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

FEBRUARY 2026
VOLUME 13 ISSUE 09

Per Drop More Crop
The Golden Revolution of Micro Irrigation

KERALA

The first state to adopt full workflow portal of Per Drop More Crop (PDMC) scheme

The National MIS Portal for the Per Drop More Crop (PDMC) scheme was inaugurated on January 7, 2026, by Minister for Agriculture, Shri P. Prasad. The portal facilitates end-to-end digital monitoring, from farmer applications to direct benefit transfer (DBT) of subsidies. Kerala is the first state to adopt this full workflow portal.

Agriculture Minister P. Prasad inaugurating the MIS portal of the 'Per Drop, More Crop' micro-irrigation scheme. Principal Secretary and Agriculture Production Commissioner Dr. B. Ashok IAS, Director of Agriculture Dr. Sriram Venkitaraman IAS, Deputy Commissioner of the Ministry of Agriculture Yogesh Ashok Raundal, Dr. Ashutosh Vadawale, State Agricultural Engineer Rajmohan C.K., Assistant Engineer Arul Raj M., and senior farmer Robinson were the other dignitaries present.

PDMC MIS PORTAL KEY FEATURES

- **Purpose:** The portal enables digital, real-time monitoring of micro-irrigation projects to increase transparency and accountability.
- **Functionality:** It manages the entire process, including farmer registration, field verification, system installation, and subsidy disbursement.
- **State Implementation:** While inaugurated with Kerala, the platform is designed for nation-wide, state-wise onboarding to support the Centrally Sponsored Scheme.
- **Launch Context:** The initiative aimed at enhancing water use efficiency through microirrigation

INSIDE

KERALA KARSHAKAN E-JOURNAL

FEBRUARY 2026 VOLUME 13 ISSUE 09

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

CHIEF EDITOR Sindhu K S EDITOR Anita C S ASSISTANT EDITORS Dr. Anju V S, Al Unais A J
COVER DESIGN & LAYOUT Rateesh Kumar Digicrow

Articles for Kerala Karshakan e-journal should be certified by head of the institution concerned stating that the article is original and has not been published anywhere. Reference should also be included wherever relevant.

Articles/ Features appearing in this e-journal are either commissioned or assigned neverthless, other articles of farm relevance are also welcome. A maximum of 750 wordage is appreciated. Such items should be addressed to The Editor, Kerala Karshakan e-journal, Farm Information Bureau, Kowdiar PO, Thiruvananthapuram, Pin: 695003

These may also be mailed to editorejournalkkfib@gmail.com in word format. Responses can be also sent to this mail.

Per Drop More Crop

Cover Photo: Navya V, Athul Krishna C P, Saranya S Krishnan
At the Precision Farming Experimental Farm, College of Agriculture, Vellayani

Agriculture today is no longer shaped by climate alone; it is driven by technology, precision, preplanned and preinformed decision-making process too. Our agriculture sector is now witnessing a new trend in farming—particularly among young agri-entrepreneurs—in adopting modern practices to optimize resources and boost productivity in an era of climate change and unseen weather fluctuations.

Of course this transition is being actively supported by the Department of Agriculture and Kerala Agricultural University through specialized schemes and technical guidance. A major catalyst for this change is the implementation of RKVY–Per Drop More Crop (PDMC) program throughout the State during last few years. By promoting micro-irrigation as a vital tool for water efficiency, this initiative has gained wide popularity among farmers saving time,water,labour,money and yielding many other benefits and more income . This year, with ₹100 crore allotment, the state is allset for a revolution in microirrigation through Per Drop More Crop (PDMC Scheme).

The cover story of this issue provides a practical overview of micro-irrigation under the PDMC scheme. It covers essential details such as subsidy structures, available technologies, suitable crops, and community-based irrigation models. We have designed this feature to be a "ready reference" for any farmer looking to modernize their irrigation methods.

Beyond micro-irrigation, this issue also features articles on digital tools for climate action, organic farming policy, fruit-based diversification and biosecurity and quarantine. Together, they reflect the expanding scientific and economic dimensions shaping Kerala's farm sector.

As these innovations gain ground, the focus must remain on productivity, sustainability, and farmer livelihoods. This edition of the Kerala Karshakan e-Journal aims to support that journey by bringing knowledge, technology, and policy perspectives closer to the farming community.

Editor

Smart Irrigation for Kerala
Government Support for Agricultural Transformation

Kerala Agriculture Enters a New Era of Micro Irrigation

RAJMOHAN C K
State Agriculture Engineer

Kerala's agricultural landscape is undergoing a profound transformation. The changing climate patterns, uncertainty in water availability, rising labor costs, and the challenge of sustaining livelihoods solely from farming income have collectively raised fundamental questions about our traditional agricultural practices. At this critical juncture, the state is enthusiastically embracing modern micro-irrigation technologies that promise climate-resilient farming, water conservation, and precise water application.

Both the Central and State governments have been leading this transformation for decades, and progressive farmers are showing tremendous interest in these systems, including automation and fertigation capabilities. The driving force behind this enthusiasm is the desire to save time, water, and effort. Micro-irrigation offers multifaceted benefits for cultivating traditional crops like coconut, pepper, cardamom, mango, and banana, as well as exotic varieties such as rambutan, pulasan, mangosteen, kiwi, and dragon fruit.

Moreover, since most Kerala farmers are not engaged in full-time agriculture or derive income from multiple sources, systems that can be controlled remotely from anywhere, operate automatically, work on timer settings, and enable fertigation have become less of a luxury and more of a necessity. The ability to manage irrigation through mobile phones or computers is a game-changer for farmers working abroad or engaged in other occupations.

However, the installation cost of these systems is substantial, particularly prohibitive for small and marginal farmers when measured against their farming income alone. The RKVY-PDMC scheme has been designed precisely to bring micro-irrigation within reach of all categories of farmers and help them realize its benefits.

Why Micro-Irrigation is Becoming Essential for Kerala

Although Kerala is blessed with abundant rainfall, the annual distribution of precipitation varies significantly across regions. Most areas face severe flooding during certain months and acute drought during others.

Both the Central and State governments have been leading this transformation for decades, and progressive farmers are showing tremendous interest in these systems, including automation and fertigation capabilities.

The traditional flood irrigation method, where water is pooled around plant bases, wastes enormous quantities of water, creates uneven water availability for plants in different parts of the field, and initially deprives roots of adequate oxygen due to waterlogging. Additionally, in sloping areas, water runoff causes soil erosion.

This is where micro-irrigation systems using pipes, such as drip and sprinkler systems, emerge as complete solutions. The drip system delivers water directly into the soil within the plant's root zone. Since it provides water drop by drop in very small quantities without creating waterlogging beneath plants, it gives plants more time and opportunity to absorb water. Without obstructing air availability in the soil, plants can extract water most efficiently. These advantages reduce water loss through evaporation, runoff, and deep percolation, saving forty to fifty percent of irrigation water while ensuring uniform water availability to all plants in the field.

Micro-irrigation systems are suitable for almost all crops, including coconut, areca

Approved Manufacturer

Performance indicator	Conventional Irrigation methods	Micro irrigation
Water saving	Waste lot of water, Losses occur due to percolation, runoff and evaporation	40 – 70% of water can be saved over conventional irrigation methods. Runoff and deep percolation losses are negligible.
Water use efficiency	30-50%	80-95%
Saving in labour	Labour engaged per irrigation is higher than drip	Labour required only for operation and periodic maintenance of the system.
Weed infestation	High	Less wetting of soil, weed infestation is very less.
Use of saline water	Concentration of salts increases and adversely affects the plant growth. Saline water cannot be used for irrigation	Frequent irrigation keeps the salt concentration within root zone below harmful level
Disease and pest problems	High	Relatively less because of less atmospheric humidity
Suitability in different soil type	Deep percolation is more in light soil and with limited soil depths. Runoff loss is more in heavy soils	Suitable for all soil types as flow rate can be controlled
Water control	Inadequate	Very precise and easy
Efficiency of fertilizer use	Efficiency is low because of heavy losses due to leaching and runoff	Very high due to reduced loss of nutrients through leaching and runoff water
Soil erosion	Soil erosion is high because of large stream sizes used for irrigation	Partial wetting of soil surface and slow application rates eliminate any possibility of soil erosion
Increase in crop yield	Non-uniformity in available moisture reducing the crop yield	Frequent watering eliminates moisture stress and yield can be increased up to 15-50% as compared to conventional methods of irrigation

Irrigation Efficiencies under Different Methods of Irrigation (Percent)

Irrigation Efficiencies	Methods of Irrigation Surface	Sprinkler	Drip
Conveyance efficiency	40-50 (canal)		
60-70(well)	100	100	
Application efficiency	60-70	70-80	90
Surface water moisture evaporation	30-40	30-40	20-25
Overall efficiency	30-35	50-60	80-90

nut, banana, mango, pepper, cardamom, and vegetables. The sprinkler system sprays water in small droplets like rainfall. While it doesn't save as much water as drip irrigation, it is highly effective and more water-efficient than traditional irrigation for crops grown in close proximity, such as rice, pulses, tubers, and fodder grass.

The greatest advantage of these systems is their compatibility with fertigation systems, which apply fertilizers along with water, and with automation and remote control via mobile phones. This increases fertilizer use efficiency by up to eighty percent and reduces fertilizer costs since less fertilizer is required. Furthermore, automation enables irrigation control from a distance via mobile phone or computer, or operation according to timer settings. This is an enormous help for farmers working abroad or engaged in other occupations.

The RKVY-PDMC Scheme: Government Support for Small Farmers

Considering all the aforementioned advantages of micro-irrigation, the RKVY-PDMC scheme has been designed with the goal of bringing micro-irrigation to all farmers in Kerala. This scheme, which began in 2015-16, is now being implemented as part of the Rashtriya Krishi Vikas Yojana. Under this program, financial assistance is provided for installing various irrigation systems including drip irrigation, micro sprinklers, mini sprinklers, sprinklers, and rain guns.

Subsidy Details and Eligibility: The financial assistance provided to farmers who apply under this scheme and install micro-irrigation systems according to the scheme guidelines is structured as follows. Small and marginal farmers receive a subsidy of fifty-five percent of the system cost, subject to maximum limits. Other farmers receive forty-five percent subsidy on the system cost. The maximum limit is that subsidy is available only for up to five hectares of land per farmer. Whether this land is contiguous or spread across multiple plots in different survey numbers, the limit remains five hectares. Even if a micro-irrigation system is installed on more than five hectares, only the subsidy applicable for five hectares will be provided.

Calculating Subsidy: Understanding the Unit Cost System: The Central Government has prepared a unit cost table based on crop spacing and cultivation area for various crops. The amounts in this table form the basis for calculating subsidies. This means that if the farmer's actual expenditure exceeds the table amount, the subsidy will be fifty-five percent of the table amount. Conversely, if the actual cost is less, the subsidy will be fifty-five percent of the farmer's actual expenditure.

Let me illustrate this with a concrete example. Consider a small farmer cultivating one hectare of banana at 1.8 meters by 1.8 meters spacing. If the unit cost according to the table is rupees ninety-one thousand five hundred sixty, and the farmer's actual expenditure is one lakh rupees, the subsidy received will be fifty-five percent of rupees ninety-one thousand five hundred sixty, which equals rupees fifty thousand three hundred fifty-eight. The farmer's own expenditure will be only rupees forty-nine thousand six hundred forty-two. However, if the farmer's actual cost is only eighty thousand rupees, the subsidy will be fifty-five percent of that amount, which is forty-four thousand rupees. The farmer would need to spend only thirty-six thousand rupees.

An important clarification here is that the government does not consider the bill provided by the dealer as the farmer's actual cost. The agriculture engineer verifies that the bill contains the prices and quantities according to the approved estimate and design, and that all components shown in the bill have been installed in the field. The value determined

by the engineer is considered the farmer's actual cost.

Financial Support for Automation Systems: The scheme also provides financial assistance for automation systems that control irrigation based on timer settings or soil moisture measurements. Benefits are available at the standard subsidy rate from an indicative value of up to rupees forty thousand per hectare. The target is that at least five percent of the total micro-irrigation area covered under the scheme should have automation.

Support for Other Interventions and Water Source Creation: In situations where farmers lack water sources, up to twenty percent of this scheme's subsidy amount can be spent on creating water sources and other activities. This includes rainwater harvesting ponds or tanks with a maximum limit of rupees seventy-five thousand to ninety thousand, rejuvenating non-functional bore wells at up to rupees five thousand, solar pump sets at up to rupees fifty thousand, diesel or electric pump sets at up to rupees fifteen thousand, and precast pipe distribution systems at up to rupees ten thousand per hectare.

How to Apply: Simple Steps to Access the Scheme

Registration and Application Submission: Since an agriculture web-based registration portal is currently under development, registration and application submission are being conducted offline for now. Once the portal becomes operational, offline applications will be transferred to the online mode. An Aadhaar card is mandatory for applying to the scheme. Those without Aadhaar must first obtain one. Fill out the application form accurately. Along with documents proving land ownership such as pattayam, receipts, or seven-year lease agreements for leased land, you must submit a self-declaration, bank account details linked with Aadhaar, and a certificate from the agriculture officer stating that no subsidy for micro-irrigation has been received from the Agriculture Department for the land mentioned in the application during the past seven years. Submit the application to the Krishibhavan (Village Level Agriculture Office) or Agricultural Engineering Office.

System Design and Estimation: After the application is approved, the farmer must select a company or dealer from the list of government-approved manufacturers. The company or dealer representative will visit the farmer's field and prepare a design based on the crop, soil, water source, and slope, along with an estimate for installing the system according to that design. This will be provided to both the farmer and the Agricultural Assistant Executive Engineer.

Approval and Installation: The Assistant Engineer in the District Agricultural Engineering Office will conduct a site visit, examine the estimate, make any necessary changes, and approve it. Based on this, a work permit will be issued, and the dealer will install the system in the field accordingly.

Inspection and Subsidy Transfer: After the system is installed, the Assistant Engineer will conduct an inspection and submit a report. The Assistant Executive Engineer will approve this, sanction the subsidy, and deposit the amount directly into the farmer's Aadhaar-linked bank account.

Important Points to Remember

Quality Assurance and Standards: Only manufacturers approved for the scheme may supply equipment. All equipment must bear the BIS mark. Only components and rates approved for each establishment may be used. This ensures that farmers receive quality equipment that will function reliably throughout its expected lifespan.

After-Sales Service Requirements: Manufacturers must provide three years of free maintenance service after installing the system. At least two toll-free numbers, one from the state and one from the company, must be made available for customer support and grievance redressal. This protection ensures farmers can maintain their systems properly and address any issues promptly.

The Cluster Approach for Enhanced Benefits: When several neighbouring farmers join together as a cluster with a minimum of fifty hectares of land and install the system collectively, there are additional advantages. Farming communities with a single water source can adopt this method. Applications can be made through Farmer Producer Organizations, self-help groups, and similar entities. The cluster approach enables better planning of water resources, facilitates sharing of infrastructure, and makes technical support and maintenance more efficient.

Integration with Other Government Schemes: This scheme can be linked with other Central and State programs such as PM-KUSUM for solar pumps, Atal Bhujal Yojana for groundwater conservation, and MGNREGS for water storage construction. This convergence helps farmers access multiple benefits. For instance, combining a solar pump with micro-irrigation creates an especially sustainable system where solar energy eliminates electricity costs while micro-irrigation ensures optimal water use.

Special Additional Subsidy for Coconut Farmers: The Kerala Government has decided to provide an additional thirty percent subsidy for farmers installing irrigation systems for coconut cultivation. Those requiring this must submit a separate application to the Agriculture Office. This special provision recognizes the importance of coconut farming to Kerala's agricultural economy and the significant water requirements of coconut palms, especially during dry periods.

Economic Returns and Investment Recovery

Beyond the substantial government subsidy, farmers need to understand the economic proposition of micro-irrigation investment. The combination of water savings, yield improvements, reduced fertilizer costs, and decreased labor requirements typically enables farmers to recover their investment within two to three years. Given that the system has a projected life of seven years, the remaining years represent pure additional profit.

Water savings translate directly to enhanced cropping security, particularly during Kerala's dry season when water scarcity affects cultivation. You can irrigate more area with the same water source or extend irrigation into drier periods when water would otherwise be insufficient. Yield improvements are substantial for many crops. Kerala farmers growing vegetables commonly report yield increases of twenty to thirty percent after adopting drip irrigation. For plantation crops like banana, coffee, and pepper, improved yields are well-documented.

> Water savings translate directly to enhanced cropping security, particularly during Kerala's dry season when water scarcity affects cultivation.

Fertilizer use efficiency improves dramatically with fertigation. Instead of broadcasting fertilizer where much is lost to leaching or volatilization, fertigation delivers nutrients directly to the root zone dissolved in water. Farmers can reduce fertilizer use by twenty to thirty percent while achieving better crop nutrition, reducing input costs while also benefiting the environment by minimizing nutrient runoff.

Labor requirements decrease significantly with micro-irrigation. Traditional irrigation requires substantial labor for channel maintenance, manual water distribution, and flow management. With micro-irrigation, once the system is installed and programmed, it operates with minimal labor input. This is particularly valuable in Kerala where agricultural labor costs are relatively high and labor availability can be challenging.

The ability to diversify cropping patterns is perhaps the most transformative economic impact. With assured irrigation, farmers can grow higher-value crops that might otherwise be risky. Vegetables, flowers, and other high-value crops require consistent water availability, which micro-irrigation provides. Many Kerala farmers have successfully transitioned from traditional crops to more remunerative alternatives after installing micro-irrigation.

Environmental Sustainability and Climate Resilience

Beyond economic benefits, micro-irrigation contributes significantly to environmental sustainability, which is increasingly important in Kerala's context of climate change and resource pressures. Water conservation is critical for Kerala despite its reputation as a water-rich state. Monsoon patterns are becoming more erratic, dry seasons are lengthening in many areas, and groundwater levels are declining in certain districts. Micro-irrigation directly addresses these challenges by using water more efficiently.

