DEPARTMENT OF AGRICULTURE DEVELOPMENT
& FARMERS' WELFARE, GOVERNMENT OF KERALA

FARM INFORMATION BUREAU

KERALA KARSHAKAN

E-JOURNAL

THE FIRST ENGLISH FARM JOURNAL FROM THE HOUSE OF KERALA KARSHAKAN

JANUARY 2026
VOLUME 13 ISSUE 08

FARMONOMICS

When money matters in agriculture

INSIDE

KERALA KARSHAKAN
E-JOURNAL

JANUARY 2026 VOLUME 13 ISSUE 08

Mail editorejournalkkfib@gmail.com Log on to www.fibkerala.gov.in Phone: 0471 2314358

THE FIRST ENGLISH FARM JOURNAL FROM THE HOUSE OF KERALA KARSHAKAN

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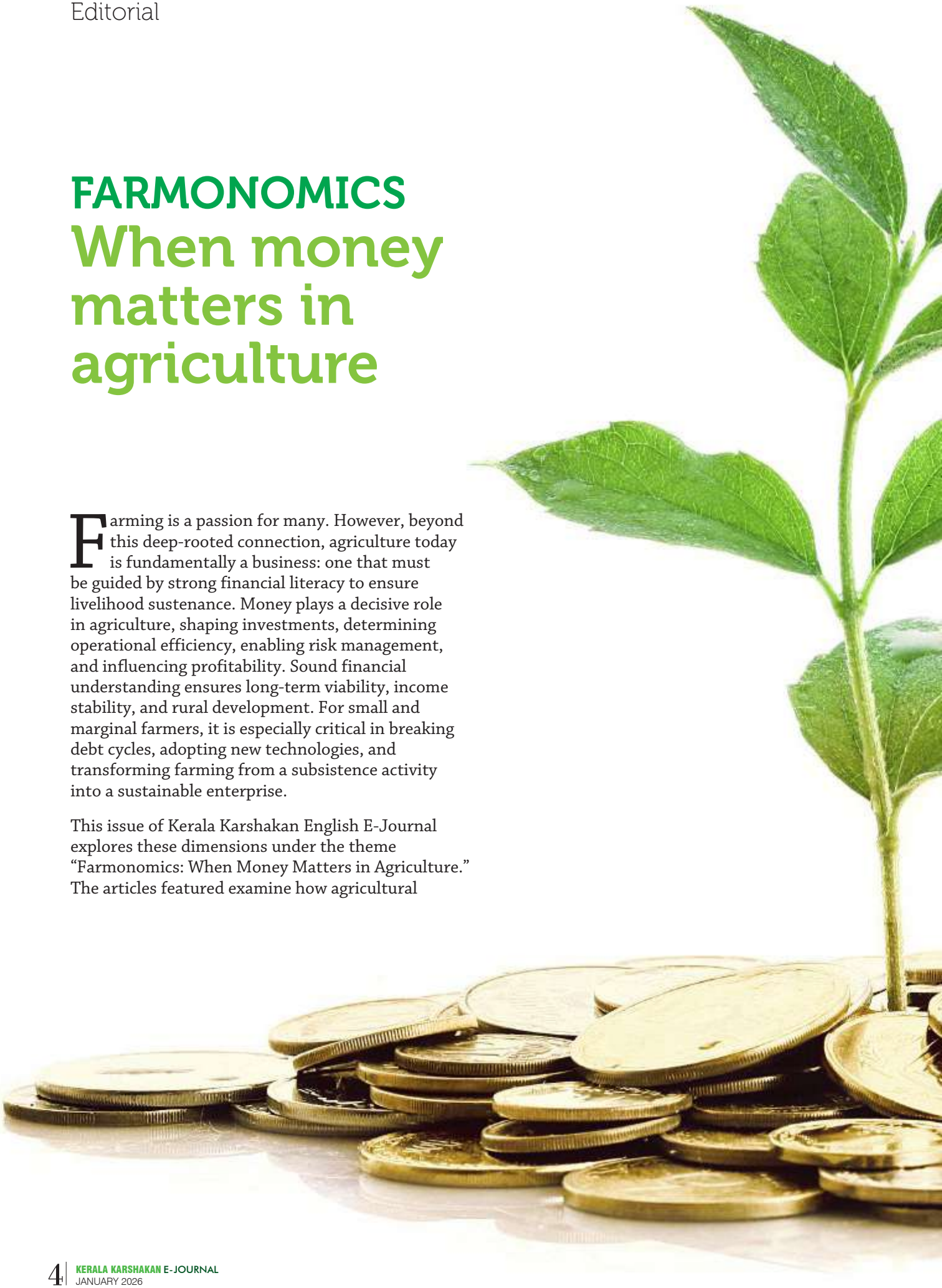
FARMONOMICS
When money matters in agriculture



Farming is a passion for many. However, beyond this deep-rooted connection, agriculture today is fundamentally a business: one that must be guided by strong financial literacy to ensure livelihood sustenance. Money plays a decisive role in agriculture, shaping investments, determining operational efficiency, enabling risk management, and influencing profitability. Sound financial understanding ensures long-term viability, income stability, and rural development. For small and marginal farmers, it is especially critical in breaking debt cycles, adopting new technologies, and transforming farming from a subsistence activity into a sustainable enterprise.

This issue of Kerala Karshakan English E-Journal explores these dimensions under the theme "Farmonomics: When Money Matters in Agriculture." The articles featured examine how agricultural

economics is applied across key domains such as climate risk and finance, fisheries, poverty and vulnerability, and agricultural trade and value chains.

The contributions are authored by researchers from Kerala who are deeply engaged in agricultural economics and allied social science disciplines. Their work reflects close interaction with policy frameworks, institutions, and field realities. Collectively, the articles demonstrate how economic thinking strengthens agriculture—by improving livelihoods, managing uncertainty, and supporting informed public decision-making, while exposing the new realities of farming in Kerala.

In addition to the cover theme, this issue explores emerging innovations and promising trends in agriculture and horticulture. Articles feature advancements such as virus elimination through in vitro chemotherapy for producing quality planting material, cultivation practices of nutritionally rich super-fruits like Gac (Momordica cochinchinensis Spreng), and approaches to climate-smart agriculture aimed at improving resilience and sustainability. These articles provide valuable insights for farmers, researchers, extension personnel, and policymakers alike. Together, these features, alongside the cover story, offer an engaging and enriching reading experience.

As we step into 2026, we extend our warm wishes to our readers for a happy and productive New Year.

Editor

Money Matters

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When people think about agriculture, they usually think of seeds, soil, rain, and hard work in the field. Rarely do they think about prices, risks, loans, markets, or policies. However, for most farmers, these economic aspects often decide whether farming is viable or stressful, profitable or uncertain. In short, to decide whether to continue with farming or not. This is where agricultural economics quietly but powerfully comes in.

Agricultural economics is not just about profits or markets. It is about how farmers make decisions under uncertainty, how risks are shared, how benefits are distributed, and how agriculture contributes to society at large. The articles in this issue of Kerala Karshakan show how this discipline helps understand and address some of Kerala's most pressing agricultural challenges.

Climate change

When nature becomes unpredictable

Climate change has turned farming into a risky business. Floods, droughts, heat stress, and pest outbreaks affect not only crops but also household

income and debt. Agricultural economics helps us understand these risks in economic terms and design better responses. Instead of only reacting after disasters, economists study climate finance, crop insurance, early-warning systems, and anticipatory cash support. These tools help farmers prepare for shocks, not just recover from them. In simple terms, economics helps convert climate uncertainty into manageable risk.

Fisheries

Livelihoods beyond the shore

Fisheries are central to Kerala's economy and culture, yet they face unique challenges. Fish resources are shared, technologies are expensive, work is risky, and markets are often unequal. Women play a major role, especially in post-harvest activities, but their contributions are often invisible. Fisheries economics helps analyse who benefits, who bears the risk, and how institutions like cooperatives, insurance schemes, and regulations can work better. It reminds us that sustainable fisheries depend not only on fish stocks, but also on fair markets and strong social institutions.

Poverty

Why income alone is not enough

Kerala has made impressive progress in reducing poverty. Still, many agricultural households remain vulnerable. Their incomes depend heavily on wage labour, they carry high levels of debt, and they face growing climate risks. Agricultural economics helps look beyond average income figures to understand vulnerability. By studying debt cycles, risk exposure, and access to safety nets, economists help design policies that prevent households from slipping back into poverty. Poverty-proofing agriculture is not about charity; it is about smart, preventive policy.

Markets and trade

Prices decide more than crops

Kerala's agriculture is deeply linked to national and global markets, especially for plantation crops and spices. Price swings affect farm incomes, consumer prices, and investment decisions. Agricultural economists study price behaviour, value chains, and trade rules to provide market intelligence. This helps farmers decide what to grow, when to sell, and how to add value. It also helps policymakers ensure that markets reward producers fairly rather than concentrating gains elsewhere.

Across climate change, fisheries, poverty, and trade, one message is clear: agriculture does not operate in isolation. It is shaped by money flows, institutions, risks, and choices. Agricultural economics helps bring these elements together and translate evidence into action. The articles in this issue are written by researchers from Kerala who have specialised in agricultural economics and allied fields, working closely with farmers, institutions, and policymakers. Their work shows how economic thinking, rooted in local realities, can help agriculture serve not just production goals, but livelihoods, equity, and long-term sustainability. In an increasingly uncertain world, understanding the economics of agriculture is no longer optional. It is essential. ■

> Agricultural economics is not just about profits or markets. It is about how farmers make decisions under uncertainty, how risks are shared, how benefits are distributed, and how agriculture contributes to society at large.

Climate Finance and Agriculture
Why It Matters for Kerala's Farmers


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For farmers, climate change is not only an environmental concern but also a direct economic shock. When a crop fails or yields drop, it immediately affects household income, food security, and the ability to invest in the next season.

In Kerala, agriculture has long been closely linked to the climate, particularly the monsoon and the water it brings. But in recent years, this relationship has become unpredictable, forcing farmers to farm with uncertainty rather than confidence. In 2018, for instance, Kerala received approximately 2,346.6 mm of rainfall between June and August, approximately 42% above normal, resulting in severe flooding and widespread crop failures. Flash floods and landslides have become more frequent in recent years, pest outbreaks are harder to anticipate and control, and the cost of cultivation continues to rise. What were once described as occasional shocks are increasingly becoming part of everyday farming life. Together, these overlapping pressures

are steadily reshaping Kerala's agriculture from a seasonal livelihood into a daily struggle for survival.

For farmers, climate change is not only an environmental concern but also a direct economic shock. When a crop fails or yields drop, it immediately affects household income, food security, and the ability to invest in the next season. In Kerala, this vulnerability is sharper because most farms are extremely small and fragmented. Official census data indicate that marginal holdings account for 96.7% of operational holdings in the state, and the average operational holding is 0.18 hectares. With limited savings and few reliable safety nets, one bad season can be managed; repeated cop failures can push a family into long-term debt and distress.

