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**From Deployment to Real Impact:
What Will Define the Next Phase of**

PM-KUSUM



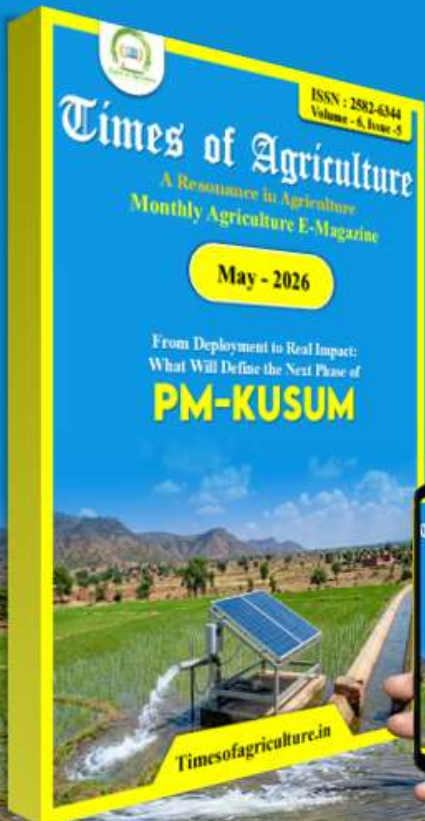
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PM-KUSUM



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AGRICULTURE UPDATES



Centre Announces Higher MSP for Kharif Crops for 2026-27

The Union Cabinet has approved an increase in the Minimum Support Price (MSP) for 14 Kharif crops for the 2026-27 marketing season, aiming to provide better returns and income security to farmers ahead of the sowing season. The decision was taken by the Cabinet Committee on Economic Affairs chaired by Prime Minister Narendra Modi. According to the government, the revised MSP rates ensure that farmers receive at least 50 percent higher returns over the cost of production, in line with the Union Budget commitment made in 2018-19. Officials said the total estimated payout to farmers under the revised MSP structure is expected to reach nearly Rs 2.6 lakh crore. The move is intended to encourage crop diversification, strengthen agricultural production and improve rural incomes across the country.

Among the major crops, the MSP for common paddy has been increased to Rs 2,441 per quintal, while Grade A paddy has been fixed at Rs 2,461 per quintal. Sunflower seed received the highest absolute increase of Rs 622 per quintal, taking its MSP to Rs 8,343 per quintal. Cotton saw an increase of Rs 557 per quintal, while nigerseed and sesamum registered hikes of Rs 515 and Rs 500 per quintal respectively. The MSP for tur/arhar has been raised to Rs 8,450 per quintal, moong to Rs 8,780 per quintal and urad to Rs 8,200 per quintal. For cereals, maize will now be procured at Rs 2,410 per quintal, bajra at Rs 2,900 and ragi at Rs 5,205 per quintal. The government stated that higher MSPs for pulses, oilseeds and nutri-cereals are aimed at promoting crop diversification beyond traditional cereal cultivation.

Government officials said the revised MSP rates are expected to strengthen food security while encouraging farmers to adopt crops with higher nutritional and market value. The Centre highlighted that procurement of Kharif crops and MSP payments to farmers have increased significantly during the past decade. Officials also stated that promoting oilseeds, pulses and millets remains a key focus area to reduce import dependence and improve domestic agricultural sustainability. However, some farmer organisations have criticised the announcement, arguing that MSP calculations should be based on the comprehensive C2 cost formula recommended by the Swaminathan Commission instead of the currently used A2+FL formula. Despite the criticism, experts believe the MSP hike will provide short-term support to farmers facing rising input costs and uncertain weather conditions during the upcoming Kharif season.

India Launches SEHAT Mission to Connect Farming, Nutrition and Healthcare

The Government of India has launched the SEHAT Mission, a new national initiative aimed at connecting agriculture, nutrition and healthcare to improve public health outcomes across the country. The mission, jointly introduced by the Indian Council of Agricultural Research (ICAR) and the Indian Council of Medical Research (ICMR), was launched in New Delhi by Union Health Minister JP Nadda and Agriculture Minister Shivraj Singh Chouhan. Officials described the programme as an important step towards preventive healthcare by encouraging healthier food production and consumption. The initiative focuses on improving nutritional security, reducing lifestyle diseases and promoting sustainable farming practices through scientific collaboration between the agriculture and health sectors.

Under the mission, the government plans to promote the cultivation of nutrient-rich and biofortified crops such as millets, pulses and fortified cereals. Experts associated with the programme said India is currently facing challenges related to malnutrition as well as increasing cases of diabetes, obesity and hypertension. Through coordinated research and field studies, ICAR and ICMR will examine how agricultural practices and food habits influence health conditions. The mission will also encourage integrated farming systems involving livestock, fisheries and horticulture to improve both nutrition and farmers' incomes.

Government representatives stated that the mission could help create a stronger connection between food systems and healthcare policies in the coming years. Experts believe the programme may reduce micronutrient deficiencies and improve dietary awareness among people, especially in rural areas. Policymakers at the launch event highlighted that the country's next priority after achieving higher food production is ensuring access to nutritious and healthier food. The government expects the SEHAT Mission to support long-term nutritional security while strengthening sustainable agriculture and improving the overall well-being of citizens across India.



Findability Sciences Launches LactaAI for Dairy and Whey Processing Industry

Findability Sciences has launched LactaAI, an artificial intelligence-powered industrial intelligence platform designed specifically for dairy and whey processing plants. The company said the new platform aims to improve operational efficiency, reduce energy consumption and help dairy businesses make faster and smarter decisions using real-time data analysis. According to the company, LactaAI can help large dairy operations generate annual value ranging from Rs 2.35 crore to Rs 28.2 crore per plant through better production yields and lower operational costs. The platform was introduced as part of the growing use of AI technologies in manufacturing and food processing industries. Company founder and CEO Anand Mahurkar stated that dairy plants require “decision-ready intelligence” rather than additional dashboards and reports. He added that even a small improvement in production yield can create a major financial impact in high-volume dairy operations. The launch reflects increasing interest in applying AI solutions to improve productivity and sustainability in the dairy sector.

LactaAI combines two integrated systems within a single platform to support dairy and whey processors. The first system, called Lacta Insight, provides real-time process intelligence across milk reception, evaporation, drying, packaging and utilities management. It is designed to help dairy plants move from reactive problem-solving to predictive and optimized operations. The company has also introduced specialized versions including Lacta Insight Prime for products such as fluid milk, cheese, yogurt and butter, and Lacta Insight Nexus for advanced whey processing operations involving whey protein concentrate, whey protein isolate and lactose production. The second component, Lacta BPC, acts as a conversational AI layer that can answer operational and business-related questions in natural language. The platform integrates with existing industrial systems including ERP, MES, SCADA and BI systems without requiring replacement of core infrastructure, making adoption easier for processing plants.