Reduced runoff and soil erosion are important environmental benefits, particularly in Kerala's hilly regions. Flood irrigation often leads to water rushing over the soil surface, carrying away topsoil and nutrients. Drip irrigation delivers water slowly to the root zone, allowing complete absorption with virtually no runoff. This preserves soil structure and keeps nutrients where they belong.

The precision of micro-irrigation reduces the risk of waterlogging and associated problems. Excess water can leach nutrients below the root zone, increase disease pressure, and create anaerobic soil conditions harmful to plant roots. By applying only the water plants need, micro-irrigation maintains optimal soil moisture without these negative consequences.

Lower fertilizer use through fertigation means less nutrient runoff into water bodies. Kerala's rivers, canals, and backwaters face pollution pressures, and agricultural runoff is a contributor. When fertilizers are applied through drip systems directly to roots, far fewer nutrients escape into the broader environment, protecting water quality in streams and groundwater.

Technology Features:

Automation and Remote Control

Modern micro-irrigation systems offer sophisticated features that make farming more convenient and efficient. Automation systems can turn irrigation on and off based on timers or soil moisture sensors, requiring minimal manual intervention. This makes farming more convenient and ensures precise water application. Kerala farmers interested in automation can access subsidy support for up to rupees forty thousand per hectare for automation components.

Remote control capabilities via mobile phones represent a major advancement. Farmers can monitor and control their irrigation systems from anywhere, receive weather-based irrigation advisories, and make data-driven decisions. For Kerala's many part-time farmers or those working in other sectors, this technology enables them to maintain productive farms without constant physical presence.

The integration of fertigation with automated systems creates highly efficient nutrient management. Fertilizers can be injected into the irrigation water according to predetermined schedules or crop growth stages, ensuring plants receive precisely what they need when they need it. This eliminates the labor of manual fertilizer application while maximizing nutrient use efficiency.

understand these requirements and can design systems that function effectively on terraced or sloped land. The use of HDPE pipes instead of PVC in certain situations, additional control valves at vertical drops, and careful layout planning all contribute to system success in challenging terrain.

Kerala's plantation crops, including rubber, coconut, areca nut, pepper, cardamom, and various fruit trees, are particularly well-suited to drip irrigation. The scheme's design accommodates the wide spacing typical of these crops. Coconut plantations with spacing of seven to nine meters or areca nut gardens with similar spacing can be efficiently covered with drip systems. For spacing

depends fundamentally on the quality of equipment installed. The Per Drop More Crop scheme has stringent quality control measures built into its implementation framework. All components supplied under the scheme must carry BIS certification, which is India's national standards mark. Whether it's lateral tubes, emitters, pipes, filters, or any other component, they must meet Bureau of Indian Standards specifications.

The date of manufacturing must be printed on components as per statutory norms. This helps farmers verify that they're receiving fresh products rather than old stock that might have degraded. When accepting

> Kerala's plantation crops, including rubber, coconut, areca nut, pepper, cardamom, and various fruit trees, are particularly well-suited to drip irrigation.

Practical Considerations for Kerala's Diverse Landscape

Kerala's unique agricultural context presents both opportunities and considerations for micro-irrigation adoption. The state's diverse topography, from coastal plains to hilly terrain, means that system design must be carefully tailored to local conditions. In hilly regions, particularly in districts like Wayanad, Idukki, and parts of Pathanamthitta and Kollam, the undulating terrain requires special attention during system design.

The sloping land may require pressure-compensating emitters or pressure regulators to maintain uniform water distribution across different elevations. Manufacturers familiar with Kerala's conditions

not explicitly mentioned in the guidelines, the subsidy amount is calculated proportionally based on the nearest plant area.

The scheme particularly encourages micro-irrigation adoption in rainfed areas. While Kerala receives good rainfall during monsoon months, many areas face water stress during the dry season. By installing micro-irrigation systems connected to ponds, tanks, or wells, farmers can extend their cultivation into dry periods, enabling multiple cropping cycles and crop diversification. This is especially relevant for Kerala's vegetable farmers who can grow high-value crops year-round with assured irrigation.

Quality Control and Component Standards

The success of micro-irrigation

delivery of your system, check for these manufacturing dates along with BIS markings. Every micro-irrigation system installed under the scheme must have a unique QR code linked to the application number. This serves multiple purposes including tracking, monitoring, preventing duplication, and providing an easy verification method.

The implementing agency conducts quality checks through third-party inspection agencies. These independent inspectors visit fields after installation to verify that all specified components have been supplied and properly installed. They conduct trial runs to ensure the system functions correctly and document everything with photographs and videos. This inspection should be completed within sixty days of installation, and subsidies are released only

PDMC Farmer Self-Registration Window

after satisfactory verification.

Beyond initial installation checks, the scheme has provisions for ongoing quality surveillance. Joint inspection teams periodically collect samples from operational systems in the field, typically within three years of installation. These samples are sent to authorized testing laboratories for detailed analysis. If any components are found substandard, action is taken against the manufacturer, including penalties and possible de-registration.

Training and Capacity Building Opportunities

Technology adoption isn't just about hardware; it requires knowledge and skill development. The scheme places significant emphasis on human resource development, ensuring that farmers, extension workers, and officials all have the capacity to implement and manage micro-irrigation effectively. Training programs for farmers are regularly organized at district and block levels, covering system operation, maintenance schedules, fertigation practices, and crop-specific irrigation scheduling.

What makes these training programs particularly valuable is that they're not limited to individual farmers. The scheme encourages training entire families rather than just the primary farmer. This is especially important in Kerala where women often play significant roles in agricultural operations. When multiple family members understand how to operate and maintain the system, it ensures consistent proper use.

Exposure visits provide another learning opportunity. Progressive farmers or groups can visit other states to see successful micro-irrigation implementations, learn from others' experiences, and get ideas for improving their own practices. These exposure visits are fully funded under the scheme and provide invaluable practical insights that go beyond classroom training.

Implementing agencies organize workshops and seminars at the district level with participation from micro-irrigation manufacturers. These events bring together farmers, industry representatives, and technical experts, creating platforms for knowledge exchange. Manufacturers demonstrate their products, explain different options, and answer farmers' questions, helping farmers make informed decisions about which system best suits their needs.

Addressing Common Challenges and Concerns

Like any significant agricultural change, adopting micro-irrigation can present challenges, but the scheme has anticipated many of these and built in solutions. The upfront cost, even after subsidy, can be substantial for small and marginal farmers. While the fifty-five percent subsidy significantly reduces the burden, the remaining forty-five percent still requires immediate payment.

To address this, the scheme allows involvement of financial institutions like banks and NABARD. Farmers can approach banks for loans to cover their share, using the guaranteed subsidy component as security. Many banks offer special agricultural loan products for such investments, recognizing that micro-irrigation enhances farm productivity and repayment capacity.

Another consideration is the learning curve associated with new technology. Traditional irrigation methods that Kerala farmers have used for generations are straightforward, while micro-irrigation systems have multiple components and require more technical understanding. However, this challenge is temporary. Most farmers find that within a few weeks of regular operation, they become comfortable with the system. Training programs, manufacturer support, and user manuals all help flatten this learning curve.

after-sales service requirements creates an enabling environment for successful adoption. The journey begins with information gathering. Visit your local agricultural office or contact the district implementing agency to learn about the scheme's specific implementation in your area.

Attend awareness programs or district-level seminars where you can see demonstrations and speak with manufacturers. Talk to neighboring farmers who have already adopted micro-irrigation to learn from their experiences. When you're ready to proceed, ensure all your documentation is in order, particularly your Aadhaar card and land records. Prepare information about your land holding, current cropping pattern, and water sources.

variations. The RKVY-PDMC scheme is a powerful platform for bringing all these benefits to farmers' doorsteps. Automation, fertigation, and remote control are helping to transform agriculture today into a modern and profitable occupation.

This scheme represents a golden opportunity to renew Kerala's agricultural landscape. Approach your local agriculture office or agricultural engineering office and become part of this new agricultural era. This is the path to achieving more crops and more income from every drop of water. Let us all become part of this revolution. With government support making micro-irrigation affordable, quality standards ensuring reliable systems, and

> Micro-irrigation is not just about saving water; it increases yields, reduces fertilizer costs, lightens labor burdens, and enhances the ability to cope with climate variations.

Maintenance discipline is crucial. Unlike flood irrigation where you simply open a channel, micro-irrigation requires regular attention. Filters need periodic cleaning, chemical treatments must be done to prevent clogging, and components need checking for leaks or damage. Farmers who maintain their systems properly report excellent long-term performance, while those who neglect maintenance face problems.

The Path Forward: Taking Action

For Kerala farmers considering micro-irrigation, the RKVY-PDMC scheme offers an attractive entry point. The combination of substantial financial support, quality assurance mechanisms, training provisions, and

Choose your manufacturer carefully by considering not just the system cost but also the quality of their products, their reputation for after-sales service, and the proximity of their service centers. The cheapest option isn't always the best value if it leads to problems down the line. Once installed, commit to proper operation and maintenance. Follow the instructions provided, conduct regular checks, and don't postpone addressing minor issues.

Conclusion: A Drop-by-Drop Revolution

Micro-irrigation is not just about saving water; it increases yields, reduces fertilizer costs, lightens labor burdens, and enhances the ability to cope with climate

training programs building capacity, Kerala's farmers are well-positioned to embrace this transformative technology.

The combination of traditional agricultural wisdom with modern precision irrigation technology creates a powerful synergy. As Kerala moves toward a future of more intensive, productive, and sustainable agriculture, micro-irrigation will be a cornerstone of that transformation. The tools, resources, and support are available through this scheme—the opportunity is there for farmers ready to embrace it. Every drop saved, every yield increment achieved, and every input cost reduced contributes to making farming more viable and rewarding in Kerala's changing agricultural landscape. ■

Micro-Irrigation A Future Water Management Strategy

DR. ABDUL HAKKIM, V. M., DR. SAJEENA S, ER. NAMITHA M R
Kelappaji College of Agricultural Engineering & Food Technology, Tavanur

To bring more area under irrigation, it has become necessary to introduce new irrigation techniques viz. Micro & Sprinkler Irrigation for economizing the use of water and to increase productivity per unit of water.Micro irrigation is a method of delivering slow, frequent applications of water to the soil near the plants through a low pressure distribution system and special flow control outlets. It can be considered as an efficient irrigation method, which is economically viable, technically feasible and socially acceptable. It is the slow and regular application of water directly to the root zone of the plants through a network of economically designed plastic pipes and low discharge emitter. It enables watering the plants at the rate of its consumptive use thereby minimizing the losses such as deep percolation, runoff and soil evaporation. Micro irrigation is also referred to as drip, subsurface, bubbler or trickle irrigation, all of which have similar design and management criteria.

These systems deliver water to individual plants or rows of plants. The outlets are generally placed at short intervals along small tubing, and unlike surface or sprinkler irrigation, only the soil near the plant is watered. The outlets include emitters, orifices, bubblers and sprays or micro sprinklers.

Advantages of Micro Irrigation

- Water saving
- Enhanced plant growth and yield
- Uniform and better quality of produce
- Efficient and economic use of fertilizers
- Less weed growth
- Also suitable to waste lands
- Possibility of using saline water
- No soil erosion
- Flexibility in operation
- Easy installation
- Labour saving
- Suitable to all types of land terrain
- Saves land as no bunds etc. are required
- Minimum diseases and pest infestation

Types of Micro Irrigation System

The basic types of microirrigation systems are as follows:

i) Drip Irrigation

It is the system in which emitters and laterals are laid on the ground surface along the rows of crops. The emitting devices are located in the root zone area of trees. The cost of drip irrigation systems is reasonable on wide-spaced crops such as trees. The closer the crop spacing, the higher the system cost per acre.

ii)Bubbler Irrigation

In bubbler irrigation, water is applied to the soil surface as a small stream or fountain. Bubbler systems do not require elaborate

filtration systems. These are suitable in situations where large amount of water need to be applied in a short period of time and suitable for irrigating trees with wide root zones and high water requirements. Discharge rates are generally less than 225lph.

iii) Micro and Mini Sprinklers

These are small plastic sprinklers with rotating spinners. The spinners rotate with water pressure and sprinkle the water. These are available in different discharges and diameters of coverage and can operate at low pressure in the range of 1.0 to 2kg/cm2. Water is given only to the root zone area as in the case of drip irrigation but not to the entire ground surface as done in the case of sprinkler irrigation method.

iv) Spray Jets

The spray pattern of jets is fan type, giving fine droplets and uniform distribution.Jets are mainly used to maintain adequate micro environment in the canopy area. They can be used to irrigate orchards, nurseries, vineyards, green houses and delicate plants such as flowers, vanilla etc. Mature large trunk-trees or trees having wide spread root zone can also be irrigated using jets. The spray pattern is either full circle or half circle.

Half circle jet

Full circle jet

v) Fogger

Foggers are recommended for orchards and green/glass houses requiring a fine mist spray for humidity control. They are suitable for crops which need to maintain micro climate in the canopy area. They are simple in construction and has no moving parts. The spray pattern is misty and the droplets are very fine.

Fogger

Scientific method of cultivation and judicious use of all the inputs, especially of water, is called upon to become cost competitive. Keeping in view acute water scarcity in many basins, efforts were made to introduce most efficient micro irrigation system at farms around 1970. Micro irrigation saved irrigation water by 40%, fertilizer by 25%, enhanced yield up to 50%, improved water – use efficiency by 2.5 times Through the good management of micro irrigation systems, the root zone water content can be maintained near field capacity throughout the season providing a level of water and air balance close to optimum for plant growth. In addition, nutrient levels, which are applied with water through the system (fertigation), can be controlled precisely. Fertigation gives successful results in terms of yield, saving in fertilizer and improvement in quality of the produce. During the dry season in humid areas, micro irrigation can have a significant effect on quantity and quality of yield, pest control and harvest timing.

Drip irrigation system

Drip irrigation is an effective irrigation system in terms of water conservation. With drip, water is not wasted by irrigating areas between plants or due to run-off, excessive evaporation, wind-effects, overspray etc. Drip irrigation systems can be categorized as either point source or line source dissemination systems. However, each of these categories has variations within themselves. Other systems, such as wick irrigation, are currently being evaluated but are not discussed herein. Several things are common to all micro irrigation systems. They consist of a conveyance system, usually hose or pipe and a water emission device, usually called emitters. In addition, they all need a relatively fine mesh filtration and some level of pressure regulation. Most micro-irrigation systems operate at pressures between 1 to 2 kg/cm2.

Components of drip irrigation system

1. Water supply

2. A pump with energy source

3. Filters

4. Main and sub-main lines

5. Lateral lines

6. Emitters/drippers

7. Fertigation system

8. Other control and monitoring equipments

2.2. Water Source

Potential water sources for drip irrigation systems included ponds, streams, creeks, ditches, groundwater and municipal treated water. The cleaner the water, the less filtration will be required and the lower the potential for clogging. Groundwater is generally high quality, but may contain sand, sediment or chemical contamination. Running surface water (streams, creeks, etc.) has a high concentration of suspended particles. Large ponds will generally have lower levels of suspended solids. Many resources recommend using municipal water for drip irrigation because it has low particulate levels and because chlorine in the water reduces the potential for algae growth in the irrigation line. Any potential water source should be tested for chemical contamination.

2.3. Pump with energy source

Most irrigation systems will require a pump and a power unit. The selection of pump depends on the type of crop to be irrigated and the total area under irrigation. Water should be supplied under pressure and this can be achieved by erecting a water storage tank of suitable capacity at desired height or directly from the pump. Extremely hilly or mountainous terrain may allow for the use of gravity. However, in less ideal situations two types of pump are recommended. For pumping water from a source that is on the surface or groundwater depths of less than 5 metres, the straight centrifugal or self-priming centrifugal pump should be used. If the source is more than 7 metres deep, a submersible or deep-well turbine pump is recommended. There are several factors to be considered when choosing a pump including total pressure of the system, volume of water required, and the type of power unit. The total dynamic (pressure) head is calculated using the elevation head (total difference in elevation between the water source and the higher emitter location), friction head (pressure drop resulting from water flowing through the pipe, fittings, and valve) and pressure head (pressure required at the most distant emitter).

2.4.Filters

Water does not exist in its purest form in nature. It is always contaminated with physical, chemical and biological impurities. Proper filtration is of much importance to prevent low pressure diffuser like emitters from clogging. Wide range of water filters is available in market to protect the system from clogging hazards. All types of drip irrigation equipment and almost all water sources will require filtration. Filters remove suspended particles in water, but have no effect on dissolved minerals and bacteria.

There are two types of filters - Primary filters and secondary filters.

Primary filters are located immediately downstream near the pump through which a primary filtration of large suspended material is possible and secondary filters are located nearer the field (at the end of head system) through which fine filtration is possible.

- **Primary Filter** – Media or Sand Filter and Centrifugal or hydrocyclone filter
- **Secondary Filter** – Screen Filter and Disc Filter
- **Sand or Gravel or Media filter:-** It consists of fine gravel or coarse quartz sand, of selected sizes (usually 1.5-4 mm in diameter) free of calcium carbonate placed in a cylindrical tank. These filters are effective in removing light suspended materials, such as algae and other organic materials, fine sand and silt particles. This type of filtration is essential for primary filtration of irrigation water from open water reservoirs, canals or reservoirs in which algae may develop. Water is introduced at the top, while a layer of coarse gravel is put near the outlet bottom. Pressure gauges are placed at the inlet and at the outlet ends of the filter to measure the head loss across the filter. If the head loss exceeds more than 30 - 70 kPa, filter needs back washing
- **Centrifugal / hydrocyclonefilters:-** These are effective in filtering sand, fine gravel and other high-density materials from well or river water. Water is introduced tangentially at the top of a cone and creates a circular motion resulting in a centrifugal force, which throws the heavy suspended particles against the walls
- **Screen filters:-** They are always installed for final filtration as an additional safeguard against clogging. While majority of impurities are filtered by sand filter, minute sand particles and other small impurities pass through it. The screen filter, containing screen strainer, which filters physical

Sand Separator- Hydrocyclone filter

Disc filter

Screen filters

Gravel (media) filter

impurities and allows only clean water to enter into the micro-irrigation system. The screens are usually cylindrical and made of non-corrosive metal or plastic 52 material. The wire mesh screens are available in a wide variety of types and flow rate capacities with screen sizes ranging from 20 mesh to 200 mesh. The aperture size of the screen opening should be between one seventh and one tenth of the orifice size of emission devices used.