In this context, climate finance becomes essential. Although the term "climate finance" may not be widely used in Kerala, the concept is becoming increasingly important. Climate finance refers to financial support from public or private, local or international, that helps people reduce climate risks and adapt to changing conditions. The UNFCCC describes it as financing that supports mitigation and adaptation actions to address climate change. Unlike traditional relief measures, which primarily focus on compensation after disasters, climate finance provides support before and during shocks. In simple terms, climate finance refers to financial support that helps people prepare for, cope with, and recover from climate impacts, especially as weather patterns become more unpredictable. In agriculture, it includes financial tools that help farmers manage climate stress, reduce risk, and make informed future investments. Many farmers already understand what is required to cope with climate change. Still, without affordable credit, timely insurance, or reliable support, adaptation remains out of reach for those who need it most. Climate finance is meant to bridge that gap.

Climate finance in agriculture has two leading roles: to reduce the emissions that drive climate change (mitigation) and to help farmers adapt to climate impacts (adaptation). We need climate finance for mitigation because reducing emissions at scale isn't cheap. It requires substantial investments in clean energy, efficient irrigation and machinery, improved storage and processing, and climate-smart practices that reduce the

In India, climate finance is managed through a network of ministries and public financial institutions rather than a single agency.

carbon footprint of farming. At the same time, climate finance is equally crucial for adaptation, as farmers already face increased risks: erratic rainfall, floods, droughts, heat stress, and new pest and disease outbreaks. Adaptation is about helping farmers stay productive and secure despite these shocks and uncertainties. Climate adaptation finance can also strengthen farms before losses occur. It can help farmers shift to flood- or drought-tolerant varieties, improve field drainage, adjust sowing dates to match changing weather patterns, and use weather and pest advisory services to guide day-to-day decisions. Together, these steps don't just reduce damage; they build resilience into the farming system over time.

In Kerala, many forms of climate-related financial support already exist, even if they are not explicitly described as climate finance. Crop insurance is one of the most familiar examples. It is intended to protect farmers from losses caused by floods, droughts, or pest outbreaks, providing a basic safety net during periods of distress. Farmer applications insured under Pradhan Mantri Fasal Bima Yojana and Restructured Weather-Based Crop Insurance Scheme increased from 58,135 in 2019–20 to 1,74,141 in 2023–24, signalling an apparent demand for protection in an uncertain climate. Climate finance also supports waste management and circular farming practices. In Kerala, practices such as composting, installing biogas units, and recycling agricultural waste can reduce dependence on external inputs while improving soil fertility and farm sustainability.

In India, climate finance is managed through a network of ministries and public financial institutions rather than a single agency. The Ministry of Finance helps steer the planning and tracking of climate-related funds. At the same time, the Ministry of Environment, Forests, and Climate Change serves as India's primary interface with major international climate funds, such as the Green Climate Fund. On the delivery side, institutions such as the National Bank for Agriculture and Rural Development play a major role in channelling climate support into agriculture and rural livelihoods (adaptation and resilience). The Small Industries Development Bank

of India supports climate-linked finance for MSMEs, and banks also contribute by raising and channelling funds into climate-related projects. In Kerala, these climate-finance supports reach farmers primarily through the state Agriculture Department (scheme access and advisories), banks and cooperatives (crop loans and working capital), crop insurance (to cushion losses), and disaster relief routed through the state disaster-management system. Beyond these safety nets, Kerala is also seeing larger resilience investments: The World Bank's First Resilient Kerala Program supported the Rebuild Kerala Development Program, reported to have enabled about $992 million worth of projects across 16 sectors, and agriculture-focused initiatives like KERA aim to strengthen the resilience and commercialisation of Kerala's food and agriculture sector for small farmers and agri-MSMEs.

Moving forward, for climate finance to truly support Kerala's farmers, it must shift from a reactive, fragmented approach to an anticipatory, local, and farmer-centred one.

Moving forward, for climate finance to truly support Kerala's farmers, it must shift from a reactive, fragmented approach to an anticipatory, local, and farmer-centred one. This requires moving beyond post-disaster assistance toward timely support that helps farmers prepare for climate risks before losses occur. Strengthening access to affordable credit, improving the reliability and speed of crop-insurance payouts, and integrating weather and pest advisories into everyday farming decisions are crucial first steps. Enhancing farmer awareness through trusted local institutions such as Krishi Bhavans, cooperatives, and self-help groups is equally essential. At the state level, climate objectives should be embedded within existing agricultural programmes, with schemes aligned under a clear climate-resilience lens to improve coordination and impact rather than creating parallel initiatives. Ultimately, when climate finance is designed around farmers' realities, it can help transform farming from a daily struggle under uncertainty into a livelihood that is resilient, viable, and sustainable in a changing climate.■

Fisheries Development in Kerala Emerging Scenario and Role of Economics Studies

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Fisheries sector has developed as a major economic avenue to generate employment and income through its operations in fishing, aquaculture, and emergence of newer value chains. Further, the sector is gaining importance from the perspective of food, nutrition, and utilisation of fish-based byproducts. The sector's contributions in entrepreneurship development spans across the realms of food industry, nutraceutical, pharmaceutical, cosmetics, fish meal and aquafoods, and byproduct utilisation. The emergence of circular economy principles, focus towards mitigation of climate change usage of greener technologies, energy efficient and cost effective logistics and supply chain management and innovative financing and marketing solutions have expanded the employment generation scope in the sector for the skilled and semi-skilled persons.

The fisheries sector is recognised as a sunrise sector and plays a crucial role in Kerala's socio-economic development. It supports the livelihoods of about 10.24 lakh fisherfolk. Kerala's fisheries economy encompasses marine and inland capture fisheries, aquaculture, processing, and exports. In 2023–24, fisheries contributed 0.8 per cent to the Gross State Domestic Product and 0.89 per cent to Gross State Value Added at constant prices, while fisheries and aquaculture together accounted for 10.77 per cent of GSVA from agriculture and allied sectors (GoK, 2024).

Every aspect of fisheries development calls for the involvement of fishers in participatory policy development, programme planning and its effective implementation. This is mainly on account of the very nature of fisheries where the property rights are largely common/ public (in case of capture fisheries), operations are collective, technologies are largely capital intensive, fishermen community is stratified by class, caste and religion, and occupational divisions are largely gender-based. The sector is also exposed to the vulnerabilities of climate change and variability, ocean currents, water pollution and a great extent of occupational hazards. Therefore, fishers and aquacultures remain as the centrality of fisheries development and governance. The subject of economics, agricultural economics, fisheries economics and allied social sciences have far reaching role in aiding the development of sector by providing sectoral insights, policy outlines, subject matter inputs and shouldering professional roles. In this background, this paper provides an overview of the major themes of economic, social and policy studies and capacity development in fisheries and aquaculture which are important for its development as an economic sector.

Fishing including small scale fishing, inclusiveness, livelihood, poverty

Fishing sector is mainly classified into capture and culture fisheries, in marine and aquatic environments. For Kerala, capture based fisheries, mainly from marine environment, remains relevant traditionally. However, inland based capture fisheries (notably in lakes and reservoirs) also has high livelihood and nutritional significance. Aquaculture, mainly shrimp based one, is also gradually expanding in Kerala.

Marine fisheries are the main source of livelihood for approximately 316,000 individuals (GoK, 2024), with fishing generating direct employment both on vessels and onshore. Additionally, it supports numerous jobs in related and ancillary sectors such as boatyards, transportation, supply chain, logistics, net mending, repair and maintenance of fishing vessels etc. Women play a crucial role in various stages of fisheries, predominantly to post-harvest activities, with significant participation rates of 79% in allied activities (CMFRI-DoF, 2020). Fishing operations

in Kerala are primarily characterized by small-scale fisheries, utilising traditional and motorised vessels, even though the contribution of the mechanised vessels including trawling is the foremost one. The five four decades have seen rapid technological advancements and capital expansion in marine fisheries. While this has resulted in increased fish catch, also gave way to over-capitalisation, which posed risks to resource sustainability and economic viability. The distributive impacts were far reaching and affected the small scale fishers and their operations.

Despite Kerala's advancements in poverty reduction, marine fisherfolk, mainly the small scale fishers, remain disproportionately affected, with nearly 60% living below the poverty line. Factors contributing to their poverty include income instability, high fishing costs, exploitative markets, indebtedness, and limited mobility due to low education and skills. The persistent issues highlighted a significant gap in inclusive development within Kerala's otherwise successful economic landscape. In response, the Government of Kerala has initiated several interventions for social protection . While these measures serve as mechanisms for poverty prevention and risk mitigation, it needs continued and interventions at various scales for bringing in sustainability.

Labour, occupational mobility and migration

Occupational mobility and labour migration have become key structural changes in Kerala's fisheries sector, particularly in traditional fisheries. Declining returns, hazardous conditions, capital intensification, improved education, demographic changes and changing aspirations have reduced local youth participation, leading many to seek alternative livelihoods. This has caused labour shortages, increasingly filled by inter-state migrants, who now make up 55–60% of mechanised boat crews and nearly 58% of the overall fisheries workforce, with Munambam harbour reaching 78% (Indian express, 2025). Migrants face low wages, health risks, and exclusion from welfare initiatives. Presence of migrant labourers has affected the very organisation of fishing with impacts on credit and crew management while fishing.

Occupational mobility and labour migration have become key structural changes in Kerala's fisheries sector, particularly in traditional fisheries.

Occupational mobility is increasingly evident among women in fisheries. Technological changes and socio-economic factors—such as education, economic progress, low wages in fisheries, drudgery, health risks, and limited access to financial support—have reduced young women's participation (Suresh et al.,2025).

Fish market, trade and entrepreneurship development

The domestic fish market in Kerala is unorganised. Domestic fish marketing remains dominated by traditional wet markets, roadside stalls, and mobile vendors, most of which lack cold-chain infrastructure and hygienic handling practices. Rising health awareness, increasing disposable incomes, and changing food habits have enhanced the value and demand for fish. However, fish quality and safety is a serious of concerns. The use of harmful chemicals such as formalin, ammonia, antibiotics, pesticides, and heavy metals, along with emerging pathogens, remains a major challenge in assuring the quality. There is minimal state interventions in establishment of hygienic fish markets and quality assurance system in domestic markets. On the otherhand, the state has a thriving fish export ecosystem. It is the third-largest seafood-exporting state in India by quantity and second by value. In 2023–24, Kerala exported 1.97 lakh MT of seafood valued at ₹7,231.84 crore (GoK, 2024).

Strengthening the "boat-to-plate" supply chain through policy support, cold-chain infrastructure, and enforcement of quality standards is essential to ensure safe fish, reduce losses, and enhance consumer confidence. This area provides entrepreneurship opportunity as well. Establishment of quality assurance and traceability system in fish can greatly improve the value and acceptance. Development of a domestic low cost certification system in this dimension also turn out to be important.