Pilibhit to Get India's First Integrated Basmati and Organic Demo Farm

Uttar Pradesh's Pilibhit district is set to become home to India's first integrated Basmati and organic training-cum-demonstration farm, marking a significant development for the country's agricultural and export sectors. The Agricultural and Processed Food Products Export Development Authority (APEDA), under the Ministry of Commerce and Industry, has signed a 70-year lease agreement with the Uttar Pradesh government for the project. The upcoming centre will be established at Tanda Bijaisi village in Pilibhit and is aimed at strengthening India's Basmati rice ecosystem while promoting sustainable and organic farming practices. Officials said the initiative will serve as a major platform for farmer training, agricultural research and capacity building. The project is expected to benefit farmers from Uttar Pradesh as well as neighbouring Uttarakhand, both of which are important Basmati-producing regions in northern India.

The proposed facility will include modern infrastructure such as an auditorium, conference hall, laboratory, museum and dedicated galleries showcasing Basmati rice cultivation and organic farming techniques. It will also provide storage facilities for organic agricultural inputs and quality Basmati seeds. According to officials, the centre will focus on practical demonstrations, hands-on training and awareness programmes for farmers to improve crop quality and productivity. Experts believe the project could help increase the adoption of scientific and organic farming methods among growers while improving export competitiveness. The government also announced that the facility would support national-level Basmati research trials under the All India Coordinated Research Projects programme. Union Minister of State for Commerce and Industry Jitin Prasada said Pilibhit has strong potential to emerge as a major hub for premium Basmati rice cultivation and organic farming. Officials added that the centre will include an AI-powered interactive museum to provide educational and experiential learning opportunities for students, researchers and visitors.



Andhra Pradesh to Launch India's First Mushroom Mission

The Andhra Pradesh government is preparing to launch India's first dedicated Mushroom Mission with an estimated investment of Rs 13,000 crore to transform the state into the country's largest mushroom producer. Chief Minister N Chandrababu Naidu has directed officials to prepare a comprehensive action plan for the ambitious programme, which aims to strengthen rural livelihoods, create employment opportunities and promote agricultural diversification. The mission plans to increase Andhra Pradesh's annual mushroom production to nearly 67,500 tonnes, surpassing Bihar, which currently leads the country with an annual output of around 45,000 tonnes. Officials said the initiative is designed to create a strong agri-value chain focused on high-value and quick-yielding crops while encouraging entrepreneurship in rural areas.

Under the proposed mission, the state plans to establish around 1.62 lakh mushroom cultivation and business units across Andhra Pradesh. Most of these units will be small and medium-sized facilities spread across nearly 5,000 square feet each. The government has proposed subsidy support of around Rs 5,184 crore, jointly funded by the Centre and the state government, accounting for nearly 40 percent of the total project cost. Officials said the initiative will focus on commercially viable mushroom varieties including milky mushroom, paddy straw mushroom and button mushroom, chosen for their adaptability and growing market demand. The mission also seeks to classify mushrooms as agricultural produce to ensure easier access to subsidies, institutional credit and policy support. Authorities believe the project can replicate the success achieved by aquaculture and millet missions in creating a sustainable agricultural ecosystem supported by processing, storage and marketing infrastructure.

The Andhra Pradesh government plans to use the state's strong network of Self-Help Groups to increase participation among rural women and small entrepreneurs. Experts believe mushroom cultivation offers significant potential because it requires relatively less land and water while generating faster returns compared to traditional crops.



IIT Ropar Launches India's First Integrated Agricultural Intelligence System

The Indian Institute of Technology (IIT) Ropar has launched India's first fully integrated agricultural intelligence system aimed at transforming the country's farming sector through artificial intelligence, climate science and digital technologies. Developed under the ANNAM.AI initiative, the new ecosystem has been introduced by the institute's Centre of Excellence in AI for Agriculture to support the entire agricultural value chain, from crop planning to farm management and advisory services. Officials said the system combines advanced weather monitoring, data analytics and multilingual AI-based communication tools to help farmers make informed decisions in real time. The initiative is part of the Government of India's broader push to modernize agriculture using emerging technologies while improving productivity, sustainability and climate resilience. Experts believe the project could play an important role in reducing crop losses and improving farm efficiency across different regions of the country.

The newly launched agricultural intelligence ecosystem consists of three major components designed to work together as a unified digital platform. The first component includes advanced weather stations known as Swan stations, which provide hyperlocal climate and environmental data for accurate weather forecasting and crop planning. The second component is the Krishi intelligence call centre system, developed to offer farmers timely advisory support related to irrigation, pest control, sowing and harvesting. The third component is the Annam Chat Engine (ACE), an AI-powered multilingual communication platform capable of interacting with farmers in local languages. According to IIT Ropar officials, the system integrates Artificial Intelligence, Internet of Things (IoT), climate science and predictive analytics to generate real-time recommendations for farmers. The project has been developed under the Ministry of Education-supported ANNAM.AI programme, which aims to build technology-driven solutions for sustainable agriculture and food security in India.

