food. India's National Food Security Act recognized millets as coarse cereals in 2013 and in 2018, millets officially became part of the National Food Security Mission. Thus, Government of India declared 2018 as the National Year of Millets (Amrutha2018; Dayakar et al 2022; Sri et al 2024). Given, the increase in emphasis on nutrition and benefits due to their cultivation, there is a diverse scope to promote production and consumption of nutrient rich millets. Hence, to improve millet production it is essential for investment in production technologies, research and development and investment in processing to strengthen millet value chain (Madhu et al2023).

In India, the important millets grown are sorghum, pearl millet, finger millet and small millets like foxtail millet, proso millet, kodo millet, barnyard millet, little millet; and two pseudo millets, i.e., buck-wheat and amaranthus. The major millet growing states in India are Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Gujarat, Haryana, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Uttrakhand (APEDA2023; Manoj Kumar Patil2021; Yamuna et al 2024). Given the benefits of nutritionally rich climate-resilient millet crops with immense potential to enhance food security and sustainability, the present study was carried out to understand, analyse and to assess the trends in millet production as well as understand the variations in area, production and productivity of millets in World and more specifically in India as India being the major producer and consumer of millets in the World. The study findings are intended to provide valuable insights for policymakers, farmers, and the agricultural sector to promote millet cultivation, thereby fostering a more diverse and resilient food supply, reducing malnutrition, and mitigating the impact of climate change on Indian agriculture.

## 2. REVIEW LITERATURE

Studies analysing the trends in area, production and yield of millets in India for different time periods that is 1955–1956 to 2004–2005, 1950-51 to 2011-12 had been conducted by Divya et al in 2013 and Malathi et al in 2016, respectively. The studies in general have showed negative growth rates in area and increase in production attributed to increase in productivity growth. Narmadha et al in 2017 and Thakur in 2018 have analysed the performance of major millet in Tamil Nadu and trends in area, production and yield of small millets in Madhya Pradesh respectively. Studies analysing instability in area, production, productivity and consumption of millets in India for the period 2000–01 to 2016–

17 had been conducted by Das et al in 2019 and for the period 1970–71 to 2018–19 by Manojkumar Patil in 2021. Nagaraj et al in 2013 in their study on sorghum and pearl millet economy of India future outlook and options have analysed the production and consumption trends and have identified the structural constraints in enhancing productivity growth, and identifying areas for future investment, markets, and policy options. Basavaraj and Rao in 2012 have analysed the of household consumption of sorghum in major sorghum-producing and sorghum-consuming states in India and had suggested for inclusion of sorghum in the Public Distribution System (PDS) in Maharashtra, Karnataka and Andhra Pradesh and research to increase the productivity of the rabi type sorghum, in order to make it affordable for the poorer sections of communities. Bodhisattya Pal et al in 2023 in their study on Revitalizing the Potential of Minor Millets: Agrarian Constraints, Possible Solutions and Future Roadmap have concluded that utilizing minor millets extensively can tackle global food security, sustainability, and climate change.

## 3. DATA SOURCE AND METHODOLOGY

The study has used time-series data from secondary sources such as Food and Agricultural Organization and publications of Directorate of Economics and Statistics, Government of India for the period 2000 to 2021 pertaining to area under cultivation, production and productivity of millets across the globe and in India and crop wise data collected from 2001 to 2021.

### 3.1 Compound Annual GROWTH RATE (CAGR)

The average annual compound growth rates of area, production and productivity were estimated by using the exponential growth function of the form $Y_t = ab^t e$

Where, $Y_t$ = dependent variable to be estimated (area, production, productivity),

'a' is the intercept, 'b' is (1+r), where 'r' is compound growth rate and 'e' error term

The equation was estimated after transforming into linear form as follows;

$$\text{Log } Y_t = \text{Log } a + t \text{ Log } b$$

The compound annual growth rate (CAGR) was obtained as [(antilog of b)-1] x 100

### 3.2 INSTABILITY INDEX

To measure the instability in area, production and productivity of millets, Cuddy Della Vella Index (1978) for three periods, i.e., 2000-2010, 2011-2021 and overall period of

2000-2021 was used to measure the instability. The Cuddy Della Vella Index (CDVI) as given under was used to measure instability.

$$CDVI = CV \times \sqrt{1- \text{Adjusted } R^2}$$

Where CV is the coefficientof variation (CV) (in percent) and $\bar{R}^2$ = Coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The categorization of instability range as follows:

i) Low instability: 0 > CDVI < 15;

ii) Medium instability: 15 >CDVI < 30;

iii) High instability: CDVI >30

## 4. RESULTS AND DISCUSSION

### 4.1. MILLETS PRODUCTION IN THE WORLD

In 2021, global millet production was dominated by Asia, which accounted for 56.49 per cent of the total production (169.98 lakh tonnes) and 37.69 per cent of the total millet-growing area (116.61 lakh ha) in the World followed by Africa contributing to 40.23% of the production (121.05 lakh tonnes) and 60.11 per cent of the millet-growing area (185.95 lakh ha). Europe had a relatively smaller share, with 1.97% of the production (5.92 lakh tonnes) and 1.19% of the millet-growing area (3.68 lakh ha). The Americas and Australia/New Zealand had even smaller shares, each accounting for less than one per cent of both the millet production and growing area (Fig.1). Overall, the total global millet-growing area in 2021 was 318.35 lakh ha, and the total production was 327.90 lakh tonnes (FAOSTAT, 2021).