Organised and unorganised industries in Fisheries

In Kerala, the fisheries sector operates through a clear dual structure comprising organised and unorganised industries, differentiated by scale, regulation, and labour conditions. The organised fisheries industry consists of formally registered and regulated activities such as mechanised fishing units run by firms or cooperatives, large-scale fish processing and freezing plants, ice plants, peeling sheds, and export-oriented units registered with agencies like Marine Products Export Development Agency (MPEDA) and compliant with international standards such as Hazard Analysis and Critical Control Points (HACCP), and EU regulations. This segment is capital-intensive, technologically advanced, and export-driven, contributing significantly to foreign exchange earnings and formal employment.

In contrast, the unorganised sector dominates Kerala's fisheries, accounting for over three-fourths of activities and livelihoods. Employment in this segment is largely informal, characterised by low capital investment, income instability, limited bargaining power, and restricted access to institutional credit, social security, and welfare benefits as in the case of dried fish industry. Despite its dominance and its role in sustaining nearly 3.16 lakh direct workers, the unorganised nature of the sector perpetuates vulnerability and poverty, underscoring the need for stronger formalisation and inclusive policy interventions.

Input and service delivery system in fisheries

An efficient input and service delivery system is essential for improving productivity and farm income in the fisheries sector. This includes fish feed, fish seed, veterinary drugs, therapeutants, probiotics, vaccines, and water quality management chemicals. However, both fishers and input dealers face significant constraints in accessing and supplying key inputs, largely due to weaknesses in the existing delivery mechanisms. Inconsistent supply and lack of quality control continue to constrain efficient feed delivery (Katiha et al.,2003; Suresh et al.,2022).

Extension services are crucial in linking technology, inputs, and fishers by disseminating knowledge on improved practices, disease management, and sustainable fisheries. In India, fisheries extension remains weak due to limited manpower and poor last-mile connectivity. Private sector extension services has considerable scope in this domain.

Impact assessment

Technological innovations in fisheries and aquaculture have shown strong potential to enhance productivity, environmental sustainability, and socioeconomic outcomes. However, assessing their impacts remains challenging. Further, the ecological complexity and institutional diversity of fisheries systems complicate clear attribution of outcomes, highlighting the need for context-specific, adaptive, and interdisciplinary impact assessment frameworks (Arthur et al., 2010). Impact assessment of technologies and programmes is relevant for prioritization of investments, environmental protection and devising development programmes. It needs knowledge on methodologies and advanced statistical and econometric tools. Another promising area is consultancy services for developing Detailed Project Reports and technical partnerships.

Fisheries Governance and Institutions (Property rights, non-state organisation)

Property rights constitute a core issue in fisheries governance, given the common property and/or open-access nature of marine and inland fish resource. Effective fisheries management therefore depends on clearly defined and enforceable property rights embedded within robust institutional arrangements. Evidence suggests that sustainable fisheries governance cannot be achieved through state-led or community-based initiatives in isolation, but requires coordinated interactions between state institutions and non-state actors, including fishing communities and civil society organisations (Thomson, 2005; Baiju et al., 2022). Marine fishing sector has seen introduction of regulations with respect to mesh size of gears, minimum legal size for fish catch, restriction of fishing periods, fishing time and duration, spatial regulations, and regulations with respect to engine and vessel size. It needs further research for

successful implementation of the regulations.

Climate change, Risk and Adaptations

Climate change impacts on oceans are already affecting fisheries (FAO, 2018), intensifying risks related to extreme weather events, declining fish availability, loss of livelihoods, and damage to life and fishing assets. Along the Kerala coast, where marine fisheries sustain livelihoods and food security, climate change has accentuated the risks due to cyclones, rough seas, and increased weather variability. Conventional coping mechanisms and informal risk-financing strategies are inadequate to address these growing vulnerabilities. Although insurance is a key climate adaptation tool, its adoption in the fisheries sector remains limited. Strengthening climate adaptation therefore requires affordable, diversified, and innovative risk management instruments—such as weather-based and parametric insurance—supported by improved forecasting systems, technology, and institutional coordination (FAO, 2018; Suresh & Kiran, 2023; BoBP, 2022). The emergence of climate finance and carbon credit approaches in fisheries is quite important in this context.

Collective in fisheries (Cooperatives, FPOs, SHG etc)

Collective organisations such as fisheries cooperatives, Self-Help Groups (SHGs), and Fishers'/

Farmer Producer Organisations (FPOs) play a vital role in economic empowerment, market access, and resource management in the fisheries sector, particularly for women and small-scale fishers. By pooling resources and strengthening collective identity and solidarity, these institutions help overcome individual and structural constraints (Ramanathan & Rajkumar, 2013; Suresh et al., 2025). The emergence of cooperatives like Matsyafed has helped the small scale fishers.

Women-centric cooperatives and SHGs linked to fisheries have improved economic participation by providing access to credit, training, and markets. Institutions such as Matsyafed and the Society for Assistance to Fisherwomen (SAF) have supported skill development, value addition, microcredit, and entrepreneurship among fisherwomen (Shakir, 2017; Salim et al., 2019). FPOs aim to enhance production efficiency and market integration, though challenges such as limited resources, financial constraints, and managerial complexity persist. The cooperatives can act as a platform to reduce exploitation by financiers. These areas needs rural leadership, technical assistance and research & policy supports.

Consumer preference (consumer behaviours, quality and safety etc).

Fish is a vital source of protein, micronutrients, and essential fatty acids, but it is also vulnerable to contamination from environmental pollution and unsafe handling practices. Consumer preferences for fish are largely shaped by perceptions of quality, safety, and health benefits, with notable variation across income groups and product types. Quality emerges as the most influential attribute, especially for value-added fish products. Emerging trends also reveal rising awareness of health,

Technological innovations in fisheries and aquaculture have shown strong potential to enhance productivity, environmental sustainability, and socioeconomic outcomes.

environmental safety, and sustainable production practices, signalling a gradual shift towards more informed and selective fish consumption (Rahman et al., 2021).

At the policy level, aquatic foods in India face growing risks from emerging pathogens and the use of harmful substances such as formalin, antibiotics, pesticides, and heavy metals, compounded by the absence of a comprehensive safety framework for domestically consumed fish (NAAS, 2024). This domain offers high entrepreneurship potential and research towards consumer preference and market studies.

Gender studies and Intersectionality

"Feminisation in fisheries" has been one of the most important themes addressed by gender studies in fisheries over the decades worldwide. Numerous studies show that, in the absence of any significant change in asset-holding structures or power relations, their considerable contribution to fisheries has not resulted in meaningful gains for them (Hapke and Ayyankeril, 2018; Gopal et al.,2014;Rejula et al.,2023).

An intersectional perspective shows that women's experiences in fisheries are mediated by caste, class, occupation, marital status, and age, leading to uneven forms of empowerment (D'souza, 2020; Kalpana). Although women dominate fisheries-allied activities and play a critical role in household welfare and value chains, their work remains informal, insecure, and poorly remunerated (CMFRI–DoF, 2020; Menon, 2021). Addressing these inequalities requires gender-sensitive and intersectional policies that recognise women as fishers, strengthen collective capabilities, and integrating equity concerns into fisheries governance (FAO, 2017; Rejula et al., 2023; Suresh et al., 2025).

Conclusion

Fisheries sector has high potential for employment generation, income contribution and entrepreneurship development, both in capture and culture fisheries, marketing, value addition, and delivery of inputs and services. However, the sector needs policy inputs and targeted programmes. The corner stone is that development of fishers and aquaculturists is central to fisheries development. Further, the sector needs insightful studies and skilled professionals in the domain of economic and social sciences for its development.

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Poverty-proofing agricultural households in Kerala


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Kerala has long been hailed as India's development beacon, blending high human development with social equity. In 2024, the state ranked first in the National Family Health Survey (NFHS-5) for literacy (nearly 97%), life expectancy (over 75 years), and gender parity in education. Kerala's approach to poverty reduction has been both innovative and deeply personalized, a rights-based approach playing a pivotal role. The state's Extreme Poverty Eradication Programme (EPEP), launched in 2021, identified 64,006 families as extremely poor and implemented a four-year, multi-phase strategy to lift them out of poverty by November 1, 2025. A significant component of the project was the "Avakasam Athivegam" (Rights Fast) campaign, which made access to essential documents (ration cards, Aadhaar, health insurance), housing, and healthcare, ensuring holistic support. Yet within this broader success story, agricultural households remain a critical group vulnerable to poverty. In this article, we discuss what we can learn from the success of extreme poverty reduction and how to apply this approach to make agricultural households poverty-proof in Kerala.

At first glance, agricultural households appear to be doing reasonably well. The agricultural households have shifted from agriculture as a primary occupation to non-farm employment. The recent survey estimates from the Situation Assessment Survey of Agricultural Households in Kerala (2025) show that the average monthly income of agricultural households was ₹28,984 in 2024, up 61.8% from ₹17,915 in 2019 . However, this rise masks important structural issues. A large share of income of about 61% (₹17,597) comes from wage labour, while net receipts from crop production contribute only 23%. This indicates that agriculture alone is often insufficient to sustain livelihoods, forcing households to depend on non-farm employment and casual work.

At first glance, agricultural households appear to be doing reasonably well. The agricultural households have shifted from agriculture as a primary occupation to non-farm employment.