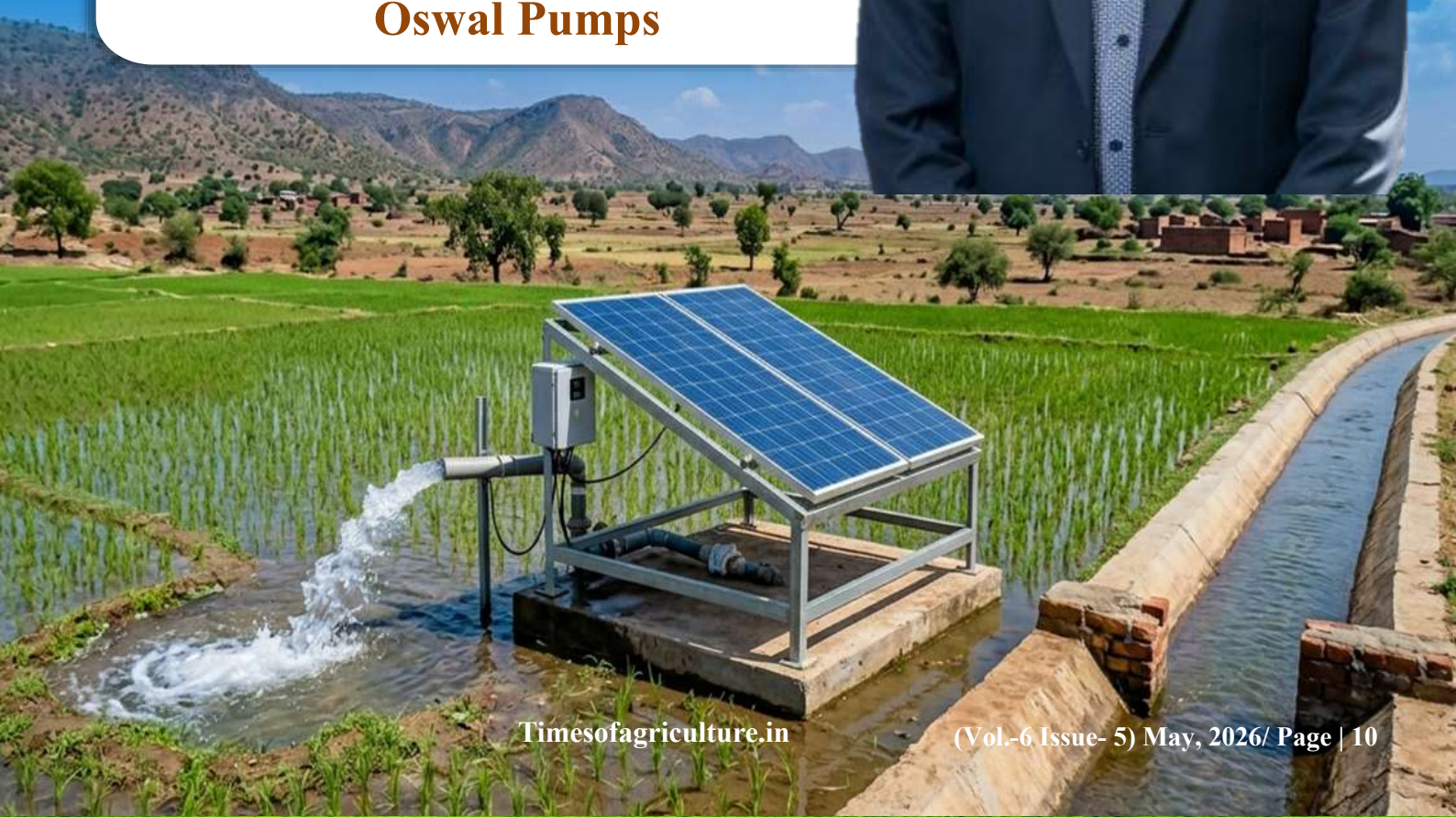
Experts associated with the initiative said the integrated system is designed to bridge the gap between scientific research and practical farming needs. The platform is expected to support precision agriculture by helping farmers optimize the use of water, fertilizers and other agricultural inputs while improving crop yields and reducing operational costs.



From Deployment to Real Impact:
What Will Define the Next Phase of
PM-KUSUM

About the Author

Mr. Amulya Gupta
Director
Oswal Pumps



India's solar irrigation story is entering a decisive phase.

Over the past few years, the PM-KUSUM scheme has significantly accelerated the adoption of solar-powered pumps, positioning them as a viable alternative to diesel and grid-based irrigation. What began as a policy intervention to expand access to clean energy in agriculture has now evolved into one of the largest decentralised renewable energy programmes globally - one that sits at the intersection of energy access, water security, and rural income growth.

However, as the scheme progresses into its next phase, the nature of the conversation around it is beginning to change. The focus is no longer limited to how many solar pumps have been installed. Increasingly, attention is shifting toward how these systems are performing on the ground: how consistently they are being used, which regions are deriving the most value, and whether the expected improvements in productivity and farmer incomes are being realised. This transition, from deployment to impact, is where the future of PM-KUSUM will ultimately be defined.

Scale Has Been Achieved, but Outcomes Remain Uneven

By late 2025, India had already achieved substantial scale under PM-KUSUM. A large number of installations have been completed under Component B (standalone solar pumps), alongside a steady rollout of grid-connected systems under Component C.

According to the Ministry of New and Renewable Energy (MNRE), more than 3.5 lakh standalone solar pumps have been installed across the country, reflecting strong policy momentum and increasing state participation. At a macro level, this progress signals that the ecosystem, from manufacturers and EPC players to state agencies, has matured to a point where large-scale deployment is not only feasible but replicable. Yet, beneath this progress lies a more complex reality. Recent studies suggest that utilisation levels vary significantly across regions. Research by the Council on Energy, Environment and Water (CEEW) highlights that actual usage of solar pumps is often influenced more by local conditions than by the availability of the technology itself.



Similarly, insights from the International Water Management Institute (IWMI) indicate that without complementary improvements in water management and agricultural practices, the full benefits of solar irrigation remain under-realised. This divergence underscores a fundamental point: while scale has been achieved, outcomes remain uneven, and that is where the next phase must focus.

Beyond Access: Understanding the Utilisation Gap

One of the most important learnings from early deployments is that installation does not automatically translate into consistent utilisation. The reasons for this are structural and interconnected. Water availability is the most immediate constraint. In regions with stable groundwater levels or reliable surface water access, solar pumps tend to be used more intensively. In contrast, in water-stressed geographies, usage remains inherently limited, regardless of the pump's efficiency or capacity.

Cropping behaviour adds another layer of complexity. Farmers growing water-intensive crops or engaging in multiple cropping cycles are naturally more dependent on irrigation, leading to higher utilisation. On the other hand, in rain-fed or low-intensity agricultural zones, demand for irrigation is more sporadic.

There is also a growing recognition that standardised deployment models can create inefficiencies. While large-scale tenders enable cost optimisation, they do not always account for variations in landholding size, water depth, or crop requirements. Over time, this can result in systems that are either underutilised or unable to deliver optimal performance. Equally important is the human dimension. The shift from conventional irrigation to solar-powered systems requires behavioural adaptation. Farmers need to understand not just how to operate the system, but how to integrate it into their broader agricultural practices. In the absence of structured training and post-installation support, utilisation often remains below potential.

Regional Variations Are Defining Outcomes

As the scheme has expanded, distinct regional patterns have begun to emerge, offering important insights into what drives success. States such as Rajasthan, Haryana, and Maharashtra have demonstrated relatively strong utilisation trends. These regions benefit from a combination of favourable groundwater conditions, higher awareness levels, and more efficient implementation ecosystems.



In these areas, solar pumps are increasingly being used as primary irrigation assets rather than backup solutions. Farmers are able to irrigate during the day, reduce dependence on diesel, and plan agricultural activities with greater certainty.

At the same time, parts of eastern and central India present a different picture. Here, factors such as fragmented landholdings, lower groundwater reliability, and limited last-mile support affect both adoption and utilisation. A report by the International Energy Agency (IEA) notes that the effectiveness of solar irrigation systems is closely tied to regional resource conditions and institutional capacity, reinforcing the need for more localised implementation strategies. These variations highlight that PM-KUSUM cannot be approached as a uniform national rollout. Its success depends on how well it adapts to local realities.

