

The Sustainable Jute Model: From Climate-Smart Cultivation to Value-Added Waste

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OPEN ACCESS

Keywords

Jute cultivation; Integrated nutrient management; Deficit irrigation; Climate- agriculture; Circular economy

How to cite this article:

Ghosh, A., Bepari, P., Ghosh, S. and Dey, S. 2026. The Sustainable Jute Model: From Climate-Smart Cultivation to Value-Added Waste. *Vigyan Varta* 7 (10): 119-123.

ABSTRACT

India dominates global jute production, with West Bengal alone accounting for over 70% of the nation's acreage. Yet, despite this stronghold, actual farm yields fall surprisingly short of their true potential. Erratic weather, strained resources, and outdated farming methods are largely to blame. To secure the future of this “golden fibre,” we need a sustainable model that bridges climate-smart cultivation with a modern circular economy. Jute is naturally hardy, but helping it handle the extreme droughts and sudden waterlogging common in rainfed regions is key to consistent harvests. Smarter farming also demands better resource management. Evidence shows that combining standard fertilisers with organic farmyard manure builds healthier, carbon-rich soil that sustains long-term fertility far better than chemicals alone. Additionally, targeted watering techniques save vital water resources without shrinking the final fibre output. The real game-changer, however, lies beyond the fibre itself. Jute sticks, once tossed aside as low-value agricultural waste, are now being transformed into valuable biochar, activated carbon, and industrial materials. This exciting waste-to-wealth approach creates powerful new income streams for rural communities. By linking climate-resilient farming, water-saving retting practices, and residue recycling, we can drastically improve farmer livelihoods across West Bengal. The blueprint is ready; the

next critical step is moving these promising innovations out of the laboratory and into the hands of farmers and everyday industry.

INTRODUCTION:

Jute, the “golden fibre” of the Indian subcontinent, remains a cornerstone of rural livelihoods and agro-industry, with West Bengal alone contributing roughly 70–81% of India’s jute acreage and over 73% of national production (Mazumdar *et al.*, 2019; Roy *et al.*, 2023). Despite this dominance, farm-level yields persistently fall short of achievable levels, with significant yield gaps reported across major jute districts and productivity constrained by climate variability, resource stress, and outdated agronomic practices (Singh *et al.*, 2019; Mazumdar *et al.*, 2019).

Jute is predominantly rainfed, requiring around 500 mm of water during its growing season, yet farmers increasingly face early-season droughts, erratic monsoons, and sudden waterlogging from heavy rainfall and cyclonic events (Mazumdar *et al.*, 2019; Singh *et al.*, 2019). These climate shocks interact with degraded soils and inefficient input use, limiting both fibre quality and farmer incomes. Emerging on-farm evidence from West Bengal indicates that climate-smart jute farming integrating improved varieties, adjusted sowing dates, line sowing, intercropping, balanced nutrient management, and water-saving retting can enhance resource-use efficiency and livelihoods for marginal landholders (Singh *et al.*, 2019). In parallel, integrated nutrient management that combines chemical fertilisers with organic farmyard manure has been shown to build soil carbon and sustain fertility more effectively than fertilisers alone, while conservation agriculture approaches such as zero-tillage have demonstrated yield gains of around 26–28% over conventional practices in participatory

trials (Mazumdar *et al.*, 2019; Saha *et al.*, 2019).

Climatic Resilience and Adaptation

- **Drought Tolerance:** Jute is a remarkably hardy crop that requires very little intervention to get started. Even in dry, pre-monsoon conditions, the seeds can sprout naturally without any pre-soaking. As the plant grows in low-moisture environments, it adapts by sending an extensive root system deep into the earth, growing side branches that actively seek out hidden underground water reserves.
- **Flood Tolerance:** Jute is equally resilient when the weather flips. When heavy monsoon rains flood the fields right around the harvest season, the plant doesn't drown. Instead, it quickly adapts by developing specialized aquatic roots. These unique roots allow the plant to pull necessary oxygen and nutrients directly out of the waterlogged environment to survive.