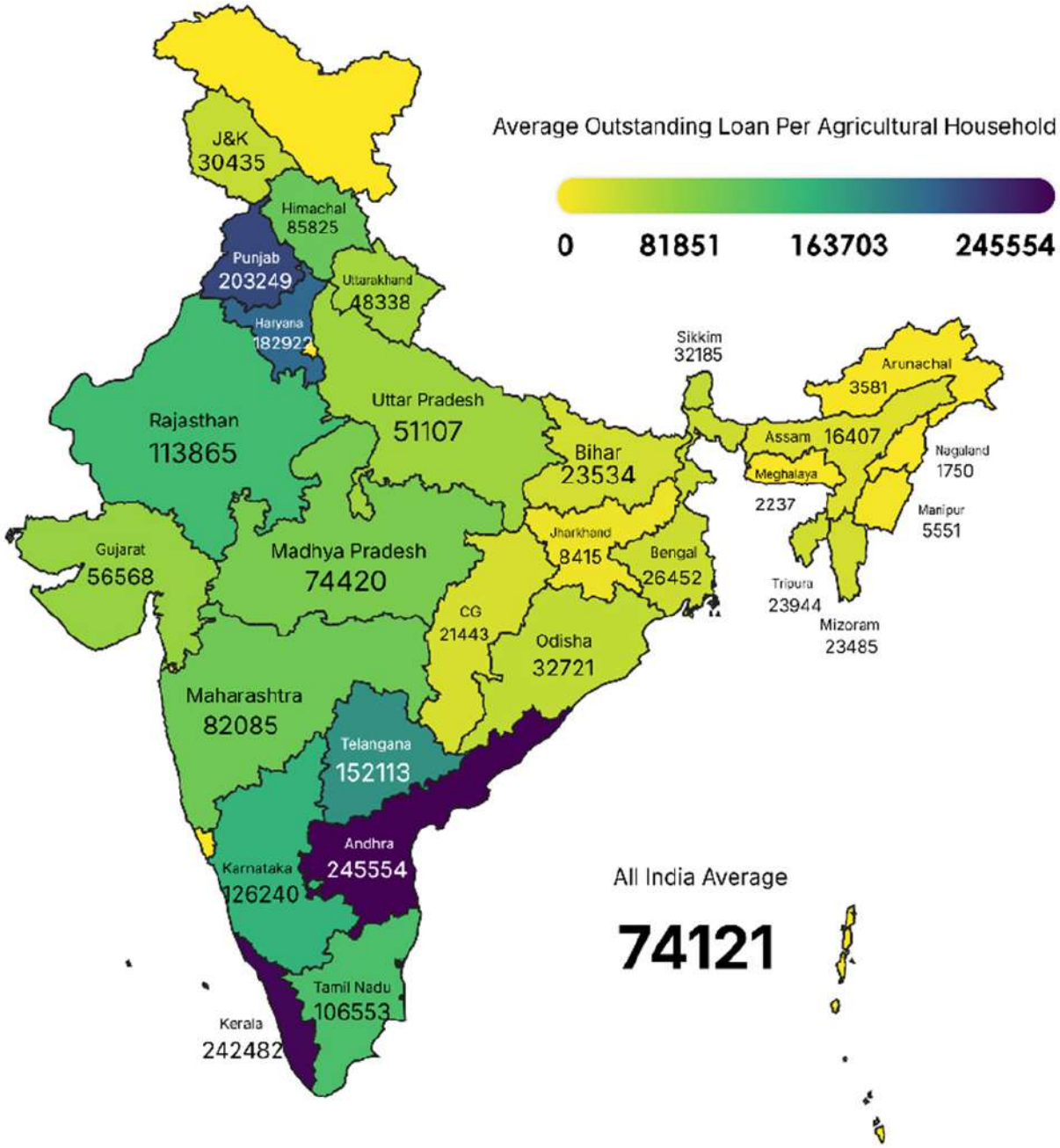

Figure 1. Average amount of outstanding loan per agricultural households in India

Source: Developed by authors based on NSS Report No. 587: Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019.

Despite observed income gains, agricultural households remain exposed to systemic vulnerabilities stemming from high indebtedness and growing climate risks. Agricultural households in Kerala carry high levels of debt, driven by rising cultivation costs, land-leasing expenses, and the need to smoothen consumption amid unstable farm earnings. According to the National Sample Survey (NSS) Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India (2019), agricultural households in Kerala carry a significantly higher loan burden than the national average. The average outstanding loan per agricultural household in Kerala stands at ₹2,42,482, which is more than three times the All-India average of ₹74,121 (Figure 1). In addition, 69.9% of agricultural households in Kerala are indebted, considerably higher than the national average of 50.2%. This indicates that while Kerala farmers may have relatively better access to institutional credit, they are also exposed to a much higher level of debt per household than farmers across India as a whole, reflecting deeper credit dependence and potentially higher financial vulnerability in the state.

Photo: Paddy fields in Elevancherry panchayat, Palakkad, Kerala with monsoons looming over. This is a study area of Subash's ongoing work on cash transfers.

Financial vulnerability is further compounded by growing climate uncertainty. Agricultural livelihoods are highly sensitive to climate variability such as erratic rainfall, floods, droughts, and pest outbreaks. Climate shocks directly reduce crop yields and farm income, while also increasing production costs. Kerala has experienced a significant decline in annual rainfall over the last five decades, averaging a decrease of 4.33 mm per year. Seasonal rainfall patterns have also shifted, with monsoon and post-monsoon seasons showing declining trends, while winter and summer seasons have seen increases. At the same time, both mean and maximum temperatures have risen steadily at seasonal and annual scales at a rate of 0.20^{o}C per decade. The frequency of climate extremes, particularly floods and droughts, has increased, although the timing and transition between these events remain inconsistent, suggesting prolonged dry spells in the future.

Kole tracts of Central Kerala. Plantation crops which account for nearly 60% of cropped area also faced heightened yield risks due to climate change. Coconut plantations in particular are highly vulnerable to prolonged dry spells while shift in rainfall patterns and heat stress have increase yield risks in high value crops like pepper, coffee and tea. Rubber cultivation also faces uncertainty due to decline in latex flows, latex duration and yields due to rising temperature. Since agriculture households rely heaving on wage labour and seasonal farm income, climatic shocks can disrupt both farm and non-farm employment opportunities.

Loan and climate risks reinforce each other. Climate-induced crop losses disrupt wage-labour opportunities, weakening farmers' ability to repay loans and forcing them to borrow further to service existing debt. This deepens financial vulnerability and increases the likelihood of distressed asset sales or withdrawal from farming. Inadequate crop insurance coverage and weak risk-mitigation mechanisms intensify this interaction, leaving households more vulnerable to poverty despite rising average incomes. The Situation Assessment Survey of Agricultural Households in Kerala (2025) also highlights limited access to institutional risk-mitigation tools. Only 14% possess Kisan Credit Cards, and crop insurance coverage is extremely low (about 3.7% of households). This weak safety net increases vulnerability, particularly for small and marginal farmers. These findings point to the limits of traditional interventions, underscoring the need for a proactive, risk-focused poverty reduction framework.

Poverty-proofing agricultural households in Kerala requires extending the state's successful rights-based poverty framework into the agricultural sector, with a stronger focus on risk management. Building on the EPEP, agricultural households facing high debt and climate exposure could be proactively identified and supported through targeted cash transfers linked to livelihood and risk indicators. Evidence from World Bank studies on anticipatory cash transfers shows that providing timely, predictable support before climate shocks such as floods or droughts helps households avoid distress borrowing, asset sales, and long-term poverty traps. Integrating anticipatory cash transfers with early-warning systems, crop loss triggers, and debt-stress indicators can help stabilize incomes during shocks. By combining income support, risk anticipation, and institutional access, Kerala can adapt the EPEP model to ensure that agricultural households are not only lifted out of poverty but protected from falling back into it. ■

Rice the staple food crop in Kerala is particularly vulnerable to climate change. Shift in rainfall patterns and increase in rainfall intensity has substantially increased crop loss risk in paddy cultivating belts of Kuttanad and Palakkad.

Agricultural Trade and Value Chain Dynamics

A Kerala perspective

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Kerala's agriculture is characterized by the cultivation of trade-dependent plantation crops and spices, which are either export-oriented or serve as import substitutes. These crops account for more than two-thirds of Kerala's total cultivated area; consequently, the state is highly sensitive to changes in the national and international trade environments. The state's vulnerability to price volatility has increased with market liberalization. This has significant welfare implications for producer households and all participants in the commodity value chain, as higher volatility increases risk-management costs, which eventually translates into higher consumer prices.

Globalization of trade, liberalization policies, and the growth of ICT have integrated Indian commodity markets more closely with international markets. Consequently, domestic prices for most commodities have become volatile, leading to unstable farm incomes.

This instability dissuades farmers from making long-term investments, especially since the flexibility of Kerala's cropping patterns to adjust to market dynamics is limited.

Price volatility is thus a priority policy issue. In this dynamic environment, market intelligence is essential for informed decision-making and ensuring remunerative prices. A clear understanding of price mechanisms and reliable forecasts helps farmers achieve stable incomes. Agricultural economists can provide the market intelligence and price forecasts needed to help farmers make "smart" decisions regarding cropping patterns, planting and harvest timing, storage, and sales locations. Such intelligence is also vital for ensuring stable income through support mechanisms like Minimum Support Prices (MSP) and price deficiency payments.

Rising living standards have led to a diversification of agricultural demand, with consumption baskets shifting toward non-cereals, processed products, exotic fruits, and organic produce. This shift is global, and producers now operate in an international marketplace. While differences in climate and technology have led to cross-border specialization, intra-industry trade—especially in processed products—is also rising. This has become a central factor driving agricultural trade in the Global South, particularly in India.

Simultaneously, the resurgence of trade protectionism and geopolitical tensions has forced countries to strategically negotiate trade agreements to protect their specialized sectors. Despite decreasing tariffs due to liberalization and Regional Trade Agreements (RTAs), many countries now resort to Non-Tariff Measures (NTMs) to safeguard sensitive sectors. In some cases, trade restrictions are disguised as Sanitary and Phytosanitary (SPS) or Technical Barriers to Trade (TBT) measures.

The rising compliance costs associated with these barriers reduce trade competitiveness, making trade policy analysis extremely significant.

While integration into global value chains—driven by trade, technology, and logistics—is expected to enhance productivity and economic growth, meeting international quality standards is a daunting task for resource-poor smallholders. This risk of marginalization necessitates tailored policies to ensure inclusive benefits. In the Indian context, many value chains see prices increase without actual value being added to the produce, leaving primary producers at the bottom of the chain. Value chain analysis is therefore crucial to identify where value is created, who creates it, and how profits are shared. Assessing competitiveness, inclusiveness, and sustainability is essential for designing interventions that enhance market access and ensure equitable growth across agricultural markets. ■

Virus Elimination through in Vitro Chemotherapy

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Plant viruses have emerged as a major threat to global horticulture in recent years, causing serious yield reductions and economic losses. Worldwide, crops suffer extensive damage from both biotic and abiotic stresses, with viral diseases alone accounting for nearly 40% loss in crop yield, greatly affecting productivity and quality. The global economic impact is equally alarming- plant viral infection result in about USD 30 billion in losses every year (Jones and Naidu 2019). To date, more than twenty-five plant virus families have been identified, infecting a wide range of crop species and contributing to substantial agricultural losses. Given the widespread damage caused by plant viruses, ensuring the availability of virus-free planting material has become a critical priority for sustainable crop production.

Importance of Virus-Free Planting Material

The persistent and widespread incidence of plant viruses across major crop systems highlights the critical need to ensure clean, virus-free planting material. The rise and recurrence of viral diseases are strongly influenced by several modern agricultural and environmental factors. These include:

1. **Extensive monocropping**, which narrows genetic diversity and increases crop susceptibility to viral pathogens.
2. **Intensified international movement of plant materials**, facilitating the long-distance transport of infected propagules.
3. **Changing climatic conditions**, which modify the abundance, distribution, and activity of insect vectors.
4. **The rapid evolutionary capacity of plant viruses,** enabling them to adapt quickly to new hosts and environments.

Although managing insect vectors continues to be a cornerstone of virus control, available measures often provide insufficient protection, especially under high disease pressure. Overall, plant virus management strategies can be grouped into two major categories:

- Immunization-based approaches, such as breeding and deploying resistant cultivars, utilizing cross-protection, or incorporating virus-resistance genes through genetic engineering.
- Prophylactic strategies, which aim to restrict virus dissemination by enforcing certification schemes, implementing quarantine protocols, controlling vector populations, and removing infected tissues or plants.

To overcome these challenges, several in vitro virus-elimination methods have gained significant attention, including meristem culture, chemotherapy, thermotherapy, cryotherapy, and electrotherapy. Across these approaches, virus removal rates range from 50% to 100%, depending on the virus, host species, and protocol used. Among them, chemotherapy involves adding antiviral compounds to the culture medium to suppress viral replication (Szabo et al., 2024).

