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BIOPESTICIDES AND BIOLOGICAL CONTROL METHODS : NATURE'S ALLIES IN PEST MANAGEMENT

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Introduction

In the quest for safer and more sustainable pest management practices, biopesticides and biological control methods have emerged as nature's allies in agriculture. Moving away from chemical-laden approaches, these environmentally friendly solutions harness the power of natural agents to combat pests and diseases, protecting crops and promoting ecological balance. Let us delve into the world of biopesticides and biological control methods and explore how they are transforming pest management.

Biopesticides: Nature's Safe Shields

Biopesticides are pesticides derived from natural sources, such as plants, bacteria, fungi, and other microorganisms. Unlike conventional chemical pesticides, biopesticides pose minimal risks to human health and the environment. They target specific pests while sparing beneficial organisms, making them a sustainable choice for pest control.

Biopesticides fall into three major categories:

1. Plant-based Biopesticides: Extracts from certain plants, like neem and pyrethrum, contain natural compounds with insecticidal properties. These biopesticides disrupt pest behaviour and physiology without harming non-target organisms.

2. Microbial Biopesticides: Bacteria, fungi, and viruses are used as microbial biopesticides to control pests. Bacillus thuringiensis (Bt) is a well-known microbial biopesticide effective against certain insect larvae, while fungi like *Beauveria bassiana* attack pests by infecting and killing them.

3. Biochemical pesticides: are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are synthetic materials that usually kill or inactivate the pest. Biochemical pesticides include substances that interfere with growth or mating, such as plant growth regulators, or substances that repel or attract pests, such as pheromones.

Biological Control: A Natural Balance

Biological control methods use natural enemies to regulate pest populations and maintain ecological balance. These beneficial organisms act as predators, parasites, or pathogens, preying on pests and keeping their populations in check.

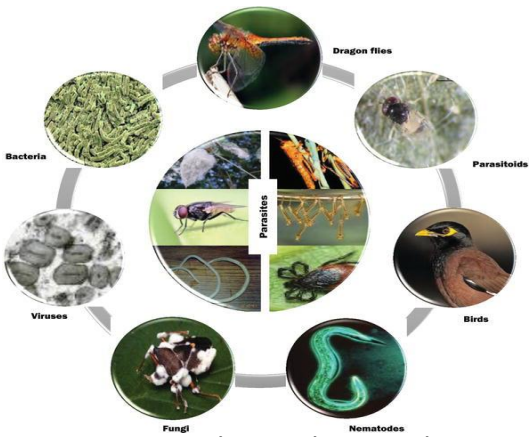
1. Predators: Beneficial insects like ladybugs, lacewings, and praying mantises feed on pests, controlling their numbers naturally. These predators act as vigilant guardians, protecting crops from unwanted intruders.

2. Parasitoids: Parasitoids are insects that lay eggs inside or on pests. The emerging Parasitoids larvae then consume the pest from the inside, ultimately killing it. These tiny assassins provide a highly effective and sustainable means of pest control.

3. Pathogens: Beneficial microorganisms, such as fungi and bacteria, can act as pathogens, infecting and killing pests. When applied correctly, these biological agents selectively target pests, leaving other organisms unharmed.

Advantages of Biopesticides and Biological Control

1. Reduced Chemical Exposure: By replacing chemical pesticides with biopesticides and biological control agents, farmers can significantly reduce the risk of chemical exposure to themselves, consumers, and the environment.



2. Preservation of Beneficial Organisms: Unlike chemical pesticides, which often harm beneficial insects and pollinators, biopesticides and biological control methods preserve the delicate ecological balance, allowing natural allies to thrive.

3. Lowering Resistance Development: Pests can develop resistance to chemical pesticides over time. Biopesticides and biological control methods pose a lower risk of resistance development, making them more effective in the long run.

4. Compliance with Organic Farming Practices: For organic farmers, biopesticides and biological control methods align perfectly with organic farming principles, offering a natural and sustainable approach to pest management.

Future scope of biopesticides in agriculture

The future scope of biopesticides in agriculture is promising and is expected to play a significant role in addressing various challenges faced by modern agriculture. Biopesticides are derived from natural sources, including microorganisms, plants, and biochemicals, and offer several advantages over conventional chemical pesticides. Here are some key aspects of the future scope of biopesticides in agriculture:

- **Environmentally Friendly Agriculture :** Biopesticides are typically less harmful to the environment than synthetic chemical pesticides. They have a lower risk of contaminating soil, water, and non-target organisms, making them a sustainable choice for agriculture.
- **Resistance Management :** As pests develop resistance to chemical pesticides, biopesticides provide an alternative mode of action. They can be integrated into pest management strategies to reduce the risk of resistance development.
- **Organic and Sustainable Agriculture :** The growing demand for organic and sustainable farming practices is driving the adoption of biopesticides. These products are often approved for use in organic agriculture and align with principles of sustainable farming.
- **Biological Contro l:** Biopesticides can be used as part of integrated pest management (IPM) programs, where they work alongside natural predators and parasites to control pest populations effectively.

- **Crop Protection and Yield Enhancement :** Biopesticides can protect crops from a range of pests and diseases, leading to improved crop yields and quality.
- **Regulatory Support :** Many countries are strengthening regulations around the use of synthetic chemical pesticides, which can lead to a greater emphasis on biopesticide development and adoption.
- **Advancements in Research and Development :** Ongoing research efforts are focusing on developing new strains of beneficial microorganisms, identifying novel biochemicals, and improving formulation techniques, all of which will enhance the efficacy of biopesticides.
- **Biotechnology and Genetic Engineering :** Biotechnology and genetic engineering can be employed to enhance the production and effectiveness of biopesticides. For example, genetically modified crops can produce their biopesticides to combat specific pests.
- **Microbial Consortia :** Researchers are exploring the use of microbial consortia, where multiple beneficial microorganisms work together to control pests and diseases more effectively.
- **Education and Adoption :** As awareness of biopesticides grows, farmers and agricultural professionals are likely to receive more training and support in their proper use, ensuring maximum effectiveness.
- **Global Market Growth :** The biopesticide market is experiencing rapid growth, driven by increased consumer demand for safer and more sustainable agricultural products.
- **Customized Solutions :** Biopesticides can be tailored to address specific pest and disease problems in different crops and regions, providing customized solutions for farmers.

Conclusion

Biopesticides and biological control methods are ushering in a new era of sustainable pest management in agriculture. By harnessing the power of nature's own defenders, we can protect crops from pests while minimizing harm to beneficial organisms and the environment. As we embrace these eco-friendly solutions, we take a step towards a healthier and more sustainable future for agriculture, where harmonious coexistence with nature leads to fruitful and bountiful harvests. The future scope of biopesticides in agriculture is promising, driven by the need for environmentally friendly, sustainable, and effective pest management solutions. As research and development efforts continue to expand, and regulatory support increases, biopesticides are likely to become an integral part of modern agriculture, contributing to food security and environmental preservation.

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APPLICATION OF REMOTE SENSING AND GIS IN PRECISION AGRICULTURE

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Abstract
The practise of "precision agriculture" (PA) involves the use of a variety of such technologies to optimise agricultural inputs in order to boost agricultural output and lower input losses. Over the past few decades, there has been a sharp expansion in the use of remote sensing technology for PA. The use of remote sensing has been encouraged in numerous PA applications, including crop monitoring, irrigation management, nutrient application, disease and pest control, and yield prediction, because to the previously unheard-of availability of high resolution (spatial, spectral, and temporal) satellite pictures. In this article, we give a review of remote sensing methods, vegetation indices, and systems, as well as some examples of contemporary PA applications. Commercial agriculture has already adopted remote sensing-based PA technologies like the variable fertiliser rate application technology in Green Seeker and Crop Circle. Due to their affordability and flexibility in acquiring the high-resolution (cm-scale) images required for PA applications, the use of unmanned aerial vehicles (UAVs) has significantly increased during the past ten years. At the same time, academics are investigating cutting-edge data storage and processing methods like cloud computing and machine learning due to the accessibility of a significant volume of satellite data. It is crucial to investigate and design an easy-to-use yet dependable workflow for the real-time use of remote sensing in PA given the complexity of image processing and the quantity of technical knowledge and skill required. Wider usage of remote sensing technologies in commercial and non-commercial PA applications is likely to result from the development of accurate yet simple-to-use, user-friendly systems.

Keywords : Big Data Analysis; Disease and Pest Management; Nutrient Management; Satellite Remote Sensing; UAV; Vegetation Indices; Water Management

Introduction

The most fundamental necessities of humanity are met by farming. Precision farming has benefited from remote sensing thanks to the availability of high-resolution satellite images, including spatial, spectral, and temporal ones. Precision farming using remote sensing offers the tools and technologies for analysing data required for better agricultural methods and higher crop yield. Remote sensors installed on satellites, aircraft, unmanned aerial vehicles (UAV), or ground-based devices collect data.

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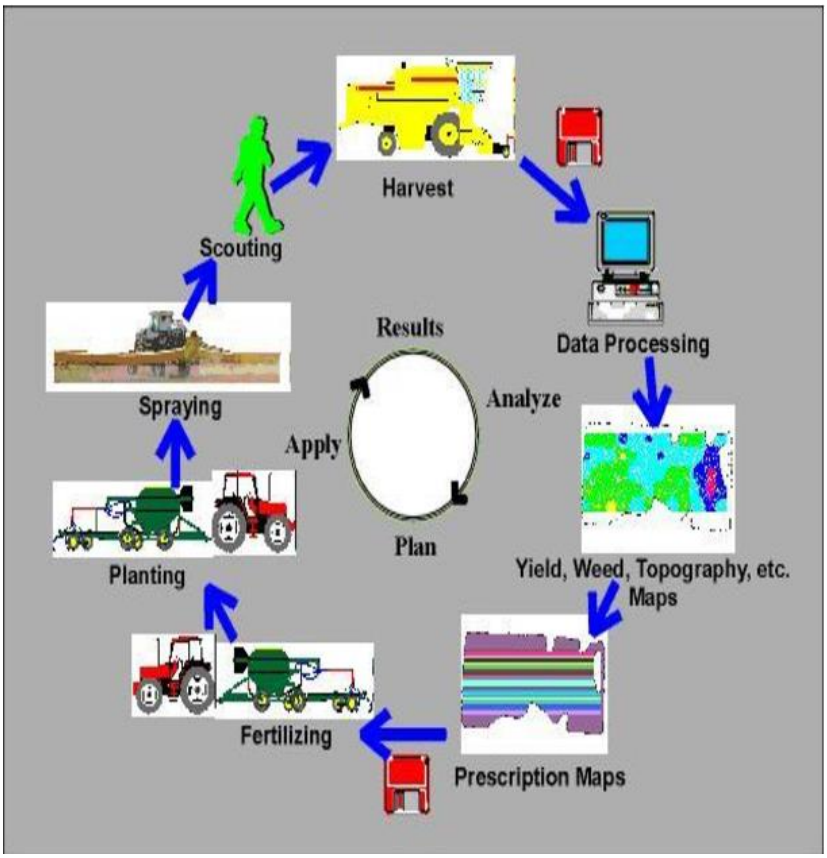

Fig 1: The application of Remote Sensing, GIS and GPS in Precision Agriculture

The following are some significant remote sensing applications in precision agriculture:

1. Soil Property Mapping

For the sustainable management of natural resources at all scales, whether local, regional, or national, soil mapping is necessary. For Variable-rate technology (VRT) to function properly, maps that show crop growth, crop diseases, weeds, crop nutrient deficits, and other crop situations are necessary. Variations in the pace of soil and crop inputs are feasible using VRT. Since sensors are installed on satellites, aircraft, or the ground, remotely sensed images from various platforms are used to create these maps.

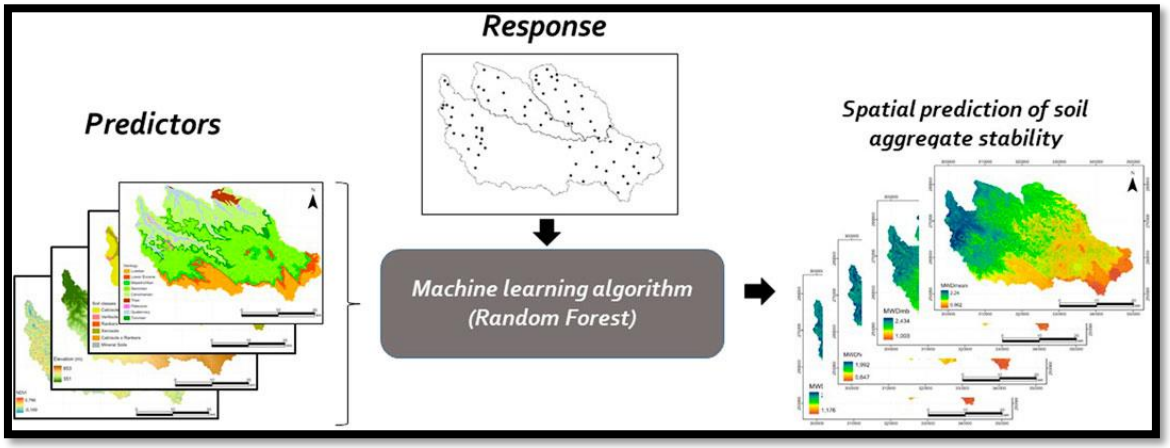

Fig 1: Soil Property Mapping

2. Classifying plant species

With each passing year, modern agriculture gets better and better. The expansion of equipment and instruments that assist precision farming operations has led to the development of new crop species. Globally, remote sensing techniques have been used to support classification and decision-making for various crop species. Field crops, horticulture, viticulture, and pasture are examples of crop groups.

3. Crop Monitoring

Utilising remote sensing technology, precision farming maximises agricultural inputs to boost output and lower losses. Throughout the growing season, farming requires frequent updates on crop status. To comprehend how a crop responds to its environment and create efficient management plans, crop growth must be monitored. Precision farming uses remote sensing data to determine the biomass of different crops; biomass is a crucial sign of the health and development of a crop.

4. Management of Irrigation

In order to minimise crop water stress and achieve optimal development, irrigation timing and volume are very important. The development and testing of various indices and procedures required for irrigation management are done with remote sensing products. Remote sensors' images of developing plants are used to calculate crop water needs and the timing of watering.

5. Management of Nutrients

To maximise crop development and crop yields, fertilisers must be applied at the proper time and rate. When minimising environmental harm brought on by the loss of nutrients, nutrition management is also beneficial. To assess the crop's nutrient condition, a number of vegetation indicators derived from remote sensing data measure the crop's chlorophyll content and photosynthetic activity.

6. Soil moisture estimation

For effective irrigation and management of natural ecosystems under the danger of climate change, knowledge of the soil moisture state is essential. Global estimations of soil moisture are made using remote sensing data from a variety of bands, including optical, thermal, and microwave. However, compared to the other bands, microwave remote sensors have a greater ability to deliver precise soil moisture estimates.

