*ISBN: 978-81-19149-19-3*

# 16. Global Status and Constraints in Millet Production

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## 16.1 Introduction:

Millets also called small millets are cultivated for their small kernels which are the products of small grassy plants belonging to the Poaceae family. The other name minor millets may indicate them to be minor crops yet are important for their nutritional values, medicinal benefits, feed for animals, and saviours during food crisis (Joshi and Agnihotri 1984; Yenagi et al. 2010). The word “millet” has originated from the French word “Mile” meaning thousand which implies a handful of millets contain thousands of grains. Millets are often grown in semi-arid conditions with very less rainfall and marginal or degraded lands with very low nutrient contents. The crops support the livelihood of people in areas where famine is a regular phenomenon and the millets yield a more dependable harvest compared to other crops in low rainfall areas. Millets are C4 plants with very superior photosynthetic efficiency, short duration, higher dry matter production capacity, and a high degree of tolerance to heat and drought. They also easily adapt to degraded saline, acidic and aluminium toxic soils (Yadav and Rai 2013). Small millets are an excellent choice for promoting healthy eating in modern society due to their rich nutrient content.

Finger millet, in particular, stands out with its remarkably high calcium content, surpassing 350 mg per 100 g. Foxtail millet, barnyard millet, and proso millet are abundant sources of protein, containing over 10% protein content. Little millet and foxtail millet are also noteworthy for their healthy fat content, with more than 4.0% fat. Additionally, foxtail millet, barnyard millet, and little millet are superior sources of crude fiber, ranging from 6.7% to 13.6%. Barnyard millet and little millet are also rich in iron, containing between 9.3 mg to 18.6 mg per 100 g, which is higher than other major cereals such as rice, wheat, barley, maize, and sorghum. These findings are supported by studies conducted by (Dwivedi et al. in 2012; Kam et al. in 2016). The growing demand for millets in both national and international markets has spurred the interest of researchers in collecting, conserving, and utilizing the global germplasm available for these important crops. This has led to efforts in crop improvement, development of genomic resources, and value addition in millets.

Moreover, the involvement of private organizations in value addition and marketing of millets has further boosted their cultivation and consumption. In this process, governments have a crucial role to play by formulating appropriate policies to incentivize millet cultivation, marketing, and consumption.

These policies can help achieve food and nutritional security by promoting the production and consumption of millets, which are rich in essential nutrients. Such policies may include providing financial incentives to farmers for millet cultivation, establishing marketing chains and infrastructure for millet products, and creating awareness among consumers about the health benefits of millets. Government support can also facilitate research and development in millet agriculture and help in the conservation of genetic diversity in millet crops.

There are no less than 14 species of millets belonging to 10 genera, that include pearl millet (Pennisetum glaucum L.), foxtail millet (Setaria italica L. subsp. italica), Finger millet (Eleusine coracana L.), barnyard millet (Echinocloa esculenta A. and Echinocloa colona L.), proso millet (Panicum miliaceum L. subsp. miliaceum), kodo millet (Paspalum scrobiculatum L.), and little millet (Panicumsumatrense Roth.) that are cultivated widely throughout the world.

A. **Pearl millet (Pennisetum glaucum L.)**: Bajra or Pearl millet is estimated to be originated as early as 5000 years in Africa (Andrews and Kumar 1992) and was introduced to the Indian subcontinent around 3000 years ago. The crop is well adapted to adverse environmental conditions with rainfall less than 250 mm and temperature of 30 _C and above and mainly grown by subsistence farmers throughout Africa, Asia, and Australia. Recently the crop is gaining importance as a commercial crop in Australia and accounts for almost half of the world's area under millets (National Research Council 1996).
B. **Proso millet (Panicum miliaceum L. subsp. miliaceum):** Broom millet or Proso millet has probably originated in Manchurian region of China (House 1995) and presently cultivated in northwest China, southern and central parts of India, Australia, the USA, and Europe. It is the third most important millet crop cultivated after pearl millet and foxtail millet and it is well adapted to temperate climatic conditions up to altitudes of 3500 m and various soil types
C. (Baltensperger 2002).
D. **Finger millet (Eleusine coracana L.):** The ear heads of the crop resemble finger of human hand thus giving it the name. The probable origin of Ragi or Finger millet is highlands of Ethiopia and Uganda (National Research Council 1996). Asia and Africa are major centers of production and India is the leading producer in the world. The crop is adapted to tropical climates with an intermediate altitude (500–2400 m) and low to moderate rainfall (500–1000 mm). The crop can thrive under dry and hot conditions up to 35 _C in well-drained soils. The grains of finger millet can be stored for up to 50 years thus serving as a good reserve against famine (National Research Council 1996).
**E. Barnyard Millet or Sawa millet (Echinocloa esculenta A. and Echinocloa colona L.):** The Barnyard millet or Japanese millet has originated in Japan province, whereas sawa millet was domesticated in the Indian subcontinent (House 1995). Both millets belong to the same genus and their morphology is similar. The crops prefer warm climatic conditions but can be cultivated in cold temperatures too. The cultivation of