- **Disk filters:-** It contains stacks of grooved, ring-shaped disks that capture debris and are very effective in the filtration of organic material and algae. During the filtration mode, the disks are pressed together. There is an angle in the alignment of two adjacent disks, resulting in cavities of varying size and partly turbulent flow. The sizes of the groove determine the filtration grade. Disk filters are available in a wide size range (25-400 microns). Back flushing can clean disk filters. However, they require back flushing pressure as high as 2 to 3 kg/cm^2

Main, sub-main, distribution pipes and fittings

Main and Sub-mains

Water from the pump may be carried to the edge of the field by a single large main. Smaller sub mains may then carry the water to laterals and ultimately to the emitters.

Mainline: Pipes of mainlines are usually made of poly vinyl chloride (PVC) or high-density polyethylene (HDPE) of 40 to 110 mm diameterdepending up on the area, crop and discharge of the well.

Submains: Submains are installed underground (PVC or HDPE) or above ground (HDPE only) having 25 to 50 mm diameterdepending up on the area, crop and discharge of the well.

Laterals

The emitters are connected to the lateral lines and the size varies from 8mm to 20mm, with 12 or 16 mm being the most common. Linear low density polyethylene (LLDPE) pipes are generally used as laterals which are quite flexible in nature and easy to make emitter connections.

The main features of the lateral pipes are:

- Manufactured from virgin LLDPE using advanced extrusion technology.
- Excellent characteristics of LLDPE provide durability and long life.
- UV stabilized. No environmental effects.
- Smooth inner surface minimizes frictional losses. Available in different size and length in rolls.
- Used in polyhouses for high pressure foggers, spray heads and jets application also.

Online emitters / drippers

Emitters/ Drippers

In drip irrigation water is applied in low volume at low pressure. Because of the low volume and pressure, the emission device used must be able to counteract pressure differences caused by topography and friction loss and yet not become clogged. Discharge rates of emitters are normally 2, 4 and 8 litres/hour. Emitters / emission devices are used for online drip irrigation system and many versions are available in the market. Innovative design, precision molding, use of quality raw material and stringent quality tests are the key factors behind the sustainable and efficient performance of drippers. These drippers are manufactured from virgin plastic for stable performance. These devices are UV stabilized and are able to withstand environmental effect. Inline emitters are also available which are factory fitted at the time of manufacturing of pipes. Inline emitters of different spacing and discharge are available to suit different crops/ purposes.

Water meter, Pressure regulators and gauges

A water meter is measures the quantity (volume) of water that passes through a pipe or other outlet. Typically, meters use a standard unit of measure for volume, such as cubic feet or gallons. Water meter works like a car odometer, recording the cumulative amount of water that has passed through the meter.

The pressure regulator reduces system pressure to proper operating pressure. Regulators need to be positioned on either side of the filter and can indicate how well the filter is functioning. A decrease in outlet pressure signals a clogged filter. Pressure relief valves are not always necessary, especially on flat terrains or at low pressure. They will usually be located at higher points in the lines and at the ends of the lines. Vacuum relief gauges (vacuum breakers) prevent potential contamination of a water source, which can occur if negative pressure occurs in the line. Vacuum relief gauges are a must if municipal or well water is used. Pressure gauge is used to indicate the operating pressure of the drip system. The pressure gauges are installed at the inlet and outlet of the sand and screen filters.

Valves

All systems need an on-off valve. The simplest type of valve is a gate valve. In very small systems where pressure fairly constant, a gate valve can be used to regulate pressure. More sophisticated solenoid or hydraulically operated valves are necessary to automate the operation or to zone fields. Zoning allows separation of crops according to water needs, providing water more frequently to zones with higher water requirements. Solenoid valves can be activated manually but usually use an automatic controller.

Pressure relief valves, regulators or bye pass arrangement: - These valves may be installed at any point where possibility exists for excessively high pressures, either static or surge pressures to occur. A by-pass arrangement is simplest and cost-effective means to avoid problems of high pressures instead of using costly pressure relief valves.

Fertigation

Efficient crop production requires efficient utilization of soil water and soil fertility. Placement of fertilizers in the correct zone of moisture availability is important to maximize fertilizer efficiency. Fertigation is the method of application of soluble fertilizer with irrigation water. Fertigation is a prerequisite for drip irrigation. Since the wetted soil volume is limited, the root system is confined and concentrated. The nutrients from the root zone are depleted quickly and a continuous application of nutrients along with the irrigation water is necessary for adequate plant growth. Fertigation offers precise control on fertilizer application and can be adjusted to the rate of plant nutrient uptake.

Advantages of Fertigation

(1) Saving of energy and labor

(2) Flexibility of the moment of the application (nutrients can be applied to the soil when crop or soil conditions would otherwise prohibit entry into the field with conventional equipment)

(3) Convenient use of compound and ready-mix nutrient solutions containing also small concentrations of micronutrients which are otherwise very difficult to apply accurately to the soil

(4) The supply of nutrients can be more carefully regulated and monitored.

(5) The nutrients can be distributed more evenly throughout the entire root zone or soil profile.

(6) The nutrients can be supplied incrementally throughout the season to meet the actual nutrition requirements of the crop.

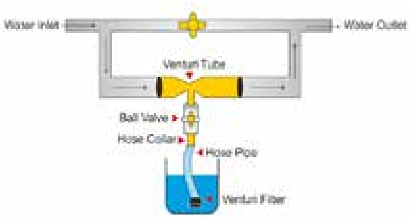
(7) Soil compaction is avoided, as heavy equipment never enters the field.

(8) Crop damage by root pruning, breakage of leaves, or bending over is avoided, as it occurs with conventional chemical field application techniques.

(9) Less equipment may be required to apply the chemicals and fertilizers.

The major fertigation equipments are venturi, fertilizer tank and fertilizer pump.

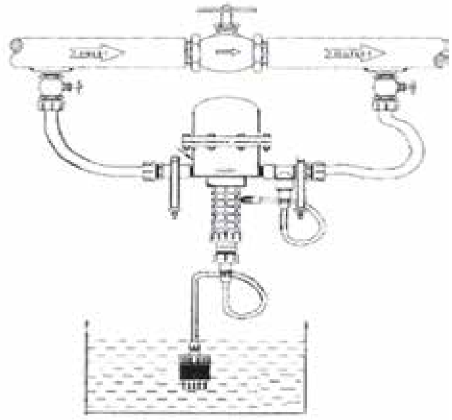
Venturi: A constriction in the main water flow pipe causes a pressure difference (vacuum) which is sufficient to suck fertilizer solution from an open container into the water flow. It is very easy to handle, and it is affordable even by small farmers.



This equipment is most suitable for smaller area.

Fertilizer tank: A tank containing fertilizer solution is connected to the irrigation pipe at the supply point. Part of the irrigation water is diverted through the tank diluting the 47 nutrient solution and returning to the main supply pipe. The concentration of fertilizer in the tank thus becomes gradually reduced.

Fertilizer pump: The fertilizer pump is a standard component of the control head. The fertilizer solution is held in non-pressurized tank, and it can be injected into the irrigation water at any desired ratio. Therefore, the fertilizer availability to each plant is maintained properly.



Tips for the proper maintenance of a drip irrigation system

Maintenance consists of two categories:

Preventive maintenance, aimed at preventing clogging of the drippers, can be divided in three categories:

- Flushing the system
- Chemical injection
- Irrigation scheduling

Corrective maintenance consists mainly of removal of obstructions already present in the drippers:

- Flushing the system And one or more of the following practices according to the nature of the obstruction:
- Organic formation - treated with hydrogen peroxide.
- Mineral sedimentation - treated with acids (or a combination of acid and hydrogen peroxide).
- Organic formation and mineral sedimentation - treated with a combination of acid and hydrogen peroxide.

Maintenance timetable

When operating a new system for the first time

- Flush the piping - main line, sub-mains and distribution pipes.
- Flush the dripper lines.
- Check actual flow rate and working pressure for each irrigation shift (when the system is active for at least half an hour).
- Compare the data collected to the data supplied with the system (planned). The tolerance should not be greater than ±5%.
- Write down the newly acquired data and keep it as benchmark for future reference.
- If the flow rate and/or the working pressure at any point in the system differ by more than 5% from the data supplied with the system, have the installer check the system for faults.

Once a week

- Check actual flow rate and working pressure for each irrigation shift under regular operating conditions (i.e., when the system is active for at least half an hour and stabilized).
- Compare the data collected to the benchmark data.
- Check that the water reaches the ends of all the dripper lines.
- Check the pressure differential across the filters. A well-planned filtration system should lose 0.2 - 0.3 bar (when the filtration system is clean). If the pressure differential exceeds 0.8 bar (11.6 PSI), check the filter/s and their controller for faults.

Once a month

- Check the pump's flow rate and pressure at its outlet.
- Flush the dripper lines. (A higher or lower frequency may be required, depending on the type and quality of the water.)
- If the filtration system is automatic, initiate flushing of the filter/s and check that all the components work as planned.
- If pressure-regulating valves are installed, check the pressure at the outlet of each one of them and compare these figures with the benchmark data.

Once a growing season

In some cases the following need to be performed twice or three times in a growing season, depending on the type and quality of the water used.

- Check all the valves in the system.
- Check the level of dirt in the system (carbonates, algae and salt sedimentation).
- Check for occurrence of dripper clogging.
- Flush the piping - main line, sub-mains and distribution pipes.
- If necessary, inject hydrogen peroxide and/or acids as required.

At the end of the growing season

- Inject chemicals for the maintenance and flushing of the main line, the sub-main lines, the distribution pipes and the dripper lines.
- Flush the dripper lines.
- Prepare the system for the inactive period between the growing seasons.
- Perform winterization of the system in regions where the temperature might drop below 0°C (32°F).

SPRINKLER IRRIGATION

A sprinkler irrigation system distributes water to crops or land by spraying it through a network of pipes and sprinklers, mimicking natural rainfall. Water is pumped under pressure and distributed evenly over the field, which makes it suitable for various soils, topographies, and crop types.

General classification of different types of sprinkler systems

Sprinkler systems are classified into the following two major types on the basis of the arrangement for spraying irrigation water.

1. Rotating head or revolving sprinkler system.

2. Perforated pipe system.

1) Rotating head

Small size nozzles are placed on riser pipes fixed at uniform intervals along the length of the lateral pipe and the lateral pipes are usually laid on the ground surface. They may also be mounted on posts above the crop height and rotated through 900, to irrigate a rectangular strip. In rotating type sprinklers, the most common device to rotate the sprinkler heads is with a small hammer activated by the thrust of water striking against a vane connected to it.

2) Perforated pipe system

This method consists of drilled holes or nozzles along their length through which water is sprayed under pressure. This system is usually designed for relatively low pressure (1 kg/cm2). The application rate ranges from 1.25 to 5 cm per hour for various pressure and spacing.

Based on the portability, sprinkler systems are classified into the following types:

(i) Portable system : A portable system has portable main lines, laterals and pumping plant

(ii) Semi portable system: A semi portable system is similar to a portable system except that the location of water source and pumping plant is fixed.

(iii) Semi Permanent system: A semi permanent system has portable lateral lines, permanent main lines and sub mains and a stationery water source and pumping plant.

(iv) Solid set system: A solid set system has enough laterals to eliminate their movement. The laterals are positions in the field early in the crop season and remain for the season.

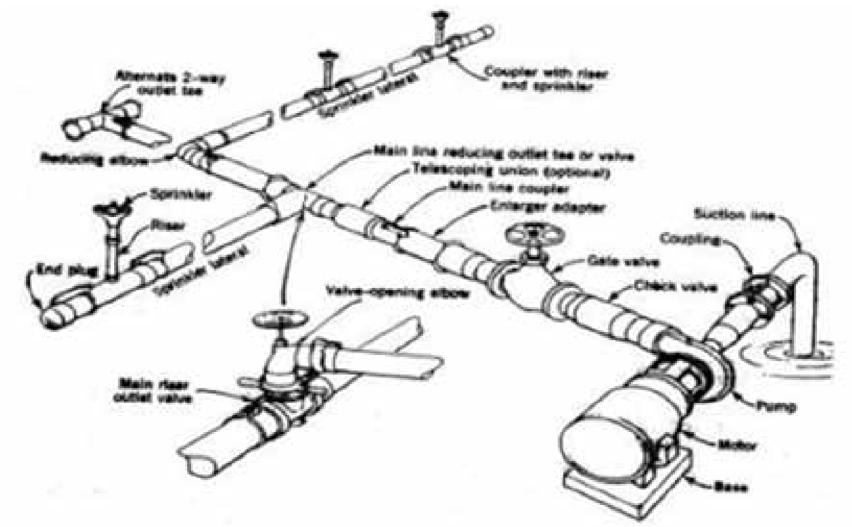
(v) Permanent system: A fully permanent system consists of permanently laid mains, sub mains and laterals and a stationery water source and pumping plant.

Components of sprinkler irrigation system

The components of portable sprinkler system are shown through figure.

A sprinkler system usually consists of the following components

or turbine pump can be used for operating sprinkler irrigation for individual fields. Centrifugal pump is used when the distance from the pump inlet to the water surface is less than eight meters. For pumping water from deep wells or more than eight meters, a turbine pump is suggested. The driving unit may be either an electric motor or an internal combustion engine.



- A pump unit
- Tubings- main/submains and laterals
- Couplers
- Sprinker head
- Other accessories such as valves, bends, plugs and risers.

Component of a portable sprinkler irrigation system

1. Pumping Unit: Sprinkler irrigation systems distribute water by spraying it over the fields. The water is pumped under pressure to the fields. The pressure forces the water through sprinklers or through perforations or nozzles in pipelines and then forms a spray. A high speed centrifugal

2. Tubings: Mains/submains and laterals: The tubings consist of mainline, submanins and laterals. Main line conveys water from the source and distributes it to the submains. The submains convey water to the laterals which in turn supply water to the sprinklers. Aluminum or PVC pipes are generally used for portable systems, while steel pipes are usually used for center-pivot laterals. Asbestos, cement, PVC and wrapped steel are usually used for buried laterals and main lines.

3. Couplers: Couplers are used for connecting two pipes and uncoupling quickly and easily. Essentially a coupler should provide (a) a reuse and flexible connection (b) not leak at the joint (c) be simple and easy to couple and uncouple (d) be light, non-corrosive, durable.

4. Sprinkler Head: Sprinkler head distribute water uniformly over the field without runoff or excessive loss due to deep percolation. Different types of sprinklers are available. They are either rotating or fixed type. The rotating type can be adapted for a wide range of application rates and spacing. They are effective with pressure of about 10 to 70 m head at the sprinkler. Pressures ranging from 16 to 40 m head are considered the most practical for most farmers. Fig.4 Sprinkler head Fixed head sprinklers are commonly used to irrigate small lawns and gardens. Perforated lateral lines are sometimes used as sprinklers. They require less pressure than rotating sprinklers. They release more water per unit area than rotating sprinklers. Hence fixed head sprinklers are adaptable for soils with high intake rate.

5. Fittings and accessories: The following are some of the important fittings and accessories used in sprinkler system.

- Water meters: It is used to measure the volume of water delivered. This is necessary to operate the system to give the required quantity of water.
- Flange, couplings and nipple used for proper connection to the pump, suction and delivery.
- Pressure gauge: It is necessary to know whether the sprinkler system is working with desired pressure to ensure application uniformity.
- Bend, tees, reducers, elbows, hydrants, butterfly valve and plugs.■

Per Drop More Crop

Yielding More from Micro Irrigation

Impact of fertigation and sensor-based automated irrigation on growth, yield and resource use efficiency of Cabbage (Brassica oleracea L. var. capitata) under protected cultivation in Kerala"

CHINNAPELLY SHAILU
M.Sc. (Agronomy), College of Agriculture, Vellayani

Abstract

The adoption of precision farming technologies is enhancing productivity, resource use efficiency, and sustainability in vegetable production systems. In Kerala, cabbage cultivation faces challenges such as climatic variability, high input costs, and inefficient water and nutrient management. This study was conducted during the Rabi season of 2025–2026 at the Department of Agronomy, College of Agriculture, Vellayani, to evaluate the effects of fertigation and sensor-based automated irrigation on the growth, yield, nutrient use efficiency and pest and disease incidence of cabbage (Brassica oleracea var. capitata) under protected cultivation. The cabbage hybrid NS 183 was grown using standard agronomic practices, with nutrients supplied through drip fertigation and irrigation scheduled using soil moisture sensors. Results indicated that the combined application of fertigation and automated irrigation improved crop growth, yield and nutrient use efficiency while reducing input losses, production costs, and pest and disease incidence. The study demonstrates that integrating protected cultivation with precision irrigation and

nutrient management is a sustainable and economically viable approach for enhancing cabbage production in Kerala.

Introduction

Agriculture in Kerala is undergoing a significant transformation with the integration of digital technologies and precision farming approaches. The adoption of smart agricultural practices aims to address challenges such as climate variability, declining resource availability, increasing input costs, and the need for sustainable intensification of crop production. Hi-tech agriculture combines traditional farming knowledge with advanced tools such as digital platforms, automated irrigation systems, protected cultivation structures, and sensor-based decision support systems, thereby enhancing productivity, profitability, and environmental sustainability.

Digital platforms and mobile-based applications have emerged as essential tools for farm management, enabling farmers to monitor crop health, manage inputs, track inventory, and access real-time market and advisory information. These technologies facilitate informed decision-making, reduce operational risks, and strengthen farmer market linkages, ultimately improving farm income and resilience.