Chemotherapy for Plant Virus Elimination

Plant virus chemotherapy refers specifically to the use of antiviral chemicals to obtain healthy, virus-free plants from infected material. The antiviral substances available for plant use do not kill the virus directly; rather, they act by suppressing viral replication, which in turn stops the infection from moving throughout the plant. Although the fundamental concept is similar to chemotherapy used against viruses in humans and animals, the approach differs because of the unique biological features and growth patterns of plants.

Since plants lack a true immune system and plant viruses remain persistently active within host tissues, chemotherapy in plants aims to completely halt viral replication. This approach ensures that any structures formed during treatment—such as meristems, shoots, bulbs, corms, tubers, seeds, or suckers—develop free of the virus, allowing them to serve as virus-free starting material for large-scale propagation. The cost of plant virus chemotherapy is generally too high to justify direct curative treatment of producing field plants or trees. Therefore, plant virus chemotherapy is primarily employed for producing virus-free planting stock rather than for treating virus-infected plants in commercial production (Hansen, 1988).

How Antiviral Chemicals Work

Understanding the biochemical targets and modes of action of antiviral agents is crucial before applying chemotherapy to ensure both treatment effectiveness and host tissue survival. Inosine monophosphate dehydrogenase (IMPDH) is a central enzyme in the formation of guanine nucleotides required for viral RNA and DNA synthesis; inhibitors of IMPDH block the conversion of IMP to XMP and thereby interfere with viral nucleic acid production. Antiviral agents can also act on S adenosyl homocysteine (SAH) hydrolase, an enzyme involved in the processing and maturation of viral mRNAs (Dolatabadi et al., 2023; Thanuja et al., 2025). Antiviral nucleoside analogues are widely used because they interfere with key steps in viral nucleic acid synthesis. For example:

- Ribavirin chemically known as 1-β-D-ribofuranosyl-1,2,4-triazole-3-carboxamide, the most popular choice (also sold as Virazole), tricks the virus into making faulty copies of its genetic material, stopping it from spreading.
- Acyclovir stops DNA viruses from copying their genome, while DHT targets viruses that use reverse transcriptase to build their DNA.
- Other drugs such as zidovudine, 3-deazauridine, vidarabine (9-β-D-arabinofuranosyl adenine), 2-thiouracil work similarly by breaking the viral replication chain.

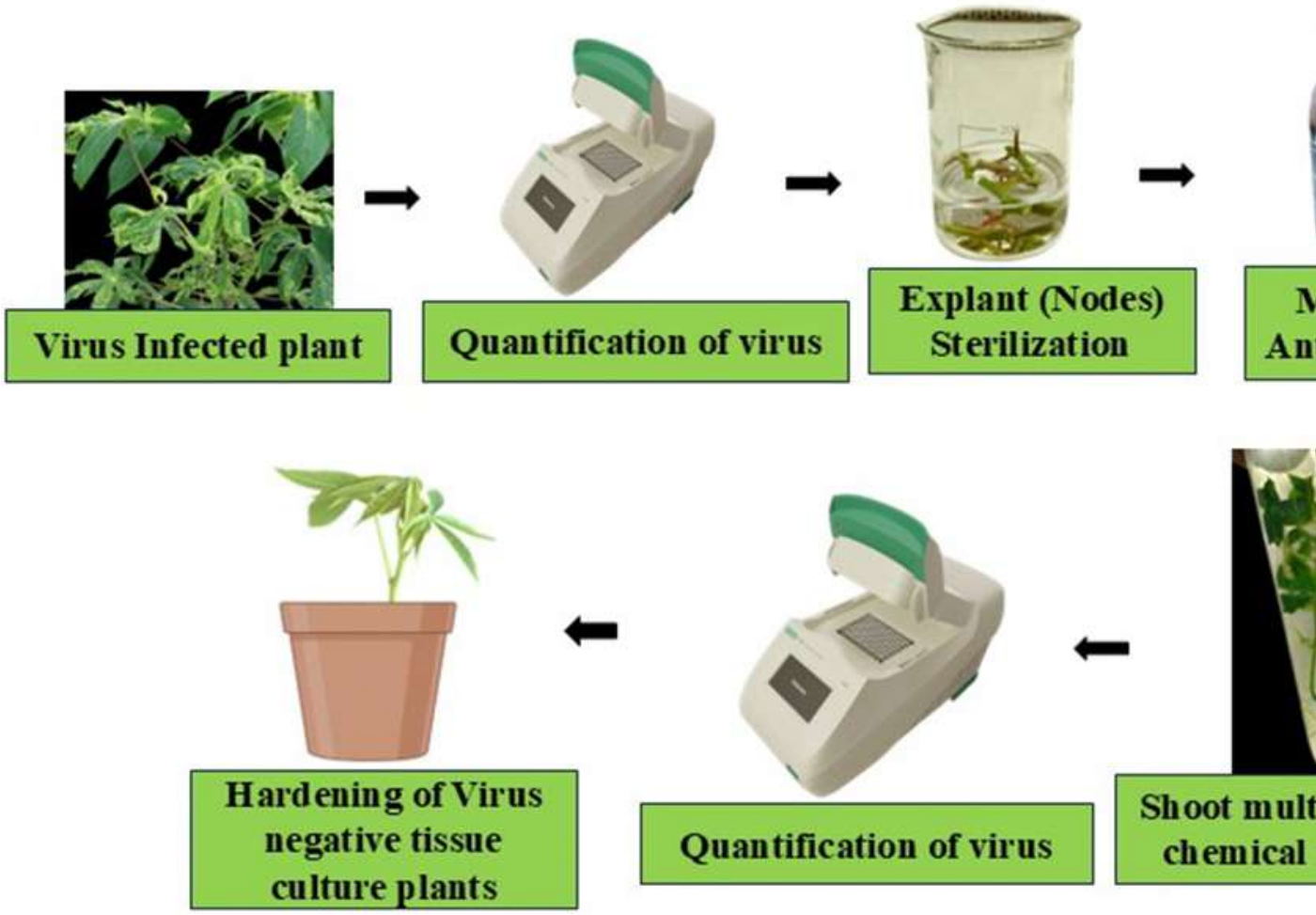


Fig:1 Schematic Representation of Plant Virus Chemotherapy Procedure

- Even plant hormones like salicylic acid and jasmonic acid help plants fight back.
- In peach trees, scientists tested acyclovir and rimantadine—both human flu drugs—and found they could produce virus-free plants.

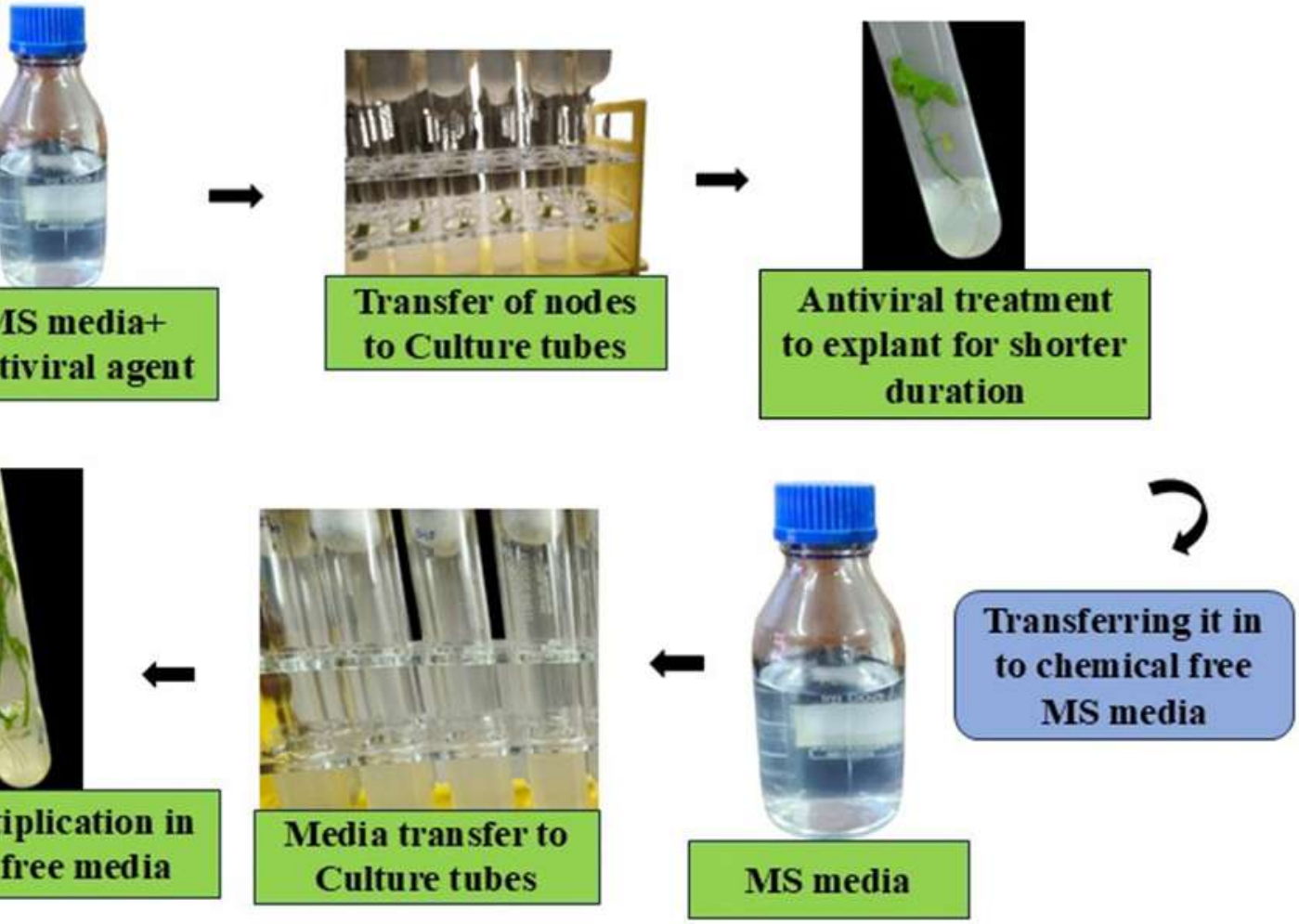
Ultimately, antiviral therapy induces lethal mutagenesis, reducing the number of infectious virus particles and enabling the regeneration of healthy, virus-free plantlets.

Both single and repeated applications of antiviral agents effectively reduce viral loads in tissue culture, with sequential treatments showing superior results. Combining multiple antivirals can further enhance virus eradication. However, many of these compounds carry risks of phytotoxicity, leading to symptoms like chlorosis, shoot-tip necrosis, and stunted growth—effects that intensify at higher doses. For this reason, pinpointing the right chemical, concentration, and exposure duration is critical to maximize virus-free plant recovery while preserving healthy shoot development and multiplication rates.

