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1. Millets: Background, Need and Importance in Climate Resilient Cropping Systems

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Abstract:

Millets, including pearl millet, finger millet, foxtail millet, proso millet, barnyard millet, and sorghum, are ancient grains with origins in Africa, India, China, and Southeast Asia. Despite their historical and nutritional significance, they have been largely overshadowed by major cereals such as wheat, rice, and maize.

This chapter delves into the historical background and traditional uses of millets, emphasizing their critical role in addressing the challenges posed by climate change. Millets are inherently resilient to extreme weather conditions, such as drought and heat, and require significantly less water and fewer inputs than other staple crops. Their deep root systems improve soil health and contribute to carbon sequestration. Case studies from India, Africa, and the United States highlight successful integration of millets into climate-resilient cropping systems.

With appropriate policy support, research, and market development, millets can play a vital role in enhancing food security, promoting sustainable agriculture, and building resilience against climate change.

Keywords:

Millets, climate-resilient, carbon sequestration.

1.1 Introduction:

Millets, a diverse group of small-seeded grasses, are ancient crops with a rich history of cultivation dating back thousands of years. Despite their historical significance, they have often been overshadowed by more widely consumed cereals such as wheat, rice, and maize.

The growing threats posed by climate change, including extreme weather conditions, water scarcity, and declining soil fertility, have renewed interest in millets as a viable solution for sustainable agriculture. This chapter explores the historical background of millets, their unique characteristics, and their critical role in climate-resilient cropping systems.

1.2 Historical Background of Millets:

1.2.1 Origins and Early Cultivation:

Millets are among the oldest cultivated crops, with evidence of their use dating back to prehistoric times. These crops were domesticated independently in various regions of the world, including Africa, India, China, and Southeast Asia. Key varieties of millets include:

- **Sorghum (*Sorghum bicolor*):** Originating in Africa, sorghum is a versatile crop cultivated widely in Africa, Asia, and the Americas. It is one of the staple crops for millions of semi-arid residents, is also known as "The KING OF MILLETS".
- **Pearl Millet (*Pennisetum glaucum*):** Originating from Africa, pearl millet is now widely cultivated in the semi-arid regions of Africa and India.
- **Finger Millet (*Eleusine coracana*):** Believed to have been domesticated in the highlands of Ethiopia, finger millet is extensively grown in the Indian subcontinent and parts of Africa.
- **Foxtail Millet (*Setaria italica*):** One of the oldest cultivated millets, foxtail millet has its origins in China and is widely grown in East Asia.
- **Proso Millet (*Panicum miliaceum*):** Domesticated in the Central Asian region, proso millet is now grown in Europe, India, and North America.
- **Barnyard Millet (*Echinochloa spp.*):** With multiple species domesticated in different regions, barnyard millet is cultivated in East Asia, South Asia, and Africa.
- **Kodo millet (*Paspalum scrobiculatum* (L.)):** It is indigenous cereal of India and is grown today in Uttar Pradesh in the North and Kerala and Tamilnadu in the South. It is widely distributed in damp habitats across the tropics and subtropics of the world.

Figure 1.1: Sorghum panicles

Figure 1.2: Pearl millet panicles

Figure 1.3: Finger millet panicles

Figure 1.4: Proso millet panicles

Figure 1.5: Kodo millet panicles

Figure 1.6: Barnyard millet panicles

Figure 1.7: Foxtail millet panicles

Figure 1.8: Finger millet panicles

1.2.2 Traditional Uses and Cultural Significance:

Millets have been integral to the diets and cultures of many communities. In Africa, pearl millet is a staple food, while in India, finger millet is traditionally used to make nutritious dishes like ragi mudde and ragi roti.

In East Asia, foxtail millet is used to prepare porridge and alcoholic beverages. Millets also play a significant role in various traditional rituals and festivals, underscoring their cultural importance.

1.2.3 Decline and Neglect:

With the advent of the Green Revolution in the mid-20th century, the focus shifted towards high-yielding varieties of wheat and rice. This shift led to the marginalization of millets, despite their adaptability to diverse agro-ecological conditions.

The decline in millet cultivation was further exacerbated by changing dietary preferences and the perception of millets as "poor man's food." Consequently, millet consumption and cultivation declined significantly, and their nutritional and ecological benefits were overlooked.

1.3 The Need for Millets in Modern Agriculture:

1.3.1 Climate Change Challenges:

Climate change poses several challenges to global food security. Rising temperatures, erratic rainfall patterns, increased frequency of droughts and floods, and the spread of pests and diseases threaten agricultural productivity. Traditional staple crops like wheat, rice, and maize are particularly vulnerable to these changes, necessitating the search for more resilient alternatives. Millets, with their inherent resilience to harsh climatic conditions, offer a viable solution.