Execution Challenges Continue to Impact Scale Efficiency

While demand for solar pumps remains strong, execution bottlenecks continue to affect the pace and quality of deployment. The implementation cycle, from sanction to commissioning, often involves multiple stakeholders and procedural steps. Delays in tendering, site verification, financing approvals, and installation can extend timelines significantly. According to analysis by the Centre for Science and Environment (CSE), administrative complexity and coordination gaps at the state level are among the primary reasons for delays in solar irrigation projects.

These delays have a cascading impact. They not only slow down adoption but also affect farmer confidence in the scheme. For grid-connected systems under Component C, the challenges are even more pronounced. Dependence on DISCOM processes introduces uncertainties related to approvals, net metering, and tariff structures. Inconsistent policy implementation across states further adds to this complexity. As a result, while the intent of the scheme remains strong, execution inefficiencies continue to limit its full potential.

The Inclusion Imperative

One of the defining goals of PM-KUSUM is to extend the benefits of solar irrigation to small and marginal farmers. However, ensuring inclusive adoption remains a significant challenge. Even after subsidies, the upfront investment required can be substantial for farmers with limited financial resources. Access to institutional credit is often uneven, particularly in rural areas where banking penetration and financial literacy remain constrained.



PM-KUSUM: FROM SCALE TO IMPACT

SCALE (THE START)

**3.5
LAK'H+**



Standalone Pumps Installed

India has achieved massive scale, proving that large-scale decentralized renewable energy is feasible and replicable.

UTILIZATION & BARRIERS



The Utilization Gap Limits Real Impact

Installation does not guarantee use; local water availability and cropping patterns dictate how often pumps are actually turned on.

Regional Success Varies by Infrastructure

States like Rajasthan and Haryana show high usage, while Eastern India struggles with fragmented landholdings and limited support.



Solving the Inclusion and Finance Barrier

High upfront costs remain the primary hurdle for smallholder farmers despite existing subsidies.

IMPACT (THE GOAL)



Prioritize Outcomes Over Installation Targets

Future success requires site-specific planning, farmer training, and streamlined administrative approvals to build trust.

A World Bank study highlights that **affordability and access to finance are among the biggest barriers to the adoption of solar irrigation technologies among smallholder farmers**. In addition, smaller landholdings can affect the economic viability of standalone systems. For such farmers, alternative models, such as community-based irrigation systems, farmer producer organisation (FPO)-led ownership, or shared infrastructure, may offer more practical solutions. Without deliberate efforts to address these challenges, there is a risk that adoption will remain skewed toward relatively better-off farmers, limiting the scheme's broader developmental impact.

Reframing the Next Phase: From Targets to Outcomes

As PM-KUSUM enters its next phase, there is a clear need to recalibrate its approach. The emphasis must shift from achieving installation targets to delivering measurable outcomes. This includes improving utilisation rates, enhancing farm productivity, and ensuring long-term sustainability of assets.

A key step in this direction is strengthening pre-installation planning. Site-specific assessments that consider water availability, cropping patterns, and farmer requirements can significantly improve system performance.

Equally important is streamlining implementation processes. Reducing delays across approval, financing, and installation stages will be critical to maintaining momentum and building farmer trust. Financing innovation will also play a central role. Flexible models, such as pay-as-you-go systems or aggregated financing structures, can make solar pumps more accessible to small and marginal farmers. Capacity building must be integrated into the core design of the scheme. Training, awareness programmes, and after-sales support should not be treated as optional but as essential components of long-term success. Finally, stronger coordination with DISCOMs and greater policy clarity will be necessary to unlock the full value of grid-connected systems.

The Road Ahead

India has already demonstrated its ability to scale solar irrigation at an unprecedented pace. The progress achieved under PM-KUSUM is both significant and encouraging.

The next phase, however, will require a deeper focus on quality, consistency, and impact. Solar irrigation is not just about replacing diesel pumps or reducing electricity consumption. It is about enabling farmers to access reliable irrigation, optimise water use, and improve agricultural productivity in a sustainable manner.

Achieving this vision will require a shift in perspective, from viewing solar pumps as standalone assets to understanding them as part of a broader agricultural ecosystem. Ultimately, the success of PM-KUSUM 2.0 will be defined not by how many systems are deployed, but by how effectively they transform farming outcomes on the ground. That is the transition India must now focus on, from scale to impact, from access to efficiency, and from intent to measurable change.





BEEKEEPING IN THE AGE OF ARTIFICIAL INTELLIGENCE A SWEET REVOLUTION

About Author  

Reshma. M.*

Deptt. of Entomology,
School of Agril. Sciences, Malla
Reddy University, Hyderabad

Suddapalli Anka Pujitha

Deptt. of Entomology,
Acharya N.G. Ranga Agricultural
University, Bapatla (A.P.)

Ponduri Sai Aditya

Research Intern, ICRISAT,
Hyderabad, UP

Beekeeping, one of the oldest agricultural practices known to humankind, is undergoing a remarkable transformation. Traditionally, beekeepers relied on experience, observation, and intuition to manage colonies. Today, with the rise of Artificial Intelligence (AI), apiculture is entering a new era often referred

to as “precision beekeeping.” This integration of technology is not only enhancing productivity but also offering solutions to some of the most pressing challenges faced by honey bees worldwide.

Honey bees play a crucial role in global agriculture. They are responsible for pollinating nearly one-third of the food crops we consume, including fruits, vegetables, and oilseeds. However, in recent years, bee populations have been declining due to multiple stress factors such as pests, diseases, pesticide exposure, climate change, and habitat loss. Among these, the parasitic mite *Varroa destructor* is considered one of the most destructive threats to bee colonies. These honey producers can also be utilized for the study of sub lethal effects of Insecticides by using different remote sensing techniques like

radio frequency and optical bee counters. (Olivares-Pinto *et al.*, 2024)

In this context, AI-driven technologies are emerging as powerful tools to monitor, protect, and manage bee populations more efficiently. One of the most significant contributions of AI in beekeeping is hive monitoring. Smart beehives equipped with sensors can collect real-time data on temperature, humidity, sound, and bee activity. These sensors are connected to AI systems that analyse the data and provide insights into colony health. For instance, a sudden drop in hive temperature or unusual sound patterns may indicate problems such as disease, queen loss, or swarming. By detecting these issues early, beekeepers can take timely action, thereby reducing colony losses.



Another promising application of AI is in pest and disease detection. Traditionally, identifying infestations like Varroa mites and Colony Collapse Disorder requires manual inspection, which is time-consuming and often inaccurate. AI-powered image recognition systems can now analyse photographs of bees or hive frames to detect the presence of mites with high precision. (Center. D., 2025) Similarly, machine learning algorithms can identify symptoms of diseases such as American foulbrood or Nosema infections. This not only saves time but also improves the accuracy of diagnosis, leading to better management practices.