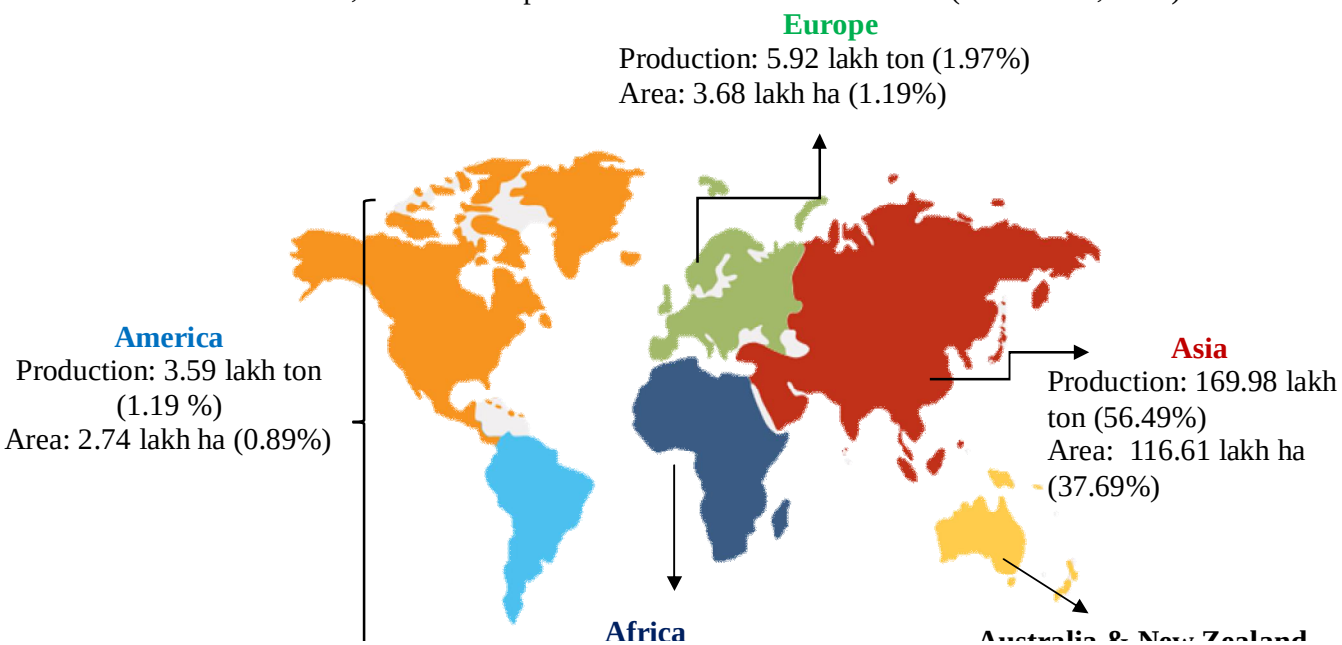

**Fig. 1:** Global millets production in 2021

### 4.2. Country wise Millet Production in the World

In 2021, global millets production reached 32790.12 lakh tonnes, cultivated on an area of 31835.04 lakh ha India emerged as the top producer of millets, accounting for 40.29 % of the global production, with a productivity of 1.35 tonnes per ha on 9764.82 ha of land. Niger, Sudan, Mali and Nigeria were the other major millets producing countries, with productivity levels ranging from 0.35 to 0.96 tonnes per ha (Table 1).

**Table 1: Major millets producing countries in the World (2021)**

| Sl.No | Countries | Area (000' ha) | % | Production (000' tonnes) | % | Productivity (tonne/ha) |
|---|---|---|---|---|---|---|
| 1 | India | 9764.82 | 30.67 | 13210.00 | 40.29 | 1.35 |
| 2 | Niger | 6145.77 | 19.31 | 2146.71 | 6.55 | 0.35 |
| 3 | Sudan | 2800.00 | 8.80 | 1500.00 | 4.57 | 0.54 |
| 4 | Mali | 2079.08 | 6.53 | 1487.68 | 4.54 | 0.72 |
| 5 | Nigeria | 2000.00 | 6.28 | 1922.00 | 5.86 | 0.96 |
| 6 | World | 31835.04 | 100.00 | 32790.12 | 100.00 | 1.03 |

### 4.3. Growth in Area Production and Productivity of Millets in the World

During the period of 2000-01 to 2021-22, millet production and productivity have increased globally, despite a decreasing trend in the area under millets. Specifically, production grew at the rate of 1.38 % but this increase is not statistically significant, 1.63 %with strong statistical significance at the 1 % level and 0.48 % per annum, but this increase is not statistically significantduring the periods of 2000-2010, 2011-2021 and overall period of 2000-2021 respectively. Productivity also showed positive growth rates during both the periods. However, the area under millet cultivation saw a decline in growth rates, with -0.11 % but it is not statistically significant, -0.38 %, and -0.69 % per annum for the periods of 2000-2010, 2011-2021, and overall period of 2000-2021, respectively.During 2011-2021 and overall period, both significance at the 1% level ($p<0.01$) means there is a less than 1% probability that the observed change is due to random chance, indicating very strong evidence of a real trend (Table 2).