1.3.2 Nutritional Security:

Malnutrition remains a critical issue, especially in developing countries. Millets are highly nutritious, offering a rich source of essential nutrients such as proteins, dietary fiber, vitamins, and minerals. They have a low glycemic index, making them suitable for people with diabetes. Incorporating millets into diets can help combat malnutrition and associated health problems, providing a sustainable solution to global nutritional security.

1.3.3 Economic Viability for Smallholder Farmers:

Millets are less labour-intensive and require fewer inputs like fertilizers and pesticides compared to other major cereals. This makes them economically viable for smallholder farmers, who often have limited resources. Additionally, the rising demand for health foods has created new market opportunities for millet-based products, contributing to rural development and poverty alleviation.

1.4 Importance of Millets in Climate-Resilient Cropping Systems:

1.4.1 Drought Tolerance:

Millets are highly drought-tolerant crops, capable of thriving with minimal water. Their short growing season and deep root systems allow them to access water from deeper soil layers. This drought resilience ensures food production even under water-scarce conditions, making millets ideal for regions prone to droughts.

For instance, in parts of sub-Saharan Africa where prolonged dry spells are common, pearl millet and sorghum have proven to be lifelines for farmers, ensuring food security during periods of drought.

1.4.2 Heat Tolerance:

Millets can withstand high temperatures better than many other staple crops. As global temperatures rise, the ability of millets to grow in hot climates becomes increasingly valuable. This heat tolerance helps stabilize yields and supports food security in regions where temperature extremes are becoming more common. In India, for example, the cultivation of finger millet (ragi) is notable in the hotter southern states, where the crop's ability to endure high temperatures without significant yield loss makes it a reliable source of nutrition and income for farmers.

1.4.3 Low Water Requirement:

Millets require significantly less water than other major cereals such as rice and wheat. This characteristic is crucial in water-scarce regions and helps conserve water resources. Incorporating millets into cropping systems can reduce the overall water footprint of agriculture, which is particularly important as freshwater availability becomes more limited. The cultivation of millets can also alleviate the pressure on groundwater resources. In India, where groundwater depletion is a severe issue, shifting from water-intensive crops like paddy to millets could make a substantial difference in sustainable water management.

1.4.4 Soil Health Improvement:

Millets contribute to improved soil health. Their cultivation helps prevent soil erosion due to their robust root systems, which stabilize the soil. Additionally, millets enhance soil fertility through organic matter addition and nitrogen fixation, especially when grown in rotation with legumes. Healthy soils are fundamental to sustainable agriculture, as they support better crop growth and resilience against pests and diseases. In the Sahel region of Africa, millet farming has been integrated with agroforestry practices to combat desertification. The deep roots of millet plants hold the soil together, preventing erosion and promoting the accumulation of organic matter, which improves soil fertility over time.

1.4.5 Carbon Sequestration:

The deep root systems of millets play a role in carbon sequestration, helping to mitigate climate change. By storing carbon in the soil, millets contribute to reducing atmospheric CO_2 levels. This environmental benefit aligns with global efforts to combat climate change and promotes the long-term sustainability of agricultural ecosystems.

Millets' contribution to carbon sequestration can be particularly impactful in regions with degraded lands. By revitalizing these areas with millet cultivation, it's possible to turn them into carbon sinks, thereby supporting climate mitigation strategies.

1.5 Nutritional and Economic Benefits of Millets:

1.5.1 Nutritional Value:

Millets are highly nutritious, offering a rich source of essential vitamins and minerals such as calcium, iron, magnesium, and phosphorus. They also provide a good balance of protein and dietary fiber, making them a valuable food source in addressing malnutrition and promoting overall health. As climate change impacts food availability and quality, millets can help ensure that populations have access to nutritious diets.

For instance, finger millet is known for its high calcium content, which is crucial for bone health, particularly for children and the elderly. Incorporating millets into diets can thus address specific nutritional deficiencies prevalent in many developing regions. Moreover, the dietary fiber in millets aids in digestion and helps prevent chronic diseases such as diabetes and cardiovascular diseases.

1.5.2 Economic Viability:

Millets are less labour-intensive and require fewer inputs like fertilizers and pesticides, which lowers production costs. This economic viability makes millets attractive for smallholder farmers who have limited resources. Moreover, the growing market for health foods has increased demand for millet-based products, creating new economic opportunities for farmers and contributing to rural development.

In regions like Karnataka in India, farmers have benefited economically from cultivating millets due to government subsidies and the promotion of millet-based food products. This economic upliftment also helps reduce rural poverty and improve livelihoods. Additionally, the rising awareness of the health benefits of millets has led to their inclusion in urban diets, providing farmers with a broader market and better prices for their produce.