7. Prediction of Yield

Precision farming heavily relies on remote sensing for large-scale crop inventory and yield forecasting. Remote sensing-based crop yield estimation has mostly been done in two methods; Initially, through biophysical parameters derived from remotely sensed data, and secondly, by the development of statistical or empirical connections between crop metrics derived from remote sensing.

8. Identifying Crop Water Stress

A lack of water supply to crops is known as water stress, and it can be identified by a decrease in the water content of the soil or other physiological reactions. Precision farming places a high priority on crop water status evaluation because of shifting climatic conditions. To detect crop water stress and enhance irrigation management, remote sensing delivers a wide range of data.

9. Weed Control

Weed management entails reducing the weed population on a farm by ensuring that their growth doesn't do the crops any economic harm. In order to map weed patches in farms for traditional

weed management, remote sensing has been employed extensively. They distinguish between weeds and crops using their spectral signature, swiftly identifying weed characteristics.

10. Pest and Disease Control

Crop production can suffer significantly from pests and illnesses. Early pest and disease detection from farms can help to better contain the conditions and prevent spreading. In contrast to conventional field scouting, which is labor-intensive, time-consuming, and prone to human mistake, the remote sensing technology aids in the efficient monitoring of the diseases. Remote sensors identify the circumstances as they are developing.

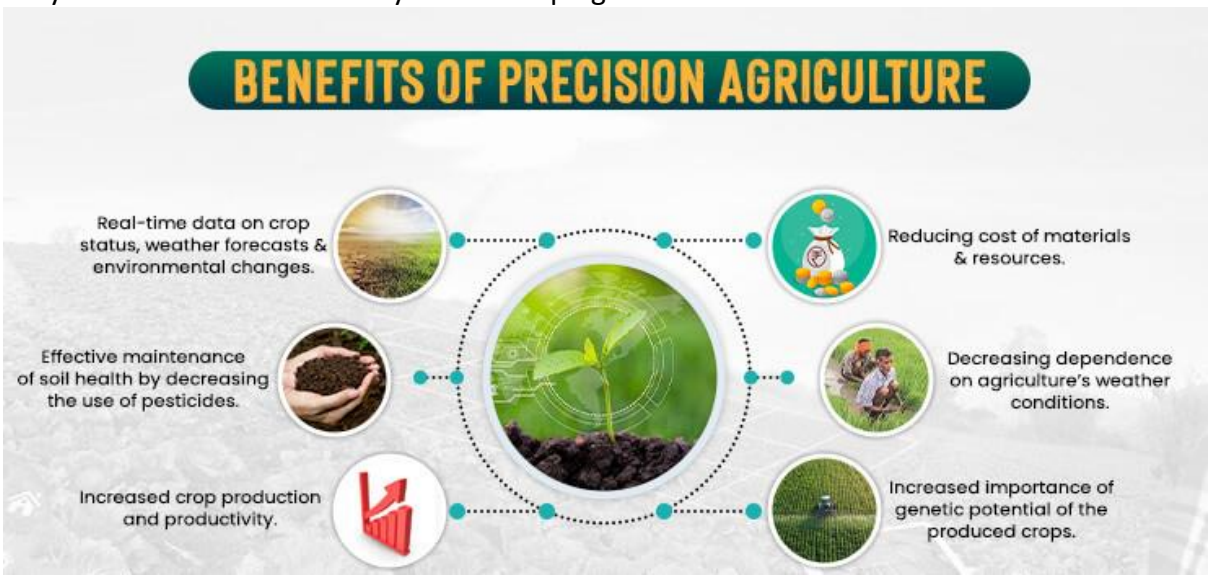

Fig 3: Advantages of precision farming

Challenges, Needs, and Progress

Nearly every element of PA, from soil preparation to harvesting, has potential implications for remote sensing. The face of PA has altered as a result of the abundance of high spatial resolution, multi-temporal satellite data, low-cost UAVs, and commercially available ground-based proximity sensors. The prospective uses of remote sensing in PA have been investigated using a wide range of cutting-edge techniques, such as empirical, regression, and different types of machine learning approaches. In a similar vein, numerous vegetation indices, such as variable fertiliser management, irrigation scheduling, disease control, weed mapping, and yield forecasting, have been created and tested for their potential to assist PA operations. Before remote sensing technologies might possibly be widely used in both commercial and non-commercial agriculture, many obstacles must be overcome.

Even though the majority of satellite data are freely accessible, processing them for practical purposes may necessitate substantial technological know-how and skill. For instance, software experts and specialised skills are needed for image pre- and post-processing. Furthermore, many PA procedures, like the management of weeds and diseases, call for data with fine spatial resolution (cm-scale) and high spectral and temporal (e.g., daily) precision. Most satellite data that is made available to the public does not adhere to these standards. Additionally, many satellite photos might not be acceptable for usage on cloudy days or when there is irregular or changeable irradiance from the sun.

Users and farmers could need to pay for high resolution satellite data, which might be prohibitively expensive, particularly for small farms. For small farm operations, a low-cost alternative may be provided by photos captured by UAVs, but the usage of UAVs and tractor-mounted sensors necessitates expert operators (such as drone licencing) and requires the use of specialised software for data analysis. The cutting-edge sensors deployed on some of the most recent satellite launches and unmanned aerial vehicles (UAVs) produce hyperspectral images that contain a wealth of data on crop biophysical parameters. However, these sensors (UAVs) are expensive, and picture processing is difficult. To synthesise and provide the useful information required for PA applications, it is necessary to investigate and develop cutting-edge information and communication technologies, as well as chemometric and spectrum decomposition methodologies. Machine learning and other artificial intelligence approaches have the ability to produce spatially and temporally continuous information from real-time satellite data at the scale required for many PA applications. Such AI techniques can be complemented by hybrid methods, which use the information from physically based models to build methodologies helpful in PA decision making.

Conclusion

Making sure there will always be enough food for everyone is essential given the expanding population. Governments, activists, scientists, and agricultural producers can research and devise strategies to assure food supply and, by extension, the survival of the human race, with the aid of GIS technology. For instance, the Food and Agriculture Organisation (FAO) has been establishing sustainable food systems all over the world for more than 30 years by utilising GIS and other geospatial technology.

GIS can be used for sustainable agriculture in a variety of ways, such as moving to organic farming, identifying the most environmentally friendly crop planting sites, and distributing lands to ensure continued food production.

The GPS receiver built into the sensor, the sensor's position and viewing angle, the time of day when the photographs were taken, and the kind of sensor utilised for image acquisition are just a few of the variables that might affect the quality of remote sensed images. It is important to pay close attention to the aforementioned features while processing, analysing, and interpreting the photos since information products made from high quality remote sensed images have the ability to enhance crop and farm efficiency while also improving the application of agricultural inputs. To ensure that the information that is retrieved is reliable, high-quality imagery is crucial.

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SUSTAINABLE FOOD PRODUCTION USING AQUAPONICS

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Introduction

Many definitions of aquaponics use the 'ponics' component of the word to refer to hydroponics, which is the practice of growing plants in water without the use of soil. Hydroponics is a unique growing method with its own set of advantages and disadvantages. It just so happens that the labour those fish undertakes (consuming and excreting waste) is the ideal fertiliser for plant growth. When fish get to work, they can develop a lot of plants. One of the most appealing aspects of Aquaponics is that it closely resembles a natural ecosystem. Aquaponics is the study of the interaction of water, aquatic life, bacteria, nutrient dynamics, and plants in streams all over the world. Aquaponics, inspired by nature, leverages the power of bio-integrating these different components: exchanging the waste by-product from the fish as a meal for the bacteria, to be turned into a perfect fertiliser for the plants, and to return the water to the fish in a clean and safe state. In every aquatic environment, Mother Nature does the same thing. Aquaponics combines the greatest aspects of all growing methods, repurposing one element's waste to help another, much like a natural ecosystem. Aquaponics relies on the recycling of nutrient-rich water continuously. In aquaponics, there is no toxic run-off from either hydroponics or aquaculture.

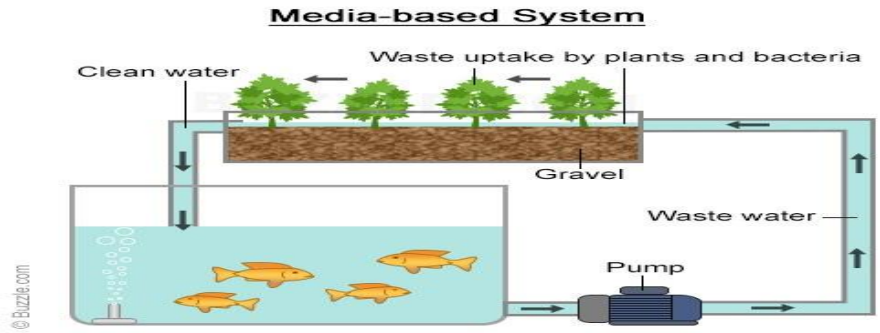
- Aquaponics requires a tenth of the amount of water that soil-based farming does, and even less than hydroponics or recalculating aquaculture. There can be no petrochemicals, pesticides, or herbicides utilised.
- Gardening tasks are drastically reduced or eliminated in this natural ecosystem. The aquaponics grower can concentrate on the more pleasurable activities of feeding the fish and caring for and harvesting the plants.
- You can utilise aquaponics systems outside, in a greenhouse, in your basement, or even in your living room. A place can be turned into a fruitful garden by applying grow-lighting.
- Aquaponics systems can be scaled up or down. From modest countertop herb systems to backyard gardens to full-scale farms, aquaponics can accommodate most sizes and budgets.
- The nicest thing is that you may harvest plants as well as fish from your garden.
- Grow your complete supper in your own backyard. Rather than using dirt or hazardous chemical treatments to grow plants, aquaponics makes use of very nutritious fish effluent, which provides all of the nutrients needed for optimal plant growth.
- Instead of discharging water, aquaponics cleans and purifies it using plants, naturally existing microorganisms, and the substrate in which they thrive, before returning it to the fish tank.

There are a few basic aquaponic growing methods that are extensively used today

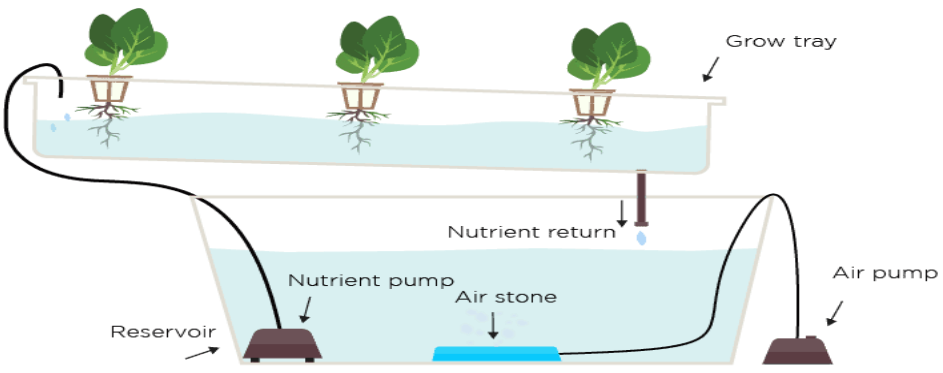
- **Deep water culture** (DWC) or raft based growing uses a foam raft that is floating in a channel filled with fish effluent water that has been filtered to remove solid wastes. Plant roots

dangle freely in the water after being inserted in holes in the raft. This strategy works best for cultivating salad greens and other low-nutrient plants that grow quickly. It's also the most popular choice for bigger commercial-scale installations.

- **Media-based Aquaponics** Media growing involves growing plants in inert planting media such as expanded clay pellets or shale. In the same system, the media provides biological filtration (conversion of ammonia to nitrates) as well as mechanical filtration (removal of solid wastes). You may cultivate a broad variety of crops with media-based systems, which are ideal for home and hobby scale systems. Large fruiting plants, as well as leafy greens, herbs, and other types, do particularly well.



- **Nutrient Film Technique** (NFT) NFT systems vocation by flowing nutrient-rich water throughout a narrow trough, for example a PVC pipe. Plants are inserted into holes drilled in the pipe, and their roots dangle freely in the water stream. This method of growth is ideal for plants that require little support, such as strawberries and other herbs. Because they may be hung from ceilings above other growing places, NFT is also an excellent method to make use of unused space.



- **Vertical Aquaponics** One of the furthermost aspects of aquaponics is its capability to grow an implausible amount of food in a very small area. Vertical aquaponics is the only method that achieves this well. In tower systems like the AquaVertica, plants are stacked on top of each other. Water enters the tower at the top and passes through a wicking substance, which the plant roots collect water and nutrients from. The water then drains into a trough or into the fish tank directly. This type of farming makes the most of every square foot of available area, and it's ideal for leafy greens, strawberries, and other crops that don't require much support to thrive.

Aquaponics' Advantages

1. Aquaponics systems are yielding higher yields.
2. Water is conserved in aquaponics systems.
3. The aquaponics system takes up less space.
4. The aquaponics goods are all natural systems.
5. The amount of labour required in an aquaponics system is relatively low.
6. Aquaponics is the production of two agricultural products (fish and vegetables) from a single nitrogen source (fish food).
7. Aquaponics does not necessitate the use of fertilisers or pesticides.

Disadvantages of aquaponics

1. When compared to hydroponics or soil production systems, the initial cost of aquaponics is relatively high.
2. To be successful, farmers must learn not only how to grow vegetables, but also how fish and bacteria work, as well as scientific knowledge of plumbing and wiring.
3. Aquaponics systems necessitate daily management, which necessitates the association.
4. It has higher energy demands, which equals higher energy prices.
5. Fish feed must be obtained on a consistent basis.
6. Aquaponics system goods alone are insufficient to ensure a well-balanced diet.

Conclusion

Aquaponics is a cost-effective, long-term strategy for feeding the globe. It is simple to operate and requires significantly less water than traditional farming and genetically modified crops, allowing us to respond to food security demands far more quickly than a solution like food waste management could. Foods grown in aquaponics system are high in nutrients and, unlike genetically modified

foods, pose no damage to the environment or humans who consume it. Aquaponics currently has a few drawbacks, but they are minor and can be readily overcome with more research and analysis.