Controlled Environment Agriculture (CEA) through protected structures such as hi-tech greenhouses plays a vital role in modern vegetable production systems. These structures allow precise regulation of temperature, relative humidity, light intensity, and irrigation, creating optimal microclimatic conditions for crop growth. In Kerala, where climatic conditions are highly variable and often unfavourable for year-round vegetable cultivation, protected cultivation offers a reliable solution for stable and off-season production. Protected cultivation not only enhances yield and quality but also reduces pest and disease incidence by limiting exposure to external environmental stressors. Several studies have demonstrated that the ability to control crop microclimate significantly increases photosynthetic efficiency, leading to improved biomass accumulation and higher productivity per unit area. Additionally, protected cultivation enables continuous crop production over extended periods, ensuring year-round availability of fresh vegetables.

The foundation of successful crop production lies in the use of healthy and uniform planting material. Smart seedlings are produced in automated nurseries where environmental parameters such as temperature, humidity, irrigation, and nutrient supply are carefully regulated. Automation ensures uniform germination, vigorous early growth, and higher survival rates upon transplanting. The use of smart nurseries reduces seedling mortality, improves crop stand establishment, and enhances overall crop performance in the field. Such nurseries are particularly beneficial in protected cultivation systems, where uniform plant growth is essential for efficient nutrient and water management.

Nutritional Significance of Cabbage

Cabbage (Brassica oleracea var. capitata) is an important cole crop gaining increasing attention due to the global demand for functional foods and nutraceutical-rich vegetables. The crop is a rich source of bioactive phytochemicals such as glucosinolates, phenolic compounds, flavonoids, vitamins (C, K and B-complex), dietary fibre, and essential minerals. These compounds, particularly glucosinolates and their derivatives like isothiocyanates and indoles, contribute significantly to antioxidant, anti-inflammatory, anticancer, anti-ulcer, and cardiovascular protective effects. Traditional use of cabbage juice in the management of gastric ulcers further highlights its therapeutic value. Owing to its good storability, wide adaptability, and consumer acceptance, cabbage also holds strong importance in fresh markets and food processing industries. Focused research on cabbage crop production, quality enhancement, and value-added utilization can strengthen its role as a health-promoting vegetable while improving economic returns for farmers and stakeholders in the cabbage value chain.

Fertigation is an advanced nutrient management technique in which water soluble fertilizers are applied directly through a drip irrigation system. This method ensures precise, uniform, and timely delivery of nutrients to the crop root zone, thereby improving nutrient availability and uptake efficiency. Fertigation reduces fertilizer losses through leaching and volatilization, lowers overall fertilizer requirements, and minimizes labour costs. As nutrients are supplied in small and frequent doses synchronized with crop growth stages, fertigation significantly enhances crop yield, quality, and nutrient use efficiency compared to conventional fertilizer application methods.

Automated irrigation systems integrated with soil moisture sensors represent a key component of precision agriculture. Soil moisture sensors continuously monitor the water status of the soil and transmit data to a microcontroller or server at predefined time intervals. Based on crop-specific moisture threshold values stored in the database, the system automatically initiates or stops irrigation. When soil moisture falls below the predefined threshold, the microcontroller activates the irrigation pump to supply water until the desired moisture level is reached. Once the threshold is attained, irrigation is automatically stopped, preventing over-irrigation. This system enhances water use efficiency, conserves water resources, and ensures optimal soil moisture conditions for crop growth.

MANAGEMENT	CROP DETAILS
Crop variety	NS 183
Seed rate	500g /ha
Age of seedlings	25 DAS
Time of sowing	Oct 24th
Spacing	60 cm × 60 cm
Season	Rabi 2025-2026
Manures and fertilizers	FYM 25 t/ha
RDF150:100:125 Kg ha-1 NPK (KAU, 2024)	
Weed control	Mulching sheets
Irrigation	Automated irrigation
Plant protection	Snails -copper oxy chloride 1g/1lit Caterpillar -coragen 3ml/10lit

Digital platforms and mobile-based applications have emerged as essential tools for farm management, enabling farmers to monitor crop health, manage inputs, track inventory, and access real-time market and advisory information.

The present research work is being carried out in the Department of Agronomy, College of Agriculture, Vellayani, during the Rabi season of 2025–2026. The study focuses on evaluating the effects of fertigation and sensor-based automated irrigation on crop growth, yield, nutrient use efficiency, and pest and disease incidence under protected cultivation conditions.

The ongoing research indicates that the integration of fertigation and automated irrigation systems results in higher crop yields, reduced fertilizer and water costs, and improved nutrient use efficiency compared to conventional open field cultivation. Controlled application of water and nutrients promotes better crop growth, minimizes stress conditions, and reduces pest and disease occurrence. The adoption of protected cultivation, smart nurseries, fertigation, and sensor-based irrigation offers a sustainable pathway for enhancing vegetable production in Kerala. Future research may focus on integrating artificial intelligence, machine learning, and remote sensing technologies to further optimize resource use and develop decision support systems for site-specific crop management. Such advancements will play a crucial role in ensuring food security, environmental sustainability, and economic viability of farming systems in the coming decades.

Management practices followed in crop

Conclusion

The present study demonstrates that the integration of fertigation and sensor-based automated irrigation under protected cultivation significantly enhances the growth, yield, and nutrient use efficiency of cabbage. Precise and timely application of water and nutrients created optimal root zone conditions, reduced crop stress, and promoted uniform plant development. The controlled environment further contributed to lower pest and disease incidence and improved overall crop health. Efficient resource utilization minimized fertilizer and water losses, reduced production costs, and improved economic returns compared to conventional practices. Overall, the adoption of protected cultivation combined with precision irrigation and nutrient management emerges as a sustainable and viable strategy for improving cabbage productivity in Kerala, with strong potential for wider adoption in vegetable-based farming systems. ■

Smart Fertilizers for Safe and Sustainable Future

JEENA MATHEW
Senior Scientist (Soil Science) and Saravanan Raju, Principal Scientist (Plant Physiology)
ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram

The new pressure on an old system

By 2050, the world will need roughly 60 percent more food to feed nearly 9 billion people. Yet the people who grow much of that food—the smallholder farmers—are facing a perfect storm: climate extremes, rising input prices, and soils that are slowly losing life and fertility. Climate change is not only about slow warming. For farmers, it often arrives as erratic rainfall, heatwaves, and unseasonal downpours that wipe out an entire crop. When a key season fails, farmers lose not only that year's harvest, but also the cash they need to buy seed and fertilizer for the next crop. Many turn to private moneylenders, trapped in loans that can carry interest rates as high as 2–4 percent per month entangling them in a vicious circle. The more the soils degrade, the more farmers feel they must spend on fertilizers to keep yields afloat—so the debt spiral tightens with every climate shock.

Breaking this cycle calls for a "triple win":

- Helping farmers to maintain or raise yield levels while lowering the cost of production
- Making farms more climate resilient
- Emission reduction from agricultural fields

However, this cannot be done with the yesterday's logic of "more fertilizer equals more yield." It demands smarter ways of feeding crops—approaches that increase nutrient efficiency, keep soils alive, and stabilize farm finances.

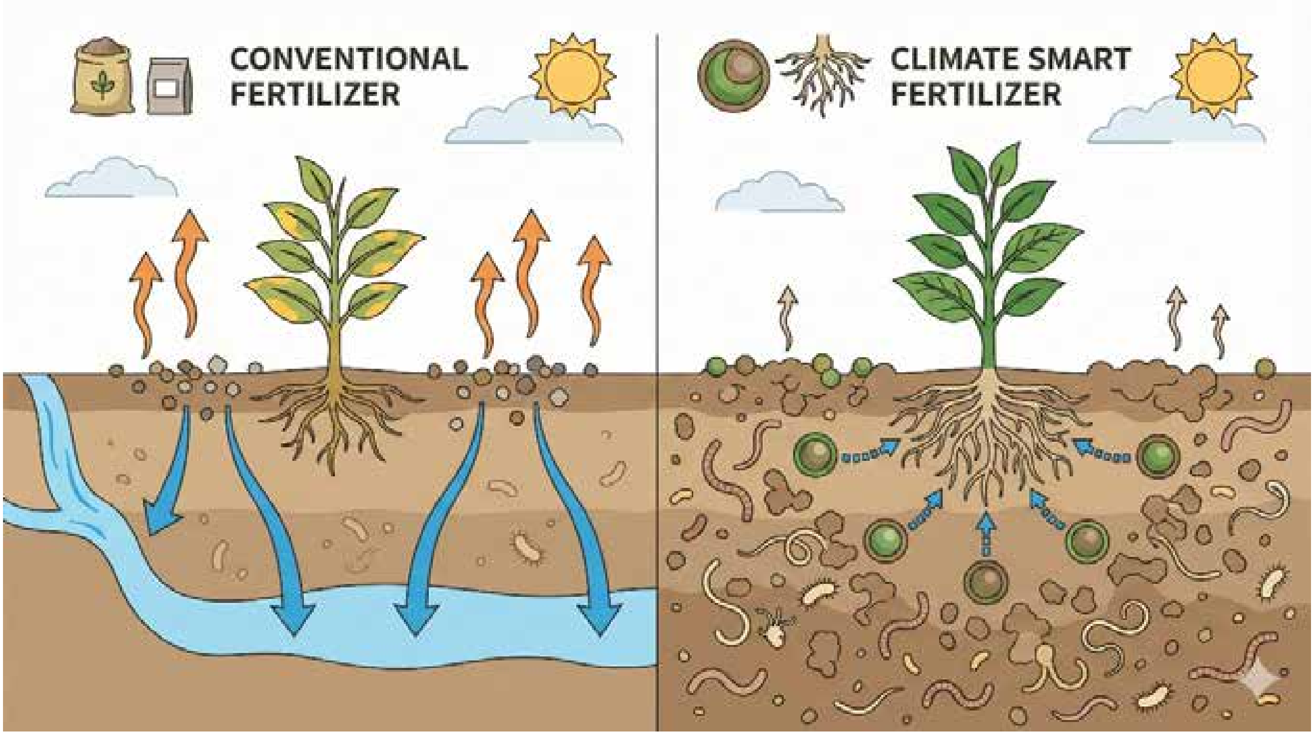
The hidden costs of chemical dependence

The Green Revolution showed how powerful fertilizer can be when combined with improved high yielding varieties and irrigation. Yields climbed, hunger declined, and many countries moved from food deficit to surplus. But this success came with hidden environmental and health concerns.

Plants can only use nutrients up to a physiological limit. Beyond that point, extra fertilizer is largely wasted. Excess nitrogen and phosphorus leach and run off into rivers and lakes, fuelling algal blooms and "dead zones" where fish and aquatic life cannot survive. Over time, repeated overuse of fertilizers can also damage soil structure, reduce aggregation, and disturb the communities of microbes and fauna that drive natural fertility.

Soils under such management often become chemically 'fertile' but biologically poor. Organic matter declines, beneficial microorganisms are suppressed by pH swings and salt stress.

There are also human health



Conventional fertilizers often dissolve too quickly, sending much of their nitrogen and phosphorus into the air and water instead of the crop. Climate-smart fertilizers release nutrients slowly near the root zone, so more of each bag feeds the plant while losses to the environment are reduced.

concerns. Synthetic fertilizers may contain contaminants such as heavy metals from industrial by-products. In the body, excess reactive nitrogen can contribute to the formation of toxic compounds and elevated ammonia levels, placing stress on organs including the brain. While the exact risks depend on dose and context, the precautionary lesson is clear: simply pushing more bags of fertilizer through the system is neither safe nor sustainable.

A smarter path is already well known in agronomy: applying the "Four Rs" of nutrient management—right source, right rate, right place, right time. Climate smart fertilizers are essentially high-tech tools designed to make those Four 'R's easier to implement in real farms, not just in textbooks.

What makes a fertilizer "smart"?

Climate smart fertilizers do not represent a single product, but a family of innovations that all pursue one core goal: deliver the right nutrient, in the right amount, exactly when and where the plant can use it best.

They include:

- Enhanced efficiency fertilizers (slow and controlled-release products)
- Bio-based and microbial fertilizers derived from organic residues
- Nano-fertilizers and nanosensors
- PH-responsive and site-specific blends
- Liquid formulations designed for rapid plant uptake

Together with better agronomic practices and digital tools, these products form a "smart toolkit" that can cut losses, improve soil health, and reduce farmers' exposure to price shocks.

Time-release nutrition: enhanced efficiency fertilizers

Enhanced efficiency fertilizers (EEFs) are often compared to time-release capsules in medicine. Instead of dissolving immediately, they are designed to release nutrients gradually, in step with crop demand.

Slow-release fertilizers achieve this through chemistry and biology—using materials that dissolve slowly, or that must be broken down by soil microbes before nutrients are freed. Traditional organic manures fall partly in this category, though their timing is at the mercy of weather and microbial activity.

Controlled-release fertilizers (CRFs) are more precise. Nutrients like nitrogen are encased in a polymer, sulphur, resin, or other coating that controls how quickly they move into the soil solution. Temperature, soil moisture, or coating thickness can be tuned so that nutrient release roughly matches the crop's uptake curve.

International guidelines specify that, for a product to be classified as slow or controlled-release, only a small fraction of the nutrient should be released in the first day, with the majority spread out over weeks or months. In practice, this means fewer losses through leaching and volatilization, lower nitrous oxide emissions, and less need for repeated top-dressings. Field studies show that such fertilizers can cut total fertilizer use by around 20–30 percent without sacrificing yield, if managed well.

In high-value crops, these efficiencies translate directly into savings. For instance, liquid blends that combine conventional urea with slow-release nitrogen sources have been shown to maintain potato yields at two-thirds of the usual nitrogen rate—simply by better aligning supply with plant demand.

Wealth from waste: bio-based fertilizers and the circular economy

Another pillar of climate smart nutrition is turning local organic waste into high-value fertilizer. Bio-based fertilizers can be made from crop residues, animal manures, composts, green manures, algae, and microbial cultures. The idea is to close nutrient loops: instead of burning, dumping, or losing residues, we transform them into products that feed soils and crops.

Microbial biofertilizers—such as nitrogen-fixing bacteria, phosphate-solubilizing microbes, and mycorrhizal fungi—help unlock nutrients already present in the soil but trapped in unavailable forms. Mycorrhizae extend the root's reach, improving water and nutrient uptake, especially under stress.

Because bio-based products can often be produced locally, they reduce dependence on imported fertilizers whose prices fluctuate with global energy markets. They also build soil organic matter, sequester carbon, and improve water-holding capacity—key attributes for climate resilience.

Real-world examples show the potential. In Kerala, the Bio + Madikai organic manure unit produced about 1,400 tonnes of enriched manure over five years, replacing chemical fertilizers on roughly 1,400 hectares and benefitting thousands of farmers (Jayasree et al., 2022). Such models, supported by universities and extension agencies, demonstrate that "wealth from waste" can work at scale when there is technical support, quality control, and a clear market.

The nano frontier: feeding plants atom by atom

Nanotechnology takes the quest for efficiency a step further by engineering fertilizers at the scale of billionths of a metre. At this size, particles have a very high surface area relative to their volume, which can dramatically change how they dissolve, move, and interact with roots and leaves.

Nano-fertilizers typically encapsulate nutrients like nitrogen, phosphorus, potassium, zinc, or iron within nano-sized carriers or coatings. These may include nano-clays, porous materials, or carbon-based structures. The result is a formulation that can release nutrients slowly and steadily, or in response to a specific trigger such as moisture, pH, or root exudates.

Because the delivery is more targeted and losses are lower, nano-fertilizers can often be applied at much lower doses than conventional products, while still boosting yields. Studies report yield increases in the range of 10–30 percent for some crops when nano-fertilizers are used appropriately. In one Indian study, nano-zinc oxide increased pearl millet yields by more than a third, and significantly improved net returns per hectare compared to standard zinc sources.

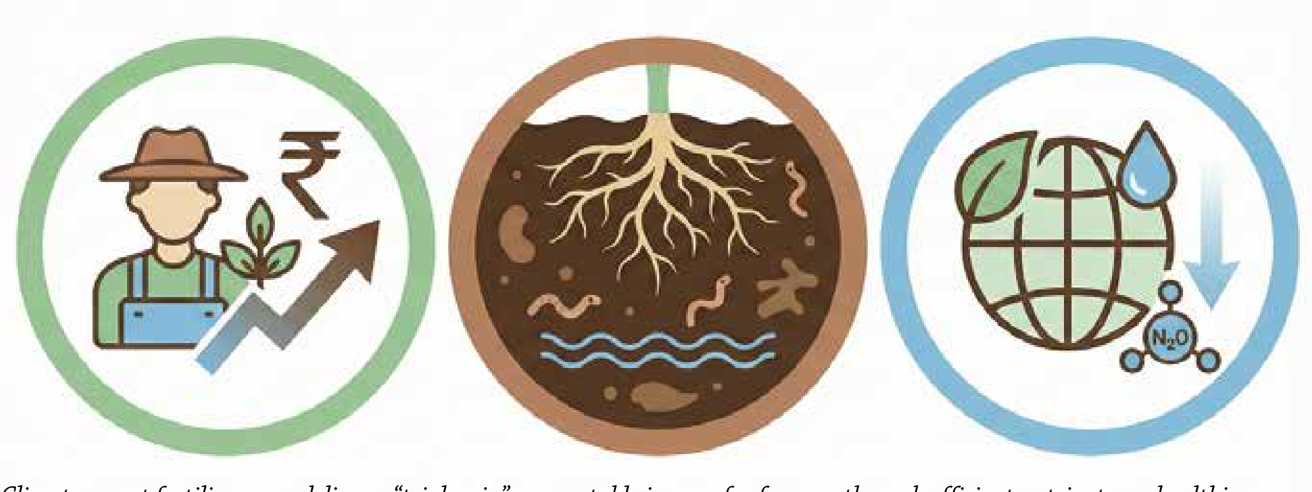
However, nano-fertilizers should not be treated as a one stop solution. Their performance depends strongly on local soil conditions, formulation quality, and correct application. As they are custom designed materials, their long-term behaviour in soils and ecosystems are to be thoroughly understood.