1.6 Enhancing Biodiversity and Agricultural Resilience:

1.6.1 Crop Diversification:

Integrating millets into cropping systems enhances agricultural biodiversity. This diversification reduces the risk of total crop failure, as different crops respond differently to climate stressors. Millets' resilience to various environmental conditions provides a safety net, ensuring some level of productivity even under unfavourable conditions.

In Ethiopia, for example, the integration of teff, a type of millet, with other crops like maize and wheat, has created a more resilient farming system. This diversity helps farmers manage risks associated with pests, diseases, and climate variability. Crop diversification also promotes soil health by reducing pest and disease cycles and improving nutrient availability.

1.6.2 Pest and Disease Resistance:

Millets are generally more resistant to pests and diseases compared to other staple crops. This resistance reduces the need for chemical inputs, promoting more sustainable and environmentally friendly farming practices. Additionally, it helps maintain stable yields and reduces crop losses, contributing to food security.

For example, pearl millet exhibits natural resistance to downy mildew, a significant disease affecting many cereals. This resistance reduces the reliance on fungicides, lowering production costs and environmental impact. The natural resilience of millets to pests and diseases also minimizes the risk of crop failure, ensuring consistent yields even in challenging conditions.

1.7 Case Studies and Practical Implementation:

1.7.1 India:

In India, climate change has severely impacted agricultural productivity. However, millets have been successfully integrated into cropping systems through government initiatives like the Millet Mission.

This program promotes millet cultivation through subsidies, awareness campaigns, and the inclusion of millets in the public distribution system (PDS). These efforts have led to increased millet production and consumption, mitigating climate change impacts on agriculture and improving food security.

In Karnataka, government support for millet cultivation has resulted in a significant increase in the area under millet production. Farmers receive better income opportunities and enhanced regional food security due to the promotion of millet-based products and their inclusion in local diets. Additionally, the introduction of millet-based meals in school feeding programs has improved child nutrition, demonstrating the multifaceted benefits of millet cultivation.

1.7.2 Africa:

In African countries like Niger and Mali, millets are staple crops in semi-arid regions. Programs focusing on sustainable agriculture and improved millet varieties have enhanced yields and resilience to climate stresses. Organizations like the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have promoted millet cultivation, offering improved seed varieties and training to farmers.

In Niger, the introduction of improved pearl millet varieties has led to increased yields and better resistance to drought, benefiting thousands of smallholder farmers. These efforts have not only improved food security but also supported local economies by providing stable income sources for farmers. The success of millet cultivation in Niger highlights the potential of these crops to transform agriculture in other drought-prone regions.

1.7.3 United States:

In the United States, the resurgence of interest in ancient grains has led to the promotion of millets as a climate-resilient crop. Researchers and farmers are exploring the benefits of millets in sustainable agriculture.

Projects focusing on crop diversification and soil health have demonstrated the potential of millets to enhance resilience in farming systems.

For example, the Rodale Institute in Pennsylvania has conducted research on integrating millets into organic farming systems. Their studies show that millets not only improve soil health and biodiversity but also provide a reliable crop option during periods of drought. This research underscores the potential for millets to contribute to sustainable agriculture practices in temperate regions.

1.8 Policy Support and Future Prospects:

1.8.1 Policy Support:

Governments and international organizations play a crucial role in promoting millets as part of climate-resilient cropping systems. Policy support can include subsidies for millet cultivation, research and development of improved millet varieties, and the integration of millets into public food programs. Awareness campaigns highlighting the benefits of millets can also encourage their consumption and cultivation.

The Indian government's Millet Mission is a prime example of how policy support can drive the revival of millet cultivation. Similar initiatives in other countries could help promote millets as a sustainable and climate-resilient crop. Additionally, policies promoting millet-based products in urban markets can increase demand and provide better prices for farmers, supporting rural economies.

1.8.2 Future Prospects:

The future of millets looks promising as more countries recognize their potential in addressing climate change and food security challenges. Continued research and development efforts are needed to improve millet yields, pest and disease resistance, and nutritional content. Additionally, efforts to market millet-based products can help increase their popularity and consumption globally.

Innovations in millet processing and value addition can create new products and markets, further enhancing the economic viability of millet cultivation.

For example, the development of millet-based snacks and health foods has opened new market opportunities, attracted health-conscious consumers and increased demand for millets. Moreover, integrating millets into school feeding programs and public food systems can significantly boost their consumption and promote nutritional security.

1.9 Conclusion:

Millets are indispensable in the development of climate-resilient cropping systems. Their ability to thrive under adverse conditions, coupled with their environmental, nutritional, and economic benefits, makes them crucial for sustainable agriculture.

As the world faces the growing challenges of climate change, integrating millets into agricultural practices offers a pathway to resilient food systems that ensure food security, promote health, and protect the environment.

The revival of millet cultivation, supported by government policies, research, and market development, can lead to a more sustainable and resilient future for global agriculture.

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