Indian being the major producer of millets in the World with 40 % share in total World's production, some of the agricultural policies have directly contributed to the decline in area under cultivation. For instance, technology mission on oilseeds and pulses to promote pulses and oilseeds, poor policy support for millets, increasing prices for cotton and soybean, disease epidemics contributed to the factors on the supply side. On the demand side, decline in consumption especially in the urban areas due to changes in consumer tastes and preferences, rapid urbanization, increase in incomes, the advent of fast food chains and ready-to-eat food products, the penetration of diversified value-added products from rice and wheat, ease of preparation and short cooking time of rice and wheat contributed to demand side factors (Parthasarathy Rao et al 2010; Sharma et al2022).

The shift in land use can be attributed to several factors. These include the low crop yields, the time-consuming and labour-intensive millet processing tasks primarily carried out by women. Furthermore, there was limited marketing of millet, and only a small portion of the grain was utilized for value-added products. However, on the productivity front, technology has significantly contributed to millets production in India with the release of improved varieties of millets, crop management, and post-harvest processing. Innovations such as drought-resistant seed varieties, and mechanized processing techniques have enhanced productivity, reduced losses and empowered farmers with valuable information, ultimately bolstering millet production (Manojkumar Patil2021; Sharma et al2022).

**Table 2: CAGR of area, production, and productivity of millets in the World**

| Years | Area | Production | Productivity |
|---|---|---|---|
| 2000-2010 | -0.11 $^{NS}$ | 1.38$^{NS}$ | 1.49 $^{NS}$ |
| 2011-2021 | -0.38* | 1.63* | 2.02** |
| Overall 2000-2021 | -0.69* | 0.48$^{NS}$ | 1.18** |

Note: *, ** indicates level of significance at one percent (p value < 0.01), five percent level of probability (p value 0.01 to 0.05), respectively; NS: Non-significant.

### 4.4. GROWTH IN AREA PRODUCTION AND PRODUCTIVITY OF MILLETS IN INDIA

Over the past two decades (2000-2021), the millet industry has undergone significant changes. While the area dedicated to millet farming has declined from 11849.13 (000'ha) to 9435.33 (000'ha), there has been a noteworthy increase in both production and productivity.

This trend is evident when examining the two individual periods (2000-2010 and 2011-2021) as well as the overall period (2000-2021). The production increased from 10974.86 (000' tonnes) to 11524.93 (000' tonnes) during the 2000-2021, with a corresponding increase in yield from 921.94 kg/ hato 1224.98 kg/ ha(Table 3). However, the CAGR of production and productivity declined marginally during the two periods. The CAGR of production was 1.89 %, 0.89 % and 0.77 % per annum for the periods 2000-2010, 2011-21, and overall period 2000-2021 respectivelybut this is not statistically significant, while the CAGR for productivity, wasincreased at a rate of 3.06 % per year during (2000-2010) period, but this increase is not statistically significant (NS), 1.98 % (2011-2021) and 2.75 % for overall period (2000-2021) at 1% significance level indicated a very strong level of confidence that the observed change is real and not due to random fluctuations.. Despite thechallenges on decline in area under millets, the production and productivity of millets have continued to increase, due to varietal improvement and ability of the crops to withstand abiotic and biotic stress.

**Table 3: CAGR of area, production and productivity of millets in India**

| | Area (000' ha) | CAGR (%) | Production (000'tonnes) | CAGR (%) | Productivity (Kg/ha) | CAGR (%) |
|---|---|---|---|---|---|---|
| 2000-2010 | 11849.13 | -1.14$^{NS}$ | 10974.86 | 1.89$^{NS}$ | 921.94 | 3.06 $^{NS}$ |
| 2011-2021 | 9435.33 | -1.36** | 11524.93 | 0.89 $^{NS}$ | 1224.98 | 1.98* |
| 2000-2021 | 10584.76 | -1.92* | 11262.99 | 0.77 $^{NS}$ | 1080.676 | 2.75* |

**Note:***, ** indicates level of significance at one percent (P<0.01) and five percent level of probability (p value 0.01 to 0.05), respectively; NS: Non-significant.