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ARTIFICIAL INTELLIGENCE FOR *Orobanche* MANAGEMENT IN MUSTARD

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Abstract

Orobanche, the insidious parasitic weed, poses a formidable challenge to mustard cultivation, causing yield losses, reduced crop quality, and economic hardships for farmers. Traditional *Orobanche* management methods, such as crop rotation and chemical control, have significant limitations. However, Artificial Intelligence (AI) emerges as a promising ally in the battle against *Orobanche*. This article explores the multifaceted issue of *Orobanche* management in mustard and highlights the pivotal role AI can play. AI offers innovative solutions, including early detection through image recognition, precision herbicide application, predictive modeling, and autonomous robotic weeders. These AI-driven approaches not only enhance efficiency and reduce costs but also promote environmental sustainability by minimizing herbicide usage. The integration of AI into *Orobanche* management holds the potential to revolutionize mustard farming, ensuring sustainable and productive agriculture.

Introduction

Orobanche, commonly known as broomrape, is a devastating parasitic weed that infests a wide range of crops, including Indian mustard (*Brassica juncea*). This noxious weed poses a significant threat to mustard production, causing yield losses and reducing crop quality. Traditional methods of *Orobanche* management have limitations, such as crop rotation and chemical control, which are often labor-intensive, environmentally harmful, and not always effective. However, recent advancements in Artificial Intelligence (AI) offer promising solutions to address these challenges. This article explores the multifaceted issue of *Orobanche* management in mustard and the pivotal role AI can play in providing innovative and sustainable solutions. We will delve into the biology and impact of *Orobanche*, the existing management strategies, and how AI can revolutionize *Orobanche* control through early detection, precision herbicide application, predictive modeling, and robotic weeders.

Understanding *Orobanche* : The Silent Menace

Orobanche is a parasitic plant that attaches to the roots of host crops, including mustard, and siphons off water, nutrients, and carbohydrates, ultimately leading to reduced crop growth and yield. It is known for its ability to adapt and evolve rapidly, making it a challenging adversary for farmers. *Orobanche* produces numerous tiny seeds, which can remain dormant in the soil for several years until triggered by host plant exudates or other factors. When stimulated, *Orobanche* germinates and forms a specialized structure called a haustorium that penetrates the host plant's root system. Once attached, it becomes a drain on the host's resources, leading to stunted growth, wilting, and often death.

The Impact of *Orobanche* on Mustard Production

1. **Yield Losses**: *Orobanche* infestations can lead to substantial reductions in mustard yields. In severe cases, yield losses can exceed 50%, jeopardizing the livelihoods of farmers.

2. **Quality Degradation**: Infested mustard crops often suffer from reduced quality, leading to lower market value. *Orobanche*-infested mustard seeds are often smaller and less oil-rich.
3. **Economic Implications**: The economic consequences of *Orobanche* infestations are significant, including increased production costs associated with weed control and lower profits due to reduced yields and quality.
4. **Environmental Concerns**: The use of chemical herbicides to control *Orobanche* can have adverse environmental impacts, including soil and water contamination.

Traditional *Orobanche* Management Strategies

1. **Crop Rotation**: Farmers often resort to crop rotation as a means to reduce *Orobanche* infestations. By planting non-host crops in infested fields, they aim to deplete the *Orobanche* seed bank. However, this method is not always effective, as *Orobanche* can infect a wide range of hosts.
2. **Chemical Control**: Herbicides, such as sulfosulfuron and imazapic, are commonly used to manage *Orobanche*. While effective, these chemicals can have negative environmental consequences, including the development of herbicide-resistant *Orobanche* strains.
3. **Manual Weeding**: Labor-intensive and not always practical, manual weeding involves physically removing *Orobanche* plants from fields. It is often employed as a last resort.
4. **Resistant Varieties**: Developing *Orobanche*-resistant mustard varieties is a long-term strategy, but it requires considerable time and resources.

The Promise of Artificial Intelligence in *Orobanche* Management

Artificial Intelligence, specifically machine learning and computer vision, offers innovative and sustainable solutions to *Orobanche* management in mustard. By harnessing AI technologies, farmers can revolutionize how they detect, monitor, and control *Orobanche* infestations.

1. **Early Detection and Monitoring**:
    - *AI-Powered Image Recognition*: AI algorithms can analyze images of mustard fields captured by drones, satellites, or ground-based cameras. These algorithms can identify *Orobanche*-infested areas at an early stage, allowing for targeted interventions.
    - *Precision Herbicide Application*: AI can optimize herbicide application by identifying *Orobanche*-infested zones within mustard fields. This precise approach minimizes chemical use and environmental impact.
2. **Predictive Modeling**:
    - *Historical Data Analysis*: AI can analyze historical data on *Orobanche* infestations, weather conditions, soil health, and crop growth. By identifying patterns and correlations, AI can develop predictive models to forecast *Orobanche* outbreaks accurately.
    - *Risk Assessment*: AI can assess the risk of *Orobanche* infestations in mustard fields based on factors such as soil type, crop rotation history, and neighboring infested fields. This information helps farmers implement preventive measures proactively.
3. **Robotic Weeders**:
    - *AI-Controlled Robots*: Autonomous robots equipped with AI-driven systems, cameras, and robotic arms can be deployed in mustard fields. These robots can identify and physically remove *Orobanche* plants without damaging the crop. They work efficiently and reduce the reliance on manual labor.

- *Continuous Operation*: AI-controlled robotic weeders can operate continuously, monitoring fields day and night. This round-the-clock surveillance ensures that *Orobanche* infestations are addressed promptly.

4. **Decision Support Systems**:
    - *Real-Time Insights*: AI-driven decision support systems provide farmers with real-time information about *Orobanche* infestations. These systems recommend appropriate actions, such as herbicide application, robotic weeding, or crop rotation adjustments.
    - *Data Integration*: AI can integrate data from multiple sources, including satellite imagery, weather stations, and soil sensors. This comprehensive data analysis allows for a holistic understanding of *Orobanche* infestation dynamics.

Benefits of AI in *Orobanche* Management

The integration of AI into *Orobanche* management in mustard brings numerous benefits:

1. **Improved Efficiency**: AI-driven systems work tirelessly, providing continuous monitoring and rapid response to *Orobanche* outbreaks. This efficiency minimizes crop damage and yield losses.
2. **Reduced Costs**: Precision herbicide application and autonomous robotic weeding reduce the overall cost of *Orobanche* management. Farmers save on labor, herbicides, and other resources.
3. **Environmental Sustainability**: AI enables precise herbicide application, minimizing chemical use and mitigating environmental harm. This aligns with sustainable farming practices and reduces the risk of herbicide-resistant *Orobanche* strains.

In summary, AI has the potential to revolutionize *Orobanche* management in mustard and other crops by providing early detection, precision control, predictive modeling, and decision support. These AI-driven solutions can reduce the economic and environmental impact of *Orobanche* infestations, ultimately contributing to more sustainable and productive mustard farming practices.

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HORTICULTURE - BASED PLANT NURSERY ENTREPRENEUR IN SHIVAMOGGA: A CASE STUDY

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Introduction

Entrepreneurship and enterprise development are critical for socio-economic development. Encouraging entrepreneurial activities can contribute to the creation of new products such as creating jobs, reducing poverty, enhancing social equity, improving living standards and bringing overall economic growth. For these reasons, entrepreneurship development is recognized as an important strategy to achieve key development objectives. Agro-based enterprise is an important entry point for agriculture development. There is an increasing emphasis on market-led development that is facilitated by income generating activities and market participation of communities. This paper on case study of a successful agro-enterprise covering a wide range of rural enterprises along the horticultural value chain. The case study reflects the endeavor, enterprise and aspiration for rural communities. This paper is expected to inspire and offer something for everybody, in addition to serving as a subsidiary occupation for farmers and rural youth. The present case could serve as a role model and motivate our youth to take up agriculture enterprises as a livelihood option.

The integrated Farm was established in the year 2016 by Mr. Vijayendra Bhat. The farm is located at vinayaka circle, hosanagara Road, Ripponpete of Shivamogga district. Presently, the nursery is on one acre land and sells different varieties of plant seedlings. The farmer nursery is a wholesale plant nursery. The total area of the farm is 6 acre of which 1 acre is under horticultural nursery. The Integrated Farm of remaining five acres maintained under natural farming with coffee, Arecanut, black pepper, nutmeg, sapota and apemidi mango with some prominent fruit crops as mother plants for grafting in the farm. Besides ornamental and flower, the farmer has planted 165 saplings of nutmeg and about 60 saplings of appemidi mango fruit as mother plants. Orchids are also grown for ornamental. The farmer also has diary of local breed (Malnad gidda) for household milk consumption and for preparation of jeevamrith for farm.

The farmer earned a total income of Rs. 24,89,800 from marketing. Selling farm produce alone fetched about Rs. 14,44,800, the horticulture nursery earned Rs. 10,45,000 through sale of fruits, spices and ornamental seedlings. The labours were paid a salary of Rs. 85,000/month for 12 labours. The farmer had a net income of Rs.9,89,600/annum with a benefit cost ratio of 1.56.

Challenges: One of the major challenges the farm is the acidic soil on which the vegetables and fruits do not grow well, hence the farmer has adopted plantation crops like Arecanut and coffee along with spice crops. To improve the soil, the farmer has been adopted organic farming along

with application of jeevamrith, farm yard manure and leaf litters continuously. The intensive care of soil is yielding good result. The farm is 30 km away from the Shivamogga city market. Due to distance market the nursery seedlings are sold at whole sale rate for nursery buyers. The farmer had a utility vehicle to ease the transportation challenge.

Message to future entrepreneurs: The Integrated Farm is one of the best examples of successful farm in the Shivamogga district of Karnataka initiated by a farmer with support from Krishi Vigyan Kendra, Shivamogga. The farmer acknowledges that for a farm to flourish, a person has to have passion, experience and multitasking capabilities. For this, one should have knowledge and skills to operate farm that can be achieved from training. The technical scientist said that proper planning is indispensable when a large area of land is to be managed. Knowledge of space management and rotation of crops are important skills. According to one of the farmer "there is a vibrant future and scope for farm businesses which will always remain there as long as one is ready to work hard"

Table 1: Receipts generated from farm produce during 2022-23

Crop	Rate (Rs/kg)	Yield (kg)	Income
Arecanut	48	5000	240000
Black pepper	500	1400	700000
Nutmeg	200	2500	500000
Nutmeg mace	1200	4	4800
		Total	**1444800**

Table 2 : Receipts generated from horticulture nursery during 2022-23

Nursery plants	Numbers	Rate	Receipts
Mango	3000	50	150000
Lemon	3000	15	45000
Black pepper	25000	10	250000
Arecanut	10000	20	200000
Sapota	3000	50	150000
Nutmeg	2500	50	125000
ornamental	5000	25	125000
		Total	**1045000**

Table 3: Benefit cost ratio

Sl. No.	Particulars	Receipts (Rs)	Cost of cultivation (Rs)	Net income (Rs)	BC ratio
1	Farm produce	1444800	1520000	969800	1.56
2	Horticulture Nursery	1045000			

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ORGANIC FARMING: THE FUTURE OF AGRICULTURE

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Abstract
Crop planting and natural animal breeding are emphasised in the practise of organic farming. This process substitutes organic components with synthetic ones in an effort to maintain ecological balance, soil fertility, and minimise waste and pollution. It has various components of organic farming i.e. crop residues, crop rotation, organic manures, vermicompost and biofertilizers. These enhances the environmental sustainability and economical viability. The rapidly increasing population requires food security and healthy food that's why organic farming plays a vital role in completing the required goals. It has numerous benefits that add on to the health of soil as well as the environment to make it sustainable and economically profound. It enhances health benefits, decreases use of GMO's, increase nutritional quality of food and enhancing bio-diversity of agriculture.

Keywords: organic, sustainable, environment and nutrition.

Introduction

Organic farming is a practise that emphasises the planting of crops and the natural breeding of animals. In an effort to preserve ecological balance and soil fertility and reduce waste and pollution, this procedure uses organic components instead of synthetic ones. In other terms, organic farming refers to a farming technique that forgoes the use of pesticides and fertilisers that have a synthetic foundation. Genetically engineered species are also not allowed. It is based on agricultural practises that are ecologically balanced, such as crop rotation, the use of organic manures, green waste, bio pest management, and the addition of minerals and rocks. Pesticides and fertilisers are used in organic farming if they are regarded as natural; different chemical insecticides and pesticides are avoided. Organic farming is an agricultural practise that makes use of biological pesticides and fertilisers derived from plant or animal waste. Actually, the practise of organic farming began as a response to the harm that synthetic fertilisers and chemical pesticides were causing to the environment. Or to put it another way, organic farming is a new type of agriculture or farming that improves, maintains, and repairs the ecological equilibrium.

Components of Organic Farming:

Organic farming includes various components that are environment friendly and economically viable. These components does not affect the environment and soil fauna or micro-organisms. These are various components of organic farming:

1. **Crop rotation:** It is an arrangement for producing several crops on the same land over a duration of two years or more in a more or less regular succession. Crop rotation is essential for the control of weeds, insects, and diseases, and soil fertility management. In any rotation, 25 to 50 percent of the land should be used for legumes.
2. **Crop residues:** Straw from some of the most important grains and pulses has a lot of potential for use in India as crop leftover. The agricultural leftovers are having great potential for

nutrient recycling. The integration of agricultural wastes, such as wheat and rice straw, had positive impacts on crop yields and physio-chemical characteristics of soil.

3. **Organic manure:** The biological sources for the organic manure include leftovers from people, animals, and plants. Many techniques exist for organic manure to improve crop development and soil production. These are categorised into bulky organic manures and concentrated organic manures. Bulky organic manures includes FYM, compost and green manuring. Concentrated organic manures includes wastes i.e. industrial and municipal waste.
4. **Biofertilizers:** Reduce external inputs while increasing the amount and quality of internal sources with the help of bio-fertilizer, which is both economically appealing and environmentally good. Bio-fertilizer is a culture of microorganisms that, when sprayed on the right crops, can fix atmospheric nitrogen.

Types of biofertilizers:

a) **Symbiotic N-fixation**: These are several strains of Rhizobium culture that symbiotically fix nitrogen in the roots of suitable legumes. These bacteria in legumes provide over half of the plant's nitrogen needs. Example: Rhizobium
b) **Asymbiotic N-fixation**: In addition to producing nitrogen compounds for their own growth and development and growing on decaying soil organic matter, they also release a considerable quantity of nitrogen into the environment. Example: mycorrhizae, azotobacter, azo-spirillum, BGA, azolla.

5. **Vermicompost**: It is organic manure that earthworms have created. It is a technique for creating compost that makes use of earthworms, which typically inhabit soil, consume biomass, and expel it after being digested. They are abundant in vitamins, growth hormones, macro and micronutrients, and immobilised microorganisms. Vermicompost often has a considerably greater nutritional value than FYM.