AI is also playing a crucial role in improving honey production. By analyzing environmental data such as weather conditions, flowering patterns, and nectar availability, AI models can predict the best times for honey flow. This allows beekeepers to optimize hive placement and management strategies to maximize yield. In addition, AI systems can recommend feeding schedules and supplemental nutrition during periods of scarcity, ensuring that colonies remain strong and productive throughout the year. (Astuti *et al.*, 2024)

A particularly innovative aspect of AI in beekeeping is the use of acoustic monitoring. Bees communicate through vibrations and sounds within the hive. Advanced AI algorithms can analyse these acoustic signals to

interpret bee behaviour. For example, specific sound frequencies may indicate swarming, stress, or queenlessness. By continuously monitoring these signals, AI systems can alert beekeepers to potential issues without the need to open the hive, thus minimizing disturbance to the bees.

Robotics is another area where AI is making an impact. Researchers are developing robotic systems that can assist in hive inspection, honey extraction, and even pollination. Although still in the experimental stage, these technologies have the potential to reduce labour and increase efficiency, especially in large-scale commercial beekeeping operations. In the future, autonomous drones may be used to monitor apiaries spread over vast areas, providing real-time updates and recommendations.

Despite its many advantages, the adoption of AI in beekeeping also presents certain challenges. The cost of smart equipment and the need for technical expertise may limit its accessibility, particularly for small-scale and rural beekeepers. Additionally, the reliability of AI systems depends on the quality of data collected, which can vary depending on environmental conditions. There is also a need for training and awareness programs to help beekeepers understand and effectively use these technologies.

In India, where beekeeping is an important source of

income for rural communities, the integration of AI holds great promise. Government initiatives and research institutions are increasingly focusing on digital agriculture, including smart apiculture. By combining traditional knowledge with modern technology, Indian beekeepers can enhance productivity, improve colony health, and contribute to sustainable agriculture.

Looking ahead, the future of beekeeping lies in the harmonious integration of nature and technology. AI cannot replace the skill and intuition of beekeepers, but it can significantly augment their capabilities. By providing accurate, real-time information and predictive insights, AI empowers beekeepers to make informed decisions and respond proactively to challenges.

In conclusion, the fusion of beekeeping and Artificial Intelligence represents a “sweet revolution” in agriculture. As bee populations continue to face threats, innovative solutions like AI offer hope for their conservation and sustainable management. By embracing these advancements, we can ensure the survival of honey bees and, in turn, safeguard global food security. The buzzing of bees, once guided solely by nature, is now being supported by the silent intelligence of machines-working together for a more resilient and productive future.





BIODYNAMIC FARMING

A NOVEL APPROACH TO AGROECOLOGY

About Author



*Pragti Negi

Ph.D. Scholar
V.C.S.G. Uttarakhand University
of Hort. & Forestry, Bharsar,
Pauri Garhwal

Shivani Bisht

Ph.D. Scholar
School of Agri., Uttaranchal
University, Dehradun

Abhay Sharma

Ph.D. Scholar
Deptt. of Plant Pathology,
GBPUAT, Pantnagar

Pioneered by Rudolf Steiner in the 1920s, *Biodynamic Farming* has been recognised as an alternative approach to conventional chemical agriculture. Based on

the energies of the cosmos, earth, plants and animals, this system aims to provide high environmental efficiency while alleviating the energy consumption rate at the same time. This resource-efficient system strongly aligns with the UN's Sustainable Development Goals for 2030, treats farms as self-sustaining ecosystems, maintains soil health, enhances biodiversity and promotes food rich in essential nutrients. According to various studies, biodynamic farms have improved soil quality and attained greater net returns, unlike traditional ones, as the BD principles help to restore soil fertility by adding organic matter, recognising soil as a living system, and fostering the use of green manure, crop rotation and cover crops. Overall, a robust biodynamic farm

facilitates a holistic agricultural system beyond the scope of organic farming.

The current agricultural era is highly susceptible to the emerging environmental obstacles, including resource depletion (soil, water and nutrients), loss of biodiversity, climate-driven effects, and the rise of novel pollutants like microplastics and PFAS compounds. These components, altogether, are stressing the food security and sustainable development goals of achieving good health and well-being, along with ecological health at the same time. This is where “Biodynamic Farming” gains prominence. It is derived from the two Greek words: “bios” meaning life, and “dynamis” meaning energy or force. It is the *first modern organic agriculture*, which treats



the farm as a living organism, emphasising detailed interactions between soil, plants, animals and people. The concept was developed through Rudolf Steiner's lectures around the early 1900s, when he integrated scientific understanding of nature with the spiritual perspective of farmers. This comprehensive agricultural approach combines composting, crop rotation, special preparations made through fermented herbs and minerals that will eventually lead to improved soil fertility and biodiversity. Below are some of the key components of biodynamic farming that will not only boost the crop yield but also elevate the nutritional quality and integrated pest management.

Concept

"*Biodynamic agriculture*" is based on organic farming with the main focus on anthroposophical ideas about the soil and the life it supports. This alternative method has been practised by more than 5,500 farmers worldwide and is of significant importance among consumers who prefer organic products. Moreover, it treats all the organisms with respect and conceptualises the farm as an organism, as an independent entity.

Components of biodynamic farming

More like organic farming, biodynamic agriculture employs management strategies that aim to restore, maintain and optimise ecological harmony. The

key features include crop diversification, avoiding chemical substances and off-farm inputs and treating soil as a living system. The following are the major principles of biodynamic farming-

1) Crop rotation and diversification

These techniques represent the core measures of sustainable agriculture, which provide positive impacts to both farmers and the environment. Cultivating a variety of crops on a piece of land, by crop diversification, facilitates soil health and allows the crops to enhance each other's nutritional value. Both of these approaches promote soil fertility, lower the insect population and boost nutrient availability simultaneously. For instance, a legume-based rotation increases the nitrogen level in soil by carrying out biological nitrogen fixation.

2) Relationship between matter and energy

Biodynamic agriculture stresses the interaction that occurs between the matter and the energies in a balanced system. Since both of these factors are required for our existence, we need to make sure that the food we consume fulfills the body's requirements, by providing essential nutrients and energy content from a well-balanced soil.

3) Livestock well-being

This farming follows a specific belief that animals, like humans, also have a soul and

should be given respectful treatment.

4) Biodynamic preparations

The fundamental principle of BD farming is the "Biodynamic Preparations". They work similarly to any homoeopathic practice. Their production is easier as the inputs can be generated from the farm only. The biodynamic management shows higher SOM levels compared to non-biodynamic treatments. These preparations are further categorised into 2 sub-Groups: Group A and Group B.

A. Biodynamic field spray-

It includes sprays - BD-500, known as "Horn Manure", and the other is BD-501, called as "Silica Manure".