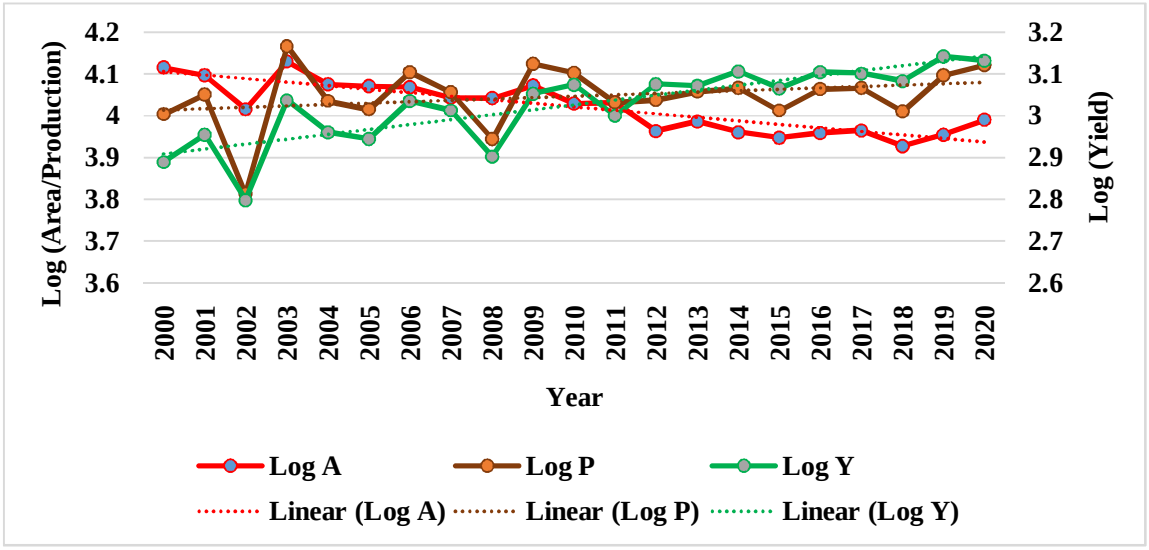

**Fig. 2:** Trends in area, production, and productivity of millets in India

## 4.5. CROP-WISE TRENDS IN AREA PRODUCTION AND PRODUCTIVITY OF MILLETS IN INDIA

Sorghum, pearl millet, finger millet are classified as major millets while foxtail millet, proso millet, kodo millet, barnyard millet, little millet are classified as minor millets. CAGR of area production and productivity of both major millets and minor millets in India for the period 2001-02 to 2020-21 is presented in table 4.

**Table 4: CAGR of millet crops in India (2001-02 to 2020-21)**

| Crops | Area | Production | Productivity |
|---|---|---|---|
| Pearl Millet (*Bajra*) | -1.64* | 1.37** | 3.07* |
| Sorghum (*Jowar*) | -4.32* | -3.37* | 0.99** |
| Finger Millet (*Ragi*) | -2.32* | -1.10 $^{NS}$ | 1.25** |
| Minor Millets | -5.56* | -2.02* | 3.76** |

**Note:***, ** indicates level of significance at one percent (P<0.01) and five percent level of probability (p value 0.01 to 0.05), respectively; NS: Non-significant.

**4.5.1. PEARL MILLET:** Pearl millet cultivation over the years in India has shown a declining trend (Figure 3). The area under cultivation which was 10.61 million ha in 2003-04 declined to 7.11 million ha in 2018-19 with marginal upswing at 7.57 million ha area in 2020-21. The CAGR of area under pearl millet for the period 2001-02 to 2020-21 showed a negative growth rate of 1.64 % indicating non-significant. However, CAGR of production was positive at 1.37 % per annum, with moderate statistical significance at the 5 % level (p value > 0.01 to < 0.05), indicating a likely genuine increase. The production hit a low of 4.72 million tonnes in 2002-03 peaked to 12.11 million tonnes in 2003-04 and 10.86 million tonnes during 2020-21. The yield of pearl millet showed fluctuating trends with yield reaching a peak of 1436 kg/ha in 2020-21 and a low of 610 kg/ha in 2002-03.