Benefits of Organic Farming

The world's population is expanding rapidly, making it increasingly challenging to feed everyone. Sustainable food production and cultivation are urgently needed. No matter what we eat, choosing organic food is the finest decision you'll ever make. To do this, you must support organic agricultural practises. The following are the justifications for adopting organic farming practises:

1. **Nutritional benefit**: Compared to foods from conventional farms, those from organic farms are packed with nutrients including vitamins, enzymes, minerals, and other micronutrients. The study's findings indicated that foods from organic farms had much more nutrients than those from industrial or conventional farms. The study went on to confirm that five servings of these organically grown fruits and vegetables provided an adequate amount of vitamin C.
2. **Refrain of GMO's:** Genetically modified foods (GMOs) are affecting natural food supplies at a startling rate and causing serious impacts that are inexplicable. They are not even labelled, which makes them a serious hazard. The only way to lessen these serious impacts of GMOs is to stick to organic foods obtained from reliable sources.
3. **Conserves agricultural diversity:** Today, it is common to receive news about extinct species, which is a serious problem. It is estimated that 75% of the agricultural variety of crops has been lost in the last century alone. A bias in favour of one type of farming will only lead to

tragedy down the road. To ensure a sustainable future, we require organic agricultural practises that result in crops that are resistant to disease and pests.

4. **Economical**: In organic farming, crops are planted without the use of high-priced fertilisers, pesticides, or HYV seeds. There is thus no additional cost. Use of natural fertilizers makes it a more economical and farmer pocket friendly method of farming so that, farmer can reap more benefits from the produce.
5. **Helpful in climate changing scenario**: Organic farming uses less non-renewable energy by using fewer agrochemicals. Organic farming is able to sequester carbon in the soil, which helps to reduce the warming of the planet through the greenhouse effect. Several management techniques employed in organic agriculture (such as minimal tillage, returning crop wastes to the soil, using crop rotations, and including more nitrogen-fixing legumes) boost the soil's ability to hold carbon, increasing productivity. Organic farming results in markedly elevated soil organic carbon concentrations.
6. **Free from chemically infused poison:** Pesticides, weed killers, and other harmful chemicals are not used in organic farming. According to studies, a significant portion of the population exposed to the hazardous chemicals employed in traditional agriculture has developed ailments including cancer. Organic farming decreases illness and illnesses because it avoids harmful chemicals.

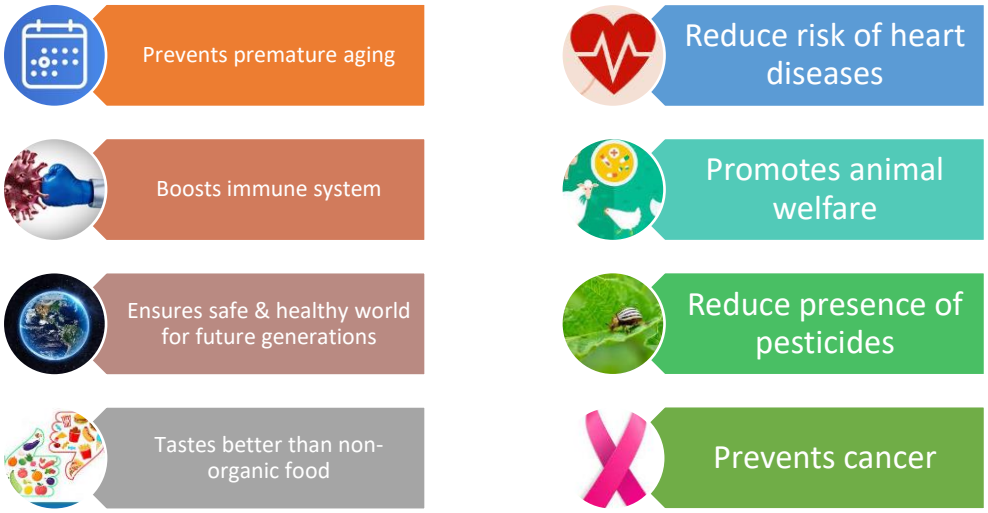

Figure 1: Benefits of organic food

Why is modern agriculture not suitable?

1. Soil fertility loss brought on by improper crop rotation and overuse of chemical fertilisers.
2. Water supplies become contaminated by nitrate discharge during rain
3. Biodiversity decline brought on by monoculture.
4. Native animals and flora are forced to make way for hybrids and foreign species.
5. Soil erosion brought on by thorough ploughing and persistent rain.
6. Increased fuel needs for agriculture.
7. Use of toxic bio-cide sprays to control weeds and pests.

Conclusion

Organic farming is gaining popularity in developing nations as a result of its lower cost and greater reliance on local people and natural resources. According to the current research, organic farming

is advantageous in regions with little rainfall and low levels of natural and soil fertility . Organic agriculture has the potential to increase local food security, particularly in deprived areas. Organic farming promotes consumer health by preserving the purity of the environment and the health of the soil. Compared to foods from conventional farms, those from organic farms are packed with nutrients including vitamins, enzymes, minerals, and other micronutrients. It also more economical and farmer pocket friendly method of farming so that, farmer can reap more benefits from the produce.

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BIOCHAR FROM– AN ECOFRIENDLY WAY FOR SUSTAINABLE AGRICULTURE

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Biochar is a type of charcoal that is produced through the pyrolysis of organic materials, such as wood, crop residues, and other biomass. It has several key features and properties that make it valuable for various applications, particularly in agriculture and environmental sustainability. It is essential to apply biochar with a good understanding of the specific conditions and requirements of each application to maximize its benefits.

Abstract
Effective environmental management strategies must be put into operative in circular economies to combat resource depletion. The potential of agricultural crop waste in reducing greenhouse gas (GHG) emissions and advancing global carbon neutrality has gained more attention in recent years. Crop residue burning in open fields contributes significantly to greenhouse gas emissions and air pollution despite the lack of effective management solutions. Producing biochar from the pyrolysis of agricultural crop residue could be a solution to this problem. Through the sequestration of atmospheric carbon and the reduction of greenhouse gas emissions from the soil, the use of biochar in agriculture can aid in the fight against global warming.

Introduction
A key component of a robust and sustainable food system is healthy soil. Agricultural practices disrupt natural soil mechanisms, such as nutrient cycling and the release and uptake of nutrients, as the land is used for cultivation. One method of controlling soil health and fertility is through the effective use of biomass, which is present in crop residues and other farm wastes. A potential soil improvement and carbon-sequestration tool is biochar. Additionally, it enhances soil quality and decreases farm waste.

The primary objective of agriculture both today and in the future is to supply the world's population with nutritious food. The impact of global climate change on crop productivity and soil health, is greater in agriculture. The adoption of better crop types, fertilizers, pest control techniques, and irrigation frequently results in high yields, which have led to food and nutritional security. Farmers observe a number of challenges related to current intensive agriculture systems notwithstanding their great production. It puts strong emphasis on integrating biological, chemical, and physical measurements of soil quality that have an impact on farmers' profitability and the environment. The most effective way to increase the fertility and productivity of the soil in rainfed areas is to amend it with crop residues.

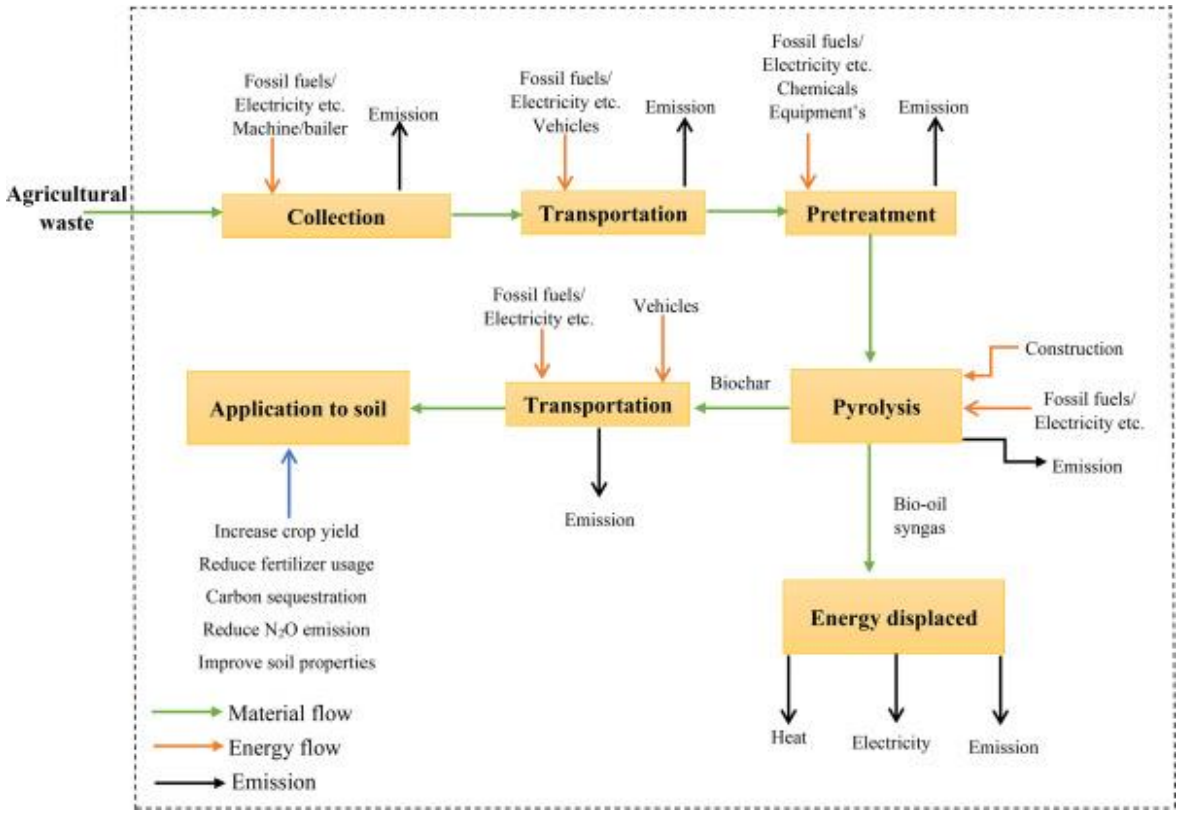
India produces 500 Mt of crop waste per year, of which 141 Mt are surplus. Due to various restrictions, these residues are either completely unutilized or only partially used. When left

unchecked, surplus and unused agricultural waste frequently impede early crop growth, crop establishment, and land preparation. As a result, they usually burn on farms, which results in significant nutrient losses and environmental issues Biochar, an organic soil additive, has come to light as a promising approach to combat climate change, preserve the health of the soil, and assure the sustainable production of food.

The challenging responsibilities of creating effective strategies and methods to sustain the deteriorating environments through sustainable means belongs to the scientific communities and a number of other politicians. The co-product of pyrolysis, biochar, is recognized as a crucial tool for addressing the aforementioned problems.

Biochar and its importance

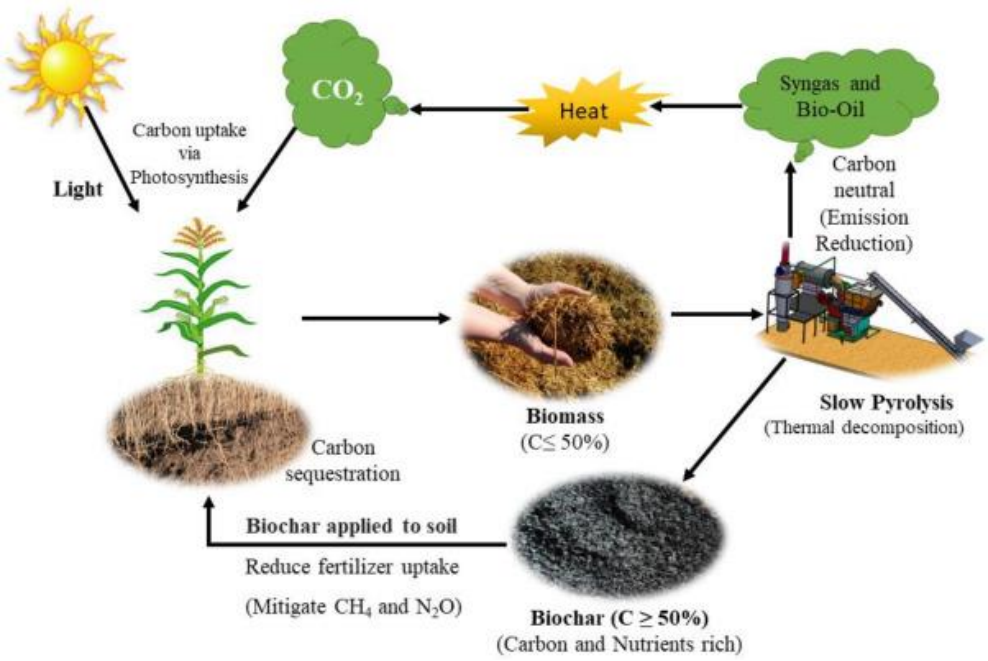
Biochar is a solid substance formed through the thermochemical conservation of biomass in an atmosphere with limited oxygen. After plant biomass has been put through a thermo-chemical conversion process (pyrolysis) at temperatures (350-600°C) in an atmosphere with little to no oxygen, a fine-grained, carbon-rich, porous product known as biochar is left behind. The word Biochar is derived from Greek word. Bios means life; char means charcoal (product of carbonization of biomass). The term biochar was invented by Peter Read (lobbyists for biochar plantations). As a soil amendment, biochar is a carbon substance created by the pyrolysis process It is the dark, carbon-rich byproduct of heating biomass with little oxygen. It removes CO2 from the atmosphere over a longer period of time than the original biomass because it is more chemically and biologically stable.



Importance

- Applications of biochar are becoming more and more popular as a sustainable technology that helps to improve weathered and degraded soils.

- It improves the physical, chemical, and biological properties of the soil, including its bulk density, water holding capacity, permeability, and microbial population as well as its earthworm and enzyme populations. As a result, plant growth and development are improved. Its resistance to microbial degradation ensures that soil fertility will be improved over the long run.
- Aside from that, it also enhances the saturated hydraulic conductivity of the topsoil in rice fields and the xylem sap, both of which contribute to increased crop yields and a better response to treatments with chemical fertilizers including N and NP
- The risk of contamination is quite low because they have very fewer heavy metals or hazardous substances like As, Cd, Pb, and polycyclic aromatic hydrocarbons. They can boost crop yield, soil fertility, water and fertilizer usage efficiency, as well as reduce N2O emissions. The long-term storage of carbon in soil can reduce the rising level of atmospheric CO2. In this context, biochar has become a practical choice for locking up carbon in soil.



C sequestration cycle of biochar in soil and crop plant system.

Necessity of Biochar Research in India

1. Minimize field burning of crop residue

Crop wastes are traditionally burned in open fields to increase soil fertility in terms of P and K; however, this method frequently results in the loss of other nutrients like N and S, organic matter, and microbial activity needed to maintain better soil health (IARI, 2012). To maintain the physical, chemical, and biological health of rainfed soil, however, a threshold amount of organic matter must be maintained. An alternate method of handling surplus and unusable crop residues is to convert them into biochar through a thermochemical process (slow pyrolysis). Examples of agricultural residues are provided in Table 1 for better management and disposal of crop and agroforestry residues.