Nanosensors: a digital nervous system for the farm

Advanced fertilizers work best when paired with advanced diagnostics. Nanosensors—tiny devices that convert chemical or biological signals into electrical outputs—offer that capability.

Placed in the soil or on plants, nanosensors can monitor moisture, pH, nutrient levels, or even early signs of disease. Linked to GPS and wireless networks, a network of such sensors can feed real-time data into a farmer's phone or a decision-support system.

This allows farmers to know not only how much fertilizer to apply, but exactly where and when it is needed. For smallholders, such tools will likely be delivered through cooperatives, service providers, or extension platforms rather than as individual gadgets. But the principle is the same: smarter inputs plus smarter information



Climate-smart fertilizers can deliver a "triple win": more stable income for farmers through efficient nutrient use, healthier living soils with better water storage, and lower greenhouse gas emissions and water pollution at the landscape scale.

equals more resilient farms.

pH-controlled and liquid formulations: rapid and targeted responses

Another strand of innovation uses coatings that respond specifically to soil pH. In alkaline soils, certain nutrients become unavailable; in acidic soils, others are easily lost. pH-responsive fertilizers try to release nutrients only under conditions where roots can actually absorb them, reducing the loss to the environment and enhancing the use efficiency of the targeted nutrient.

Liquid fertilizers, meanwhile, provide a rapid way to correct nutrient deficiencies during critical crop stages. Applied through irrigation systems or as foliar sprays, they are quickly taken up and can help farmers rescue a crop under stress. When combined with bio-based additives, they can also stimulate soil biology, boosting crop productivity.

Why promising technologies struggle to spread

If climate smart fertilizers are so powerful, why are they not yet standard practice everywhere? Three intertwined challenges stand out: cost, trust, and safety.

The cost paradox

Most advanced fertilizers, especially coated and nano-formulations, cost more per kilogram than conventional urea or single superphosphate. For farmers already in debt and operating with razor-thin margins, paying more upfront—even for a product that may give higher returns later—feels risky.

Economic analyses suggest that, when used correctly, many smart fertilizers do pay for themselves. However, these averages are not enough to convince a farmer who has lived through crop failure and bad experiences with new products. What matters is not only the expected return, but the risk of a worst-case outcome. That is why access to credit, insurance, and safety nets is so crucial for adoption.

The trust gap: performance and transparency

Like any sophisticated technology, climate smart fertilizers can fail if misused, poorly manufactured, or promoted in unsuitable conditions. In India, early versions of nano urea with low nitrogen content did not perform well in independent trials, leading to criticism and confusion. Newer formulations are being tested, but the episode highlighted a core issue: farmers need clear, transparent, and locally validated evidence before they will trust novel inputs.

This implies:

- rigorous, independent testing under diverse agro-ecological conditions
- honest communication of both benefits and limitations
- and investment in training for extension workers, retailers, and farmers so that these products are applied correctly

Without that support, the very properties that make smart fertilizers powerful—slow release, stimuli-responsiveness, nano-scale behaviour—also make them vulnerable to misuse or disappointment.

Nanotoxicity: the unanswered questions

Conventional fertilizers are already known to stress soil life when overused. Nano-fertilizers aim to reduce the quantities of chemicals applied, but they also introduce new materials whose long-term fate in soil, water, and food chains is not yet fully understood.

Laboratory and field studies so far suggest that many nano-formulations can be safe when used at recommended levels. Yet there are still knowledge gaps. Do nanoparticles accumulate in certain soil layers? How do they interact with beneficial microbes, earthworms, or pollinators? Could they move into groundwater or edible plant parts in ways that matter for human health?

These questions do not argue against innovation; they argue for robust regulation, transparent risk assessment, and continuous monitoring. Smart fertilizer policies must move in step with smart fertilizer products.

Kerala as a testbed for climate smart agriculture

Kerala provides a useful glimpse of how technology, finance, and policy can be aligned. The World Bank–supported Kerala Climate Resilient Agri-Value Chain Modernization (KERA) project aims to support around 400,000 farmers by promoting climate resilient agriculture practices across different agro-ecological zones.

Beyond promoting resilient varieties and low-carbon rice cultivation methods like alternate wetting and drying, the project invests heavily in extension, digital advisory tools, and value-chain development. It also tackles finance by linking farmer groups with agribusinesses and creating credit guarantee facilities to unlock longer-term loans.

In such an enabling environment, climate smart fertilizers have a better chance of being adopted not as isolated products, but as part of a broader package: improved seeds, better water management, digital advice, and market access.

Linking climate benefits to farmer income

Many smart nutrients—especially bio-based fertilizers and improved nitrogen management—reduce greenhouse gas emissions or increase carbon stored in soils. At scale, these benefits matter for national climate goals and international commitments.

If those climate gains can be measured and verified, they can also be monetized through carbon markets or result-based finance. Properly designed, such mechanisms could help bridge the cost gap for smallholders, making it easier to adopt inputs that are more expensive at the bag level but cheaper at the system level.

Towards a resilient food system

Feeding the world in a hotter, more uncertain climate will require both better seeds and better soils, both smarter policies and smarter fertilizers. Climate smart fertilizers are not a silver bullet, but they are an important set of tools for making agriculture more efficient, less polluting, and more resilient.

For farmers, the promise is straightforward:

- Enhancement of nutrient use efficiency and lower long-term input costs
- Healthy soils that buffer major climatic shifts
- Stable crop yields in a world of unstable weather

Adoption of climate smart fertilisers can ensure the sustainable use of natural resources with reduced emission, environmental sustainability and assured food security. In this regard there should be a paradigm shift from promising pilot projects and research plots to widespread, equitable adoption—ensuring that every farmer has access not only to smart products, but also to the knowledge, finance, and trust needed to use them well. ■

AI, ML, and Geospatial Intelligence

The Digital Frontiers of Climate Action

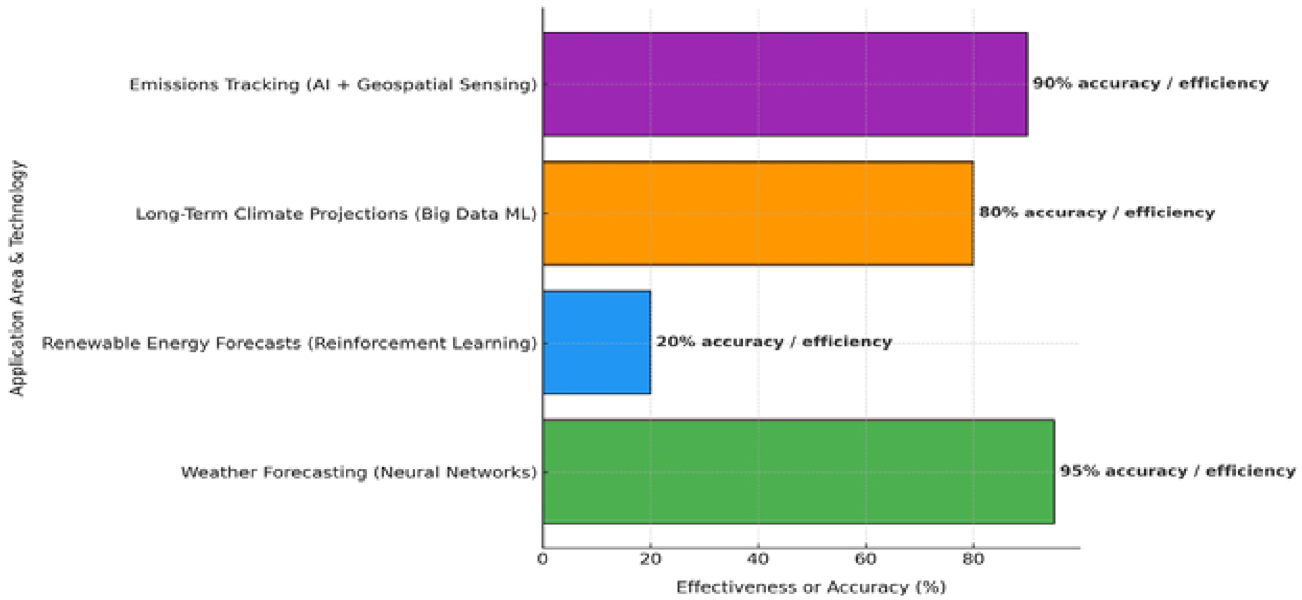
FAWAZ PARAPURATH
PhD Scholar, Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore – 641003, Tamil Nadu

A planet in peril

Global warming has moved from scientific theory to lived reality. Across the world, temperatures are rising, glaciers are shrinking, and weather extremes are becoming more intensive. Despite decades of research and policy discussions, the gap between climate awareness and climate action remains alarmingly wide. Traditional methods viz., reforestation, renewable energy adoption, and emission control have made progress, but they alone cannot counter the accelerating pace of climate disruption. As humanity faces mounting ecological uncertainty, new technological frontiers are emerging, offering hope for smarter, faster, and more resilient climate responses.

The rise of digital world

In the 21st century, a new ally has joined the fight against climate change, that is Artificial Intelligence (AI). Together with Machine Learning (ML), Quantum Computing, and Geospatial Technologies, AI helps decoding the complexities of our planet. These tools process vast datasets, identify hidden



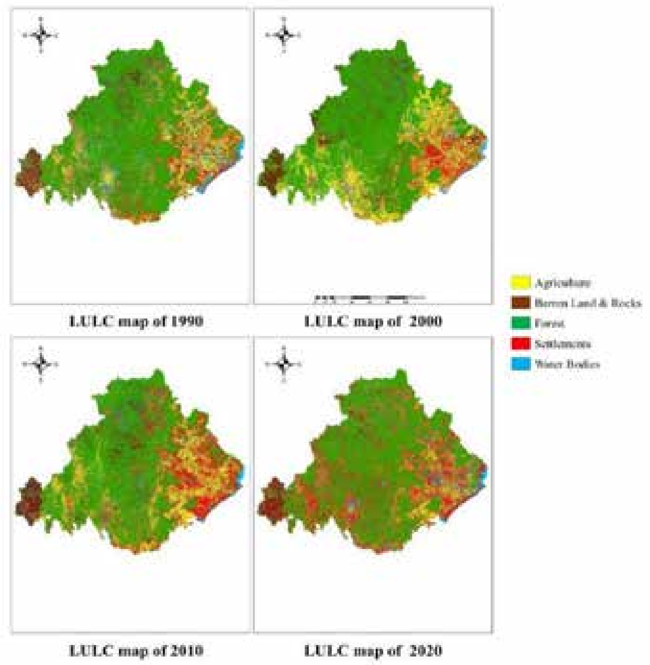


Fig. 2a Climate variability induced Land use land cover change detection study conducted by Senapati et al. (2024) over the Northeastern Ghat Zone of Odisha, India using Google Earth Engine (GEE). In this study, a significant increase in the settlement area was identified during the study period. Whereas, the vegetation cover reduced from 72.65% to 57.06% of the total study area (NEGZ).

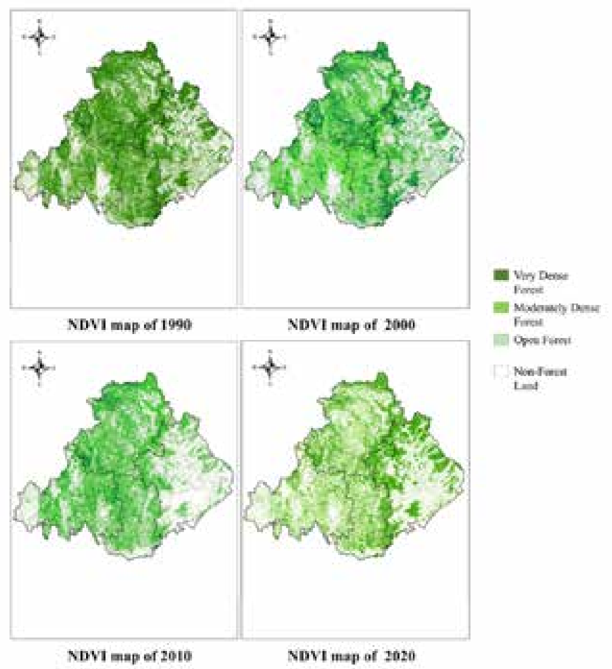


Fig. 2b Climate variability induced Deforestation assessment study using NDVI conducted by Parapurath et al. (2025b) over the Northeastern Ghat Zone (NEGZ) of Odisha, India with the help of GEE platform. The results inferred that the forest cover reduced by 20%, wherein a gradual decrease in the Very Dense Forest Area (VDF) was observed by 14.21% of the NEGZ.

patterns, and simulate future scenarios with unprecedented accuracy (Fig. 1). From predicting monsoon rainfall in India to optimizing energy use in European cities, AI and ML are transforming how we observe and respond to environmental change.

Seeing the earth anew: The power of geospatial intelligence

Geospatial technologies satellite remote sensing, drones, and Geographic Information Systems (GIS) have revolutionized climate observation. They allow scientists to map forest loss, track glacial retreat, monitor drought stress, delineate groundwater potential zones and assess flood risks with a precision that was unthinkable just decades ago. When combined with AI, these tools can analyze millions of data points in real time, helping decision-makers act before crises unfold. In India, for instance, researchers have used remote sensing and machine learning to monitor forest cover, revealing patterns of degradation and regeneration that guide conservation planning (Fig. 2a & 2b). Similarly, ML and cloud computing are creating a new paradigm for groundwater assessment and restoration. By fusing multi-source datasets including satellite imagery (Landsat, Sentinel), UAV photogrammetry, and in-situ measurements, researchers are now able to deliver accurate, timely, and actionable insights for sustainable groundwater governance. ML algorithms, such as Artificial Neural Networks (ANN) and Support Vector Regression (SVR), have demonstrated significant improvements in forecasting groundwater levels. Concurrently, cloud platforms like Google Earth Engine (GEE) are pivotal for processing massive datasets on a planetary scale, enabling near-real-time analysis (Fig. 3)

Learning the language of climate: How machines decode weather and climate change

Traditional climate models rely on physical equations to describe atmospheric processes. Even though they are powerful, but it is limited by computational demands and uncertain long-term projections. Whereas, ML offers a new approach, as it studies the data by analyzing the trend and pattern of the data without much human commands or instructions. Therefore, these ML models and AI systems can detect correlations between weather variables by training on satellite imageries and meteorological records. Google's DeepMind has used similar models to improve wind forecasts, while AI-based monsoon prediction systems in India have boosted rainfall accuracy to nearly 90%, giving farmers a vital edge in planning their crops.

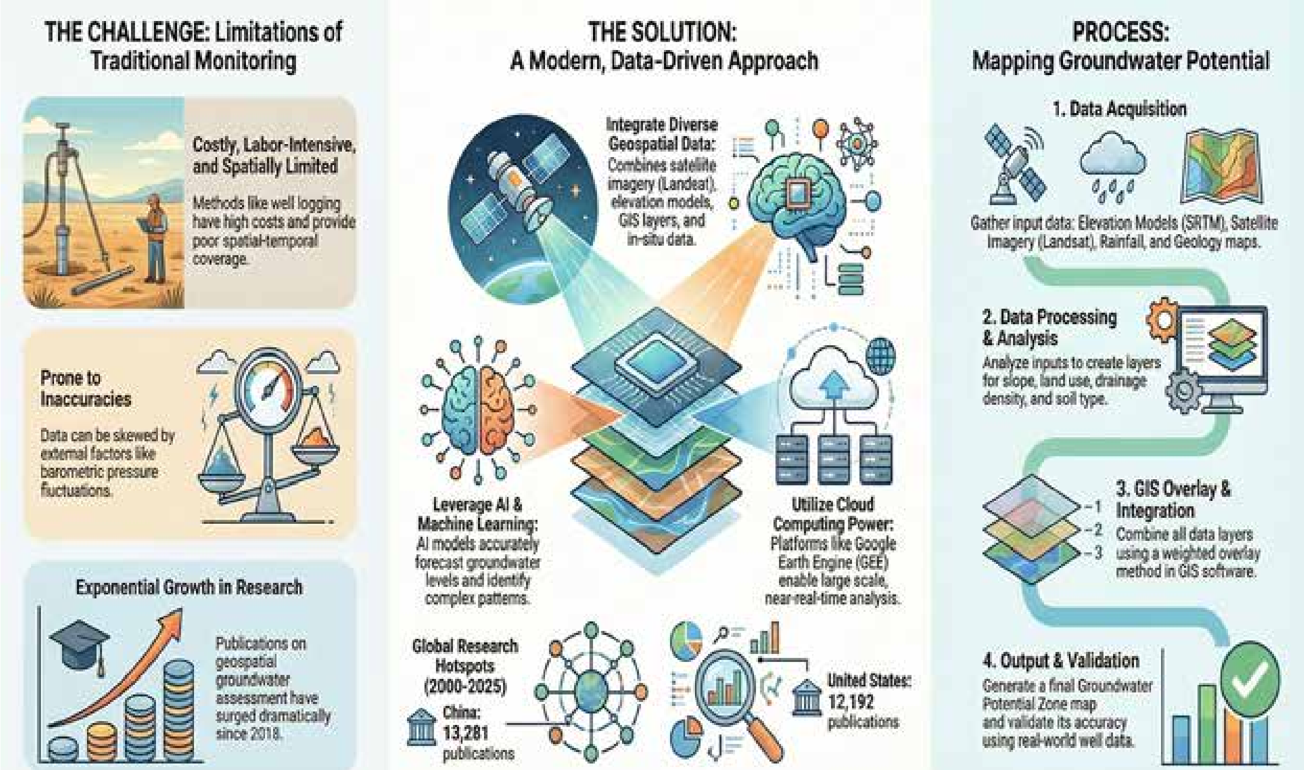


Fig. 3 Delineation of Groundwater Potential Zones (GWPZs) using RS (Remote Sensing), AI & ML Technology (Source: Prakash et al., 2025a)

Predicting the unpredictable: Data-driven forecasts for a changing planet

Extreme weather events mainly cyclones, droughts, floods, hailstorms, heatwaves, and thunderstorms are becoming more frequent and severe. GEE and AI-driven models assist in mapping the vulnerable hotspots and forecast these disasters with more accuracy. For instance, the Hailstorm dynamics study conducted by Subba Rao et al. (2025) in India using geospatial technology could identify that the hail events have covered majority of the country in the recent past (1998–2020) compared to 1975–1997 with a net increase of 307 events and maximum occurrence in the North and North-west region with a hailstorm density of 12.79%, confined to the period from January to May (Fig. 4).