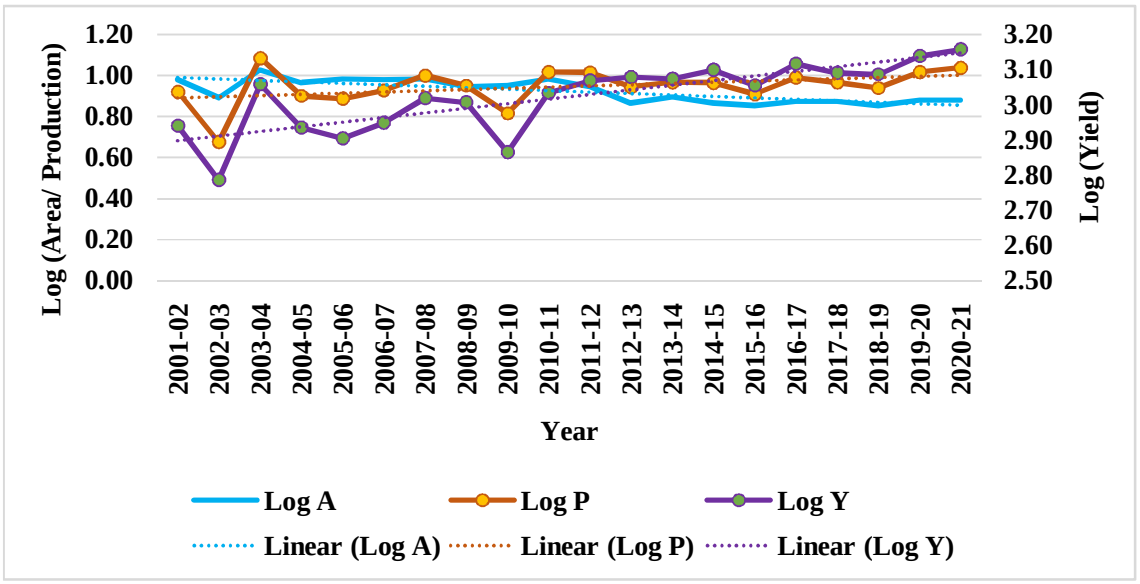


**Fig. 3:** Trends in area, production and productivity of pearl millet in India

**4.5.2. SORGHUM:**The trends in area production and productivity of sorghum for the period 2001-02 to 2020-21 is presented in figure 4. The findings show that its cultivation reached its highest point in 2001-02 at 9.8 million ha, then decreased gradually to 4.09 million ha in 2018-19, after which it increased marginally to 4.82 million ha in 2019-20 and then decreased again to 4.24 million ha in 2020-21. The CAGR of area under sorghum for the period 2001-02 to 2020-21 was negative at 4.32 % per year, with significance at the 1 % level. The production was found to be highest (7.93 million tonnes) in 2007-08 and the lowest (3.48 million tonnes) in 2018-19. However, the production in the last two years has shown an increasing trend with 4.77 million tonnes and 4.78 million tonnes in 2019-20 and 2020-21 respectively. The growth rate for production was negative at 3.37 % per year at 1 % level of significance,while the yield of sorghum per ha has increased gradually over the years. It was 771 kg/ha in 2001-02 and increased to 1128 kg/ha in 2020-21. However, the growth rate in productivity was low at 0.99 % per year, with moderate statistical significance at the 5% level.

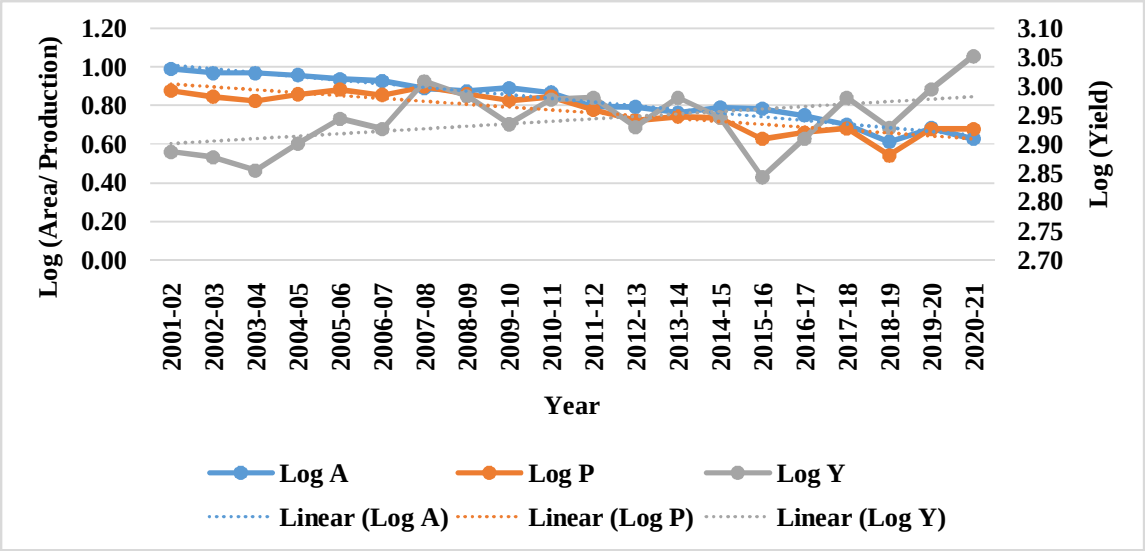


**Fig. 4:** Trends in area, production and productivity of sorghum

**4.5.3. RAGI:** The trends in area, production and productivity of ragi for the period 2001-02 to 2020-21 is presented in figure 5. The area under cultivation of ragi has fluctuated over the years, with a peak of 1666.4 thousand ha in 2003-04 and a low of 890.94 thousand ha in 2018-19 a decline of 46 % over the last two decades. The CAGR of area under cultivation of ragi for the period 2001-02 to 2020-21 was negative at 2.32 % per year, with significance at the 1% level.