2. To increase soil organic carbon

Organic matter and minerals included in biochar raise soil pH, EC, and organic carbon levels enhancing soil fertility.

3. To slow the growth of CO2 in the atmosphere

Agricultural waste, in example, produces huge amounts of CO2 when it is burned or naturally decomposed. A stable method of storing carbon in the ground for centuries, biochar may be able to slow or stop the increase in atmospheric greenhouse gas concentrations.

4. Degradation of the environment

By minimizing soil nutrient loss, lowering bioavailability of pollutants, capturing carbon, lowering GHG emissions, and increasing crop yield in heavily weathered or degraded soil, biochar aids in the improvement of environmental quality.]

Properties of Biochar

Biochar is a unique material with several distinctive properties that make it valuable for various applications, particularly in agriculture and environmental sustainability. Here are the key properties of biochar:

Carbon-Rich: Biochar consists of highly stable carbon, making it a long-term carbon sink. It sequesters carbon from organic materials, reducing atmospheric carbon dioxide (CO2) levels.

Porous Structure: Biochar has a highly porous structure with a large surface area, providing ample sites for adsorption and nutrient retention.

Nutrient Retention: Its porosity allows biochar to adsorb and retain nutrients, reducing nutrient leaching and making nutrients more available to plants.

Microbial Habitat: Biochar provides a habitat for beneficial soil microorganisms, promoting a healthy soil ecosystem and improved plant growth.

Reduced Greenhouse Gas Emissions: The production of biochar can lead to reduced greenhouse gas emissions compared to open burning of organic waste.

Sustainable Agriculture: Biochar supports sustainable agricultural practices by enhancing soil quality, reducing the need for synthetic fertilizers, and improving overall crop productivity.

Diverse Feedstock Sources: Biochar can be produced from a wide variety of feedstock materials, making it adaptable to local resources and waste streams.

Economic Opportunities: The biochar industry has created economic opportunities, including biochar production, sales, and research into novel applications.

Conclusion

Agriculture is a vital industry that sustains global food production, but it also generates substantial quantities of organic waste and byproducts. Recognizing the need for sustainable and eco-friendly solutions to address both agricultural waste management and soil improvement, biochar produced from agricultural waste has emerged as a promising innovation.

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PRECISION FARMING: A SUSTAINABLE REVOLUTION SHAPING THE FUTURE OF AGRICULTURE

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Abstract
Precision farming, also known as precision agriculture, is an approach to farm management that uses information technology, a wide range of items such as GPS guidance, control systems, sensors, robotics, drones, autonomous vehicles, variable rate technology, GPS-based soil sampling, automated hardware, telematics, GPS yield monitoring, GPS crop scouting, and automated hardware to optimize production with regards to soil farming, field farming management with a regard to the cropping system, and weather patterns. The goal of precision farming is to improve crop yields, reduce input costs, and minimize environmental impact by using data-driven decision-making processes. It plays a crucial role in modern agriculture as the industry seeks to feed a growing global population while addressing environmental concerns.

Introduction
Our nation and economy are based on agriculture, which generates over 30% of the GDP and employs 70% of the workforce. Due to a growing population and industrialization, agricultural production has stagnated since the green revolution and the horizontal expansion of arable land has been constrained. India had 0.33 ha of land available per person in 1952, but that number has since dropped to 0.15 ha. To preserve crop productivity, eco-friendly technology must be developed. It has long been understood that different fields have different crops and soils. Technical approaches have been developed during the past ten years to use contemporary electronics to react to field fluctuation.

In today's world, where the global population continues to grow and environmental concerns are mounting, traditional farming practices face significant challenges. Climate change, resource scarcity, and the need for sustainable food production are pushing agriculture to evolve rapidly. This is where precision farming steps in. Precision farming (PF), also known as precision agriculture (PA), is revolutionizing the agriculture industry by harnessing the power of technology and data to optimize farming practices. This innovative approach is redefining the way we grow crops and manage agricultural resources, with promising prospects for increased productivity, sustainability, and food security.

With the most recent advancements in sensors, greenhouses, and protected agricultural structures, precision agriculture is now possible. This method can be effectively used in hot, arid areas with limited water resources, salty soil, high temperatures, and little rainfall. It is also a given that there won't be enough labor for agricultural activities in the future, especially in developing nations. The moment has come to make the most of all the contemporary resources by combining agricultural science, information technology, and environmental sustainability to produce crops that are more economically and environmentally sustainable.

An integrated crop management approach called precision agriculture (PA) aims to match the kind and quantity of inputs with the actual crop needs for small areas within a farm field. The tremendous growth in human and animal populations over the past century, along with the rapid industrialization and urbanization of the previous several decades, have put excessive demand on the natural resource base, causing it to deteriorate much more quickly than in the past.

Since some of the current industrial processes rely on the unsustainable use of resources, achieving the necessary growth won't be simple. The natural resources are already showing indications of exhaustion, which is of grave concern to scholars, decision-makers, and planners alike. To manage the geographical and temporal variability associated with all facets of agricultural production for enhancing output and environmental quality, precision agriculture is the application of technology and principles. Farmers are searching for novel strategies to boost productivity and reduce expenses in the current environment of rising input costs and falling commodity prices. To increase profitability and productivity, precision agricultural technology would be an effective substitute.

What is precision agriculture?

The idea of precision farming first emerged in the 1980s in the United States. According to Professor Pierre C. Robert, who is regarded as the father of precision farming, precision agriculture is more than just the introduction of new technologies; rather, it is a revolution in information made possible by new technologies that result in a higher level, more accurate farm management system. It determines intrinsic spatial variability and the essential factors where yield is constrained by controllable constraints. Precision farming, as it pertains to the farming environment in India, could be defined as the precise application of agricultural inputs depending on soil, weather, and crop requirements to enhance sustainable production, quality, and profitability. It is a holistic system that maximizes the use of agricultural resources already in place, eliminates pollution to safeguard the environment, and encourages sustainable agriculture.

Precision agriculture is the application of technology to assist farmers in more accurate and exact field management. PA aims to guarantee economic success, environmental protection, and sustainability. As-needed farming, satellite agriculture, and site-specific crop management (SSCM) are further terms for PA. IT services, specialized tools, and equipment are necessary for precision agriculture. Using information technology (IT), precision agriculture (PA) is a method of farm management that makes sure the land and crops get exactly what they need for optimum health and yield.

The gathering and analysis of data could be automated and made simpler with precision agriculture. It enables the quick and effective implementation of management choices on smaller fields within bigger fields. Farmers can use crop inputs like fertilizers, insecticides, tillage, and irrigation water more efficiently because of precision agriculture. They are utilizing inputs more efficiently resulting in higher agricultural output and quality without harming the environment. Amid rising input costs, falling commodity prices, and environmental concerns, farmers and government officials are seeking innovative solutions to boost productivity, reduce expenses, and support sustainable agriculture.

The Goal of Precision Farming

The goal of precision farming is to ensure profitability, sustainability, and protection of the environment. It involves analyzing data from multiple sources, such as satellites, GPS technology, aerial imagery, and sensors, to understand variations within a field and optimize various factors,

including irrigation, fertilization, and pest control. Precision farming is described as an information and technology-based farm management system that identifies, analyses, and manages spatial and temporal variability within fields for maximum productivity and profitability, sustainability, and protection of the land resource by reducing production costs.

Crop performance and environmental quality are improved by precision farming. It is characterized as the use of methods and ideas to control the geographical and temporal variability connected to all facets of agricultural output. In other words, precision farming involves matching the use of resources and agronomic techniques to the various soil characteristics and crop requirements present in a field. We must change agricultural management practices to sustainably conserve natural resources including water, air, and soil quality while being commercially successful due to the general public's growing environmental awareness.

Need for Precision Farming

Precision farming is required since the world's food system is currently facing significant difficulties that will only get worse over the next 40 years. With today's knowledge and technology, a lot can be done right away with enough effort and money. The food system will need to undergo more significant adjustments to meet future challenges, and research funding will need to be increased to develop fresh answers for brand-new issues. Precision farming is required for the following purpose (Figure 1):

1. To increase agricultural productivity in a way that maximizes profit.
2. Stops soil deterioration on arable land.
3. Lessening the usage of chemicals in crop production.
4. Effective utilization of water resources.
5. The spread of new farming techniques to increase crop quality and quantity while lowering production costs.

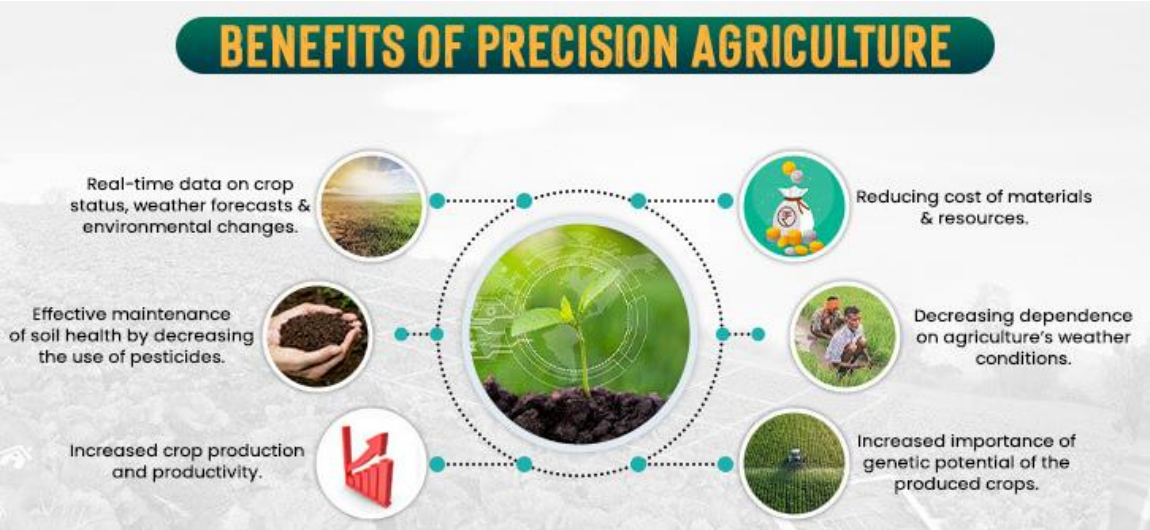

Figure 1

Precision agriculture can automate and simplify information gathering and analysis for evaluating and managing field variability.

Tools and Equipment

Precision Agriculture is a synthesis of numerous technological applications. The developments are caused by each of these combinations and are related to one another. Some of the key components and equipment (Figure 2) associated with precision farming are listed below:

1. Geographical Positioning System (GPS): A group of 24 satellites in Earth orbit make up this system. To pinpoint its precise location on Earth, it broadcasts radio signals that a ground receiver can decode. 95% of the time, the specified location on the earth will be within 10 to 15 meters of the real location. When used in conjunction with the appropriate software, GPS enables accurate mapping of farms, allowing the farmer to receive information on the status of his crop and which areas of the farm need what inputs, such as water, fertilizer, pesticides, etc.

2. Geographic Information System (GIS): It is software that handles globally scattered data that is physically and temporally distributed.

3. Grid Sampling: It is a technique for dividing a field into grids that are between 0.5 and 5 hectares. To calculate the ideal rate of fertilizer application, soil samples taken from the grids are helpful. From each grid, several samples are collected, mixed, and transported to the lab for evaluation.

4. Variable Rate Technology (VRT): The field equipment that is already in use, with an added Electronic Control Unit (ECU) and onboard GPS, can meet the input requirement for variable rate. Patch spraying has been done successfully with spray booms and the Spinning disc applicator with ECU and GPS. Profit-maximizing fertilizer rates should be taken into account more so than yield-maximizing fertilizer rates when developing the nutrient need map for VRT.

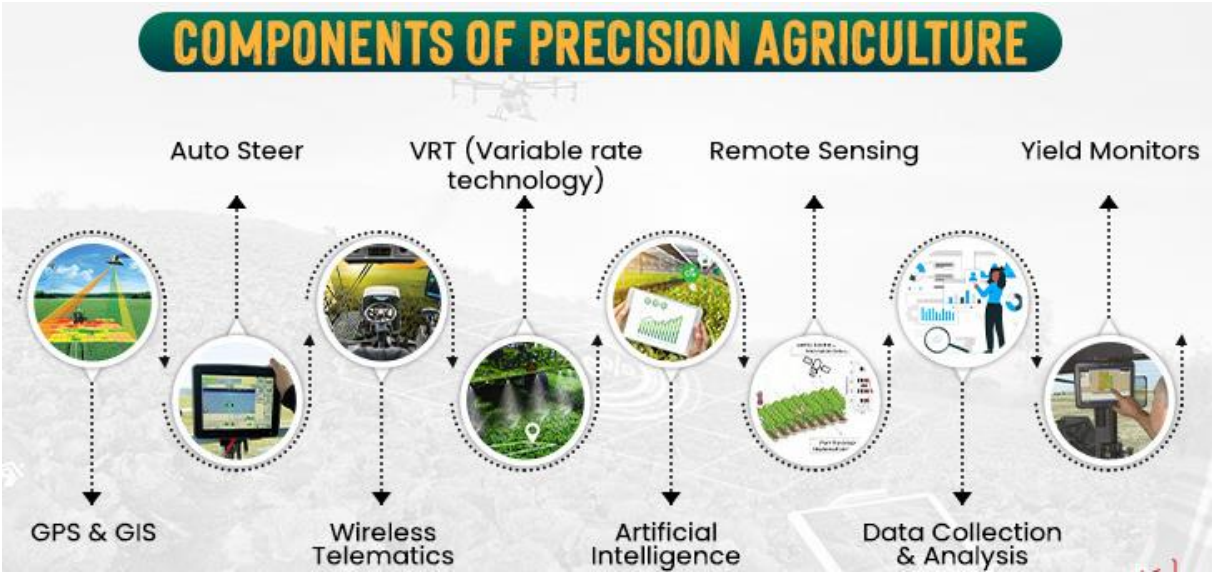

Figure 2

5. Yield Maps: Data from a modified combine harvester fitted with a GPS, or one that is integrated with a yield tracking system, is processed to create yield maps. Yield mapping includes simultaneously documenting the position in the field and the grain flow through the combined harvester.

6. Remote Sensors: These are typically subcategories of satellite or airborne sensors. Depending on the soil type, crop development, field boundaries, roads, water, etc., they can indicate variations in the color of the field. Vegetative indices, which represent plant health, can be generated from processed aerial and satellite data.