B. Biodynamic compost preparation-

This consists of several elements like BD-502 (fermented yarrow flowers), BD-503 (fermented head of German Chamomile), BD-504 (Stinging nettle), BD-505 (Fermented oak bark), BD-506 (fermented flower head of dandelion and BD-507 (Valerian flower juice).

5) Planting calendar

This technique is based on the suggestions of Rudolf Steiner, highlighting the importance of astrological signs and the moon phases on the growth and development of plants, including soil. This is considered the astrological feature of biodynamic farming that evaluates the plant's growth with



Biodynamic Planting Calendar - 2026

Month	Moon Opposite Saturn	New Moon	Full Moon	Moon's		Moon in		Node	Sowing / Planting Based on Moon's Position				SUN	
				Ascending	Descending	Apogee	Perigee		Seed- Fruit Day	Root Day	Flower Day	Leaf Day	Enters	Date
Januaray	9	19	3	18	4, 31	14	2, 30	8, 22	6, 7, 8, 16, 17, 18, 25, 26	1, 9, 10, 19, 20, 27, 28, 29	2, 3, 11, 12, 13, 21, 22, 30, 31	4, 5, 14, 15, 23, 24	Makara / Capricorn ♑	14
February	5	17	2	15	28	10	25	4, 18	3, 4, 12, 13, 14, 21, 22	5, 6, 15, 16, 23, 24, 25	7, 8, 9, 17, 18, 26, 27	1, 2, 10, 11, 19, 20, 21, 28	Kumbha / Aquarius ♒	13
March	5	19	3	14	27	10	22	3, 17, 30	2, 3, 12, 13, 21, 22, 29, 30, 31	4, 5, 6, 14, 15, 16, 23, 24	7, 8, 17, 18, 19, 15, 16, 23, 24	1, 9, 10, 11, 19, 20, 27, 28	Meena / Pisces ♓	15
April	1, 29	17	2	10	23	7	19	14, 27	8, 9, 10, 17, 18, 26, 27	1, 2, 11, 12, 19, 20, 28, 29	3, 4, 5, 13, 14, 21, 22, 29, 30	6, 7, 15, 16, 23, 24, 25	Mesha / Aries ♈	14
May	27	17	1, 31	8	20	5	17	11, 23	5, 6, 7, 15, 16, 23, 24	8, 9, 17, 18, 25, 26, 27	1, 2, 10, 11, 12, 19, 20, 28, 29	3, 4, 13, 14, 21, 22, 30, 31	Vrishabha / Taurus ♉	15
June	23	15	30	4	17	1, 28	15	7, 19	2, 3, 11, 12, 19, 20, 29, 30	4, 5, 6, 13, 14, 21, 22, 23	7, 8, 15, 16, 24, 25	1, 9, 10, 17, 18, 26, 27, 28	Mithuna / Gemini ♊	15
July	20	14, 29	29	1, 28	14	25	13	4, 17, 31	8, 9, 10, 13, 14, 17, 18, 26, 27, 28	1, 2, 3, 11, 12, 19, 20, 29, 30	4, 5, 13, 14, 21, 22, 23, 31	6, 7, 15, 16, 24, 25	Karka / Cancer ♋	16
August	17	12	28	25	11	22	10	13, 28	5, 6, 13, 14, 22, 23, 24	7, 8, 15, 16, 25, 26	1, 9, 10, 17, 18, 19, 27, 28, 29	2, 3, 4, 11, 12, 20, 21, 30, 31	Simha / Leo ♌	17
September	13	11	26	21	7	19	7	10, 24	1, 2, 9, 10, 11, 19, 20, 28, 29	3, 4, 12, 13, 21, 22, 23, 30	5, 6, 14, 15, 24, 25	7, 8, 15, 16, 17, 18, 26, 27	Kanya / Virgo ♍	17
October	10	10	26	18	4	17	2, 28	7, 21	7, 8, 16, 17, 18, 26, 27	1, 9, 10, 19, 20, 28, 29	2, 3, 4, 11, 12, 13, 21, 22, 30, 31	5, 6, 14, 15, 23, 24, 25	Tula / Libra ♎	17
November	6	9	24	15	1, 28	13	26	3, 17, 30	3, 4, 12, 13, 14, 22, 23, 30	5, 6, 7, 15, 16, 24, 25	8, 9, 17, 18, 19, 26, 27	1, 2, 10, 11, 20, 21, 28, 29	Vrishchika / Scorpio ♏	16
December	3, 30	9	24	12	25	11	24	14, 27	1, 10, 11, 19, 20, 21, 28, 29	2, 3, 4, 12, 13, 14, 22, 23, 30, 31	5, 6, 15, 16, 24, 25	7, 8, 9, 17, 18, 26, 27	Dhanu / Sagittarius ♐	16

respect to the RHYTHMS like Cosmic solar and Lunar rhythms and Earth rhythms. Many biodynamic farmers follow this calendar and schedule the activities like cultivating, pruning, harvesting or spraying. Consequently, they aspire to bring life back into the soil to produce a crop with more nutrition, which ultimately will foster human welfare.

Biodynamic certification

“Demeter”, the oldest and most recognised certification system for biodynamic farming, ensures that products are grown and produced in accordance with biodynamic principles. The Demeter label signifies that the

food has been cultivated in a manner that takes care of nature and adheres to the principles of sustainability. Currently, 60+ countries are practising biodynamic farming and have more than 7000 certified farms. Since 2008, the Biodynamic Association of India has hosted and governed the Demeter Certification Office of India.

Advantages of biodynamic farming

1) Improves the soil quality- It views the soil as a habitat for numerous living organisms that contribute to the ecosystem services, such as soil fertility. This holistic farm management has the potential to improve the soil microbiome. Biodynamic farming shows 52% higher microbial indicators in contrast to organic and conventional agriculture.

2) Environmental sustainability-

The main aim of biodynamic farming is to achieve balance by promoting on-farm circularity, which relies on the input generated (animal/green manures) within the farm and not on the off-farm inputs.

3) Spiritual aspects-

It encourages the sense of connection between nature and humans. It asserts that farming should work in harmony with all the vital life forces of the ecosystem.

Is Biodynamic Food a Better Choice?

According to the various research studies, the produce obtained from biodynamic farming contains more dry matter, remains fresh for a longer period and has a good flavour and texture. Along with this, nitrate levels are lower, and vitality is enhanced. Hence, biodynamic



Table 1- Average variation in the nutrient levels of biodynamic and organically grown crops

Nutrient	Biodynamic % difference	Organic % difference
Vitamin C	+47.6	+22.7
Iron	+33.9	+17.2
Calcium	+7.4	+30.8
Phosphorus	+6.6	+12.5
Sodium	+20.3	+19.6
Potassium	+7.9	+14.1
Magnesium	+13.2	+24.4
Beta-carotene	+14.0	-0.3
Nitrates	-49.8	33.9

(Nabi *et al.*, 2017)

food is regarded as a nutritionally balanced food, often rich in antioxidants, vitamins and minerals.

