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Review Article

Millets of India and their significance in climate change scenario

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Abstract: Millets, including sorghum (*Sorghum bicolor*; jowar), pearl millet (*Pennisetum glaucum*; bajra), finger millet (*Eleusine coracana*; ragi), as well as foxtail, barnyard, kodo, little, and proso millets, have been recognized as climate-resilient cereals that have long been cultivated in India's semi-arid and sub-humid regions. Considering their growing importance, a study was conducted in 2025 to document the significance of millets through field surveys in Odisha and a comprehensive review of existing literature. This study synthesised evidence related to agronomic, nutritional, environmental, and socio-economic aspects of millets in the context of climate change. The authors highlighted key physiological traits that contribute to millet's resilience and compared their resource footprints and greenhouse gas (GHG) implications to those of water- and input-intensive cereals. The findings indicate that diversifying Indian farming systems with millets could reduce climate risks, stabilise yields during stressful conditions, reduce the demand for blue water, and improve household nutrition, particularly for smallholders, women, and those in marginal ecologies. Additionally, the authors recommend research and policy priorities that focus on climate-smart agronomy, formalising the value chain, enhancing public procurement, promoting behavioural change communication, and innovating circular postharvest processing methods.

Keywords: Agricultural practices, food security, rural and tribal people, sustainability

Introduction

Indian agriculture is facing several challenges, including rising temperatures, erratic monsoons, prolonged dry spells, extreme rainfall events, and increased pest and disease pressures (Habib-Ur-

Rahman et al., 2022). The dominance of rice and wheat in irrigated regions, along with the expansion of rice cultivation into ecologically fragile areas, increases vulnerability due to high blue-water usage, methane emissions from flooded paddies, and sensitivity to heat stress during critical reproductive stages (Wu et al., 2017; Lamlom et al., 2024). Therefore, diversifying cereals to incorporate more resilient, low-input crops is a national imperative for ensuring food security, nutritional well-being, and livelihood sustainability (Appiah-Twumasi and Asale, 2022).