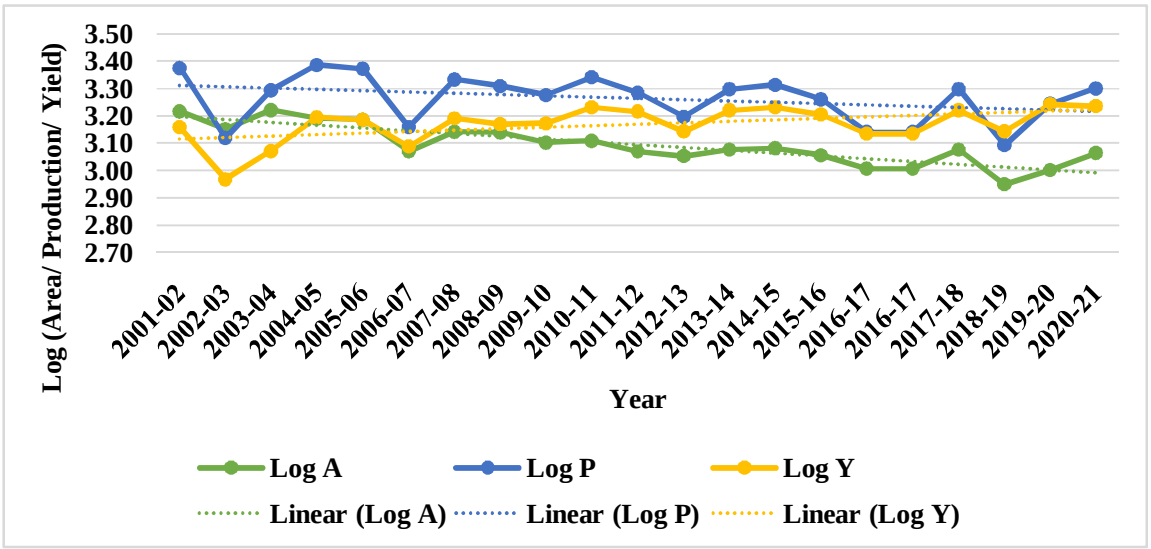

**Fig. 5**: Trends in area, production and productivity of ragi

Production saw the highest peak of 2432.4 thousand tonnes in 2004-05 while lowest was 1238.7 thousand tonnes during in 2018-19 with CAGR of production registering -1.10 %per year is not statistically significant, indicating that this decline could be due to random chance. The yield per ha for ragi showed an increasing trend, from 1442.04 kg/ha in 2001-02 to 1723.62 kg/ha in 2020-21 with a CAGR registering 1.25%per annum,for the overall period at 5% level of significance.

### 4.5.4. MINOR MILLETS

The trends of area, production and productivity of minor millets (Foxtail millet, Proso millet, Little millet, Barnyard millet, Kodo millet and Brown top millet) for the period 2001-02 to 2020-21 is presented in figure 6.

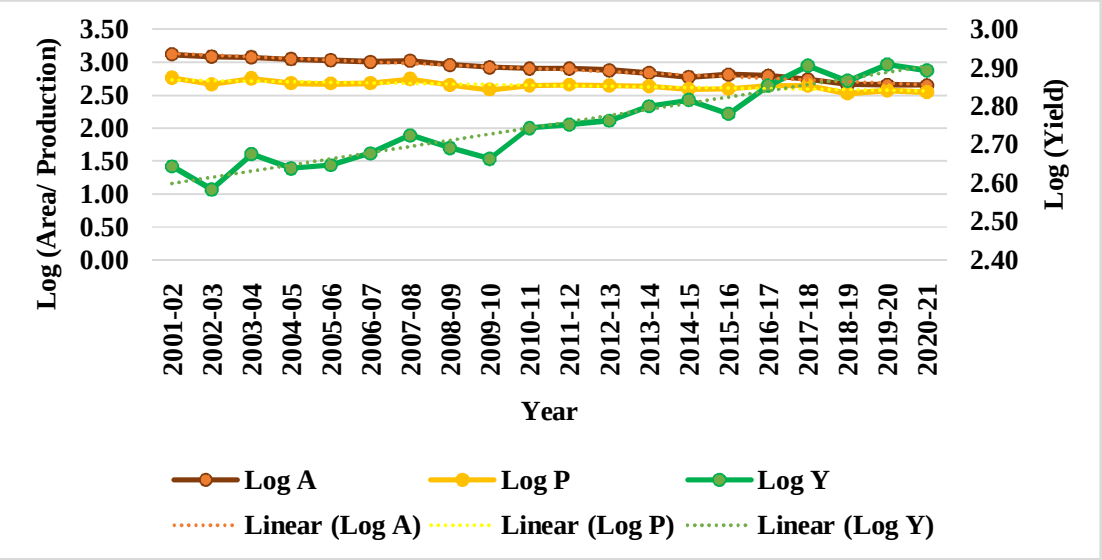


**Fig. 6:** Trends in area, production and productivity of minor millets

The area under cultivation declined from 1311 thousand ha in 2001-02 to 444 thousand ha in 2020-21 a decline of 66 % over the last two decades. The CAGR for area under minor millets during the period was negative at 5.56 % Similarly, the production of minor millets has also declined from 577 thousand tonnes in 2001-02 to 347 thousand tonnes in 2020-21, with a negative CAGR of production at 2.02 %. However, the productivity of minor millets increased from 440 kg/ha in 2001-02 to 781 kg/ha in 2020-21, with a positive CAGR of 3.76 % per year. The growth rates of minor millets, area, production and

productivity Indicates a very strong level of confidence that the observed change is real and not due to random fluctuations.