Biodynamic movement in India

The main body/organisation responsible for promoting and coordinating the biodynamic movement at the national level is “The Biodynamic Association of India (BDAI), situated in Bangalore, Karnataka. The movement started in the early 90s when an environmentalist/social worker, TGK Menon of Indore in 1993, called a farmer, “Peter Proctor” from New

Zealand, who had been associated with biodynamic agriculture since 1965, with the focus to educate the Indian farmers about this approach. The prior trainings were done Kurinji farms (Kodaikenal), Maikaal cotton project (M.P.) and the tea projects of Darjeeling. Currently, in Mysore (ISKON farm), Gujarat (Bhaikaka Krishi Kendra), along with Tamil Nadu, has been following the BD farming in India.

Summary

With the excessive and continuous utilisation of synthetic fertilisers, the agricultural system

of the nation has been significantly compromised. The soil organic matter, along with beneficial microorganisms, has already been destroyed. Therefore, as a response to these losses, the approach of biodynamic agriculture should be taken into consideration. This holistic and sustainable technique helps to improve the soil quality, biodiversity and agroecosystem as a whole. It takes into account the soil health, the diversification of crops, in addition to livestock management and cosmic rhythms. However, like every approach, the BD farming principles has its own constraints yet cannot be overlooked as it maintains ecological balance and farm resilience, for the long term, unlike the traditional approach of farming. Therefore, for a more regenerative cultivation system, biodynamic agriculture offers a promising pathway towards sustainable food production.





About Author

Dr. Himanshu Verma

Assistant Professor (Agronomy)
Surajmal University, Kichha,
Udham Singh Nagar, Uttarakhand

Sustainability has emerged as one of the most critical global concerns of the 21st century. It refers to the responsible use of natural resources in a way that meets present needs without compromising the ability of future generations to meet their own. Despite growing awareness and technological advancement, humanity faces multiple interconnected challenges that

EARTH AT RISK

KEY CHALLENGES TO SUSTAINABLE DEVELOPMENT

threaten the stability of Earth's ecosystems. These challenges are complex, systemic, and often driven by human activities, making their resolution both urgent and difficult. One of the most significant challenges is climate change, driven primarily by the emission of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. The burning of fossil fuels, industrial processes, and deforestation has intensified the greenhouse effect, leading to rising global temperatures. Consequences include melting glaciers, rising sea levels, extreme weather events, and disruption of agricultural systems. Climate change not only affects the physical environment but also threatens food security, water availability, and human health. Closely linked to climate change is deforestation and habitat destruction. Forests play a crucial role in carbon sequestration,

biodiversity conservation, and maintaining ecological balance. However, large-scale clearing of forests for agriculture, urbanization, and industrial expansion continues at an alarming rate. This results in loss of biodiversity, disruption of ecosystems, and increased carbon emissions. The extinction of plant and animal species reduces ecological resilience and weakens the natural systems that support life. Another pressing issue is loss of biodiversity. Biodiversity ensures ecosystem stability, productivity, and adaptability. Human activities such as pollution, overexploitation of resources, invasive species introduction, and land-use changes have accelerated species extinction rates far beyond natural levels. The loss of biodiversity affects ecosystem services such as pollination, soil fertility, and water purification, which are essential for human survival.



Water scarcity is also a major sustainability challenge. Although water covers most of the Earth's surface, only a small fraction is available as freshwater for human use. Rapid population growth, industrialization, and agricultural demand have placed immense pressure on freshwater resources. Over-extraction of groundwater, pollution of water bodies, and inefficient water management practices contribute to water stress in many regions. Climate change further exacerbates the problem by altering rainfall patterns and increasing the frequency of droughts.

Soil degradation and land degradation pose another threat to sustainability. Unsustainable agricultural practices such as overuse of chemical fertilizers, monocropping, overgrazing, and deforestation lead to soil erosion, nutrient depletion, and reduced soil fertility. Degraded land reduces agricultural productivity and increases vulnerability to food insecurity. Healthy soil is fundamental for sustainable agriculture, carbon storage, and maintaining ecological balance. The issue of pollution including air, water, and soil pollution remains a major challenge. Industrial emissions, vehicle exhaust, plastic waste, and improper disposal of hazardous materials contaminate the environment. Air pollution contributes to respiratory diseases and global warming, while water

pollution affects aquatic life and human health. Plastic pollution, especially in oceans, has become a global crisis, impacting marine ecosystems and entering the food chain. Overpopulation and unsustainable consumption patterns further intensify environmental stress. The global population continues to grow, increasing demand for food, energy, water, and land. At the same time, consumer lifestyles-particularly in developed and rapidly developing economies-are characterized by excessive resource use and waste generation. The imbalance between resource consumption and Earth's regenerative capacity is a fundamental barrier to sustainability. Energy production and dependence on fossil fuels remain central challenges. While energy is essential for economic development, the continued reliance on coal, oil, and natural gas contributes significantly to greenhouse gas emissions. Transitioning to renewable energy sources such as solar, wind, and hydropower is necessary but faces obstacles including high initial costs, technological limitations, and policy barriers. Another critical challenge is waste management. Increasing urbanization and industrialization generate large quantities of waste, much of which is not properly managed. Landfills, open dumping, and inadequate recycling systems lead to environmental contamination and

health risks. Electronic waste (e-waste) and hazardous waste are particularly concerning due to their toxic components. Finally, lack of global cooperation and policy implementation hampers sustainability efforts. Environmental issues are global in nature and require coordinated action among nations. However, differences in economic priorities, political interests, and levels of development often hinder effective collaboration. Even where policies exist, weak enforcement and lack of awareness limit their impact.

In conclusion, Earth's sustainability is threatened by a combination of environmental, social, and economic challenges. Climate change, biodiversity loss, water scarcity, pollution, and unsustainable resource use are deeply interconnected issues that require integrated solutions. Addressing these challenges demands a collective effort involving governments, industries, scientists, and individuals. Sustainable practices, technological innovation, environmental education, and strong policy frameworks are essential to ensure a balanced relationship between human development and the natural environment. The future of our planet depends on the actions we take today, making sustainability not just an option, but a necessity.





AQUATIC VEGETABLES AND THEIR IMPORTANCE IN HUMAN LIFE

About Author  ... 

Dr. R. Kousalya

Deptt. of Vegetable Science
R.V.S. Padmavathy College
of Horticulture, Sempatti,
Tamil Nadu

Aquatic vegetables are plants that grow either partially or completely in waterlogged environments such as lakes, ponds, marshes, lagoons, ditches, and other wetlands. These plants have adapted to survive in saturated soils or water bodies and have been traditionally harvested from natural habitats long before the development of organized agriculture.