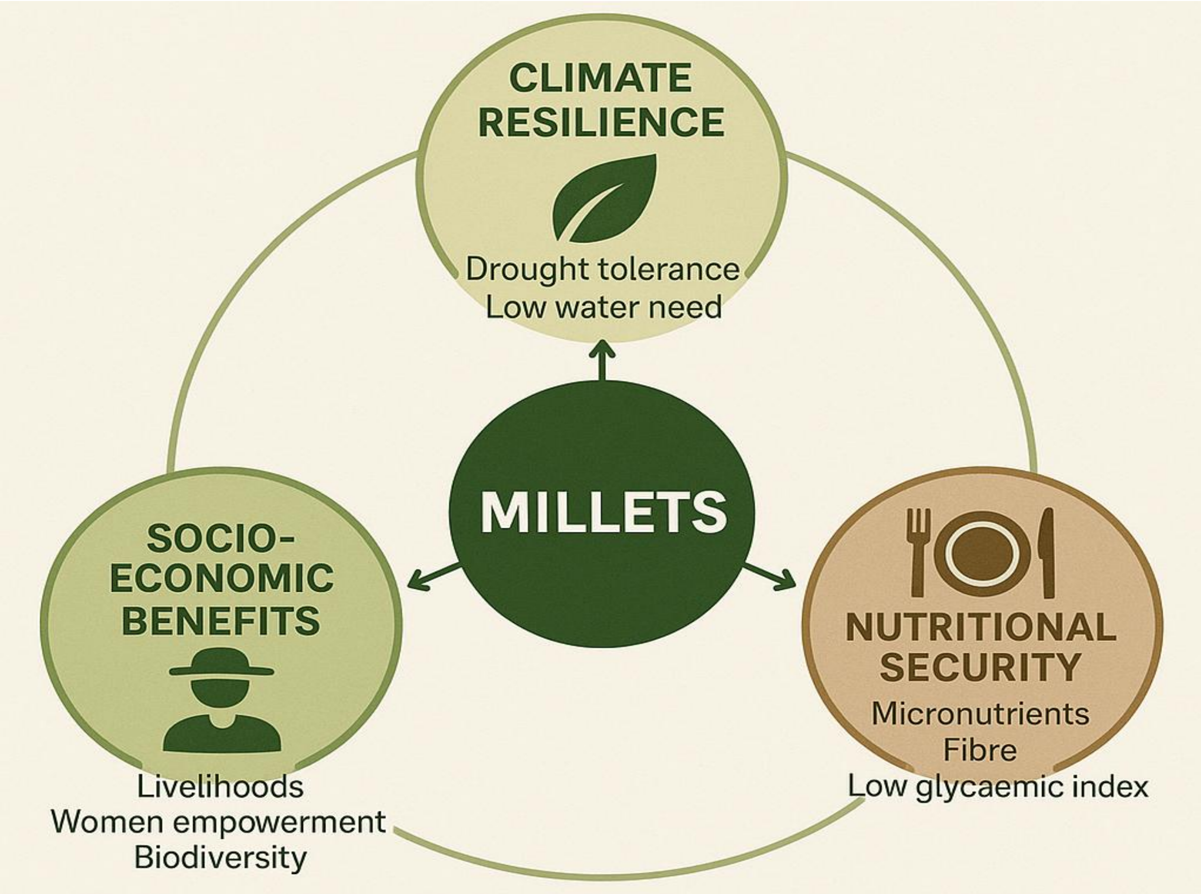

Figure 1: Role of millets in climate-resilient food systems

Millets are well-suited to adapt to climate variability, both physiologically and agronomically (Kheya et al., 2023). They typically demonstrate high photosynthetic efficiency in conditions of heat and light, exhibit superior water and nitrogen use efficiency, and have a maturation period of 60–120 days, depending on species and cultivar. Millets thrive on marginal soils with minimal external inputs (Zhao et al., 2025). Their nutrient profiles, rich in dietary fibre, resistant starch, high-quality protein, and micronutrients, address various forms of malnutrition (Jacob et al., 2024). As traditional crops for rainfed and tribal communities, millets contribute to agrobiodiversity and maintain cultural food traditions (Mohanan et al., 2025). Despite receiving renewed policy attention, there are still significant knowledge gaps regarding the comparative performance of millets under projected climate scenarios. These gaps include the water, energy, and greenhouse gas (GHG) footprints across the production and processing stages, genotype × environment × management (G×E×M) interactions that affect yield stability and nutritional quality, scalable processing technologies that maintains nutrients while appealing to consumers, and inclusive market models that benefit smallholder farmers and women's groups (Mukherjee et al., 2025; Figure 1). This study, undertaken in 2025, aims to document the significance of millets through field studies in Odisha and a comprehensive evaluation of current literature, in light of the growing impacts of climate change and the recognised value of millets.

Methodology

The study utilised a systematic review approach to gather relevant literature from various databases, including Google Scholar, Scopus, and ResearchGate. The research was conducted using keywords such as "millets," "climate change," "India," "drought resistance," "nutrition," and "sustainable agriculture." Additionally, reports from national organisations such as ICAR, ICRISAT, and FAO were reviewed and incorporated into this article (Kumar, 2025). The authors also visited various locations in Odisha state for photographic documentation.

Results and discussion

Millets, such as Pearl millet (*Pennisetum glaucum*), Sorghum (*Sorghum bicolor*), Foxtail millet (*Setaria italica*), Finger millet (*Eleusine coracana*), and Barnyard millet (*Echinochloa esculenta*), exhibit varying levels of tolerance to different environmental conditions. An analysis of the data shows that India has remarkable diversity of millets, which includes both true millets (belonging to the family *Poaceae*) and pseudo millets (from the families *Polygonaceae* and *Amaranthaceae*) (Table1; Plate 1). True millets, including *Setaria italica*, *Eleusine coracana*, *Pennisetum glaucum*, and *Sorghum bicolor*, are traditional small-grained cereals that have played a crucial role in dryland agriculture due to their resilience to drought and poor soil. These grains are collectively referred to as "nutri-cereals" because of their superior nutritional composition, which is high fiber, minerals, and essential amino acids. On the other hand, the pseudo millets, such as *Fagopyrum esculentum* and *Amaranthus caudatus*, while not taxonomically related to grasses, are nutritionally comparable and serve as important gluten-free alternatives, particularly for health-conscious individuals and those with celiac disease.