In this method, plants showing disease symptoms are first identified and their viral infection is confirmed through diagnostic assays such as PCR or ELISA. From these confirmed infected plants, small shoot tips or nodal explants are carefully excised, surface-sterilized, and transferred onto culture medium supplemented with an antiviral compound at optimized concentrations. The explants are maintained on this medium for a specific treatment duration, after which the surviving shoots are transferred to an antiviral-free medium for further shoot multiplication. This results in the regeneration of healthy plantlets in vitro. The regenerated plants are then re-tested for the presence of the virus, and only those that test negative are selected, hardened and maintained as virus-free planting material.

Conclusion

Plant viral diseases remain a major constraint on horticultural productivity, underscoring



the importance of reliable systems for producing virus-free planting material. Among in vitro sanitation methods, chemotherapy is a promising option because antiviral compounds disrupt key steps in viral nucleic acid replication, lowering viral load and enabling recovery of healthy plantlets. However, its wider use is limited by phytotoxicity, the need for crop and virus specific optimization, and relatively high costs. Careful refinement of each crop-virus-chemical combination is therefore essential to balance virus elimination with acceptable plant growth. Future progress in safer antiviral molecules, synergistic treatment schemes and scalable culture platforms will be key to establishing chemotherapy as a robust component of plant virus management.

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Arecanut
Beyond Chewing - Exploring Sustainable Alternative Uses

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Arecanut (Areca catechu L.), widely cultivated across India, Sri Lanka, Bangladesh, Indonesia, and Southeast Asia, is traditionally valued for chewing as paan. However, rapid environmental policies, emerging circular bioeconomy trends, and the global shift toward biodegradable, plant-based materials have opened new opportunities for utilizing arecanut and its by-products. The by-products such as husk, fruit coat, leaves, leaf sheath, and fiber offer immense value for natural dyes, biodegradable plates, textile applications, packaging, crafts, medicinal products, and eco-friendly business ventures. This article explores innovative uses of arecanut, with special emphasis on cloth dyeing, eco-plate manufacturing, and sustainable value-addition technologies.

Arecanut is an important commercial plantation crop grown predominantly in southern and northeastern India. Traditionally used for chewing, the crop generates large quantities of agricultural waste including husk (70–80%), leaf sheath, spadix, and plant residues. Earlier considered useless or discarded, these components now serve as raw material for industrial, environmental, and artisanal innovations. With increasing demand for chemical-free dyes, biodegradable packaging, and sustainable alternatives to plastic and synthetic materials, arecanut-based products have become an attractive research and entrepreneurial domain.

1. Arecanut Dye: A Natural and Sustainable Option for Textiles

Source of Dye

Arecanut dye is mainly extracted from:

Arecanut soap

Areca malt energy drink

Areca Tea

Arecanut timber used as chair

- Arecanut husk
- Arecanut seed (immature and mature)
- Outer pericarp or shell

These parts contain natural tannins, polyphenols, flavonoids, and catechins, making them suitable for dyeing natural fibers such as cotton, silk, wool, bamboo fiber, coir, and jute.

Dye Extraction Process

1. Cleaning and drying of husk
2. Boiling with water (1:20 ratio)
3. Addition of natural mordants (optional)
4. Filtering and concentrating the dye

Natural mordants include:

Mordant	Resulting Shade
Alum (Potassium aluminium sulphate)	Light brown
Iron sulphate	Deep chocolate brown
Copper sulphate	Reddish-brown
Vinegar / Tamarind extract	Soft tan shades

Shades and Fastness

Arecanut dye produces shades ranging from cream, tan, walnut brown, maroon, coffee brown to deep chocolate black depending on extraction period, temperature, and fabric type.

It is known for:

- Good colour fastness
- Resistance to washing and sunlight
- Skin-friendly, non-toxic properties

Applications of Arecanut Dye

- Handlooms and Khadi fabrics
- Natural clothing brands
- Traditional silk weaving
- Tie and dye / Batik / Shibori
- Leather dyeing
- Yarn dyeing for carpets and mats

With rising demand for organic clothing and chemical-free textile processing, arecanut dye is now used in sustainable fashion and ayurvedic textile therapies.

2. Arecanut Leaf Plates A Biodegradable Solution to Plastic Waste

Raw Material: Arecanut Leaf Sheath

The dried leaf sheaths shed naturally from arecanut palms are:

- Strong
- Heat resistant
- Odourless
- Naturally biodegradable within 60–90 days

Plate Manufacturing Process

1. Collection of naturally fallen sheaths
2. Cleaning and trimming
3. Heat pressing using moulds
4. Drying and finishing
5. Final sterilization (optional steam treatment)

Applications

- Disposable plates, cups, and bowls
- Food packaging trays

Ornaments made with arecanut

Areca tooth powder

Painted areca plate

Plates made with Arecanut leaf sheath

- Take-away containers
- Catering and event supplies
- Airline food packaging

These products are widely accepted in export markets (Europe, USA, UAE) due to bans on single-use plastics.

Environmental Benefits

- 100% biodegradable
- Compostable
- Reduces landfill burden
- Chemical-free production
- Promotes rural employment and women-led industries

3. Other Emerging Uses of Arecanut

Fiber and Composite Boards

Arecanut husk fibers can be converted into:

- Particle boards
- Insulation panels
- Furniture boards
- Car dashboard panels
- Decorative sheets

These serve as eco-friendly alternatives to plywood and plastic boards.

Biochar and Organic Fertilizer

Arecanut waste can be processed into:

- Biochar
- Vermicompost
- Organic potassium fertilizer
- Mulching material

Activated Carbon

Arecanut shell-based activated carbon is used in:

- Water filtration units
- Cosmetic scrubs
- Ayurvedic formulations
- Air purification systems

Cosmetics and Medicinal Uses

Extracts from arecanut contain:

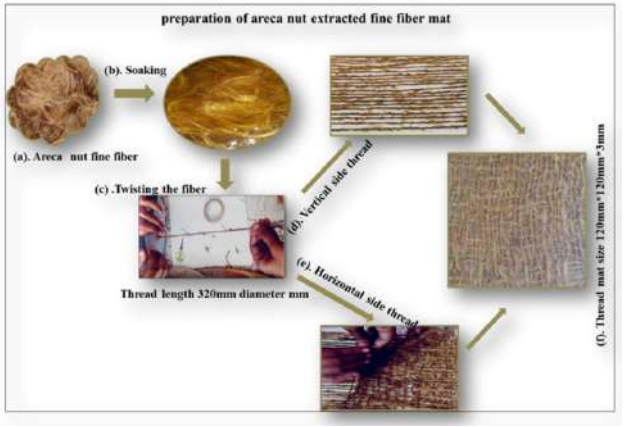
- Catechins
- Alkaloids
- Antioxidant compounds

They are used in:

- Herbal mouthwash
- Hair dye
- Anti-fungal preparations
- Ayurvedic formulations

4. Entrepreneurship and Market Potential

The growing eco-consumer lifestyle, ban on plastics,



and increasing awareness of natural dyes have created opportunities for:

Product	Market Type	Profit Potential
Cloth dye & textile craft	Boutique/ exclusive	High
Leaf plates & packaging	Mass market	Very high
Composite boards & eco-furniture	Industrial	Long-term high
Cosmetics & medicinal extracts	Niche	Premium

Government support through schemes like PMFME, Startup India, KVIC, State Rural Livelihood Missions, and export incentives encourage startups in this sector.

Conclusion

Arecanut, once known only for chewing purposes, has transformed into a versatile raw material for eco-friendly dyeing, biodegradable tableware, natural crafts, industrial composite materials, and sustainable packaging solutions. The shift from waste to value-added products not only supports environmental sustainability but also provides rural livelihood, entrepreneurship, and export opportunities. ■

Terrariums to Turnover

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Tropical terrarium

Succulent terrarium

In recent years, the world has witnessed a lush revolution in the field of indoor gardening and greening urban areas. Terrariums are a major part of this revolution. What began as a personal passion for many, are now blooming into a full-fledged business. Young entrepreneurs, homemakers, and even professionals from fields like nursing and IT are finding both solace as well as income through the process of terrarium making.

Wondering what a terrarium is? Its basically a miniature slice of nature in a closed container. Or can also be described as the art and technique for growing plants generally in a sealable glass container, containing soil, and can be opened for maintenance to access the plants inside. It adds an intriguing natural element to any indoor spaces and can be accommodated anywhere like homes, offices and restaurants to impart life and colour.

And the fact that why terrariums are gaining such popularity is simple – they're compact, low maintenance, and add life to dull corners. In urban areas with limited time, space, and sunlight, terrariums bring a touch of green without the fuss. In addition, they give clean air. Having a

Air plant terrarium

terrarium in offices and rooms lifts one's mood, boosts creativity and reduces stress.

Terrariums, as we know them today, were invented in 1829, by British physician and botanist Nathaniel Bagshaw Ward. He discovered that plants could thrive in sealed glass containers while observing a moth chrysalis. This led to the use of terrariums for growing plants indoors and for transporting plants over long distances. And later, to the invention of smaller ornamental terrariums popular today.

Terrariums aren't just decorations anymore. They're gifts, centrepieces, teaching tools and even therapy objects-bridging nature and design in a sustainable way. It has even turned into a favourite element used by interior designers, as its an attractive way to integrate plants into any home furnishings.

Open terrarium with Orchid

Types of Terrariums

Terrariums are mainly classified into Open and Closed terrarium.

Open terrarium are open to the atmosphere, having access to fresh air through the opening of the container. It is well suited for plants that prefer less humidity and soil moisture and more of sunlight. Whereas closed terrarium are sealed shut with a lid or cork. The sealing helps to maintain moisture inside it. The ones with a loose fitting glass lid needs to be watered only in every 3 months. While the ones with tight sealing can stay closed without needing any water.

Based on the selection of plants, terrarium can be further classified into air plant terrarium, succulent terrarium, tropical terrarium, hanging terrarium, tray terrarium and dish terrarium.

Making a Terrarium

The process of making a terrarium is both science and art. Whether you're doing it as a hobby or preparing a product to sell, the process is wholly satisfying. It mainly involves layering materials with care.

Materials needed

- A clear glass container (jar, bowl, bottle, light bulb, glass cloche or aquarium) or any vessel which is chemically inert.
- Pebbles or small stones (for drainage)
- Activated charcoal (to filter and prevent odour)
- Potting soil (based on plant type)
- Plants (succulents, mosses, ferns, or air plants)
- Decorative elements (shells, figurines, coloured sand—optional)
- Long tweezers or a stick (to place items neatly)
- Spray bottle (for misting)

The first step in terrarium making involves choosing the right container. Open containers work well for succulents and cacti that prefer dry environments. Closed terrariums are better for humidity-loving plants like

mosses and ferns.

The second step is to add a drainage layer. Begin with a 1–2 inch layer of pebbles or stones at the bottom. This prevents water from pooling at plant roots, which can cause rot. After this, sprinkle a thin layer of activated charcoal above the pebbles. It helps absorb toxins and keeps the terrarium fresh, especially in closed models.