Most aquatic and semi-aquatic vegetable species originated in tropical and subtropical regions, particularly in South and Southeast Asia. Due to favorable climatic conditions, these regions support a rich diversity of aquatic edible plants. Some species are also cultivated in warmer regions of temperate zones.

Aquatic vegetables produce edible plant parts such as leaves, shoots, rhizomes, corms, flowers, and seeds, which serve as important sources of nutrients including vitamins, minerals, dietary fiber, and bioactive compounds. In addition to their nutritional value, many aquatic vegetables possess significant medicinal properties and have long been used in traditional medicine systems.

These vegetables also play an important role in ecosystem stability, water purification, and biodiversity conservation. In recent years, they have gained attention as underutilized crops with potential to contribute to food security, sustainable agriculture, and human health.

Nutritional and Medicinal Importance of Aquatic Vegetables

Aquatic vegetables are valuable not only for their nutritional contributions but also for their therapeutic properties. Many of these plants contain antioxidants, phytochemicals, vitamins, and essential minerals that provide health benefits and help prevent various diseases.

Several aquatic vegetables have traditionally been used in



herbal medicine for treating diseases, and respiratory inflammatory, diuretic, and ailments such as digestive problems. Some species also antioxidant properties. disorders, inflammation, skin exhibit antimicrobial, anti-

Important Aquatic Vegetables and Their Medicinal Uses

S.No	Aquatic Vegetable	Botanical Name	Medicinal Uses
1	Water spinach	<i>Ipomoea aquatica</i>	Acts as an emetic and purgative; used in treatment of piles and febrile delirium.
2	Water cress	<i>Nasturtium officinale</i>	Mild stimulant, diuretic, expectorant and digestive aid; possesses cancer-suppressing properties.
3	Cattail	<i>Typha angustifolia</i> , <i>Typha latifolia</i>	Leaves act as diuretic; pollen used as haemostatic and astringent; helpful in uterine bleeding, wounds, burns and skin infections.
4	Eel grass	<i>Vallisneria spiralis</i>	Acts as an aperitif, demulcent, refrigerant and stomachic; used in leucorrhoea and to improve appetite.
5	Duck lettuce	<i>Ottelia alismoides</i>	Leaves used in treatment of haemorrhoids; plant possesses rubefacient properties.
6	Common water plantain	<i>Alisma plantago-aquatica</i>	Seeds are astringent and used in bleeding; roots used for oedema, nephritis, diarrhoea and fatty liver conditions.
7	Water shield	<i>Brasenia schreberi</i>	Leaves contain gallic acid and traces of vitamin B ₁₂ ; used for nutritional and medicinal benefits.
8	Papyrus	<i>Cyperus papyrus</i>	Pith used in treatment of fistula; ash used for eye diseases and ulcers.
9	Dwarf water clover	<i>Marsilea minuta</i>	Leaf juice helps stop nose bleeding and reduces swelling of gums; also useful for indigestion.
10	Wasabi	<i>Wasabia japonica</i>	Possesses anti-cancer properties; roots used in treatment of diarrhoea, asthma, arthritis, allergies and cardiovascular diseases.
11	Fragrant water lily	<i>Nymphaea odorata</i>	Rhizomes used for diarrhoea and dysentery; flowers act as cardio-tonic; seeds have cooling and restorative properties.
12	Paracress	<i>Spilanthes acmella</i>	Flower heads relieve toothache; leaves treat skin diseases; plant exhibits antimicrobial, antifungal and anti-malarial properties.
13	Indian blue water lily	<i>Nymphaea stellata</i>	Rhizomes used for dyspepsia, diarrhoea and piles; plant has hypoglycaemic activity.
14	Keysoor	<i>Scirpus grossus</i>	Roots possess cooling, laxative and diuretic properties; useful in fever and burning sensations.
15	Hydrolea	<i>Hydrolea zeylanica</i>	Leaves used as poultice for ulcers and intestinal disorders.
16	Water pepper	<i>Polygonum hydropiper</i>	Leaves show anti-inflammatory, carminative and diuretic properties; seeds act as stimulant and digestive aid.





1. Water spinach
(*Ipomea aquatic*)



2. Water cress
(*Nasturtium officinale*)



3. Cattail
(*Typha angustifolia*)



4. Eel grass
(*Vallisneria spiralis*)



5. Duck lettuce
(*Ottelia alismoides*)



6. Common water
plantain (*Alisma
plantagoaquatica L.*)



7. Water shield
(*Brasenia schreberi
J.F. Gmel*)



8. Papyrus
(*Cyperus papyrus L.*)



9. Dwarf watercress
(*Marsilea minuta*)



10. Wasabi
(*Wasabia japonica
(Miq.) Matsum*)



11. Fragrant Water
Lily (*Nymphaea
odorata Ait.*)



12. Paracress
(*Spilanthes acmella
L.*)



13. Indian blue water
lily (*Nymphaea stellate
Willd.*)



14. Keysoor
(*Scirpus grossus*)



15. Hydrolea
(*Hydrolea zeylanica
(L.) Vahl*)



16. Water pepper
(*Polygonum
hydropiper*)

Ecological and Environmental Importance

Aquatic vegetables play a vital role in maintaining ecological balance in wetland ecosystems. These plants contribute to:

Water purification

Many aquatic plants absorb excess nutrients, heavy metals, and pollutants from water bodies. This process, known as phytoremediation, helps improve water quality.

Flood control

Aquatic vegetation helps stabilize soil and reduce erosion in wetlands, thereby minimizing flood damage.



Biodiversity conservation

Wetland plants provide habitat and food for fish, birds, insects, and other aquatic organisms, supporting overall ecosystem health.

Climate regulation

Aquatic ecosystems contribute to carbon sequestration and help regulate microclimatic conditions in surrounding environments.

Socio-economic importance

Aquatic vegetables also have important socio-economic benefits:

- Provide nutritious food sources for rural and local communities

- Serve as traditional medicinal plants in many cultures
- Offer opportunities for sustainable aquaculture and wetland farming
- Can be cultivated as alternative crops in waterlogged or flood-prone areas

Due to their adaptability and low input requirements, aquatic vegetables can become important components of sustainable agriculture systems.

Conclusion

Although aquatic vegetables currently contribute only a small portion to global food supply, they possess immense potential as nutritious and medicinal food

sources. Their ability to grow in wetland environments makes them valuable crops in areas unsuitable for conventional agriculture.

In addition to their nutritional and medicinal importance, aquatic vegetables play a significant role in ecosystem conservation, flood control, biodiversity maintenance, and phytoremediation of polluted water bodies. Greater research attention, conservation efforts, and promotion of cultivation practices are required to fully utilize these underexploited plant resources for sustainable food systems and improved human health.



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