Table 1: Various millets and pseudo-millets of India

Millets			
Botanical name	Common name	Family	Group
Echinochloa esculenta (A.Braun) H.Scholz	Barnyard millet	Poaceae	Grass
Eleusine coracana (L.) Gaertn.	Finger millet	Poaceae	Grass
Panicum miliaceum L.	Proso millet	Poaceae	Grass
Panicum sumatrense Roth	Little millet	Poaceae	Grass
Paspalum scrobiculatum L.	Kodo millet	Poaceae	Grass

Pennisetum glaucum (L.) R.Br.	Pearl millet	Poaceae	Grass
Setaria italica (L.) P. Beauv.	Foxtail millet	Poaceae	Grass
Sorghum bicolor (L.) Moench	Great millet	Poaceae	Grass
Urochloa ramosa (L.) T.Q.Nguyen	Browntop millet	Poaceae	Grass
Pseudo-millets			
Botanical name	Common name	Family	Group
Amaranthus caudatus L.	Amaranth millet	Amaranthaceae	Amaranth
Fagopyrum esculentum Moench	Buckwheat millet	Polygonaceae	Knotweed

Plate 1: Some millets of India: a) Barnyard millet, b) Little millet, c) Foxtail millet, d) Proso millet, e) Pearl millet, and f) Finger millet

Environmental footprints and climate co-benefits

Millets have a lower water footprint compared to rice and wheat, making them water-efficient crops that are well-suited for semi-arid regions. Their cultivation contributes to reduced GHG emissions, primarily because they are grown in upland, non-flooded conditions and require minimal fertilizers. Additionally, they enhance soil organic carbon levels and decrease reliance on groundwater resources, which contributes positively to ecological stability (Jain et al., 2024; Figure 2-4).