7. Proximate Sensors: As the sensor-equipped tractor travels through the field, these sensors can be utilized to measure crop qualities as well as soil data (such as soil pH and N status).
8. Computer Hardware and Software: Computer support is necessary, along with specialized software support, to interpret the data gathered by other Precision Agriculture technology components and make it accessible in formats like maps, graphs, charts, or reports.

9. Precision irrigation systems: By using GPS-based controllers to regulate the motion of the irrigation equipment, recent innovations in sprinkler irrigation are now available for commercial usage. To increase the effectiveness of irrigation systems' use of water, wireless communication, and sensor technologies are being developed to track soil and environmental conditions as well as their operational characteristics (such as flow and pressure).

10. Precision farming on arable land: The most common and sophisticated application of PA techniques among farmers is on arable land. CTF (Controlled Traffic Farming) is a whole-farm strategy that tries to prevent unneeded crop damage and soil compaction by heavy machinery, hence lowering the costs imposed by conventional methods. Controlled traffic methods use decision support systems to keep all field vehicles inside the smallest possible area of permanent traffic lanes. The efficient use of fertilizers, especially those containing nitrogen, phosphorus, and potassium, is another significant use of precision agriculture in arable land.

Opportunities for Precision Agriculture in the Indian Agricultural Situation
Precision farming is a tried-and-true technology that is only used in developed (American and European) nations. Limitations 1. Limited landholdings 3. Heterogeneity of cropping systems 2. The cost-benefit analysis of the PF system 4. Lack of regional technical proficiency 5. Information and technological divides It's challenging to apply PF approaches at the individual field level, but it is possible in India, where more than 57.8% of operational holdings are smaller than one ha and subsistence farming predominates and demands adjacent fields, the same crop, and similar management techniques. Because agroecological units, such as agroecological units, constitute the foundation of most management methods like seed rate, fertilizer rate, etc., they tend to be consistent over a wide area. In these circumstances, PF can be used as an information-based agricultural system, meaning that the farmer at least knows the soil type of his field before using fertilizer techniques. To aim samplings toward the variability pattern and circumvent the aforementioned issues, soil categorization based on remote sensing will be necessary. The implementation of PF approaches also faces a lot of financial challenges.

Future possibilities : The future of precision farming holds immense promise, with several key prospects:

1. Enhanced Sustainability: Precision farming can reduce the environmental impact of agriculture by minimizing the overuse of resources like water, fertilizers, and pesticides. This contributes to more sustainable farming practices, aligning with global goals for environmental protection.

2. Increased Yields: By fine-tuning inputs and management practices, precision farming has the potential to significantly increase crop yields. This is vital for meeting the world's growing food demands.

3. Crop Diversity and Customization: Precision farming allows farmers to experiment with different crop varieties and adapt to changing market demands. This flexibility can lead to increased profitability.

4. Data-Driven Insights: As data analytics and artificial intelligence continue to advance, precision farming will provide farmers with increasingly sophisticated insights into their operations. This will enable them to make even more precise and informed decisions.

5. Reduced Labor Dependency: Automation and robotics will likely reduce the labor-intensive nature of farming, making it more attractive to a new generation of tech-savvy farmers.

6. Global Adoption: The adoption of precision farming is expected to grow globally as more regions recognize its potential benefits. Governments, research institutions, and private companies are likely to invest in its development and adoption.

Studies in precision agriculture will still be possible. Tools will be made accessible to administer pesticides, fertilizers, tillage, and seed to a field differently and to collect the crop yield or plant biomass by position across the field. With the aid of remote sensing technologies, we will be able to track changes caused by imposed management modifications inside a field throughout the growing season. There is monitoring equipment available to collect the surface water and groundwater samples required to calculate the environmental impact of surface runoff or leaching. It is technically possible to prevent the atmospheric evaporation of nitrogen or pesticides due to altered procedures. The ability of the scientific community to carry out this kind of study, with faith from the environmental and producer communities that reforms will benefit the environment and boost the efficiency of agricultural output, will determine the path that agriculture will go in the future.

Conclusion

Precision farming is not just a buzzword; it's a transformative force that is reshaping agriculture for the better. With its potential to increase yields, reduce environmental impact, and ensure food security, precision farming offers a bright future for both farmers and consumers. As technology continues to advance and awareness grows, precision farming is poised to play a pivotal role in meeting the agricultural challenges of tomorrow. With the use of precision agriculture, farmers may use agricultural inputs like fertilizers, herbicides, tillage, and irrigation water more efficiently. Greater crop output and quality without environmental pollution result from more efficient input usage. Farmers and government officials are looking for innovative ways to boost productivity, lower costs, and support sustainable agriculture in the current climate of rising input costs, falling commodity prices, and environmental concerns. Precision farming has drawbacks, but there is a lot of hope that using this technology would dramatically increase the advantages for farmers who choose to use it.

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APPLICATION OF GENE EDITING FOR CLIMATE CHANGE IN AGRICULTURE

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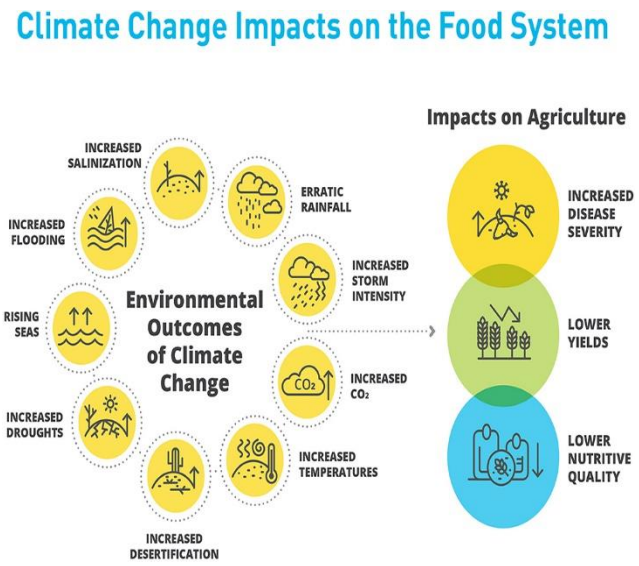
Summary

Climate change imposes a severe threat to agricultural systems, food security, and human nutrition. Meanwhile, efforts in crop and livestock gene editing have been undertaken to improve performance across a range of traits. Many of the targeted phenotypes include attributes that could be beneficial for climate change adaptation. In regards, gene editing applications helps for improvement of crops and livestock adaption in changing climate.

Introduction

Climate change poses a severe threat to the future of the environment as it pertains to agriculture, biodiversity, human society, and nearly every facet of our world. The primary cause of climate change is the anthropogenic addition of greenhouse gases to the atmosphere. Due to these human emissions, the average temperature of the planet has risen by nearly 1°C since 1850. The magnitude of the effects depends on the amount of emissions; in general, more frequent heatwaves, droughts, floods, and persistent sea level rise and global temperature increases are expected. Rising temperatures and shifting precipitation regimes will drastically alter the biological landscape, resulting in species migration, invasion, and extinction. One meta-review of more than 130 studies has estimated that one in six species may go extinct due to the changing climate. Simultaneously, global food supplies are declining as droughts and floods impact agricultural output. Under a range of warming scenarios, agricultural output is expected to decline globally. Productivity of major commodity crops will be affected, especially in lower latitudes where the effects of climate change on yield will be more severe. In response to these challenges, the use of gene editing, also referred to as genome editing or genome engineering, has emerged as a method to either aid in the adaptation of organisms to climate change or help mitigate the effects of climate change on agriculture (IPCC, 2018; Nunez *et al.*, 2019).

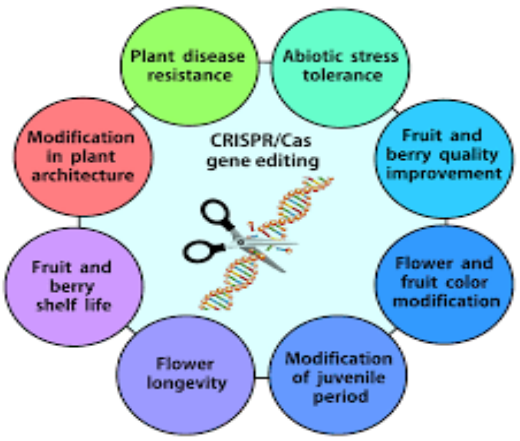


What is genome editing?

Genome editing refers to the process of making specific changes to an organism's DNA sequence. It involves modifying or deleting existing genes, inserting new genes, or altering the regulation of genes. This can be done using various techniques, such as CRISPR-Cas9, zinc finger nucleases (ZFNs),

and transcription activator-like effector nucleases (TALENs). The precision and efficiency of generating edits has been tremendously improved by the introduction of CRISPR/Cas systems, although there is certainly still a role for other gene editing technologies. The application of gene editing techniques has generated great potential for developing crops and livestock that can better manage the impositions of climate change.

CRISPR-Cas9 is the most widely used genome editing tool. It utilizes a guide RNA molecule that directs the Cas9 enzyme to a specific target sequence in the DNA. Once at the target site, Cas9 cuts the DNA, allowing for gene modifications to be made. These modifications can include gene knockout (disabling a gene), gene insertion (adding a new gene), or gene correction (repairing a faulty gene).



Gene editing can be applied in agriculture to address climate change in several ways:

1. Developing climate-resilient crops: Gene editing techniques like CRISPR-Cas9 can be used to modify the genes of crops to make them more resilient to climate change-related stresses such as drought, heat, and pests. For example, scientists can edit the genes responsible for water-use efficiency in crops, enabling them to thrive with limited water resources.

2. Enhancing carbon sequestration: Gene editing can be used to modify the genes of plants to enhance their ability to capture and store carbon dioxide from the atmosphere. This can help mitigate greenhouse gas emissions and reduce the impact of climate change. By manipulating genes involved in photosynthesis or carbon fixation pathways, plants can potentially become more efficient at capturing and storing carbon.

3. Improving nutrient utilization: Gene editing techniques can be employed to enhance the nutrient uptake and utilization efficiency of crops. By modifying genes responsible for nutrient transport and metabolism, plants can be engineered to better utilize available nutrients in the soil, reducing the need for synthetic fertilizers. This not only reduces greenhouse gas emissions associated with fertilizer production but also helps prevent nutrient runoff that contributes to water pollution.

4. Developing climate-smart livestock: Gene editing can also be applied to improve the resilience and productivity of livestock in the face of climate change. For instance, scientists can use gene editing techniques to develop animals that are more resistant to diseases or have improved feed conversion efficiency, reducing methane emissions from livestock farming.

5. Enhancing crop diversity: Gene editing allows for precise modifications in plant genomes, enabling the development of new crop varieties with desired traits. This technology can be utilized to diversify crop species by introducing genetic variations that enhance their adaptability to changing climatic conditions. By increasing crop diversity, farmers have a wider range of options for selecting resilient varieties suitable for different climates.

Conclusion

One way gene editing can help is by developing crops that are more resilient to climate change-related stresses, such as drought, heat, or pests. By modifying specific genes responsible for stress

tolerance, scientists can potentially create crops that can thrive in harsher environmental conditions, reducing the negative impact of climate change on agricultural productivity. Additionally, gene editing can also be used to enhance the efficiency of agricultural practices. For example, it can be employed to improve the nitrogen use efficiency of crops, reducing the need for synthetic fertilizers. This can help mitigate the environmental impact of excessive fertilizer use, such as water pollution and greenhouse gas emissions.

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OPPORTUNITIES OF E- MARKETING IN INDIA

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Abstract
E-Marketing is the use of information to create, communicate, and deliver customer value, managing customer relationships for organizations. With millions of internet users accessing websites daily, businesses are jumping on the bandwagon to reach target customers. India's internet business is rapidly evolving, with 4G and 5G services, lower costs, and affordable cell phones expanding access to rural areas. This growth is boosting the web client base and closing the gap between potential and genuine web users. Organizations must adapt to ensure customer loyalty and seamless experiences.

Introduction
E-marketing, commonly referred to as Internet marketing, stands for electronic marketing. E-marketing, in contrast to traditional marketing, uses marketing principles and strategies on the internet as an electronic medium. E-marketing is the practise of promoting a brand online. It makes use of a variety of technologies to connect companies with their customers and incorporates both direct response marketing and indirect marketing components. Using digital technologies to market your products or services is known as emarketing. Regardless of the size of your firm or your business model, these technologies are a significant addition to conventional marketing strategies. The fundamentals of marketing are still developing a plan to reach the appropriate audiences with the appropriate messaging. E-marketing introduces a completely new component to the marketing mix, even though organisations will continue to use classic marketing strategies like advertising, direct mail, and PR. with e-marketing, many companies are seeing fantastic results, and small firms can benefit most from its flexibility and affordability. E-marketing, often known as electronic marketing, is the practise of applying marketing tactics and ideas using electronic media, particularly the Internet. E-marketing, Internet marketing, and online marketing are phrases that are widely used interchangeably and are frequently regarded as synonyms.

E-MARKETING TOOLS
E-marketing tools allow companies to distribute, build customer relationships, collect money, generate leads, advertise using Google ad words, and collect direct responses through platforms like voting systems for games. They can also generate leads by attracting potential customers for short-term subscriptions.

COMPONENTS OF E-MARKETING
Search Engine Optimization : Search engine optimization (SEO) is the process of improving a website's visibility in search engine results. It targets various types of search, such as image, local, video, academic, news, and industry-specific vertical search engines. The earlier a website appears in the search results, the more visitors it receives. SEO can be used in various ways, such as in a game show voting system.

E-Mail Marketing Strategy : Email marketing is a method of sending messages about products or services via email to existing or potential consumers. Direct digital marketing is used to send ads, build brand loyalty, build customer trust, and increase brand awareness. This low-cost method allows companies to easily promote their products and services, attracting customers through an attractive mix of graphics, text, and links.

Online Advertising : Online advertising, also known as internet advertising, is a crucial aspect of digital marketing, allowing companies to effectively communicate their products or services to consumers. It provides content and ads that align with consumer interests, allowing publishers to provide free information. Effective and relevant ads are essential for companies to effectively manage their budget and maintain control over time.

Online Newsletters : Online newsletters are a useful tool for businesses to communicate product information and promote their products and services. They inform regular customers about new introductory offers and upcoming products, unlike email marketing, which is sent at regular intervals.

Social Media Marketing : Social media is a rapidly growing and innovative online marketing strategy that has been utilized by many online fish and fish product sellers to enhance their brand image. It is a cost-effective and effective platform for business growth without the need for expensive websites and advertisements. To effectively utilize social media, entrepreneurs should consider various online channels, including traditional social networking sites like Facebook, Google+, Twitter, YouTube, LinkedIn, and Instagram, as well as niche networks, forums, discussions, and dynamic blog groups.