Then add enough potting mix (1:1:1:1 ratio of soil : sand : Farm Yard Manure : coco peat) for your plants to take root. Succulents need sandy, well-draining soil; ferns prefer richer, moisture-retaining mixes. After this, using tweezers or your fingers, carefully place your plants into the soil. The largest plants among the selected ones can be planted in the middle of the glass container, and then the smaller ones can be planted around. Gently press the roots in and make sure each plant has room to grow.

Decorate your world by adding mosses, stones, coloured sand, or small figurines to give your terrarium the perfect look. This is where creativity shines—some make fairy gardens, others mimic forests or deserts.

How long can they live? With proper care, a terrarium can live for many years, with the oldest known terrarium almost 60 years old! Terrariums are extremely easy to care for and require minimal effort to thrive.

Selection of suitable plants

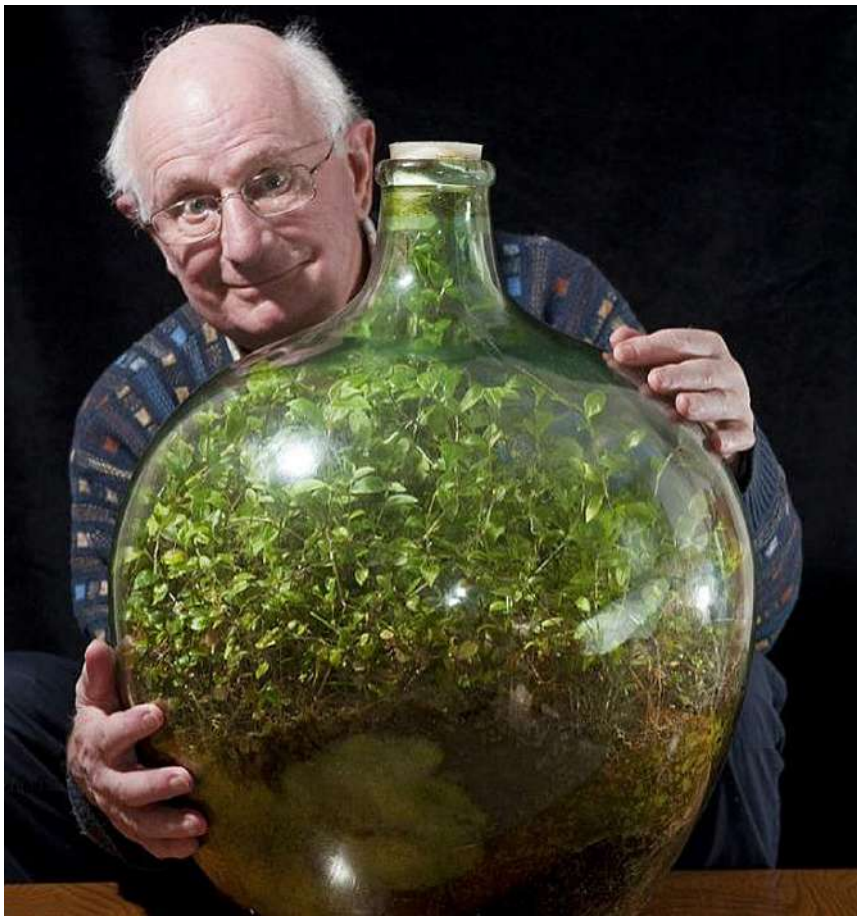
In Kerala, where the climate is humid, makers are adapting by choosing hardy plants like ferns, moss, succulents, and air plants. Some of the most suitable plants for Terrarium include :

1) Ferns like Pellaea rotundifolia, Phlebodium aureum, Davallia fejeensis, Adiantum microphyllum, Nephrolepis cordifolia, Nephrolepis exaltata, Adiantum raddianum
2) Peperomia species like Peperomia prostrata, Peperomia rotundifolia, Peperomia tetraphylla, Peperomia caperata
3) Air plants like Tillandsia ionatha, Tillandsia bulbosa, Tillandsia stricta
4) Foliage plants like Begonia maculata, Calathea orbifolia, Philodendron hederaceum, Pellaea rotundifolia, Syngonium podophyllum, Fittonia albivenis, Tradescantia zebrina, Pilea glauca
5) Mosses like Leucobryum glaucum, Thuidium delicatulum, Hypnum cupressiforme, Tortula ruralis, Selaginella kraussiana
6) Bromeliads like Cryptanthus Bivittatus, Neoregelia
7) Orchids like Paphiopedilum, miniature Phalaenopsis, Masdevallia, Pleurothallids, Jewel orchids and Miniature Angraecum

Other must-have plants in a terrarium are Dracena borgata, Hedera helix, Pothos, Pentas, Spathiphyllum, Chlorophytum, Aloe vera, Sansevieria and Calla lily. Also, money plants, jade and syngonium are among the most preferred terrarium plants.

Designing a terrarium

The terrarium can be designed according to the creativity of the designer. Particular themes can be selected, like, tropical rain forest, fairy garden, waterfall, desert, water garden etc. The shape of the container,



David Latimer's 60 year old terrarium.
Picture from : www.tropicalglass.co.uk

decorative elements and plants can be chosen according to the theme.

Certain principles should be followed while designing a terrarium. They are :

1) Balance: A state of equilibrium should be created either symmetrically or asymmetrically around the central axis. Symmetry can be created with exact duplication on both sides. Whereas, asymmetry creates curiosity and can be achieved by including different colour, texture and shape on either sides.

2) Unity and Harmony: It refers to the overall effect of all the elements, colours and features to the whole of the terrarium. It can be attained by following the rule of three- planting in odd numbers.

3) Proportion or Scale: Its the size of one component relative to another. This can be attained by planting small / fine textured plants on the periphery and large / coarse textured plants on the centre.

4) Focal point: The point where the viewer is first attracted. Different coloured rocks, small statues or different coloured / textured plants can be used for this.

5) Rhythm: Can be achieved by repetition of an object or plant in a cyclic pattern.

6) Simplicity: Avoid overcrowding with plants or other objects.

Care and Maintenance

Terrariums can live upto many years with proper care. They must be watered to create an ideal environment for the growing plants. Watering can be done with a sprayer with utmost care. Water only enough to keep the substrate damp. Overwatering can lead to rotting of the plants. Open terrariums should be watered weekly once. At the same time closed terrariums with loose fitting lids needs to be watered only in every 3 months. Whereas closed terrariums with tight enclosures can stay without needing water at all!

Another important factor to consider is the lighting. Do NOT keep the terrarium under direct sunlight. Instead, keep it under bright indirect sunlight or under artificial LED lights. Also, artificial light is more consistent compared to natural light during cloudy days. An LED light of 5w-10w power consumption with 5500k-7500k white light is recommended as this best replicates natural sunlight. And a good lighting cycle is 12 hours on and 12 hours off, this provides the optimum time period for plant growth.

Other care practices include removing the dead leaves and plants inside to make the terrarium look clean. Also, keep the glass of the container clean from algae or other buildups inside. Clean it off with a paper towel or cloth. Otherwise, light will be blocked from reaching the plants.

Sand art terrarium

A sand art terrarium is a visually striking miniature garden that combines vibrant layers of colored sand with low-maintenance plants like succulents or cacti, all arranged within a transparent glass container. Unlike traditional terrariums, sand art

terrariums focus on both artistic expression and plant display, making them a perfect blend of nature and creativity. To make one, start by adding a drainage layer of gravel, followed by activated charcoal, a small pocket of potting soil for the plant, and then carefully layer colored sand in decorative patterns. Finally, place the succulent in the soil and add finishing touches like pebbles or miniature figurines. These terrariums are easy to make, require minimal upkeep, and serve as beautiful decorative pieces for homes, offices, or classrooms. For care and maintenance, place them in a bright location with indirect sunlight, water sparingly only when the soil is dry, and avoid disturbing the sand layers to maintain their artistic appeal.

Turning into business

Setting up a terrarium business requires minimal space, minimal investment in raw material and maximum attention to detail. Most ventures begin at home or small studios, with recycled glass jars and a few succulents. As demand grows, so do options—closed terrariums, moss art, preserved plants, bottle ecosystems and even customized pieces.

Terrariums stand out as eco-friendly, aesthetic, and long-lasting alternatives to traditional gifts. Whether it's a birthday, weddings, anniversary, housewarming, or festive occasion, terrariums are appreciated for their symbolic value of life, growth, and sustainability.

Another scope lies in its interactive element. Entrepreneurs don't just sell finished products—they also conduct live workshops at cafes, colleges, and exhibitions. Many offer DIY kits with complete instructions, making it easy for anyone to build their own miniature forest.

With innovative designs, from hanging jars to bike-shaped planters, pricing depends on size and design. Starting from ₹200 for small simple pieces and going up to ₹3,000+ for elaborate setups. With workshops, custom orders, and curated kits, average monthly earnings can range from ₹20,000 to ₹60,000 for a moderately active seller.

Marketing of terrariums can be done through social media platforms like Instagram, Facebook, Pinterest etc and also through Flipkart, Amazon etc. Offline marketing can be done through Nurseries, Home decor shops, by participating in local craft fairs, farmer's markets, by corporate gifting etc.

Terrariums are more than just decor. They're a creative expression, a mindful craft, and a blossoming business. For many, it's not just about growing plants, but growing purpose. As more people seek nature in concrete spaces, these miniature gardens promise more than beauty—they offer serenity, sustainability, and now, serious turnover!

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Gac Fruit

An exotic "super fruit" hidden inside a spiky exterior

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Gac fruit (Momordica cochinchinensis Spreng) comes from the melon family, cucurbitaceae inclusive of cucumbers, gourds, melons, squashes and pumpkins. Gac fruit is also known as spiny bitter gourd, sweet gourd, chinese bitter cucumber and cochinchin gourd. It is called as 'Madhurapaval' in Malayalam. This little-known but extraordinary fruit is native to the rich landscapes of Southeast Asia and commonly grown as food crop in Vietnam, Thailand, Laos, Myanmar and Cambodia.

Traditional uses

The ripened Gac aril is commonly used as a colourant for the preparation of red glutinous rice known as Xoi Gac, which is served at occasions during new year celebration and weddings in Vietnam. According to their culture, red is said to offer longevity and good fortune in the upcoming year. In Thailand and Myanmar, gac is sometimes added to curries, soups, and desserts for color and nutrition. The leaves as well as immature fruits are used for culinary purposes.

Potential of gac fruit in Kerala conditions

Gac fruit cultivation in India is limited to a few states and Kerala is one of the prominent adopters. Kerala's warm, humid tropical climate with well-distributed rainfall and fertile lateritic soils appears suitable for gac cultivation, which is grown in a similar climate in Southeast Asia. Gac is being successfully grown in Kerala on a small scale (home gardens, terraces). It is gaining good market potential and the fruit fetches high prices locally, the seeds and by-products (juice, oil) also have good value. According to the Kerala State Biodiversity Strategies and Action Plan 2022–2032, Gac is listed among the recognized Cucurbitaceae species found or cultivated within the state. Thus, its cultivation, conservation, or sustainable use can be supported, promoted, or studied further.