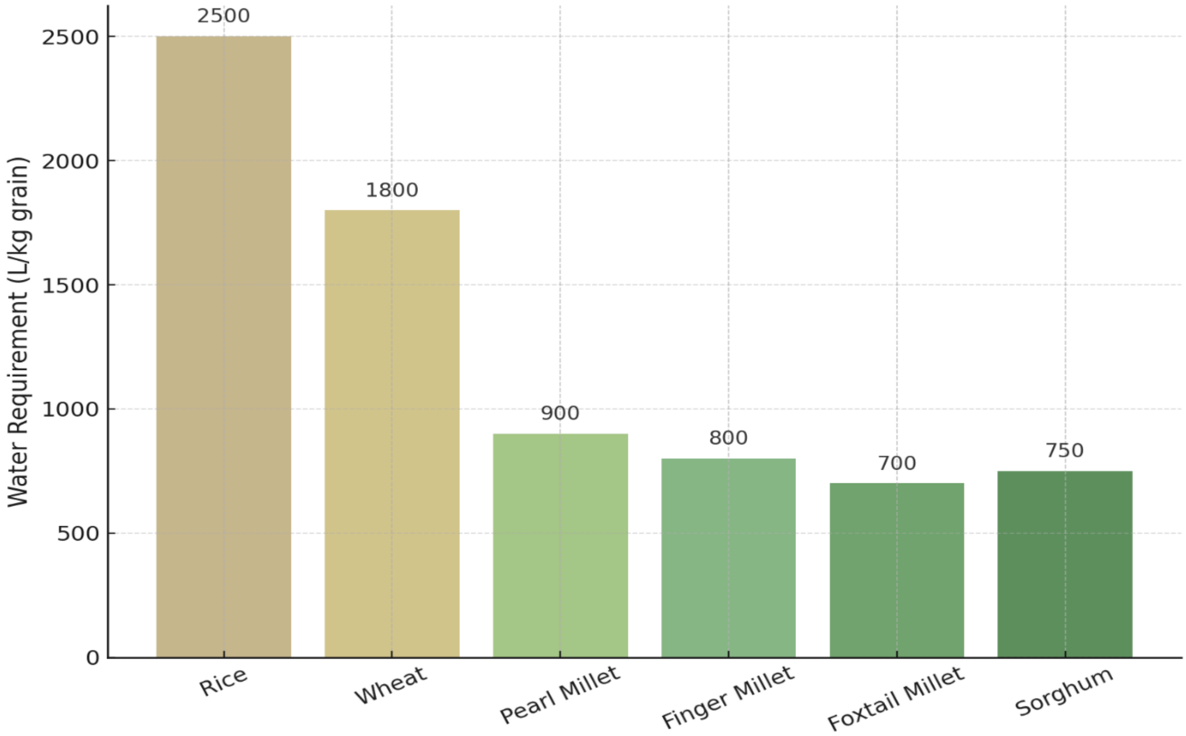

Figure 2: Comparison of the water footprint of major crops with millets

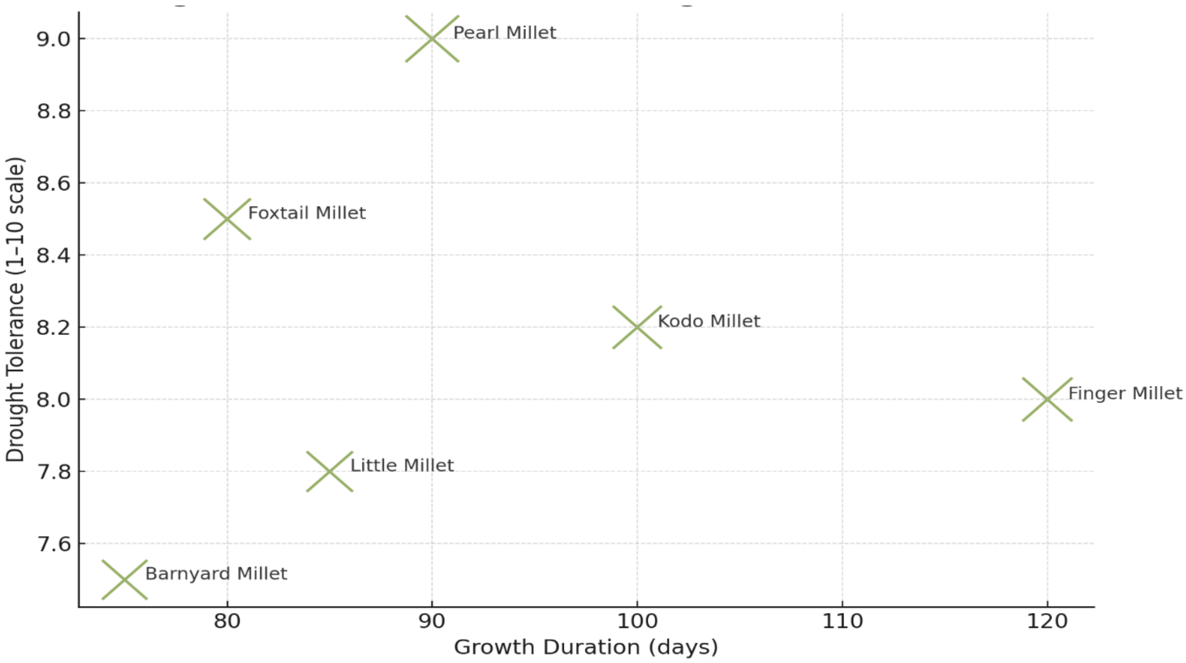