Pay Per Click (PPC) : Pay-per-click marketing is a strategy that uses search engine advertising to drive website clicks, rather than organically. It benefits both searchers and advertisers, offering low costs and increased engagement with products and services, making it the optimal approach for companies.

Indian companies must identify important issues when entering the Internet marketing zone, such as different target customers, alternative ways to contact customers, internet security, and new competitors. Chaffey et al. (2006, 20) suggest a process for developing and implementing Internet marketing with different steps: defining the online opportunity, selecting the strategic approach, and delivery result online. Key strategic decisions for e-marketing include selecting target customer groups and specifying how to deliver value to these groups. Segmentation, targeting, differentiation, and positioning are key to effective digital marketing. In the 21st century, internet marketing strategies are an indispensable part of the business plan for businesses looking to reach a broad customer reach. Companies that lack an easy-to-find, accessible website will struggle to reach customers who don't live in the same town or have never heard of the company. Companies like Thumbs up and Life style, which aren't household names of global visibility, begin on the web. To ensure success, businesses continue to refine their tactics and strategy with a focus on engagement, audience, tools, and measurement. A sound Internet marketing strategy ensures the best chance of success for businesses in the digital age.

Opportunities of E- Marketing

Empowering Effect:

Online marketing offers numerous advantages, particularly for small businesses. It can expand market reach and operational efficiency, creating a democratized environment where even small businesses can promote and brand their products on a larger scale. Online marketing eliminates

geographical limitations, allowing for unlimited global reach at a lower cost. Traditional media was once the exclusive domain of large multinational corporations, but cost-effective internet technologies have enabled smaller businesses to enjoy this reach. With internet access, marketers can present products and services to different customer groups worldwide, breaking down geographic barriers and enabling marketers to reach a wider audience.

24 Hours / Seven Days Availability

The internet offers customers 24/7 access to information, allowing them to shop anytime, anywhere. Online shops provide no time limitations, as they don't have special closing or opening times. Customers can also visit physical markets after searching the internet or search for competitive prices after visiting physical stores. This convenience allows customers to shop and access information anytime, anywhere.

Cost-Effectively

Online marketing is cost-effective compared to traditional advertising media channels, as it can achieve objectives at a fraction of the cost. Launching an ad online is significantly less expensive than placing ads in magazines or billboards. Establishing a virtual presence, networking with institutions, and communicating with consumers is also significantly less expensive.

Trackability

Online marketing's trackability is a significant asset, as it allows for easy measurement of all activities on the internet. This allows marketers to track clicks and website traffic, understand visitor behavior, and determine the effectiveness of their campaigns. It also helps companies determine the type of customers interested in their products and their origins. Overall, the trackability of online marketing is a crucial aspect of effective marketing strategies.

Personalization

Online marketing, also known as personalized marketing or one-to-one marketing, involves gathering detailed information about each customer's needs through electronic interaction. This allows firms to automatically tailor products and services to meet these needs, resulting in personalized products and better impact compared to impersonalized, generic messages sent indiscriminately. Personalization also fosters sustainable relationships with customers, as it allows for more personalized and targeted marketing efforts.

Conclusion

The future of marketing will be shaped by factors such as consumer control, improved strategy integration, refined metrics, wireless networking, receiving appliance convergence, and the semantic web. E-marketing, a technology-driven approach, requires constant learning and adaptation to the latest developments in computer science and information technology. Mistrust between clients and marketers is created by poorly executed programs, such as spam, identity theft, intrusive advertising, technical issues, and gaps between ordered products and actual deliveries. The growth of e-marketing depends on business ethics and consumer protection laws. Credibility in business, particularly e-marketing, is crucial for success. Skill development in information technologies can help address this issue. E-marketing offers numerous opportunities, opening doors for new product opportunities that provide value to future customers. Internet marketing is a popular trend for online businesses, and successful businesses must analyze their strategies and combine them effectively. E-marketing supports the customer base around the clock, with global reach and convenience. However, the virtual marketplace is not yet acceptable to

orthodox buyers who prefer physical interaction and review before buying. Building trust in the virtual world is an ongoing process that may take time.

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EPITHELIOGENESIS IMPERFECTA IN A GRADED MURRAH BUFFALO CALF: A RARE CASE REPORT

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Introduction

Epitheliogenesis imperfecta (EI) is a congenital abnormality characterized by the absence of skin in specific areas of the body at birth. This condition has been documented in various species including cattle, buffaloes, cats, dogs, horses, and sheep. In cattle, it has been observed in several breeds, including Holstein-Friesian, Hereford, Ayrshire, Jersey, Shorthorn, Angus, Dutch Black Pied, Swedish Red Pied, and German Yellow Pied. Swine also commonly experience EI, and in these cases, large lesions are noticeable at birth as distinct, shiny red areas where the skin or mucous membranes are absent. The precise cause of many congenital defects, including EI, remains unknown, but some are known to have a hereditary basis. In cattle, most inherited disorders are the result of autosomal recessive genetic traits. EI can lead to infection and ulceration in the affected areas, and in cattle, affected calves typically succumb to septicemia shortly after birth. In some cases, one or more hooves or claws may be deformed or missing. The severity of the condition determines its fatality, with extensive cases being fatal, but smaller defects may be correctable through surgical intervention.

Case history and clinical findings

A Graded Murrah buffalo, approximately 7.5 years old and in its third parity with a full-term pregnancy, was presented to the mobile ambulatory veterinary clinic in Tuni, Kakinada district, Andhra pradesh. The owner reported that the buffalo had been experiencing labor pains for the past 15 hours, but there had been no progress in the birthing process even after the rupture of the first water bag. Upon obstetrical examination, it was observed that the cervix was fully dilated, and the fetus was positioned longitudinally with both forelimbs extended within the birth canal, and the head was laterally deviated. Various other clinical parameters from the animal were measured viz. rectal temperature, pulse rate and respiratory rate. Temperature of the animal was raised and recorded to be 101.5ºF, mucous membranes were observed to be pink, pre-scapular lymph node size was normal and respiratory rate was slightly depressed.

Treatment and management

To address the buffalo's condition, intravenous fluids containing Normal saline and Ringer's lactate were administered in sufficient quantities. Following this, caudal epidural anesthesia (5 ml; 2% lignocaine hydrochloride) was administered, and the birth canal was carefully lubricated using liquid paraffin. After correcting the position of the head, fetus was then delivered by the application of a hook in the inner canthus of the eye and securing both forelimbs with a chain along with mild traction. After relieving the fetus, the dam was examined per vagina for injury checking if any, due to handling. The dam delivered a dead male calf having epithelia imperfecta weighing 25kg. Only 5-10 % of calf’s body is covered by skin. To manage pain and prevent secondary bacterial infections,

the cow received a course of antibiotics (inj. Enrofloxacin 15ml), along with anti-inflammatory (inj. Melonex 20 ml) and antihistamine (inj. Anistamin 10 ml) medications via intramuscular injection for five days. The animal had an uneventful recovery after 3 days.

Figure 1: Epitheliogenesis imperfecta in Graded Murrah buffalo calf

Conclusion

Epitheliogenesis imperfecta was initially observed in cattle in 1928, and it was suggested that inbreeding could be a contributing factor. This condition was named "epitheliogenesis imperfecta neonatrum bovum" at that time. Subsequently, cases of epitheliogenesis imperfecta have been reported in various species. Other scientific literature has described this condition as the absence of patches of skin in different parts of the body, such as below the knee, hock, oral mucosa, muzzle, nostril, tongue, hard palate, and cheeks. However, in the current case, the lesions were much more extensive. They were observed throughout the entire body, with only a few patches noted on the face and thigh region. This makes this particular case a rare occurrence.

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GOVERNMENT SCHEMES FOR WOMEN EMPOWERMENT

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Women's empowerment can be defined to promoting women's sense of self-worth, their ability to determine their own choices, and their right to influence social change for themselves and others.

Women's empowerment (or **female empowerment**) may be defined in several ways, including accepting women's viewpoints, making an effort to seek them and raising the status of women through education, awareness, literacy, and training. Women's empowerment equips and allows women to make life-determining decisions through the different societal problems. They may have the opportunity to re-define gender roles or other such roles, which allow them more freedom to pursue desired goals.

Women's empowerment has become a significant topic of discussion in development and economics. Economic empowerment allows women to control and benefit from resources, assets, and income. It also aids the ability to manage risk and improve women's well-being. It can result in approaches to support trivialized genders in a particular political or social context. While often interchangeably used, the more comprehensive concept of gender empowerment concerns people of any gender, stressing the distinction between biological and gender as a role. Women empowerment helps boost women's status through literacy, education, training and awareness creation. Furthermore, women's empowerment refers to women's ability to make strategic life choices that were previously denied them.

Principles

- Create high-level corporate leadership for gender equality
- Treat all people fairly at work, respecting and supporting non-discrimination and human rights
- Ensure the health, wellbeing and safety of all workers, whether male or female
- Promote education, training and professional development for women
- Implement supply chain, marketing practices and enterprise development that empower women
- Champion equality through community initiatives and advocacy
- Measure and report publicly on progress to create gender equality

Significance of women empowerment

Gender equality is a basic human right, and it is also fundamental to having a peaceful, prosperous world. But girls and women continue to face significant challenges all around the world. Women are typically underrepresented in power and decision-making roles. They receive unequal pay for equal work, and they often face legal and other barriers that affect their opportunities at work.

In the developing world, girls and women are often seen as less valuable than boys. Instead of being sent to school, they are often made to do domestic work at home or are married off for a dowry before they are adults. As many as 12 million underage girls are married every year.

While some progress is being made in various parts of the world, there is still a great deal left to be done to right the problems of gender inequality empowering women is essential to the health and social development of families, communities and countries.

When women are living safe, fulfilled and productive lives, they can reach their full potential. contributing their skills to the workforce and can raise happier and healthier children. They are also able to help fuel sustainable economies and benefit societies and humanity at large.

- Women empowerment enables a greater degree of self-confidence and a sense of independence among women.
- Women empowerment is a process of acquiring power for women in order to understand her rights and to perform her responsibilities towards oneself and others in a most effective way.
- Women empowerment enables women to organise themselves to increase their self-reliance.
- Women empowerment provides greater autonomy to women.
- Women empowerment means women's control over material assets, intellectual resources and ideology.
- Women empowerment abolishes all gender-based discriminations in all institutions and structures of society.
- Women empowerment means participation of women in policy and decision-making process at domestic and public levels.
- Empowerment of women enables women to realise their full identity and powers in all spheres of life.
- Empowerment also means equal status to women.
- Women empowerment occurs within sociological, psychological, political, cultural, familial and economic spheres and at various levels such as individual, group and community.
- Women empowerment is a process of creating awareness and capacity building.

Women rights

- Fundamental right to equality before Law that is, equal protection of laws in India- Article 14
- Prohibition of discrimination on grounds of religion, race, caste, sex or place of birth. However, art 15(3) empowers state to make any special provision for women and children - Article 15
- Equality of opportunity in matters of public employment or opportunity to any office under state and prohibits discrimination on ground of sex- Article 16
- Freedom of speech and expression and freedom to practice any profession or to carry out any occupation, trade or business – Article 19
- Protection of life and personal liberty- Article 21
- Right to Privacy- Article 21
- Right to property- Art. 300-A
- Political rights- women reservation in for instance, panchayats. Art 15 of the Constitution allows special provisions for women and children to be made for their welfare.
- Under the Legal Services Authorities Act women and children are entitled to free legal aid.

Government Schemes

The Government programmes for women development began as early as 1954 in India but the actual participation began only in 1974. At present, the Government of India has over 34 schemes for women operated by different department and ministries. Some of these are as follows;

1) Rastria Mahila Kosh (RMK) 1992-1993
2) Mahila Samridhi Yojana (MSY) October, 1993.
3) Indira Mahila Yojana (IMY) 1995.
4) Women Entrepreneur Development programme given top priority in 1997-98.
5) Mahila Samakhya being implemented in about 9000 villages.
6) Swayasjdha.
7) Swa Shakti Group.
8) Support to Training and Employment Programme for Women(STEP).
9) Swalamban.
10) Crèches/ Day care centre for the children of working and ailing mother.
11) Hostels for working women.
12) Swadhar.
13) National Mission for Empowerment of Women.
14) Integrated Child Development Services (ICDS) (1975),
15) Rajiv Gandhi Scheme for Empowerment of Adolescence Girls (RGSEAG) (2010).
16) The Rajiv Gandhi National Crèche Scheme for Children of Working Mothers.
17) Integrated Child Protection scheme (ICPS) (2009-2010).
18) Dhanalakahmi (2008).
19) Short Stay Homes.
20) Ujjawala (2007)

Some schemes are detailing below

One Stop Centre and Universalization of Women Helplines : Ministry of WCD is administering two schemes from Nirbhaya Fund namely One Stop Centre and Universalization of Women Helplines. The One Stop Centres (OSCs), popularly known as Sakhi Centres, aim to facilitate women affected by violence (including domestic violence) with a range of integrated services under one roof such as Police facilitation, medical aid, providing legal aid and legal counselling, psycho-social counselling, temporary shelter etc. The Women Helpline (WHL) Scheme provides 24 hours emergency and non-emergency response to women affected by violence, both in public and private spaces by linking them with appropriate authority such as Police, One Stop Centre, Hospital, Legal Services etc. WHL also supports women in distress with rescue van and counselling services in addition to providing information about women welfare schemes and programs across the country. Women can dial 181 short code to avail services from Women Helpline.

Swadhar Greh Scheme: The Swadhar Greh Scheme is is being implemented as a Centrally Sponsored Scheme for women who are victims of difficult circumstances in need of institutional support for rehabilitation so that they could lead their life with dignity.

Ujjawala Scheme: The Ujjawala Scheme is being implemented as a Centrally Sponsored Scheme for Prevention of trafficking and for Rescue, Rehabilitation, Reintegration and Repatriation of victims of trafficking for commercial sexual exploitation.

Working Women Hostel: Working Women Hostel Scheme is implemented by the Government with the objective to provide safe and conveniently located accommodation for working women, with

day care facility for their children, wherever possible, in urban, semi urban, or even rural areas where employment opportunity for women exist.

Beti Bachao Beti Padhao (BBBP) : Beti Bachao Beti Padhao (BBBP) Scheme was launched on 22nd January 2015 with an aim to address declining Child Sex Ratio (CSR) and related issues of empowerment of girls and women over a life cycle continuum. The objectives of the scheme are, to prevent gender biased sex selective elimination, to ensure survival and protection of the girl child and to ensure education and participation of the girl child.

Mahila Shakti Kendra (MSK) : The Mahila Shakti Kendra (MSK) Scheme was approved in November, 2017 as a centrally sponsored scheme to empower rural women through community participation. The aims to facilitate inter-sectoral convergence of schemes and programs meant for women. The scheme is implemented through State Governments and UT Administrations with a cost sharing ratio of 60:40 between Centre and States except for North East & Special Category States where the funding ratio is 90:10. For Union Territories 100% central funding is provided.