In flood-prone regions, machine learning algorithms integrate

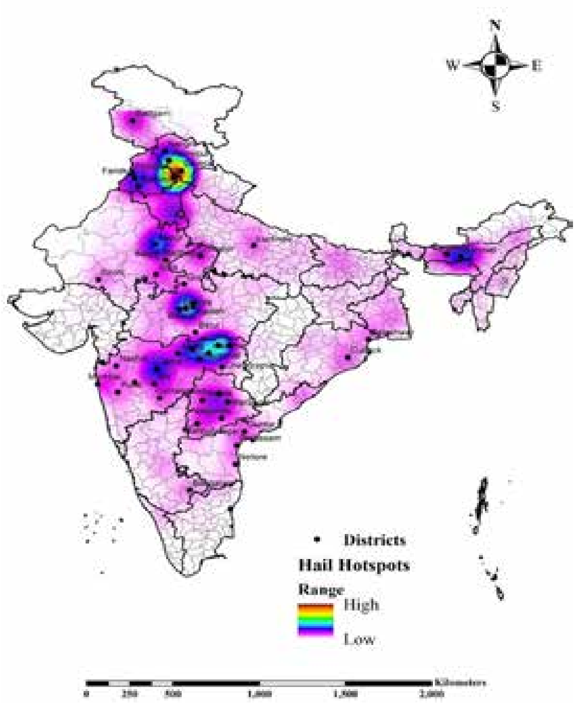


Fig. 4 The Hailstorm hotspots of India delineated using Kernal Density estimation revealed that among the states, Himachal Pradesh recorded maximum hail events spread over the majority of the months despite Maharashtra (614) being the highest hailstorm observed state of the country during the study period 1975 to 2020 (Source: Subba Rao et al., 2025)

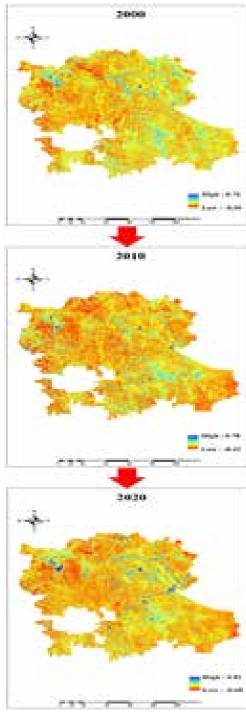


Fig. 5 The NDMI patterns in Anantapur, Andra Pradesh, India indicated that the dryness/aridity is slowly declining due to the increase in the wetness drivers over the period from 2000 to 2019 (Source: Parapurath and Veluswamy, 2025)

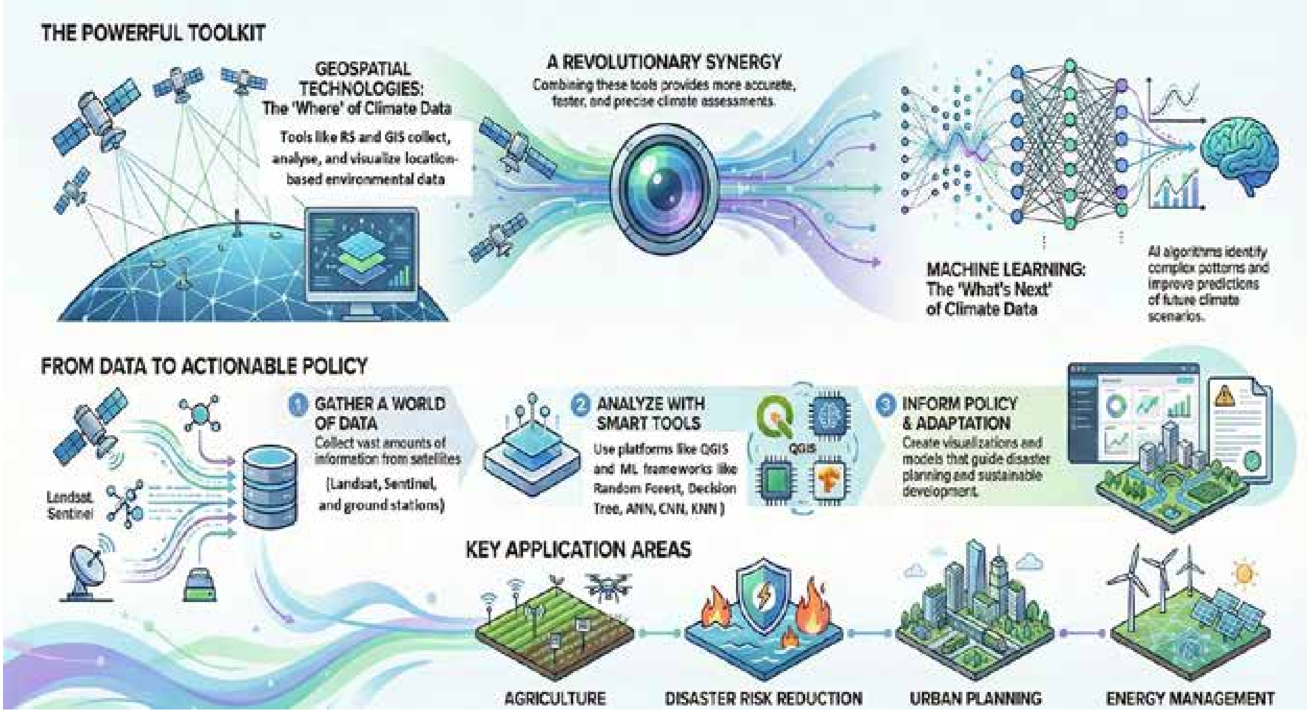


Fig. 6 Geospatial and AI based mapping, monitoring and prediction (Source: Prakash et al., 2025b)

satellite rainfall data with terrain maps to identify vulnerable zones. Similarly, drought indices such as the Normalized Difference Moisture Index (NDMI), Normalized Difference water index (NDWI), Palmer Drought Severity Index (PDSI), Standardized Precipitation Evapotranspiration Index (SPEI) etc... are derived using ML-based analytics on long-term climate datasets (Fig. 5). These predictive insights not only save lives but also guide long-term adaptation strategies for agriculture and water management

Reinventing energy and agriculture through smart systems

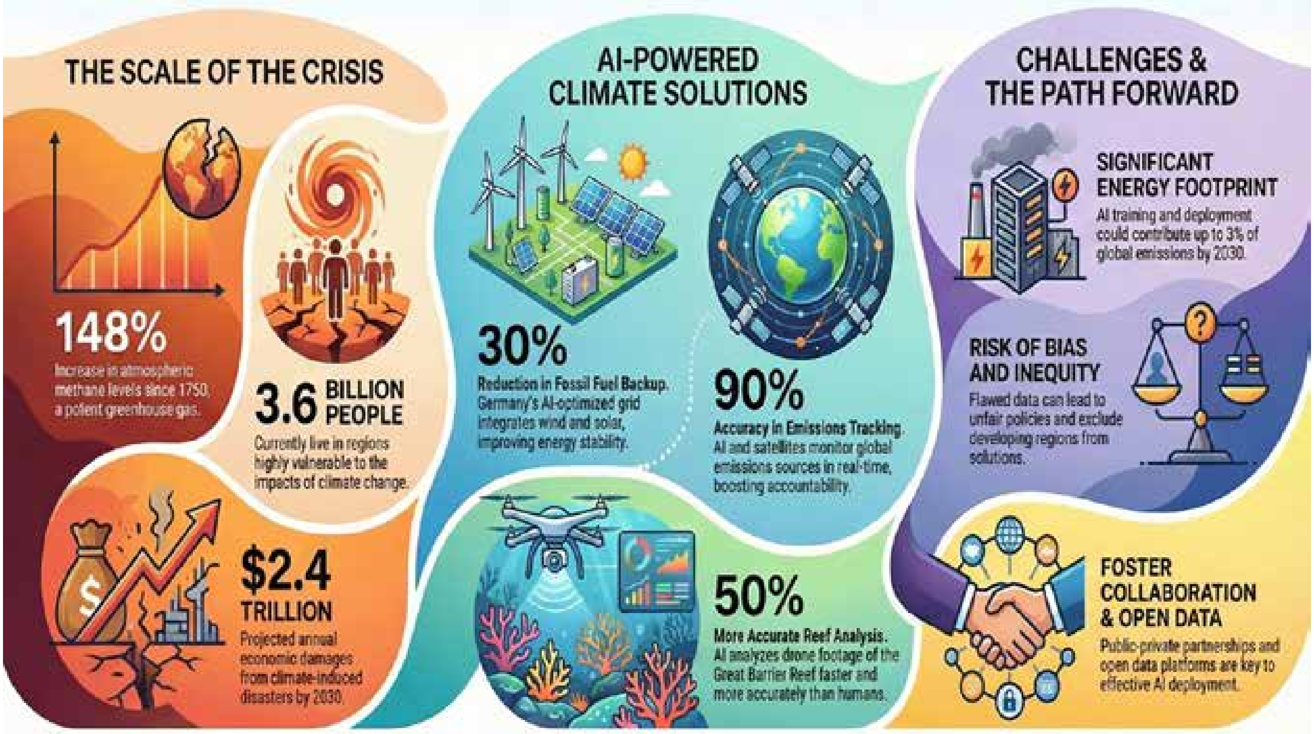
AI is at the heart of the global transition to clean energy. Smart grids powered by machine learning and deep learning models balance electricity supply and demand in real time, conversely wastage is decreased and carbon footprints is reduced. In agriculture, AI-driven sensors and drones enable precision farming optimizing fertilizer use, irrigation, and pest control. By minimizing inputs and maximizing yield, these systems boost food security while curbing emissions from farming practices. Additionally, AI-powered drones patrol forests to detect illegal logging, while underwater robots monitor coral reefs and track marine pollution. In Australia, AI is being used to map coral bleaching on the Great Barrier Reef with accuracy surpassing human surveys. These tools generate real-time insights for conservationists and policymakers, helping allocate resources where they're needed most (Fig. 6)

Cities of tomorrow: From carbon chaos to digital balance

Urban areas are responsible for over 70% of global carbon emissions. But AI and geospatial tools are helping cities evolve into sustainable ecosystems (Fig. 6). Smart city systems powered by AI can optimize traffic flow, reducing congestion and emissions by up to 10%. AI-managed buildings adjust energy use dynamically, while satellite data monitors air pollution and urban heat islands. Singapore's AI-based infrastructure planning and Europe's net-zero urban design initiatives exemplify how technology can turn cities into living laboratories of climate resilience.

Bridging ethics, equity, and innovation

While AI and geospatial analytics offer immense promise, they also come with challenges. Training large AI models requires substantial energy, and unequal access to technology can widen global disparities. Data bias is another risk, if algorithms are trained on incomplete or skewed datasets, they can misrepresent reality. Ethical governance, open data sharing, and collaboration across borders are vital to ensure that technology serves everyone. Climate technology must remain inclusive, especially when it is involved in empowering developing nations, and not excluding them.



The story of climate change is ultimately a story of information of how we collect it, interpret it, and act upon it. Artificial intelligence, machine learning, and geospatial intelligence have given humanity new eyes and sharper minds to see the planet's pulse. Yet, technology is not a silver bullet. It is a compass pointing us towards more informed, equitable, and sustainable choices. The future will depend not only on the power of algorithms but also on the wisdom with which we use them. As data becomes our new climate language, our ability to listen and respond will define the fate of our planet.

References

Parapurath, F., & Veluswamy, K. (2025). Climatic Variability and Groundnut Crop Yield: Unveiling the Scenario in Anantapur, India. International Agricultural Engineering Journal, 34(1-4), 155-170. https://doi.org/10.5281/zenodo.17007941

Parapurath, F., Senapati, R., Ghosh, A., Rath, B. S., & Verma, D. (2025b). Spatio-temporal changes of the forest cover in North Eastern Ghat Zone of Odisha, India, using multi-year Landsat data. Nature Environment and Pollution Technology, 24(3), B4291. https://doi.org/10.46488/NEPT.2025.v24i03.B4291

Parapurath, F., Waquar, T., Lalmuanzuala, B., & Prakash, A. (2025a). GLOBAL WARMING SOLUTIONS: HARNESSING AI, ML & ADVANCED TECHNOLOGIES FOR A SUSTAINABLE FUTURE. AgriGate-An International Multidisciplinary e-Magazine, 5(9), 826-840.

Prakash, A., Parapurath, F., Gautham, S. S. P., Senapati, R., & Sabharwal, G. (2025b). Geospatial based Mapping, Monitoring and Prediction of Climate Changes. In Kushwaha, S., & Kamalvanshi, V. (Eds), Climate Change and Agriculture (Vol. 13, pp. 189–209). AkiNik Publications.

Prakash, A., Parapurath, F., Nazar, S., Meena, A. K., Panchulakshmi, M., & Waquar, T. (2025a). APPLICATION OF GIS TECHNOLOGY FOR RESTORATION OF GROUNDWATER RESOURCES: A COMPREHENSIVE REVIEW. Plant Archives, 25(2), 2127-2136. https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.305

Senapati, R., Rath, B. S., Parapurath, F., Mahanty, M., Ghosh, A., Meena, A. K., & Pandit, R. (2024). Forest Cover Change Detection Over North Eastern Ghat Zone of Odisha, India Using Multi-Year Landsat Data. International Journal of Environment and Climate Change, 14(9), 787-795. https://doi.org/10.9734/ijecc/2024/v14i94456.

Subba Rao, A. V. M., Parapurath, F., Sarath Chandran, M. A., Bal, S. K., Manikandan, N., & Singh, V. K. (2025). Spatiotemporal variability and trends of hailstorms over India. Natural Hazards, 121(2), 1687-1710. https://doi.org/10.1007/s11069-024-06866-w ■

Kerala's Organic Farming Policy and its Impact

AJIL MANKUNNUMMAL
PhD Scholar, Centre for Development Studies, Thiruvananthapuram

1. Introduction

The beginning of modern agriculture practices in India was through Green Revolution in the 1960s. HYV seeds, chemical fertilizers and pesticides have played a major role in ensuring productivity in food and non-food agriculture products and food security. However, such agricultural practices have negatively impacted the sustainability of agriculture through the high cost of cultivation and declining soil fertility. The central Government is recently pushing for natural or organic farming in India. This could be seen from Prime Minister Narendra Modi's speeches on 16th December 2021 at National Conclave on Natural Farming to "liberate the country's soil from chemical fertilizers and pesticides" and on 1st January 2022 at a PM-KISAN programme urged the farmers to "switch to the chemical-free method of cultivation". Last year, on 28th May, in the IFFCO seminar, the Prime Minister again pushed for organic farming by saying that 'it is the new mantra' and would reduce the dependence on other countries for fertilizer products. The Prime minister had also advocated for organic farming mentioning it as' our duty' in his

2022 Independence Day speech. The Economic Survey 2021-22 (GoI, 2022) also specifies the importance of finding alternative fertilizers and reducing the use of chemical fertilizers in agriculture. Culminating all these, the Government proposed a new programme in the latest budget, 2023-24 (GoI, 2023), which is PM-PRANAM (PM Programme for Restoration, Awareness, Nourishment and Amelioration of Mother Earth) to promote alternative fertilizers in all the states and union territories and incentivize them in the balanced use of chemical fertilizers, which is possible through reducing the consumption of Urea, the most used nitrogenous fertilizer in India. Besides these, the Government is also trying to facilitate the farmers to adopt natural farming through Bhartiya Prakritik Kheti Bio-Input Resource Centres. The alternative that the Union Government is now pushing was already implemented by Kerala way back in 2010.

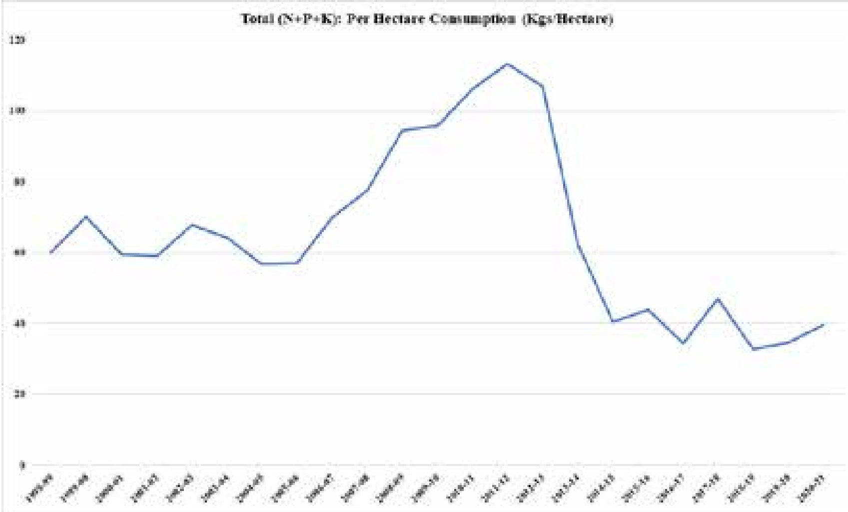
2. Promotion of Organic Farming in Kerala

The need for organic farming in Kerala initially came in 2007. Later, after five years, Kerala formed an 'Organic Farming Policy' in 2012 by Kerala State Bio-Diversity Board with the vision of 'Make Kerala's farming sustainable, rewarding, and competitive, ensuring poison-free water, soil and food to every citizen'. The policy has 24 strategies. As per the Organic Farming plan of 2010-11, Kerala started organic farming on 900 hectares in 20 selected blocks of 14 districts. Later in 2011-12, it expanded to 3500 hectares. Based on the plan, the Government declared Kasargod district as an 'Organic District' in 2012. Though the Government had planned to make Kerala a completely organic state by 2016, somehow, the state couldn't do it. However, as part of promoting the organic clusters, Kerala could bring 200 good agriculture practices in 5000 hectares in 2019-20 (Economic Review, 2021). Later with the help of Paramparagat Krishi Vikas Yojana (PKVY) and Bharatiy Prakrutik Krishi Paddhati, 12380 hectares and 84000 hectares, respectively, were brought under in Kerala (Economic Survey, 2022). Currently, organic farming is promoted through the Vegetable and Fruit Promotion Council Kerala (VFPCK) and State Horticulture Mission (SHM).