## 4.6. FACTORS RESPONSIBLE FOR INCREASE IN PRODUCTIVITY OF MAJOR AND MINOR MILLETS

In general, it has been observed that there has been a drastic decline in the area under cultivation of both major and minor millets over the last two decades. Except for pearl millet, even production showed positive growth rates over the last two decades. However, there has been a signification improvement in productivity of both major and minor millets. Attempt has been made to highlight the factors responsible for increase in productivity. The productivity growth was the highest for pearl millet followed by minor millet, ragi and sorghum.

The increase in productivity of pearl millet was due to the release of varieties that were resistant to fungus (Pray, 2009a); release of varieties with value-added attributes such as resistance to pests and diseases, drought and heat tolerance, seed replacement and private sector participation in seed production (Pray, 2009b). The increased productivity has enabled farmers to allocate less area to millets and divert the saved land to cash crops, improving their incomes (Nagaraj et al 2013). This progress has resulted in a CAGR of 3.07 per cent of productivity, indicating the potential for further improvement in pearl millet cultivation. Sharma et al., 2022 was reported that the decrease in millet cultivation was attributed due to rapid urbanization, shifting consumer tastes influenced by increasing per capita incomes, and governmental policies that prioritize other commercial crops.

Sorghum in India is cultivated both during kharif and rabi season. Farmers cultivating kharif sorghum realise a productivity advantage due to the adoption of hybrids like CSH 9, 16, and 23.Kharif sorghum productivity is double that of rabi sorghum, where there are no hybrids in rabi sorghum (Nagaraj et al2013). Kharif production of sorghum from hybrids is generally susceptible to grain mold. Consequently, the produce is of poor quality and less preferred for human consumption (Parthasarathy Rao et al 2006). The best quality kharif grain is mainly consumed by low income consumers because of its lower price than that of rabi sorghum. On the other hand, 90 per cent of the production of rabi sorghum is used for human consumption and a small proportion goes to the processed food sector (Dayakar et

al2010). There exists a wide productivity differential between the kharif and rabi sorghum. This is due to the non-availability of improved cultivars for rabi sorghum and its cultivation in residual soil moisture. Improved varieties occupy only 25 per cent to 30 per cent of the area under rabi sorghum cultivation (Nagaraj et al 2013).

Finger millet, a highly nutritious millet crop predominantly cultivated in Karnataka, Tamil Nadu, and Andhra Pradesh, stands as a vital staple for smallholder farmers across these states. Despite fluctuations in cultivation and production levels (Mahto 2023), the crop's productivity has consistently remained above 1,000 kg per ha. The improved varieties developed and released as Central and State leads has led to increase in productivity. The varieties such as GPU-28, GPU67, RAU-8, CO (Ra)-14, and Paiyur-2 of finger millet hybrids has led to increase in productivity (Anbukkani, et al2017). Finger millet farming is influenced by diverse factors, including climatic conditions, market dynamics, and governmental policies, all of which can significantly impact its production and productivity (Patil et al2011; Mahto2023).

The productivity of minor millets has shown increasing trends over the decade and the states of Puducherry, Gujarat and Uttarakhand have the highest productivity of minor millet at 2375 Kg/ha 1541 Kg/ha and 1449 Kg/ha respectively (Sangappa et al 2023). Millets thrive well even under low rainfall and arid climatic conditions and minimal inputs (water, fertilizers) and are also adaptive to diverse ecological conditions. The productivity of minor millets has been increasing by 3.76 % per annum due to the availability of high-yielding varieties, pest and disease resistant varieties and adoption of improved cultivation practices. However, a study conducted by NABARD in 2023 has indicated huge potential for bridging yield gaps and with the right combination of state–millet specific policy and practice to increase production.

## 4.7. INSTABILITY IN AREA, PRODUCTION AND PRODUCTIVITY OF MILLETS IN THE WORLD

Details of instability in area, production and yield of millets in the World for the three periods (2000-2010, 2011-2021 and 2000-2021) is presented in Table 6. It was found that the coefficient of variation (CV) for millets area in the World was 3.90 % during period I (2000-2010) and decreased to 3.31 % during period II (2011-2021). The CV for area under millets in the World for the entire period (2000-2021) was 5.95 % and CDVI of instability was low for all the periods i.e., period I (4.10), period II (3.21) and overall period (3.93). The CDVI for production for all the three periods was in the range of (4.08 – 11.43) and was categorized

as low instability. However, both CV and CDVI for period I were higher than period II for area, production and productivity. The instability indices for production were high when compared to area and productivity. The CV for millet productivity was 9.61, 7.42 and 9.91 % for period I, II and overall period respectively while CDVI was 8.79, 3.75 and 6.76 during period I, II and overall period respectively. The instability indices for area, production and productivity in period I were high compared period II.

Instability of area, production and productivity of millets for period II (2011– 2021) over period I (2000 – 2010) had declined in the world. The low instability indices suggest that, despite some inherent variability, the global area, production, and productivity of millets have been relatively stable over the period 2000-2021. This stability is likely due to advancements in agricultural practices, improved crop varieties which are drought resistant, adoption of sustainable agronomic practices (Ayalew 2015; Sharma et al 2022)and effective management strategies that have reduced the impact of fluctuations in external conditions.