Integrated Nutrient Management (INM) vs. Inorganic Farming

- **The Yield vs. Soil Health Trade-off:** When farmers rely strictly on heavy doses of synthetic chemical fertilizers, they see a massive spike in their immediate fiber harvest. However, decades of field research show a major downside: this chemical-only approach steadily exhausts and degrades the soil over time, making it harder to grow future crops.
- **The Sustainable Choice:** The smarter, long-term strategy is Integrated Nutrient Management. By blending a moderate

amount of synthetic fertilizers with organic farmyard manure, farmers strike a healthy balance. While this method results in a very slight dip in maximum peak yield, the trade-off is highly beneficial. The organic manure drastically revitalizes the soil's organic carbon and overall fertility, ensuring the land remains rich and productive for years to come.

Strategic Water Management

The vast majority of jute farming relies entirely on natural rainfall, making the crop highly vulnerable to unpredictable dry spells before the monsoon arrives. If the soil is too dry during the plant's crucial early development, growth is severely stunted. To solve this without draining local water supplies, experts recommend "deficit irrigation." By providing targeted, minimal watering *only* during the plant's most critical early growth phases, farmers can ensure the plant establishes a strong foundation. Once mature, the plant can handle the stress on its own. This careful timing results in a substantial boost in total fiber production compared to purely rain-dependent farming, all while strictly conserving precious water. Value-added and industrial uses

Value-added and industrial uses

An increasing number of studies in materials science show that jute stick can be turned into higher-value products. Its fine porous structure and large specific surface area make it a good material for biochar, activated carbon, energy-storage materials and environmental cleanup agents. A recent review explained how biological, chemical, physical and combined treatments can change jute stick into these forms. The work highlights residue valorisation as a way to build bio-based industries and support income in rural areas (Sinha *et al.* 2024). At the same time, engineering research has used jute stick to

make particleboard. It is seen as a locally available alternative to wood chips suitable for furniture, tabletops, partitions and false ceiling panels (Roy Chowdhury *et al.*, 2024). Other studies have found that lignin from jute stick extracted through soda pulping can replace up to 50% of the phenol used in phenol-formaldehyde adhesives for particleboard. This reduces reliance on petroleum-based binders (Chowdhury & Sarkar 1989).



NINFET SATHI



CRIJAF SONA

Figure 1: Value-added jute products and diversified applications developed by ICAR-NINFET and ICAR-CRIJAF.

Residue management as a climate and circular-economy strategy

Together, these applications change jute stick from a value fuel or waste material into a multi-output biorefinery resource. This shift impacts both climate mitigation and farm earnings. Turning some of the residue into biochar or burning it openly reduces emissions of short-lived climate pollutants. It also helps return carbon to farmland. This boosts the organic matter benefits of the management methods described in Section 3. Sending jute stick biomass to make particleboard, pulp, or energy-storage products reduces the need for wood-based materials. It also creates agricultural income opportunities in rural areas. These opportunities are linked to the jute crop base. This helps align jute residue management with circular-economy and sustainable-development goals (Sinha *et al.* 2024). Still, much of the evidence remains limited to lab or pilot scale.

CONCLUSION

West Bengal's jute sector stands at a turning point. The region already leads India and the world in jute acreage, yet yields remain far below what the land and climate can support. Closing this gap will require more than incremental tweaks; it demands an integrated, farmer-centred model that ties climate-smart cultivation to circular-economy opportunities. Evidence points to three practical levers. First, building climate resilience through drought- and waterlogging-tolerant practices can stabilise harvests in rainfed areas where weather is increasingly erratic. Second, smarter resource use such as combining chemical fertilisers with organic farmyard manure and adopting targeted irrigation improves soil health and saves water without sacrificing fibre output. Third, and perhaps most transformative, is turning "waste" into wealth: converting jute sticks into biochar, activated carbon, and other industrial materials opens new income streams for rural households while reducing post-harvest losses.

The blueprint for this transition already exists in pilot studies and laboratory work. The challenge now is implementation at scale: extending these innovations through farmer field schools, local cooperatives, and industry partnerships so that better seeds, soil practices, water-saving retting, and residue recycling become everyday realities in villages across West Bengal. If research, policy, and market incentives align behind this agenda, jute can move from a struggling "golden fibre" to a resilient, high-value backbone of rural livelihoods and sustainable industry.

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