barnyard millet is mainly taken up in Japan, China, Korea, and India and the crop is known for its good storability.

F. **Kodo Millet (Paspalum scrobiculatum L.):** or Ditch millet is known to be domesticated 3000 years ago and is indigenous to India (House 1995). Kodo millet is majorly produced in India and the production accounts for 90% of total world production (Hedge and Chandra 2005). Although kodo millet is well adapted to tropical and sub-tropical climatic conditions, the crop takes 120–180 days to mature and the grain yields are very low (250–1000 kg/ha).

G. **Little millet (Panicum sumatrense Roth.):** Eastern Ghats of India are known to be the place of domestication of little millet as early as 2000 years ago and the crop is majorly cultivated in peninsular Indian states like Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala. The crop is adapted to both dry and humid conditions and can be cultivated in drought-prone areas as well as water-logged conditions, as the crop matures early and withstands adverse conditions. The genetic diversity of this crop is very little because of its restricted cultivation in India, Sri Lanka, Nepal, and Myanmar, with India accounting for more than 98% of the area and production of little millet.

## 16.2 Global Scenario of Millets Cultivation:

Millets are a critical staple food source in the developing world, particularly in the drylands of Africa and Asia. Many millet varieties are indigenous to Africa and have been domesticated in other parts of the world. Currently, millets are cultivated in 93 countries, but only 7 countries have millet acreage exceeding 1 million hectares. Remarkably, over 97% of millet production and consumption occurs in developing nations. However, there has been a concerning trend in millet cultivation. From 1961 to 2018, there has been a decline of around 25.71% in the global area under millet cultivation across continents. This decline has been observed in most parts of the world, with the exception of Africa where millet production has shown an upward trend. Despite the decrease in millet cultivation area, there has been an increase in millet productivity globally.

From 1961 to 2018, millet productivity has risen by 36%, with the average yield increasing from 575 kg/ha to 900 kg/ha. This increase in productivity can be attributed to various factors, including improved farming practices, enhanced seed quality, and technological advancements. Africa has been a notable exception to the declining trend, with millet production expanding in the continent. This could be due to the fact that millets are well-adapted to the dryland regions of Africa and are an integral part of local diets and food systems. Additionally, efforts by local farmers, governments, and organizations to promote millet cultivation and utilization, as well as the recognition of millets' nutritional and ecological benefits, have contributed to the positive trend in Africa. In West Africa, millet cultivation has seen the highest increment, nearly doubling from the levels recorded in the 1960s. In Asia, although the area under millet cultivation has declined, the production trend has shown a gradual increase, leading to improved productivity.

In India, millet production peaked during the 1980s but has since decreased gradually due to a sharp reduction in cultivated area. Despite this, India remains the largest producer of millets, accounting for 37.5% of the total global output, followed by Sudan and Nigeria. In terms of millet trade, the years 2011-2017 saw the highest global import and export values recorded, with imports totalling 155.26 million US$ and exports reaching 127.60 million US$. This indicates the continued demand for millets in the international market. The decline in global millet cultivation can be attributed to various factors. One factor is the shifting of agricultural land to other crops, as well as changing food habits and preferences among consumers. Additionally, the availability of assured irrigation facilities and the perceived higher returns from major commercial crops may have led to a reduction in millet cultivation. It is important to address the challenges facing millet cultivation, such as changing agricultural practices and shifting food preferences, in order to promote their conservation and sustainable production.

This includes supporting farmers with access to improved agricultural practices, quality seeds, and market opportunities. Additionally, raising awareness about the nutritional benefits of millets and advocating for policies that support millet cultivation can contribute to their revival as an important staple food source in the developing world. Efforts should also be made to promote millet trade, both domestically and internationally, to ensure sustained demand and market access for millet farmers.