Figure 3: Growth duration and drought tolerance of various millets

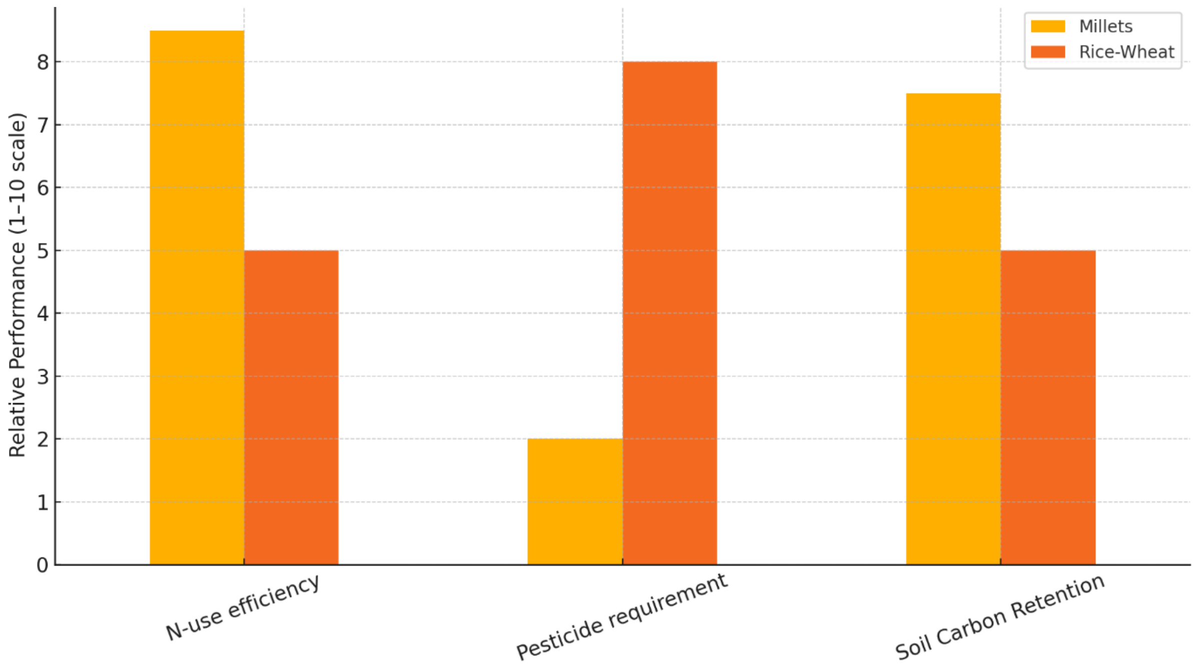

Figure 4: Comparative chart of soil and input efficiency between millets and rice