This article examines the impact of the organic farming policy of Kerala on the consumption of Chemical Fertilizers and pesticides and agriculture productivity using the data from Agriculture Statistics, Govt of India, Economic Review, Govt of Kerala and Economic Survey, Govt of India.

3. Consumption of Chemical Fertilizers and Pesticides & Agriculture Productivity

The Government is promoting Integrating Nutrient Management through soil testing, giving importance to organic fertilizers. One of the 24 strategies adopted in the organic farming policy in 2012 is eventually reducing the consumption of chemical fertilizers and pesticides in Kerala without compromising agricultural productivity. The Government recommends chemical fertilizers at a prescribed amount by the Agriculture University in its Package of Practices. Figure 1 shows the per-hectare consumption of chemical fertilizers in Kerala from 1998-99 to 2020-21.



The graph indicates that the per hectare consumption of chemical fertilizers (N+P+K) has declined since 2012, though there had a continuous hike from 2005 to 2012. By 2021, the consumption has been reduced to 39.62 kg/hectare. On the other hand, compared to 2017-18, pesticide use declined in 2019-20 (Department of Agriculture Development and Farmers' Welfare, 2020).

However, given that Kerala's total cropped area is continuously declining after 2005-06 (Agriculture Statistics, GoI), improving the productivity of agriculture draws particular importance. A prime criticism

Table 1: Productivity of Kerala Agriculture, 2000 to 2020 (Kg/Hectare)

Year	Cereals	Pulses	Oil Seeds	Spices	Horticulture	Coconut	Areca Nut	Cashew
2000-01	2095.02	793.89	614.04	NA	NA	5979.69	1005.72	760
2004-05	2278.1	852.94	791.67	541.75	5520	6378.93	1090.16	627.45
2010-11	2399.87	777.6	1050	481.69	6140	7918.15	1153.29	910.26
2011-12	2695.12	747.06	1226.32	443.14	6240	8108.63	1208.03	892.64
2012-13	2546.9	1028.57	1044.92	757.96	6370	7264.26	996.89	906.95
2013-14	2530.33	1107.81	979.59	683.16	6440	7486.12	1110.68	943.46
2014-15	2822.57	1131.15	1054.05	838.24	5840	7534.98	1302.41	946.41
2015-16	2756.31	1132.57	1048.74	769.71	6520	9640.8	1020.98	827.49
2016-17	2532.3	984.46	1024.53	840.35	6414	9663.66	1273.03	924.18
2017-18	2735.85	1026.83	900.05	1220.97	6612	10472	1320.54	950.11
2018-19	2890.05	926.8	697.48	NA	NA	10097	NA	NA
2019-20	3025.39	966.05	733.26	NA	NA	NA	NA	NA

Source: Agriculture Statistics, Govt of India

Note: Coconut is the Number of Coconut/Hectare

against organic farming is that it reduces productivity. The best example is Sri Lanka, which completely banned the import of chemical fertilizers and pesticides on 6th May, 2021 through its 'vistas of prosperity and splendour' policy in 2019 and moved to organic farming on a fine morning without educating the farmers. Such a move had resulted in a decline in agriculture production and an uncontrollable price hike. Later, after six months, with protests from the farmers, Sri Lanka had to withdraw the decision and imported chemical fertilizers and pesticides in November, 2021. Under this circumstance, it is essential to check whether the reduced consumption of fertilizers and fertilizers impacted Kerala's agricultural productivity.

Table 1 shows the productivity of major agricultural products in Kerala from 2000 to 2020. Productivity is measured based on the yield that Kerala is getting from one hectare of agricultural land. Though the cropped area in Kerala is less compared to other Indian states, compared to 2000-01 and 2010-11, all major crops' productivity had improved in 2020. Among cereals, Rice's productivity had improved from 2162.01 kg/hectare in 2000-01 to 3055.65 kg/hectare in 2019-20. Fruits and vegetables from horticulture, coconut, areca nut, and cashew from commercial crops also had benefits over the years in terms of productivity.

4. What Next in Organic Farming?

Over the years, declining cropped areas and high dependence on other states for agriculture products have been a major debate in Kerala. Kerala has to move strategically in bringing more organic land in future. Local bodies, Kudumbashree, and Cooperative societies could contribute more to bringing organic farming to ward levels. Collaboration with agriculture institutes, professionals and farmers would also be relevant in promoting organic farming to another level. Introducing specific markets for organic products would enable the farmers to find markets for their products. Moreover, Household targeted plans would help make Kerala at least self-sufficient in agricultural products and make organic farming much more popular in Kerala.

References

Government of India. 2022. 'Agriculture and Food Management'. Economic Survey, 2021-22.

EPW Research Foundation. 'Agricultural Statistics'. EPWRF India Time Series.

Govt of India (2023), Budget Speech (2023-24), Ministry of Finance.

Govt. of India (2022), Economic Survey (2021-22), Ministry of Finance, Department of Economic Affairs, Economic Division.

Kerala State Planning Board. 2018. Economic Review. Govt of Kerala

—. 2019. Economic Review.

—. 2020. Economic Review. ■

FRUITANOMICS

Rethinking Kerala's Farming Systems

Diversification through Fruit Crops

VINOJ ABRAHAM[1] & SACHU SARA SABU[2]
[1]Professor and [2]Post-Doctoral Researcher (NRPPD)
Centre for Development Studies (CDS), Thiruvananthapuram, Kerala, India 695 011
vinoj@cds.edu; sachusara@cds.edu

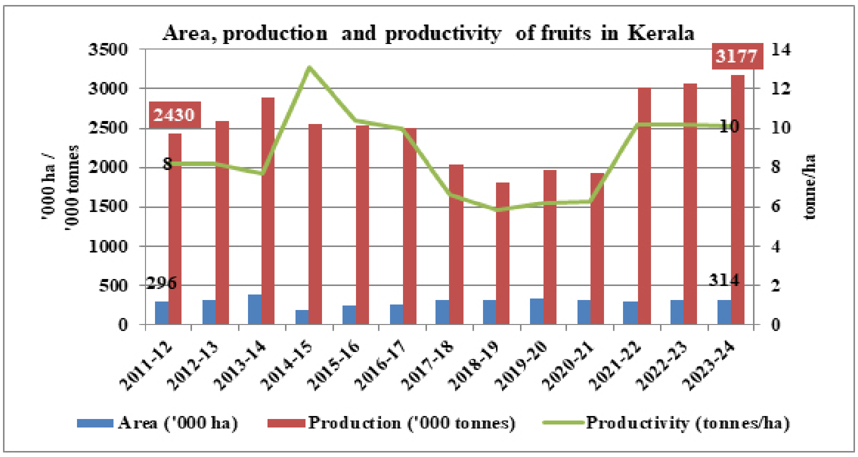
ABSTRACT

Kerala's agriculture has gradually shifted from food crops towards cash crops, particularly plantation crops that are largely cultivated as monocultures. While this transition has raised income of the producer, it has also increased vulnerability to price volatility, pests, and ecological stress. In contrast, homestead orchards and diversified intercropping systems, including multi-tier plantations and fruit-tree combinations can enhance productivity, income stability, and ecological health. Despite their proven advantages, adoption remains limited by legal, policy, and infrastructure constraints. Targeted interventions such as value addition, cold-chain development, farmer-producer organisations, and regulatory reforms could unlock Kerala's underutilised fruit-crop potential and support a more resilient and sustainable farm economy

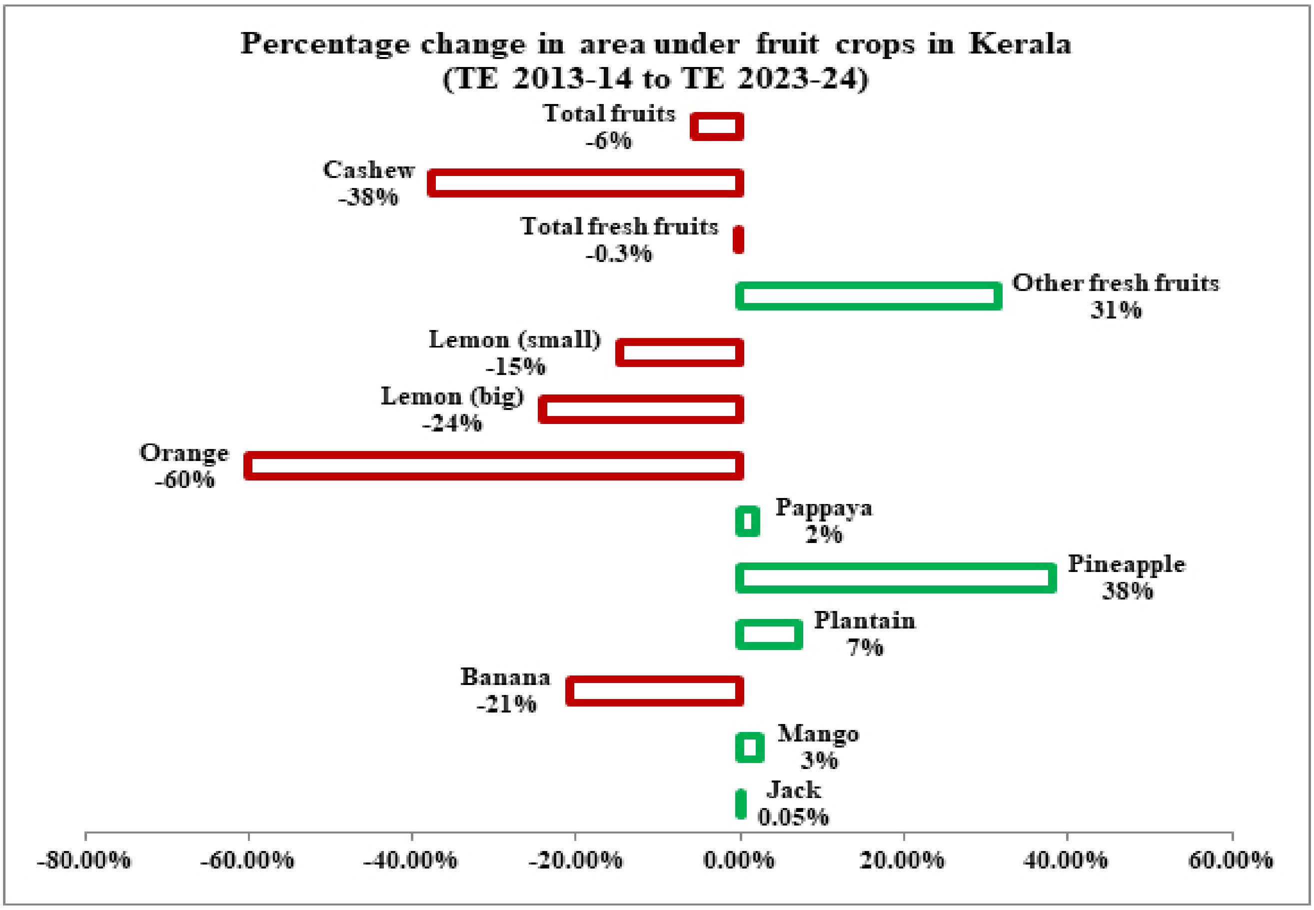
A slow structural shift

Kerala's reputation as a land of coconut palms and rubber plantations is well earned. Yet behind the postcard image lies a deeper economic story: over the last five decades, the state's cropping pattern has been dramatically reshaped by urbanisation, gulf remittances and global commodity cycles. Paddy and tapioca fields have shrunk, cash crops like rubber, coconut, cardamom and pepper have spread, and the once-ubiquitous homestead fruit tree has become more a relic than an engine of rural income. This shift has left Kerala increasingly dependent on neighbouring states for staples and fruit alike, even as consumer preferences move towards fresh, health-oriented produce. It is a paradox. Despite its favourable agro-climatic diversity and high rainfall, Kerala contributes only about 3% of India's fruit output, and its productivity remains well below the national average. The central question, therefore, is whether Kerala can convert its underutilised fruit-growing potential into a new growth pathway, one that raises smallholder incomes, improves dietary diversity, and enhances ecological resilience.

Official statistics capture the magnitude of this shift. In 1960-61, food crops occupied two-thirds of Kerala's cultivated area; today, non-food cash crops take up nearly two-thirds. Within horticulture, cashew has declined sharply while perennial fresh fruits such as jackfruit, mango and plantain have slowly gained share. Between 2013-14 and 2023-24, banana acreage fell by a quarter while pineapple rose by



Source: Department of Economics and Statistics, GoK



Note: TE is Triennium Ending
Source: Department of Economics and Statistics, GoK

nearly 38 percent, reflecting the pull of processing industries and inter-state trade (Fig. 1).Kerala's fruit area has shrunk from 2.96 lakh hectares in 2011–12 to 3.14 lakh hectares in 2023–24 (Fig 2). But production has risen from 2.43 million tonnes to 3.18 million tonnes due to productivity gains (Fig. 2). Even so, Kerala lags far behind the national average: 10.2 tonnes per hectare compared to 15.6 nationally (Fig 3). States such as Maharashtra doubled its productivity, whereas Andhra Pradesh saw strong but less-than-doubling growth by adopting scientific orchard management, improved varieties, and value chain integration (Fig 4). The gap highlights Kerala's underutilised potential.

Fruit crops present a compelling opportunity in this context. Compared to annual food crops, they are relatively less labour-intensive, more climate-resilient, and better suited to Kerala's fragmented landholdings. They also align with changing nutritional priorities, shifting the focus from calorie sufficiency towards diversified, nutrient-rich diets. Importantly, fruit cultivation offers income diversification for farm households exposed to price volatility in plantation crops.

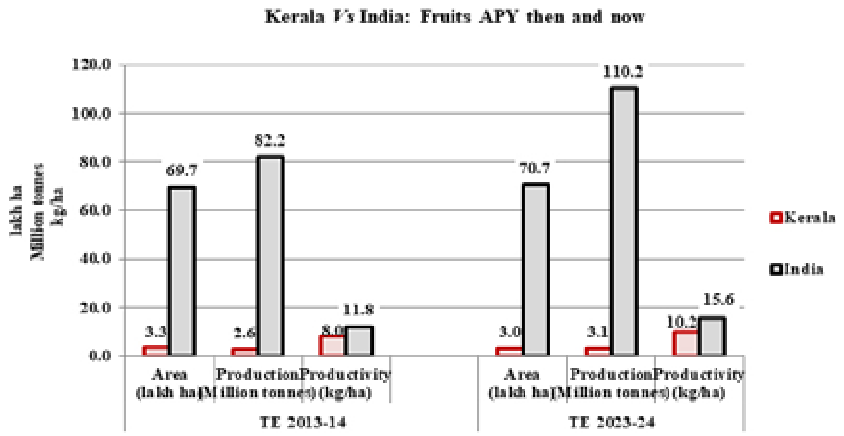
Homesteads as hidden orchards

Kerala's agrarian structure is dominated by small and marginal holdings, with the homestead forming a distinctive production system. Traditionally, homesteads combined fruit trees, food crops and livestock, serving as a buffer against income and consumption shocks. Empirical studies show that diversified systems integrating crops with dairy, goats and poultry generate higher household incomes while improving nutritional outcomes (Balakrishnan, 2018). Perennial fruit trees such as jackfruit, mango and guava thrive in these systems with relatively low external inputs. Recent evidence points to the untapped commercial potential of homesteads. A study conducted in Kerala Agricultural University (KAU) illustrate the revenue potential of dragon fruit, with yields of 21 tonnes per hectare and prices around ₹170/kg, net returns can exceed ₹25 lakh a hectare under proper management (Sethunath et al., 2025). Such numbers are eye-catching in a state where small farmers have been squeezed by stagnant rubber prices and volatile spice markets. The implication is that homestead farming is not a quaint tradition but an under-capitalised asset. Credit, insurance and extension services tailored to mixed farming, not just single crop would let smallholders scale up fruit production and tap into value chains without sacrificing resilience.