## 16.3 History of Millets in India and World:

Millets are among the oldest crops domesticated and cultivated in the world form human food and animal fodder and their cultivation dates back to 8700–10,300 years ago (Lu et al. 2009a, b). Millet species, such as Foxtail millet and Proso millet, were initially domesticated in different regions of the world, including South Asia, East Asia, East Africa, and West Africa. However, they spread beyond their original areas of domestication.

The earliest recorded evidence of millet domestication and cultivation comes from China around 3000-2000 BC. The Indian valley of Kashmir is considered a hub of integrated networks, where millets were traded between Asia, Europe, and Africa. (Oelke et al., 1990)

**Table 16.1 Global Millets (Except Sorghum) Area and Production by Region.**

| | **Area (lakh ha)** | | | | | | **Production (lakh tons)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1971-1973** | **1981-1983** | **1991-1993** | **2001-2003** | **2011-2013** | **2016-2018** | **1971-1973** | **1981-1983** | **1991-1993** | **2001-2003** | **2011-2013** | **2016-2018** |
| **Africa** | 133.227 | 108.751 | 168.994 | 197,694 | 191.280 | 207.067 | 74.512 | 77.617 | 109,664 | 142.483 | 113.391 | 140.569 |
| **America** | 2.529 | 2.457 | 2.259 | 2149 | 1.670 | 1.676 | 2.983 | 3.067 | 3.355 | 2.885 | 2.448 | 3.628 |
| **Asia** | 272.350 | 229.054 | 174.644 | 144.703 | 121.958 | 109.255 | 181.630 | 178.191 | 142.069 | 137.569 | 142.501 | 139.522 |
| **Europe** | 26.865 | 28.023 | 22.453 | 8.182 | 6.278 | 4.029 | 26.753 | 21.400 | 16.277 | 9.043 | 8.363 | 6.237 |
| **Oceania** | 0.334 | 0.327 | 0.295 | 0.357 | 0.353 | 0.351 | 0.363 | 0.317 | 0.262 | 0.288 | 0.358 | 0.359 |
| **Australia & New Zealand** | 0.334 | 0.327 | 0.295 | 0.357 | 0.353 | 0.351 | 0.363 | 0.317 | 0.262 | 0.288 | 0.358 | 0.359 |
| **World** | 435,305 | 368.613 | 368.645 | 353.085 | 321.539 | 322.378 | 286.242 | 280.593 | 271.627 | 292.268 | 267.061 | 290.314 |

"Each figure is an average of 3 years for the respective period, for example, 1971-1973
Source: FAOSTAT 2018

### 16.3.1 History in India:

The cultivation of millets in India dates back to ancient times, with evidence of foxtail millet cultivation during the Harappan civilization, pearl millet in the Neolithic period in South India (2000-1200 BC), and kodo millet, finger millet, little millet, native small millet, browntop millet, and bristly foxtail millet during various periods in Indian history, including the early Iron Age and Neolithic-Chalcolithic period.

**A. Harappan civilization:** the foxtail millet spread from China and its cultivation started during Harappan civilization in India. Around 2500–2200 BC (Harappan levels) the cultivation of foxtail millet started in Shikarpur (Kutch) and around 1900–1400 BC (late Harappan levels) the cultivation began in Punjab.

**B. Yajurveda or Indian Bronze age (1500 BC):** The mention of millets foxtail millet (priyangava), proso millet (aanava), and Barnyard millet (shyaamaka) in Indian Sanskrit text Yajurveda's verses, indicated that millet cultivation and consumption was very common in India (Roy 2009).

**CAncient Indian texts:** There is a mention of millet cultivation in ancient Indian texts like Sushruta Samhita (600–500 BC)—classification of cereals into millets, Charaka Samhita (100–200 AD)—Sorghum, Vishnu Purana (450 AD)—classification of cereals and millets, Abhijnana Shakuntalam (400–500 AD)—foxtail millet and Ramadhanya Charithre (1600 AD)—finger millet.

## 16.4 Constraints in Millet Production:

Millet farming, which is primarily concentrated in developing nations, faces challenges with low productivity compared to the world average, as highlighted by (Sood et al. 2020). One of the key reasons for this is the lack of well-established markets for millet grains in these countries, resulting in poor economic returns for farmers.

Additionally, the availability of improved millet seeds is limited in many developing countries, as the seed supply is largely dependent on informal seed chains. The informal seed chain in developing countries often leads to the use of less productive and heterogeneous landraces or local cultivars for millet cultivation (Rakshit and Wang, 2016). This means that farmers may not have access to improved seeds that are bred for higher productivity, disease resistance, or other desirable traits.