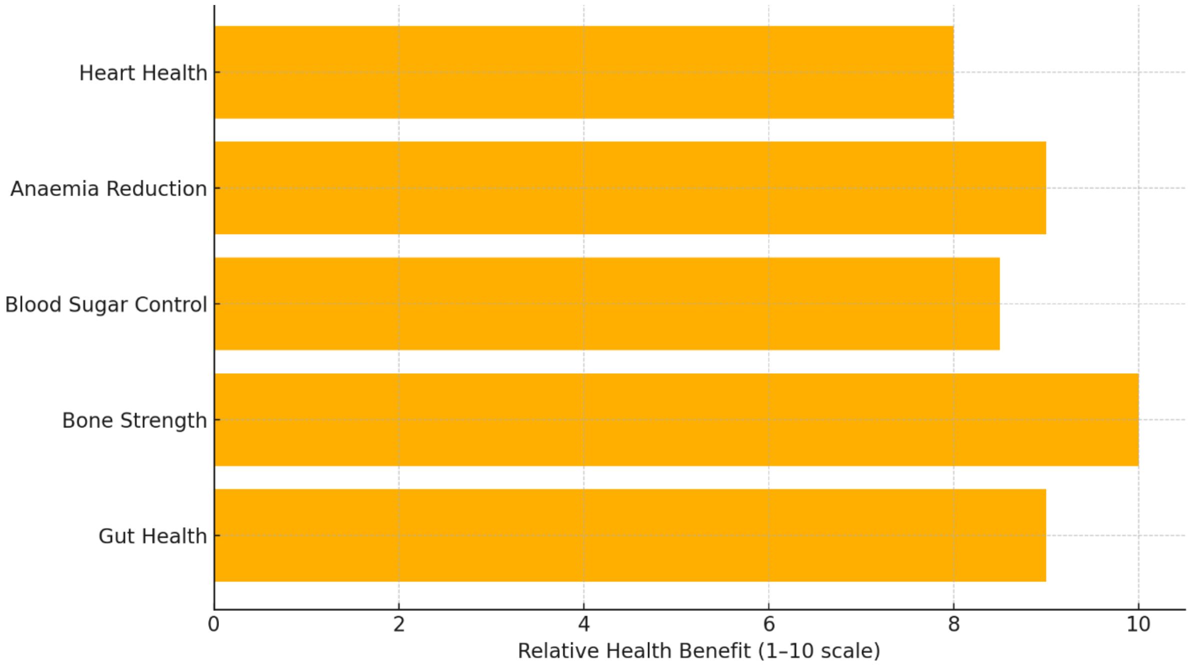

Figure 5: Health Benefits of Millets

Nutritional and health aspects

Millets are highly nutritious grains that offer greater amounts of calcium, iron, zinc, and dietary fibre compared to polished rice. Finger millet, in particular, is an excellent source of calcium, making it an essential dietary grain for bone health. Additionally, their low glycaemic index helps in managing diabetes and obesity. Consumption of whole millets promotes gut health and provides antioxidants that help reduce oxidative stress (Jacob et al., 2024; Figure 5).

Socio-economic, market perspectives and future uses

Millets form the backbone of rainfed agriculture and are commonly cultivated by small and marginal farmers, especially in tribal areas (Kaur et al., 2024). The declaration of 2023 as the International Year of Millets has increased awareness and prompted policy actions. However, marketing challenges persist due to inadequate post-harvest handling, limited processing technologies, and weak consumer demand (Mohanan et al., 2025). Millets hold exceptional potential as climate-resilient crops that can contribute to multiple Sustainable Development Goals (SDGs), including zero hunger, climate action, and good health.