Cultivation practices of gac fruit

Propagation

Gac is a perennial dioecious plant with separate male and female plants. The propagation of the crop is mainly from seeds, branches and roots. The seeds

are sown in grow bags filled with farm yard manure and coir pith for germination and it takes about 1.5 to 2 months to germinate. Cuttings from female plants can also be used to propagate the vines. Grafting is a difficult but effective process that would allow the use of undesired male gac plants by grafting of female scion material onto the main branch of a male plant. Multiplication through root tubers is also practiced. Propagation through seeds is the most commonly practiced method in Kerala.

Planting and training

A well-drained soil with good air circulation and ample sunlight is essential for the crop. Raising pandals or horizontal trellis and allowing the vines to trail on them is the most typical form of training practiced. Before planting, compost and manure can be applied. Like passion fruit vines, it can also be cultivated on terraces too. The vines of gac plant can grow up to 6-10 meter long. It is a tendril-bearing climber, scarcely without tendrils.

Flowering and fruiting

The plant contains leaves of 3-5 palmately lobed, along with white to ivory yellow flowers. Gac plants usually flowers 6-8 months after being planted. Female flowers can be identified by a small, immature fruit-like bulge at the base of the blossom, whereas male flowers lack this swelling and have lighter-colored petals that open more fully. Hand pollination through dusting the pollen on receptive stigma by paint brush is crucial in order to obtain higher fruit setting and yield, especially when the native pollinators are absent.

In Kerala conditions, the fruiting season of the gac vine generally begins in December-January, following flowering during the monsoon months. Fruit initiation occurs within a few days after successful fertilization, with the tiny developing fruit becoming visible about 2-5 days after pollination. The fruits produced are mostly oblong in shape. They can also be round or ovoid. As the fruit matures, it passes through four distinct color stages beginning with parrot green, then turning yellow, orange, and finally bright red at full maturity. Fruits matures in 60-80 days from the day of pollination. A single plant yield approximately 40-60 fruits for a season. The vines are pruned after a fruiting season and maintained for the better harvests in the next year.

Fruit Description

The weight of an individual gac fruit is around 1 Kg. The young green fruit can be cooked and used for culinary purpose. The fruit consists of three layers: the exocarp, which has orange or yellow spines covering the skin; the mesocarp, a thick, spongy orange layer known as the pulp; and the endocarp, which contains red, soft, sticky arils surrounding black seeds. The mesocarp and the arils constitute the edible part of the fruit. Each fruit comes with an average of 15 to 20 seeds. The seeds are mainly round, compressed and have a sculptured seed coat covered with red aril. The yellow pulp covers 50% of the total weight while the aril forms 10 - 25% of the fruit's weight. The skin and seeds are 17 % and 16 % of the fruit's total weight, respectively.

The fruit is hard at harvest but turns soft quickly after harvesting, thus leading to problems in transportation of the fruit and in its shelf-life. Fruits stored at low temperatures (10–13°C) remained fresh for 30 days, whereas at higher temperatures (25°C), their shelf life was reduced by half compared to those stored at low temperatures. Thus, storage at low temperatures was the best way to maintain the quality of the fruit and its products. However, fruit exhibited chilling injury symptoms both internally and externally at 4°C.

Nutritional Value

Gac fruit gained the name "super

fruit" or "heaven's fruit" because of its phytonutrient composition like carotenoids, essential fatty acids and other compounds such as fat-soluble vitamins like α-tocopherol (vitamin E), phenolic compounds, flavonoids and Vitamin C. All parts of the Gac fruit (i.e. the peel, pulp, and aril) were found to be an excellent source of carotenoids. The aril inside the fruit, is the portion that is highly nutritious in nature. The highest amount of phenolic content is observed in the arils and least in the seeds.

The content of lycopene in the fruit has been reported to be five times higher than tomatoes, and that of beta-carotene to be 8 times more than the amount found in carrots. The fruit also contained 60 times more vitamin C compared to that from oranges, and 40 times more zeaxanthin than that found in yellow corn.

Pharmacological Potential

Aside from being used as food source, gac fruit also possess medicinal properties. The tonic from the fruit is used to treat xerophthalmia and night blindness. Application of gac oil is used to heal skin infections, wound and burns, and has helped to stimulate cell growth. It is very valuable for anti-inflammatory, antioxidant, antimicrobial, antiulcer and anti-cancer activities and reducing cardiovascular diseases. High amount of antioxidants with good bioavailability are present in the gac fruit. The biological activities of the bioactive compounds such as lycopene, β-carotene, vitamin E have been established via their ability to scavenge free radicals.

Industrial and Economic Value

The fruits cost 1500/- per kilogram. Even though the taste of the pulp is not appealing, the phytochemicals present in them make it more valuable. Gac fruit is thus value-added due to its importance in health benefits. The fruits are consumed along with honey and sugar usually or even with other added flavours as they are little bitter in taste. Kerala Agricultural University recently reported that value-added products such as nutraceutical nectars can be prepared from gac fruit and snap melon which are underutilized, seasonal vegetables that contain high levels of bioactive components.

The fruit oil is sold for about 20,000/- in the market The ripened fruits are used to prepare jam, juices, and are even used as natural colourants. The fruits also find use in the preparation of products such as Gac powder, Gac oil capsules, Gac juice, Gac seed oil and frozen Gac fruit. Moreover, these products have been released into the market serving as food additives, in cosmetics, and for medicinal and pharmaceutical purposes. Cosmetics such as face gel, face cream can also be prepared from the fruit because of its anti-ageing properties.

Gac fruit is currently not commercially cultivated in Kerala due to limited awareness of its medicinal properties and potential uses. However, farmers are increasingly showing interest in its cultivation after learning about its benefits and the potential financial returns. The crop serves a dual purpose, functioning both as a vegetable and a fruit, and it holds significant value for processing into a variety of value-added products.

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Santol
An Emerging Fruit Crop for Kerala

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Santol (Santoricum koetjape), a tropical fruit crop native to Indochina and Malaysia, is gaining popularity not only in Southeast Asia but also among farmers of various region for its unique flavor and health benefits. It is often called as lolly fruit, cotton fruit and wild mangosteen. Santol is known for its sweet, tangy flavour and creamy fibrous pulp. It is consumed as fresh and also used for various processed products. In Kerala where cultivation of exotic fruits and underutilized crops has become a growing trend, santol is gaining attention among farmers with its potential for both domestic consumption and export.

Origin and distribution

Santol originated in Indo-China and Malaysia, and it is now cultivated across tropical Asia, particularly Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. It has also been introduced and cultivated in some parts of India.

Uses and composition

The fleshly fruits of Santol are recognized for their sweet and sour taste and are commonly enjoyed for raw consumption. Apart from being consumed fresh, they can also be cooked into jams, jellies, syrups, chutney and juices, preserved for long-term storage, or made into candies. Both the rind and flesh are also used in cooking to add a slight flavour to curries, sauces, and soups. Beyond the fruits and its processed products, the large canopy of the trees provides excellent shade. The wood is also valuable for making boats, furniture, household utensils and tools. Additionally, santol has various traditional medicinal uses; its leaves help to reduce fever, while its bark and roots are used to treat diarrhea and stomach aches, and it can also be applied to get rid of ringworm. From the santol fruits, seeds, leaves and bark, various phytochemical compounds, including alkaloids, flavonoids, saponins and tannins have been identified. In santol, various medicinal properties such as antimicrobial effects, inflammation reduction, cytotoxicity, and antiangiogenic effects in cancer cells have been reported.

The edible pulp of the Santol fruit is a good source of carbohydrates, providing approximately 13.9 g per 100g, while it contains fair amount of iron but is low in calcium (9mg/ 100 g). In terms of nutritional value, every 100 grams of the edible portion contain 57 kcal energy, 17mg phosphorus, 328 mg potassium, 14 mg ascorbic acid and 14 IU Vitamin A.

Plant description

The plant is a large, fast-growing, semi-deciduous tree that can reach up to a height of 40-50 m and with a straight trunk. The vegetative propagated trees tend to be smaller with a bush habit of growth and produce fruits 3- 5 years after planting. Its leaves are alternate, trifoliate and long-petiolate, with elliptical to ovate leaflets. The leaves are glossy green above and pale green below. The Inflorescence is an axillary panicle; flowers are bisexual, yellowish-green coloured, the calyx is club shaped and is produced in the axils of young shoots. The fruit is a berry, depressed and globose, having 4 to 6 cm in diameter with a golden yellow colour, soft, hairy textured. The outer portion is thick and tough, while inner portion is soft, white and has a sour to sweet taste. The seeds are 2-5 in number, ovoid , and glossy brown in colour.

Species

There are two different species based on distinct colour change of leaves before abscission: Yellow santol (Sandoricum indicum) and red santol (Sandoricum nervosum). The leaves of Sandoricum indicum turn yellow, while Sandoricum nervosum turn red before they are shed. The yellow variety has

a thin peel and a sweet tissue, while the red variety has a thicker peel and a tissue that has a slightly sour flavor. Another difference between the two is that the red santol falls from the tree when ripe, while that's rarely the case with the yellow santol. In the Philippines, two principal cultivars are 'Native' and 'Bangkok'. The 'Bangkok' santol is known for its superior eating quality compared to the 'Native' variety, with its yellowish to golden skin colour being an important trait. However, it is susceptible to postharvest browning after harvest.

Cultivation

Santol can be propagated through several methods, including seed, inarching, air layering, grafting, and budding. The commercial method of propagation is wedge grafting and shield or patch budding. In seed propagation, seeds are cleaned by rubbing them with fine sand and washing them well to remove the fibrous covering. Then the seeds are sown 5cm apart in the seedbed and later transplanted to the container when the first pair of leaves has fully developed. However, seed propagation and marcottage are generally not recommended, as seed propagation may result in the production of sour fruit, and marcottage requires 5-6 months for separation from a mother plant.

The ideal time to plant santol is with the onset of the rainy season. The one-year-old seedling or the vegetative propagated plants are planted at a spacing of 8x5 m to12x 12 m. For high-density planting, a spacing of 4-6 m is recommended. During the first year of planting, regular weeding, mulching around the trunk, and irrigation are essential for the development of flowers and fruits. In Thailand, fruit bagging is practiced for young fruits to improve their quality and prevent fruit fly attacks.

Fruit development and harvesting

Trees grown from seeds generally start producing fruits within 5-7 years, while the vegetatively propagated plants may flower 3-4 years after planting. The inflorescence is produced in the axil of the young shoots from the main flush, with flowering usually occurring from February to March. The pollination is by insects and the flowers are protandrous. The fruits are ready for harvest between June – October. While harvesting, fully ripe fruits turn yellow to golden brown and should be left on the tree until they are fully mature. On an average, single tree can produce over 20,000 fruits annually. ■

JANUARY 2026
VOLUME 13 ISSUE 08

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Printed and published by Sindhu. K.S, Principal Information Officer, FIB Owned by Department of Agriculture, Government of Kerala.
Published at Farm Information Bureau, Kowdiar P.O, Thiruvananthapuram-3. Editor Anitha C S
Mail: editorejournalkkfib@gmail.com Log on www.fibkerala.gov.in Phone: 0471 2314358