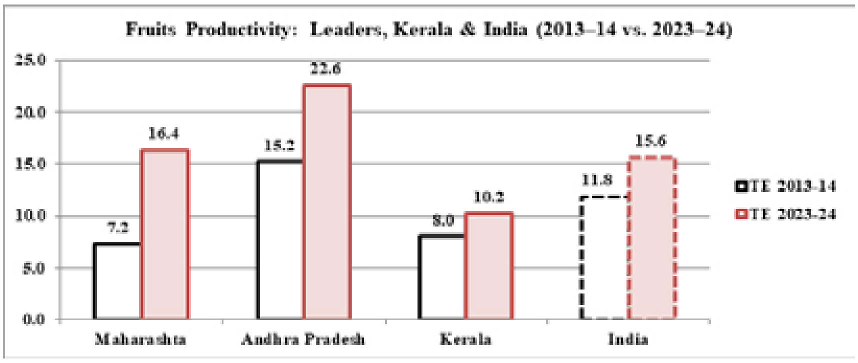
Intercropping: making plantations pay again

Plantations once powered Kerala's rural economy. In 2012-13, they brought in ₹21,000 crore; by 2018-19, the figure had fallen to less than half (Balakrishnan, 2018). Monocropping of rubber, coffee or coconut exposes growers to pests, diseases and price shocks. By contrast, multi-tier systems, coconut with banana and turmeric, rubber interplanted with pineapple or jackfruit, coffee shaded by mango or avocado, generate steadier income streams and improve soil health. Trials by KAU and Indian Council of Agricultural Research (ICAR) institutes show that such diversified models consistently outperform monocrops in productivity, profitability and ecological indicators (Namitha et al., 2025 & Nair, 2020). Passion fruit under coconut palms can yield ₹1.6 lakh per acre annually; banana and pineapple planted between young rubber rows bring interim income during the long non-tapping phase (Arunachalam et al., 2025). Coffee plus pepper plus fruit trees in Wayanad has proven more stable than coffee alone when global prices fall. Legal and policy barriers, however, hamper this transition (Kumar et al., 2018). The Plantation Labour Act, 1951 and land-use rules were written for monoculture estates, making it cumbersome to integrate other crops without extra clearances. Rethinking these regulations, while safeguarding worker welfare and environmental norms could unlock significant new income on existing plantation land.

High-value niches and



Note: TE is Triennium Ending
Source: MoA&FW, GoI



Source: MoA&FW, GoI

under-used diversity

Kerala has already declared jackfruit its state fruit and supports "fruit villages" for exotic crops like rambutan and mangosteen. Demand from processing industries for pineapple and papaya is growing. Underutilised minor fruits from the Western Ghats offer complementary income and biodiversity benefits if post-harvest losses and poor consumer acceptance can be overcome. What is missing is a coherent strategy to connect these dots. Value addition i.e., turning fruit into chips, dried slices, jams, pickles or beverages, remains fragmented. Cold storage, ripening chambers and pack houses are concentrated in a few hubs, leaving most small growers dependent on middlemen. And while Kerala sits close to major ports and airports, its export presence is limited to a handful of products.

Building the fruit economy's backbone

A viable model would combine public support, cooperative ownership and user fees to spread risk and cost. Local "fruit resource centres" equipped with modular cold rooms, solar dryers, pulping units and refrigerated vans could be co-funded by the state under horticulture schemes, managed by Kudumbashree groups or farmer-producer companies, and accessed by individual growers at affordable rates. This would make advanced storage and transport infrastructure economically sustainable even at the grassroots level. On the market side, farmer-producer organisations can aggregate, grade and brand mixed produce from homesteads, negotiate contracts with supermarkets and online platforms, and secure certifications needed for export. Developing geographical indications (GI) for signature fruits, Kerala jackfruit, dragon fruit, and mangosteen would improve visibility and fetch premium prices.

Land, law and the long view

Expanding fruit cultivation also means tackling Kerala's land-use and tenure issues. Weak property rights in hilly terrains deter investment in long-gestation tree crops. Informal tenancy and the absence of legal sanctity for land leasing limit the scale and professionalism of fruit farming. And while the Kerala Conservation of Paddy Land and Wetland Act, 2008 rightly protects food security and ecology, its blanket restrictions on land conversion make it hard to shift suitable areas into perennial fruit trees, even when these could enhance nutrition and carbon sequestration compared to seasonal monocrops. Clarifying property rights, allowing regulated tenancy and revisiting land-use rules with clear environmental safeguards could give farmers and estate owners the confidence to plant fruit trees for the long term.

Why business should care

The story here is not just about agriculture policy. It is about an emerging set of investible opportunities in production, processing, logistics and retail:

- Input and nursery businesses supplying high-quality grafts, tissue-culture banana and climate-resilient rootstocks.
- Decentralised cold-chain and micro-processing run on public-private or cooperative models.
- Branding and marketing platforms for GI-tagged or organic Kerala fruits.
- Insurance and credit products tailored to diversified orchards and intercropping systems.

A new growth narrative

The decline of monoculture plantations and the stagnation of paddy acreage are not just problems; they are openings. By reallocating land from low-return or high-risk crops to perennial fruit trees, and by strengthening the homestead and intercropping, the state can build a more resilient farm economy and meet rising demand for diversified diets. It will require policy tweaks, legal flexibility for plantations, tenancy reform, incentives tied to crop diversity rather than mere seedling distribution as well as investment in decentralised infrastructure and market linkages. But the payoff is compelling: higher and steadier incomes for smallholders, reduced import dependence for consumers, and a greener landscape that sequesters carbon and supports biodiversity. With the right policies and investments, Kerala has the chance to lead a Fruit Revolution that can nourish its people, revitalise farms, and strengthen the rural economy. For businesses attuned to sustainability and inclusive growth, it is time to look beyond the coconut palm and rubber tree and see the orchard waiting to bloom.

Reference

1. Balakrishnan, A., Economic analysis of homestead farming systems in Kerala, PhD thesis, National Dairy Research Institute, Karnal, 2018.
2. Sethunath, K., Kuruvila, A. and Bhaskar, J., Economics of production and marketing of dragon fruit in Kerala, International Journal of Agriculture and Food Science, 2025, 7(3), 126–128; doi:10.33545/2664844X.2025.v7.i3b.322.
3. Namitha, V. V., Raj, S. K., Pillai, S., Radhakrishnan, N. V., Paramesh, V. and Nath, A. J., Impact of crop combination and nutrient management on productivity, profitability and soil health in a coconut-based multistoried cropping system in Kerala, India. Frontiers in Sustainable Food Systems, 2025, 9, 1605962.
4. Nair, K. P., Technological advancements in coconut, arecanut and cocoa research: a century of service to the global farming community by the Central Plantation Crops Research Institute, Kasaragod, Kerala State, India, in Tree Crops: Harvesting Cash from the World's Important Cash Crops (ed. Nair, K. P.), Springer International Publishing, 2020, pp. 377–536.
5. Arunachalam, V., Paramesh, V. and Salgaonkar, D. C., Economics, energy budgeting and environmental impact assessment of coconut-based cropping system in the west coast of India. Current Research in Environmental Sustainability, 2025, 9, 100289.
6. Kumar, A. N., Panicker, N., Saleem, A. I. K. and Balakrishnan, V., Coffee, climate and biodiversity: understanding the carbon stocks of the shade coffee production system of India, in Handbook of Climate Change and Biodiversity (eds. Springer, Cham), Springer International Publishing, 2018, pp. 113–134.

Enforce Quarantine
Exterminate Non-Native Invasive Pests

*JOSEPHRAJKUMAR A., ANES K.M., SHAREEFA M., MERIN BABU, JILU V. SAJAN AND REGI J. THOMAS
ICAR-CPCRI, Regional Station, Kayamkulam
Alappuzha– 690 533, Kerala, INDIA
Corresponding author: joecpcri@gmail.com; 7907474959

The word "Quarantine" literally means "forty-days" has now become a common global buzzword after COVID pandemic. The controlled isolation for forty days are so crucial to offload consignment of live materials or food stocks that are imported so as to ensure complete arrest or any accidental entry of any "Non-native Invasive Species (NIS)" in to the importing country. Nevertheless, these consignments need to be strictly inspected by responsible Quarantine Officials so that the materials under import are absolutely free from any biosecurity risks and are mandatorily certified.

Quarantine is a government endeavour enforced through legislative measures to regulate the introduction of planting materials, plant products, soil, living organisms etc., in order to prevent inadvertent introduction of pests harmful to agriculture of a country/state/region, and if they are introduced, to prevent their establishment and further spread. India ranks second in the global list of countries with the highest economic impact from biological invasions. The estimated papaya yield losses due to invasive papaya mealybug alone were 57%, with an associated annual economic loss of US$3,009 per ha at the farm level.

Why Quarantine?

Due to liberalized trade and tourism, entry of NIS has become so common upsetting the economic and environmental stability of a nation. Global impact of NIS costs about 423 billion USD every year, which is a huge sum for a nation to withstand mainly because of biotic imbalance due to the absence of defenders. It was found that NIS has cost Indian economy between US$ 127.3 billion to 182.6 billion over 1960–2020, and these costs have increased with time. While several countries implement biosecurity risks with stringent laws and greater penalties, such a strict enforcement is lacking in certain other countries including India. A recent penalty enforced on to a renowned actress from India who had travelled to Australia with a piece of jasmine string attracted global attention on how severely quarantine is being enforced in some countries. Do we have such stricter laws in our country? Yes of course, but the course of implementation is definitely a wake-up call for sure.

Why such stringent laws and hefty penalties?

Entry of the non-native spiralling whitefly, Aleurodicus dispersus Russel into Kerala in 1993 through casual import of cut flowers caused havoc in the country till early 2000, as this exotic whitefly invaded more than 400 host plants including cassava, guava, ornamentals etc and caused significant economic setbacks. Accidental advent of coconut eriophyid mite, Aceria guerreronis Keifer again in 1998 from Kerala has caused severe productivity decline in coconut and is still a matter of concern in certain coconut growing states in India. A recent introduction of rugose spiralling whitefly, Aleurodicus rugioperculatus Martin and Bondar's Nesting Whitefly, Paraleyrodes bondari Peracchi during 2016 and 2018, respectively possibly through

Aleurodicus dispersus

Damage by eriophyid mite

ornamental palms from Central America again reported first from Kerala is still regarded as invasive pests of national concern and importance that had upset the coconut production in the country. A silent introduction of the invasive nematode, Meloidogyne enterolobii is ruining the guava industry and is getting transported through horticultural plants by the contaminated soil across the nation especially by the adoption of unscientific nursery techniques and business promotion. Several exotic fruit plants are entering in to the country without proper quarantine procedures even today in numbers that are unimaginable through ports and land borders that have inadequate quarantine check.

These introductions of transboundary pests in to the country is mainly attributed to such insecure entry through ports both sea and air and also by land boundaries by traders, tourists etc bringing cut flowers, ornamental plants, contaminated seeds and soils leading to great economic loss to the nation. While India many times failed to snatch the illegal entry of these planting materials either through wilful or unknowing means, countries like Australia, New Zealand and others are so vigilant that even unknowing carrying of a string of jasmine resulted in hefty penalties. This is because such entry of biosecurity risks will collapse the national economy and become a national threat in no time. In order to counter such illegal entry, every citizen and students should be made aware of the consequential catastrophe. We should introduce COVID pandemic kind of checks in these vulnerable points of district borders, state borders, national borders targeting illegal entry of planting materials and other live products. Is our common citizen really aware of this impact and their consequences? Surely a big No.

Brontispa longissima

Domestic Quarantine

In the past, domestic quarantine was strictly enforced under the Destructive Insects and Pests Act (DIPA), 1914, to contain the spread of the potato cyst nematode by restricting the movement of potatoes from Ooty in the Nilgiris district of Tamil Nadu to other regions. However, due to lapses in implementation (or other factors), the nematode eventually spread to Himachal Pradesh. Similarly, during the 1920s, the State Department of Agriculture maintained strict vigilance along district boundaries in peninsular India, invoking the same Act to prevent the movement of coconut fronds infested with the black-headed caterpillar into pest-free zones. What became of such rigorous measures in the years that followed remains a matter of concern.

Due to lack of any domestic quarantine, movement of exotic whitefly infested Chowghat Orange Dwarf seedlings were unknowingly made all over the country by the nurseries. In no time, all the five non-native invasive whiteflies infesting coconut reported primarily from Kerala/Tamil Nadu were established in every nook and corner including Lakshadweep and Bay Islands in less than two years since it was reported in 2016. Besides providing livelihood security to millions of farmers, coconut is also an ecosystem service provider for coastlines and Island inhabitants. Any introduction of quarantine pests will definitely collapse the ecosystem services as well. Furthermore, there are potential invasive pests such as coconut leaf beetle, Brontispa longissima Gestro, hard scale, Aspidiotus rigidus and red ring nematode, Bursaphelenchus cocophilus (Cobb) Baujard waiting at our doorsteps to threaten coconut. Coconut leaf beetles and hard scales have severely affected coconut palms in all South-East Asian nations impairing the tourism industry and remain as a potential threat to India.

What is the need of the hour?

Strengthening Quarantine

- Mandatory checks of all passengers (international and domestic) at all ports and land borders should be made to combat the entry of illegal plant materials/seeds/soils etc along with hefty penalties imposed on the defaulters. While officials are focussed on bullion snatches, such biosecurity risks are more catastrophic because NIS will not have native defenders in the newly introduced country leading to their population explosion.
- Establishment of a modernized central hub with high end equipment linked to AI networking tools at airports, seaports, inter-sate and transboundary check points
- Entry of such planting materials/seeds/soils should be made possible only through notified research organizations by Government of India through well-established procedures in vogue including phytosanitary certificate.
- No planting materials/seeds should be transported or traded from disease/pest endemic zones to any other parts of the country by strict enforcement of domestic quarantine.
- Agriculture being a state subject, however, Quarantine is a national subject and therefore all Agricultural Officers responsible for biodiversity documentation and conservation should be oriented to biosecurity risks and movement of planting materials within their jurisdiction and across their panchayat.
- Regular updating of quarantine officials on the NIS, enforce strict monitoring and curbing illegal entry of any unwanted materials at all strategic entry points.
- Quarantine facilities should be regularly upgraded with modern diagnostic tools to enhance their capacity to detect and prevent the pest entry.
- Ministry of Agriculture and Farmers Welfare should have a strong organizational set up for monitoring and curbing biosecurity risks at national level including certification of nurseries and the planting materials with necessary QR code of authenticity.
- Adoption of biosecurity procedures should be strictly enforced in all horticulture nurseries with proper annual certification process deciphering the source of planting material, propagation techniques and their source material. A certificate to that effect should be made mandatory for all nurseries from accredited laboratories to arrest the illegal import and distribution of planting materials and ensure that the materials are free from any NIS.
- Special incentives should be provided to whistleblowers so that the national economy is protected.
- Engage more enforcement officials and strengthen the network in the best possible manner so that NIS is curbed at the nib.

Strict surveillance and monitoring

- A network of experts and national incursion management team should be formed to monitor the strategic points (airports, seaports & land borders) including Lakshadweep and Bay Islands for the possible of entry of potential NIS. They should work at tandem with the custom officials to curb the entry of any potential threats including potential invasive pests at our doorsteps.
- Just like patrolling team of National Highways, such teams should be the patrolling teams at strategic points and if met with any organism of suspicion, it should be destroyed instantaneously with proper documentation and reported to officials concerned.
- ICAR, SAU and National Horticulture Board should have representatives in this National team of monitoring and incursion management so that all NIS are nibbled at the bud.
- Biodiversity authority should be given equal opportunities to impart biosecurity awareness to all officials implementing even at the

Panchayat level.

Awareness call

When we purchase a planting material, can we ensure it is free from invasive pests and nematodes? Are any certificates endorsed that the planting materials are safe that we take from a nursery. Are biosecurity risks penetrated in to the nursery protocols? Whether every citizen is aware what he can carry or not during travel within the country and abroad?

- Farmers, nursery operators, traders and extension workers must be educated on invasive pest risks and trained to identify and report unusual pest occurrences.
- To create awareness about these biosecurity risks, routine campaigns need to be conducted for the general public at regular place of assemblage including village offices, health clinics, agricultural offices (Krishi Bhavans), nationalized banks etc to understand and appreciate the implications so that such hefty fines are not imposed when they move abroad and within the country.
- Just like traffic rules inculcated in school text books, quarantine issues and vigilance should form a part of school curriculum so that high school students are aware of the dire consequences of entry of biosecurity risks and their responsibility to avoid it.
- Sensitization online courses on biosecurity risks shall be convened for the general public and students for knowledge enrichment and correct adoption.
- The nursery team and dealers should be sensitized on the impending danger of NIS and strategies to combat them and for strict compliance in their nurseries and all illegal entry of planting material should be arrested from national security point of view.
- In the yearlong diploma course offered to the agriculture input dealers (DAESI) by Krishi Vigyan Kendras, SAU or ICAR Institutes, this topic on tackling biosecurity risks should be compulsorily introduced imparting greater awareness.
- Awareness posters can be placed at strategic points (airports, seaports & land borders) and mega advertisement boards in malls and convention centres, clippings in between movies so that the general public is aware and for strict compliance in future.
- Educational reels and short films and documentaries to be displayed in TV channels, Cinema houses, YouTube, Mobile App etc utilizing all digital modes of communication for effective outreach
- Diploma in Biosecurity and Quarantine course to be made mandatory for officials working under DPPQ and Quarantine officers posted at Airports, Seaports and inter-state and transboundary check posts

International Collaboration and information sharing

Considering the transboundary nature of invasive pests, regional and international cooperation is of paramount importance. No single country can effectively manage these threats in isolation, as pests often cross borders through trade, travel, and natural dispersal. Collaborative initiatives such as joint surveillance programs and harmonized quarantine protocols significantly strengthen biosecurity systems. Timely exchange of information on pest outbreaks, potential pathways of introduction and successful management practices enable countries to adopt preventive measures in advance. Furthermore, active participation in global early warning and forecasting networks not only enhances national preparedness but also reduces the likelihood of sudden pest incursions.

Epilogue

Biosecurity risks pose a serious threat to the economic well-being of a nation. Therefore, every citizen is urged to strictly comply with the recommended measures to prevent the entry of non-native invasive species (NIS) into our country. By enforcing these measures, we can effectively conserve our native flora and fauna, safeguard livelihoods, and ensure the economic security of the nation. As responsible nation-builders, it is our collective duty to conserve biodiversity and combat the intrusion of NIS, especially in the era of climate change. A biologically diverse nation provides the foundation for the "One Health" approach, ensuring a safe and sustainable future for citizens by protecting ecosystems, human health, and food security from the threats posed by invasive species.

It is not the absence of rules or legislation that hinders us, as the country already has sufficient legal frameworks in place. The real challenge lies in their effective enforcement. At this juncture, strict implementation of quarantine regulations is imperative. Ensuring compliance will not only safeguard our biodiversity and economy but can also lead to savings amounting to trillions of rupees for the national exchequer. ■

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