As a result, the overall productivity of millet farming remains low, as farmers continue to rely on traditional landraces or local cultivars that may not perform well under changing environmental conditions or evolving market demands.

The lack of established markets for millet grains in developing countries further exacerbates the economic challenges faced by millet farmers. Without well-functioning markets, farmers may struggle to sell their millet grains at fair prices, or may face issues such as lack of price transparency, inadequate storage facilities, or limited access to transportation and distribution networks.

These challenges can result in reduced economic returns for farmers, discouraging them from investing in improved agricultural practices or technologies that could potentially increase millet productivity. In developed nations and some developing nations like India and China, the socioeconomic conditions of farmers are comparatively better, with well-developed marketing systems and improved accessibility to agricultural inputs, including improved millet varieties. These factors collectively contribute to a positive impact on millet production, resulting in higher productivity compared to Africa. One of the reasons for the higher productivity of millets in developed nations and some developing nations is the availability of improved agricultural technologies and mechanization.

However, many minor millet varieties are not well-adapted to modern agroecosystems and mechanization due to inherent problems such as high seed shattering and unsynchronized maturity. High seed shattering refers to the tendency of millet seeds to detach from the plant and scatter, making it difficult for farmers to harvest and collect seeds. Unsynchronized maturity, on the other hand, means that millet plants in a field may mature at different times, resulting in uneven harvesting and reduced yield.

**Table 16.2 Area, production, and productivity of millets in India (1951-2018)**

| | Finger Millet | | | Sorghum | | | Pearl Millet | | | Total Millets |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area (M/Ha) | Production (Mt) | Productivity (Kg/Ha) | Area (M/Ha) | Production (Mt) | Productivity (Kg/Ha) | Area (M/Ha) | Production (Mt) | Productivity (Kg/Ha) | Area (M/Ha) |
| 1951-1960 | 2.33 | 1.70 | 725.4 | 17.09 | 7.65 | 446 | 10.66 | 3.21 | 300.00 | 30.08 |
| 1961-1970 | 2.49 | 1.86 | 746.8 | 18.30 | 9.29 | 506.9 | 11.58 | 4.00 | 345.0 | 32.37 |
| 1971-1980 | 2.51 | 2.41 | 956.3 | 16.36 | 9.75 | 596.6 | 11.97 | 5.35 | 444.40 | 30.84 |
| 1981-1990 | 2.43 | 2.57 | 1059.1 | 15.83 | 11.09 | 701.6 | 10.94 | 5.08 | 460.40 | 29.20 |
| 1991-2000 | 1.85 | 2.42 | 1319.5 | 11.76 | 9.80 | 831 | 10.32 | 7.33 | 64.60 | 23.92 |
| 2001-2010 | 1.48 | 2:07 | 1395 | 8.76 | 7.27 | 836.9 | 9.39 | 7.87 | 829.50 | 19.63 |
| 2011-2020 | 1.17 | 1.79 | 1591.375 | 6.07 | 5.07 | 883.375 | 8.05 | 9.02 | 1130.10 | 15.29 |

"Each figure is an average of 10 years for the respective period, for example, 1951-1960

Source: INDIASTAT 2020

Despite the challenges posed by high seed shattering and unsynchronized maturity, efforts are being made in developed nations and some developing nations to address these issues through research and innovation. For instance, research is being conducted to develop millet varieties with reduced seed shattering and improved maturity synchronization. Additionally, there are efforts to develop appropriate mechanization technologies that can be used for millet cultivation without causing excessive seed loss or damage.

Traditional methods of dehulling, or removing the outer husk from millet grains, followed in developing countries are often labor-intensive and time-consuming. These methods involve manual processing, which can be physically demanding and time-consuming, resulting in drudgery for the farmers and processors involved. This drudgery can be a significant deterrent to the consumption and commercialization of small millets at a large scale.

The labor-intensive nature of traditional dehulling methods can limit the scale of millet processing and commercialization, as it requires significant human effort and time. This can also result in higher production costs, as more labor is required, which may negatively impact the economic viability of millet production and processing enterprises. Additionally, the physical strain and time-consuming nature of manual processing can lead to reduced motivation among farmers and processors to engage in millet production and processing activities, which can further hamper the overall growth and development of the millet sector. To overcome these challenges, there is a need for appropriate and improved millet processing technologies that can reduce the labor-intensive nature of dehulling and other processing activities. For instance, mechanical dehulling machines or equipment can significantly reduce the manual effort and time required for dehulling millets, making it more efficient and less labor-intensive. Such technologies can improve the commercialization and consumption of millets by making processing more feasible at a larger scale, reducing the drudgery for farmers and processors, and increasing the economic viability of millet enterprises.