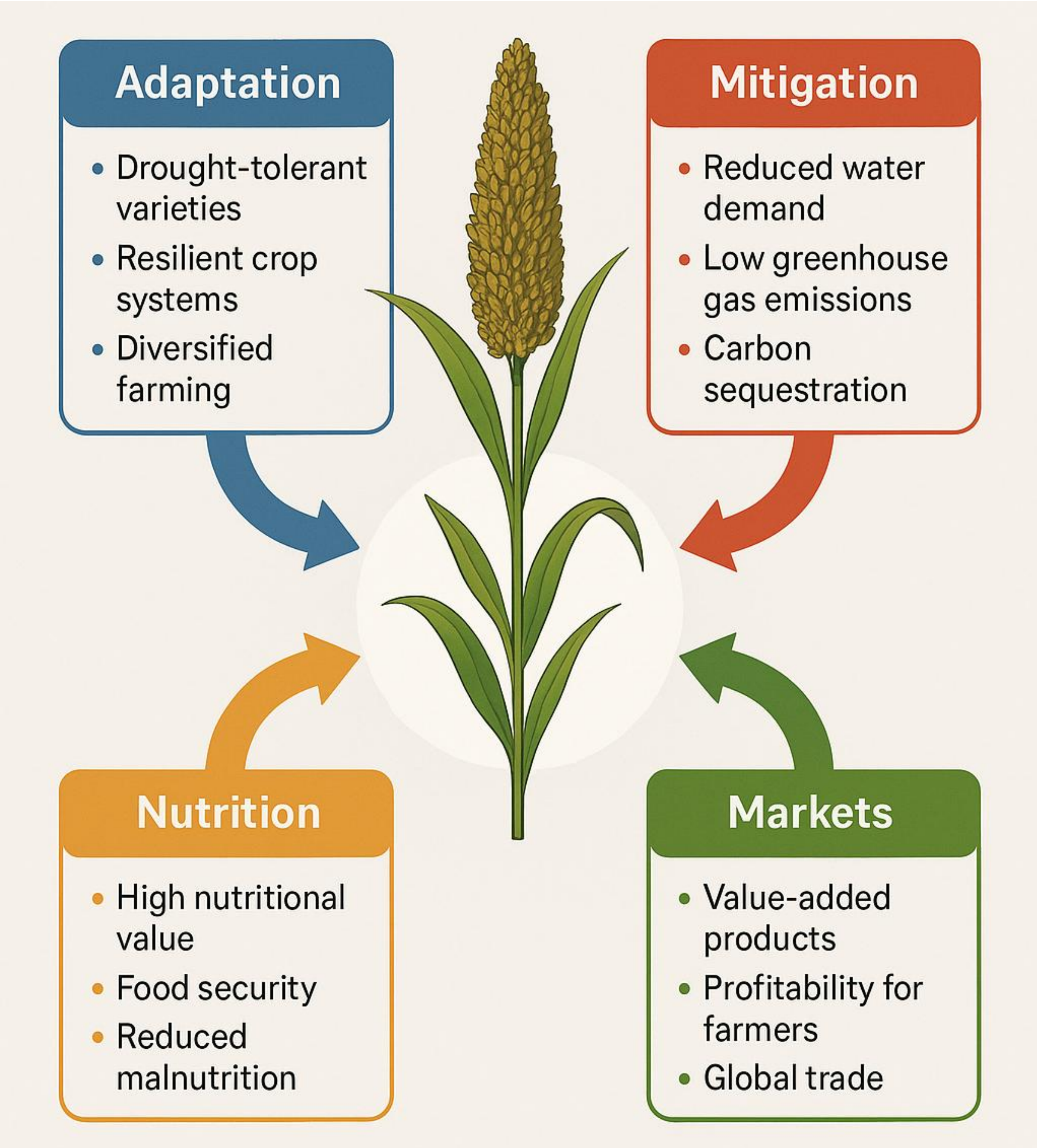

Figure 6: Future uses of millets in a climate change scenario

Processing and value addition are essential for enhancing consumer acceptance of millet-based products. Traditional processing methods, such as decortication and polishing, often reduce the nutritional quality of these grains. Therefore, development of low-cost, energy-efficient, and nutrient-preserving technologies will make the millet-based products more appealing (Figure 6). Additionally, connecting farmers with agro-industries and encouraging entrepreneurship among rural youth and women through training programs can strengthen the entire millet value chain.

Conclusion

Millets symbolise a crucial link between food security, nutritional well-being, and ecological resilience. As climate change accelerates, these ancient grains offer a viable alternative to traditional cereal farming systems that rely heavily on inputs. They are capable of sustaining production under unpredictable rainfall and high temperatures. Due to their diverse genetic base, short growth cycle, and efficient water usage, millets are ideal candidates for climate-smart agriculture. This study concludes that promoting millet cultivation in India requires a comprehensive strategy. This includes enhancing research on varietal improvement, supporting decentralised processing units, and ensuring fair market access for smallholder farmers. Policy initiatives, such as including millets in the Minimum Support Price (MSP), facilitating public procurement, and integrating them into nutrition-based programs like the Mid-Day Meal and Integrated Child Development Services (ICDS), can accelerate their adoption. At the same time, raising consumer awareness and encouraging behavioural changes are essential to rebranding millets from “coarse grains” to “smart foods” that contribute to health and sustainability. Through cohesive efforts in research, policy, and market systems, India can transform millets into the cornerstone of climate-resilient and nutrition-sensitive food systems. This transformation will not only enhance national food sovereignty but also serve as a global example for sustainable agriculture in the face of climate change.

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