**Table 6: Instability indices of millets in the world**

| Period | Area | | Production | | Yield | |
|---|---|---|---|---|---|---|
| | CV (%) | CDVI | CV (%) | CDVI | CV (%) | CDVI |
| **2000- 2010** | 3.90 | 4.10 | 11.70 | 11.43 | 9.61 | 8.79 |
| **2011- 2021** | 3.31 | 3.21 | 6.63 | 4.08 | 7.42 | 3.75 |
| **2000-2021** | 5.95 | 3.93 | 9.27 | 8.99 | 9.91 | 6.76 |

## 4.8. INSTABILITY OF AREA PRODUCTION AND PRODUCTIVITY OF MILLETS IN INDIA

The instability indices for area, production and yield of millets in India for the three period (2000-2010, 2011-2021 and 2000-2021) has been presented in Table 7. For overall period, area, production and yield showed low instability at 7.09, 14.99 and 10.98 % respectively. Instability of area under cultivation of millets was low in India for all the three periods compared to production and yield. Higher instability indices for production and productivity as compared to area was attributed to droughts observed during 2002, 2009, 2012, 2014-16 and 2019 leading to decline in production. Also, the low instability in production signifies that millets production in the country was chiefly dependent on the area allocated by the farmers under millet crops (Sharma 2022). Factors contributing to low

instability in India was due to adoption of better farming techniques and improved seed varieties could have contributed to more consistent millet yields and production. Government policies aimed at stabilizing millet production, such as subsidies, support prices, and insurance schemes, might have reduced the impact of adverse conditions and market stability, leading to lower instability in the area, production, and productivity of millets (Manojkumar 2021; Sharma 2022).

**Table 7. Instability indices of millets in India**

| Period | Area | | Production | | Yield | |
|---|---|---|---|---|---|---|
| | CV (%) | CDVI | CV (%) | CDVI | CV (%) | CDVI |
| **2000- 2010** | 7.97 | 7.61 | 21.05 | 21.64 | 17.47 | 16.11 |
| **2011- 2021** | 7.71 | 6.48 | 8.36 | 8.56 | 8.50 | 5.99 |
| **2000-2021** | 13.99 | 7.09 | 15.24 | 14.99 | 18.77 | 10.98 |

## 4.9. CROP-WISE INSTABILITY INDICES FOR AREA, PRODUCTION AND PRODUCTIVITY IN INDIA

Table 8 presents the crop-wise instability indices for area, production and productivity in India. Except for production of pearl millet and ragi, the instability index was low for area, production and productivity for all the crops for the period 2001-2021. The instability index was categorized as low for area, production and productivity of minor millets. For production, among crops, sorghum and minor millets (11.11 and 9.08) exhibited low instability while pearl millet and ragi exhibited moderate instability (18.51 & 16.96). Some of the factors that could be attributed to low and moderate instability of production of millets was due to their climate adaptability, steady demand, and drought-resistant traits (Smith et al2018; Kumar et al2016). Though the instability for area was categorized as low for all millets, among them ragi exhibited highest instability at 8.79compared to pearl millet and sorghum which were more stable compared to ragi. For production, the instability index at 18.51 for ragi was high compared to pearl millet and sorghum. Factors such as climate conditions, government policies, changes in agricultural practices, and market dynamics can all play a significant role in influencing variations in production.

**Table 8: Crop-wise instability in area, production and productivity in India (2001-2021)**

| Sl.No | Crop | Area | | Production | | Productivity | |
|---|---|---|---|---|---|---|---|
| | | CV (%) | CDVI | CV (%) | CDVI | CV (%) | CDVI |
| 1 | Pearl millet | 12.89 | 8.47 | 17.99 | 16.96 | 20.57 | 12.78 |
| 2 | Sorghum | 25.57 | 5.98 | 21.82 | 11.11 | 12.35 | 11.20 |
| 3 | Ragi | 17.02 | 8.79 | 19.17 | 18.51 | 13.83 | 12.24 |
| 4 | Minor millets | 32.79 | 5.14 | 15.02 | 9.08 | 23.15 | 7.01 |

## 5. CONCLUSION

The global millet production reveals a significant contribution from Asia, with India leading as the top producer. Over the past few decades, the area under millets has declined due to factors of urbanization, changing consumer preferences, and government policies. Pearl millet, sorghum, ragi, and minor millets present varying levels of instability in terms of area, production, and productivity. The millet industry in India has experienced shifts with decreasing area but increasing production due to increase in productivity. The upward trend of production led by productivity in the face of changing dynamics underscores the potential for continued growth and development in the millet industry, aligning with the changing agricultural landscape and consumer demand. Millets which are rich source of nutrition especially iron, calcium, and zinc help in mitigating malnutrition and also help to tackle health issues such as obesity, diabetes and lifestyle problems. International Year of Millets of 2023 and various schemes of government of India have served as global platform to raise awareness about the significance of millets in addressing food security, reducing malnutrition, and sustaining agricultural livelihoods and are in the right direction.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology. Chat GPT 3.5 for improving grammar of the manuscript and validating meaning of the sentences and I have also used the Grammarly to find grammatical mistakes in the content and to find synonyms for certain words.

## COMPETING INTERESTS

Authors have declared that no competing interests exist

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