In addition to the factors mentioned earlier, climatic and edaphic factors, as well as the socioeconomic status of farming communities, play crucial roles in determining the performance of millet production systems. Climatic factors such as rainfall pattern and distribution are critical as millets are typically rainfed crops and their growth and yield are directly influenced by the availability and distribution of rainfall. Edaphic factors such as soil type and soil fertility also impact millet production, as millets have specific soil requirements for optimal growth and yield. Agronomic management practices, such as nutrient management, pest and disease control, and water management, also affect millet production. Moreover, the socioeconomic status of farming communities, including access to resources, knowledge, and markets, can influence their ability to adopt improved millet production practices and achieve better performance in terms of productivity and profitability. Therefore, a holistic approach that considers the interplay of climatic, edaphic, agronomic, and socioeconomic factors is essential for the sustainable and successful production of millets (Sood et al. 2019). The incidence of diseases, insect-pests, parasitic nematodes, birds, parasitic plants, and weeds pose significant biotic constraints to millet production. Millets are susceptible to various diseases such as downy mildew, blast, grain mold, smut, rust, ergot, and charcoal rot, depending on the specific type of millet. Weed infestation is also considered a major constraint in global millet production, as it can cause a significant reduction in millet grain yield, with studies indicating more than 29% reduction associated with weed infestation alone. Managing these biotic constraints is crucial for ensuring optimal millet production and maximizing yields, necessitating the adoption of appropriate pest and disease management practices and weed control strategies.

The poor initial vigor of small millets promotes excessive growth of weeds resulting in more competition for sunlight, nutrient, space, and water in early growth stage, which ultimately reduce crop productivity (Lall and Yadav 1982). Changing food habits and consumer preferences have led to a shift in land allocation towards the cultivation of other high-value cereal grains, resulting in a decline in millet production. This trend is evident in countries like India, where the millet cropping area has reduced from 8 million hectares during the late 1940s to 2.3 million hectares during 2011-2012. The reduction in millet cultivation can be attributed to the changing dietary preferences and increased demand for other cereal grains, which has led to farmers switching to more profitable crops. This shift in land allocation has contributed to the decrease in millet production, posing challenges to the conservation and promotion of these nutrient-rich crops, which have significant cultural, nutritional, and environmental value. Efforts to raise awareness about the nutritional benefits of millets and promote their consumption could help address this challenge and encourage their sustainable cultivation.

## 16.5 Conclusion:

Millets, with their unique nutritional profile, health benefits, and C4 photosynthetic pathway, are well-suited crops for diversifying cropping systems in climate-resilient agriculture. They have been traditionally grown by resource-poor farmers in drylands and tribal communities in less productive and fragile ecosystems. However, the growing awareness of their potential health benefits and industrial uses has led to a renaissance of millets. The main concern associated with millet production is the shrinking global millet cropping area. Limited availability of improved cultivars, agricultural inputs, and policy support are major limiting factors that contribute to lower productivity of millets and the reduction in their cultivation area. Addressing these challenges is crucial for promoting sustainable millet production and ensuring their continued cultivation for their nutritional, environmental, and cultural significance. To promote millets as "golden crops" of the future, well-planned and long-term public sector investments are needed for multidisciplinary research activities, especially in major millet-growing countries. For example, in India, the government has initiated the Initiative for Nutritional Security through Intensive Millet Promotion (INSIMP) and launched a national nutraceutical mission to harness the immense nutraceutical potential and climate-resilient nature of millets.

The national nutraceutical mission prioritizes eight millets (sorghum, pearl millet, finger millet, barnyard millet, foxtail millet, proso millet, kodo millet, and little millet) and two pseudocereals (amaranth and buckwheat) as "nutri-cereals" for their significant nutritional value. Collaborative efforts among countries, supported by sustained investments, are crucial for realizing the full potential of millets as future crops for nutritional security and climate resilience. National and international multidisciplinary public sector initiatives are essential for promoting and enhancing the consumption of millets in other major millet-growing countries. In addition, linking small millets to the industry through value addition can provide higher returns to marginal farmers in Asia and Africa.

Policy support, combined with focused crop improvement efforts and public awareness about the nutritive value of millets, can help regain the lost cultivated area under millets and ensure their sustainable cultivation for improved nutrition, livelihoods, and climate resilience.

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