Pradhan Mantri Matru Vandana Yojana (PMMVY) : Pradhan Mantri Matru Vandana Yojana (PMMVY) is a Centrally Sponsored Conditional Cash Transfer Scheme, for implementation across the country with effect from 01.01.2017. The maternity benefit under PMMVY is available to all Pregnant Women & Lactating Mothers (PW&LM), excluding PW&LM who are in regular employment with the Central Government or the State Governments or Public Sector Undertakings (PSUs) or those who are in receipt of similar benefits under any law for the time being in force, for first living child of family. Under the scheme Rs.5,000/- are provided to the eligible beneficiary in three installments during pregnancy and lactation in response to individual fulfilling certain nutrition and health seeking conditions. The eligible beneficiary also receives the remaining cash incentive as per approved norms towards maternity benefit under Janani Suraksha Yojana (JSY) after institutional delivery so that on an average, a woman gets Rs.6,000/-.

Conclusion

Women empowerment refers to increasing the spiritual, political, social, educational, gender or economic strength of individuals and communities of women. Women's empowerment in India is heavily dependent on many different variables that include geographical location (urban / rural) educational status social status (caste and class) and age. Policies on Women's empowerment exist at the national, state and local (Panchayat) levels in many sectors, including health, education, economic opportunities, gender based violence and political participation. The Empowerment of Women has become one of the most important concerns of 21st century not only at national level but also at the international level. Government initiatives alone would not be sufficient to achieve this goal. Society must take initiative to create a climate in which there is no gender discrimination and women have full opportunities of self decision making and participating in social, political and economic life of the country with a sense of equality.

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INSECTS AS A FOOD SOURCE IN INDIA: A CULINARY JOURNEY

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Abstract
This article delves into India's rich history of incorporating insects into its culinary traditions, showcasing their cultural significance, nutritional value, and versatility as a food source. It explores the various ways insects are consumed and highlights commonly enjoyed insect-based dishes across different regions of India. While acknowledging the challenges of cultural acceptance, regulatory hurdles, and supply chain development, the article emphasizes the potential for insects to play a vital role in addressing India's food sustainability and nutritional needs, positioning the country as a leader in the global movement towards insect-based nutrition.

Introduction
India, known for its diverse and flavorful cuisine, has a long history of incorporating insects into its culinary traditions. Insects have been consumed as a food source in various regions of the country for centuries, providing not only unique tastes but also valuable nutrition. In this article, we will explore the rich tapestry of how insects are used as a food source in India, delving into traditional dishes, cultural significance, and the nutritional benefits they bring to the Indian table.

A Heritage of Entomophagy
The practice of eating insects, known as entomophagy, has deep roots in India's cultural and culinary heritage. In many tribal communities and rural areas, insects have been a part of traditional diets for generations. They are often considered a delicacy and a source of pride in local cuisine.

Insects have become a popular food source in India for several reasons:

1) **Nutritional Value:** Insects are rich in essential nutrients, including protein, healthy fats, vitamins, and minerals. They provide a valuable source of complete protein, which is especially important in regions where protein deficiency is a concern. Insects also contain nutrients like iron, zinc, and B vitamins, including vitamin B12, which can be scarce in vegetarian diets.
2) **Cultural Tradition**: Insect consumption has a long history in many tribal and rural communities in India. In these areas, insects are considered a traditional and culturally significant food source. They are often integrated into local culinary practices and rituals, making them an integral part of the cultural heritage.
3) **Availability:** Insects are readily available in many regions of India, particularly during specific seasons. The ease of harvesting or collecting insects from the environment contributes to their accessibility as a food source.
4) **Sustainability:** Insects are an environmentally sustainable protein source. They require minimal resources, such as land and water, and produce fewer greenhouse gas emissions compared to traditional livestock. As sustainability becomes an increasing concern, the low environmental impact of insect farming has garnered attention.

5) **Flavor and Texture:** Insects offer unique flavors and textures that appeal to some palates. Their crunchiness or earthy taste can be a source of culinary intrigue and enjoyment.
6) **Culinary Creativity:** Indian cuisine is renowned for its diversity and creativity. Chefs and home cooks alike have found innovative ways to incorporate insects into a wide range of dishes, from snacks to main courses and condiments. This culinary creativity has contributed to the popularity of insects as a food source.
7) **Cultural Celebrations:** Insects are often featured in traditional celebrations and festivals within tribal communities. They play a role in strengthening cultural bonds and are seen as a symbol of abundance and fertility.
8) **Health Benefits:** The nutritional benefits of insects, including their high protein content and nutrient profile, contribute to their perceived health benefits. In some cases, they are considered a wholesome and nutritious food choice.
9) **Innovation:** The adoption of insect-based products and snacks, such as protein bars and chips, has expanded the range of insect-based foods available to consumers. These innovative products have contributed to the growing popularity of insects as a food source.

Different ways to eat insects in India

a) **Whole:** Insects can be eaten whole as a snack or appetizer. They can be fried, roasted, or steamed. For example, crickets are often eaten whole as a snack in India.
b) **Ground:** Insects can be ground into a flour that can be used to make bread, pasta, and other baked goods. For example, mealworm flour is often used to make chapatis and other Indian breads.
c) **Insect protein powder:** Insect protein powder can be added to smoothies, yogurt, and other foods to boost protein intake. For example, grasshopper protein powder is often added to smoothies and yogurt in India.
d) **As an ingredient:** Insects can be used as an ingredient in a variety of dishes, such as curries, soups, and stews. For example, ants are often used in curries in India.
e) **In desserts:** Insects can even be used in desserts! For example, silkworms are sometimes used to make a sweet dish called "silkworm pupae candy" in India.

Commonly consumed edible insect in different parts of India

a) **Silkworm Pupae (Eri):** Consumed in Assam, these pupae are known as "Eri." They are often prepared as "Eri Polu," a popular dish.
b) **Bamboo Worms:** Found in northeastern states like Nagaland and Manipur, these are the larvae of bamboo borer beetles. They are enjoyed as a crunchy snack.
c) **Red Ants:** In Chhattisgarh, red ants are used to prepare "Chaprah," a spicy chutney that accompanies rice.
d) **Termites:** Termites are consumed in various regions of India, often roasted or fried. They are sometimes added to dishes like porridge and stews.
e) **Ant Eggs**: In some parts of India, ant eggs are considered a delicacy and are used in culinary preparations.
f) **Moths and Caterpillars:** Certain species of moths and caterpillars are consumed in India, particularly in tribal communities.
g) **Grasshoppers and Crickets:** While not as commonly consumed as some other insects, grasshoppers and crickets are found in parts of India and may be consumed by specific communities.

h) **Ant Larvae:** In some regions, ant larvae are harvested and used in traditional dishes.
i) Wood-Boring Insects: Larvae from wood-boring insects are consumed in some parts of India, often roasted or prepared in curries.
j) **Water Bugs:** In certain states, water bugs are collected and incorporated into regional dishes.
k) **Larvae of *Rhynchophorus ferrugineus* (Red Palm Weevil):** In some regions of India, particularly in Kerala, the larvae of the Red Palm Weevil are collected from infested palm trees and used in cooking. They are often stir-fried with spices and coconut to create a flavorful dish.

Insect-based dishes from different parts of India

a) **Assam - Eri Polu:** This Assamese dish features silkworm pupae, locally known as "Eri." The pupae are boiled, sautéed with spices like turmeric, garlic, and chili, and served as "Eri Polu." It's a flavorful and protein-rich dish that reflects Assam's culinary heritage.
b) **Chhattisgarh - Chaprah:** In Chhattisgarh, red ants are used to prepare "Chaprah," a spicy and tangy chutney. The red ants are carefully cleaned, mixed with various spices and herbs, and transformed into a unique condiment. Chaprah is traditionally served with rice.
c) **Nagaland and Manipur - Bamboo Worms:** In northeastern states like Nagaland and Manipur, bamboo worms, the larvae of bamboo borer beetles, are a popular snack. They are typically fried or roasted until crispy and enjoyed for their crunchy texture.
d) **Termite chutney (Andhra Pradesh):** A chutney made with termites and spice.
e) **Ant eggs (various parts of India):** Boiled and eaten as a snack.
f) **Chaprah chutney (Bihar):** A chutney made with ground grasshoppers and spices.
g) **Sisunak saag with weevil (Jharkhand):** A dish made with spinach and weevils.

Challenges of Insect-Based Food in India

a) **Cultural Acceptance:** While insect consumption is a tradition in some regions of India, it is not universally accepted across the country. Overcoming cultural taboos and biases against eating insects may be a challenge in areas where entomophagy is not a part of the culinary heritage.
b) **Regulatory Hurdles:** There may be regulatory challenges in promoting insect-based food products in India. Establishing clear guidelines and standards for insect farming and processing, as well as labeling and marketing, is essential.
c) **Supply Chain Development**: Building a reliable supply chain for insect production and distribution can be a challenge. Ensuring the availability of safe and quality insect-based products to consumers is crucial.
d) **Education and Awareness:** Many consumers may not be aware of the nutritional and environmental benefits of insect-based foods. Education and awareness campaigns are needed to inform the public about the advantages of incorporating insects into their diets.

Conclusion

Insects have the potential to play a significant role in India's food system. Insects are a nutritious, sustainable, and versatile food source that can help to address the country's growing food needs. By overcoming the challenges and promoting entomophagy, India can position itself as a leader in the global movement towards insect-based food. As the world grapples with the need for sustainable and nutritious food sources.

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MILLETS: POTENTIAL FUTURE GRAINS TO COMBAT FOOD AND NUTRITION INSECURITY

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Ensuring food and nutrition security for a huge and diverse population at the macro and micro-level, is a very big challenge. Today, more than 820 million people are still hungry and at least 2 billion more lack sufficient nutrients; paradoxically, there are also already more than 2 billion people who are overweight or obese. This triple burden of malnutrition has been noted as the 'new normal' (and remember that 'malnutrition' means bad nutrition, not only under-nutrition).

Food security of a nation refers to a situation when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food to meets their dietary needs and food preferences for an active and healthy life. Limited land and water availability, dwindling natural resources, climate change and labor shortages are the challenges to achieve food and nutrition security all over the world. In India, the PDS (public distribution system) has achieved some degree of success in improving food security, but it has not been able to achieve food and nutrition security at the desired level, nor to address the malnutrition and childhood morbidity (Chander et al., 2017, George and McKay, 2019). Crop diversification is an area that needs attention to improve food and nutrition security. Implementation of green revolution technologies focused on major cereal crops, primarily rice, and wheat, taking away emphasis from other crops. Even the recent National Food Security Mission action plan (2014) focused primarily on food grain production with limited access to pulses and coarse cereals. The over-emphasis on major cereals (rice and wheat) and de-emphasis on legumes and coarse cereals caused an increase in overall food production, but failed to improve the nutritional security. Indeed, pulses and coarse cereals have not been included in the PDS. Diversification of the production system by including drought-resistant crops into the cropping system can improve nutritional security in India. Millets, a group of coarse grain cereals, can play a significant role to this end. In India, millets are the fourth major crops after rice, wheat, and sorghum.

Millets are a group of diverse small-grain cereal crops grown in marginal soil and under stressed conditions. They comprise about a dozen crop species originated in Asia and Africa, primarily in the third world countries (Gupta *et al*., 2017). Millets have gained popularity in the West because they are gluten-free and boasts high protein, fiber, and antioxidant contents. India is the largest producer of millets producing nearly 40 percent of the world's millets despite much negative pressure from competing crops in terms of policies and production supports. Pearl millet is the most common in India accounting for nearly 75 percent of the total area devoted to millets. Ability of millets to withstand adverse climatic conditions, requirement of minimal inputs, low labour requirement, resistance to pests and diseases and superior nutritional qualities are among the specific characteristics of millets rarely found in other common cereals. Millets possess specific molecular, biochemical, and morpho-physiological characteristics that allow them to withstand harsh

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environmental situations like drought and poor soil conditions (Bandyopadhyay *et al.*, 2017). Their shorter lifecycle, short stature, and small leaf area may also offer an added advantage. Considering their adaptability to high light, high temperature, and dry weather as C4 photosynthetic capacity, millets are more efficient than common cereal crops and hence are climate change compliant. These mechanisms allow millets to have enhanced photosynthetic rates and lower photorespiration rates, as well as water and nitrogen use efficiency under warm conditions (Bandyopadhyay *et al.*, 2017). There are varieties particularly in little millet and proso millet which mature in 60-70 days; yet providing reasonable and assured harvests even under most adverse conditions. Millets sequestrate carbon and thereby reduce the burden of greenhouse gases. Millet cultivation is the mainstay of rain-fed farming on which 60% of Indian farmers depend. They provide food as well as fodder and can be mix-cultivated (polyculture) with pulses and vegetables. Despite these attributes, millets are losing their pride of place in production and consumption in India. Between 1966 and 2006, India lost 44% of millet cultivation areas to other crops due to lack of policy support. Although all millet varieties belong to the *Poaceae* family, but they are differing in color, appearance, and species. Millets are categories into two groups — large and small millets, with major millets being the most popular or commonly cultivated varieties.

Large millets			**Small millets**		
Common name	**Hindi name**	**Scientific name**	**Common name**	**Hindi name**	**Scientific name**
Pearl millet	Bajra	*Pennisetum glaucum*	Kodo millet	Kodon	*Paspalum scrobiculatum*
Proso millet	Barre	*Panicum miliaceum*	Barnyard millet	Sanwa, Jhangon	*Echinochloa crusgalli*
Finger millet	Mandua, Ragi	*Eleusine coracana*	Little millet	Kutki	*Panicum sumatrense*
Sorghum	Jowar	*Sorghum bicolor*	Foxtail millet	Kangni, Kakum	*Setaria italica*

Millets have been neglected due to the following possible reasons. First, these crops are mostly used by low-income subsistence farmers living in arid or semi-arid regions of Asia and Africa, who have little aspirations and aim to produce more, rather than to increase the crop's quality. They also have limited access to technology due to several factors, such as limited education and finance. Second, millets are among the food choices of low-income households. Third, which is perhaps the most important reason, is the explicit lack of attention to millets both from researchers as well as from policy makers. Recently, some attention has been paid to breed better yielding and higher quality varieties of millets, as staple foods in the PDS in some states of India.

Nutritional profile

Food also needs to contain sufficient nutrients -nutrients are a necessary contributor to food security. Millets are counted on around the world to provide basic nutrition for many developing

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nations. Nutritional profile of millets is similar to that of other cereals. Like most cereals, millets are starchy grains i.e. they are rich in carbs, vitamins and minerals. Also, millets provide more essential amino acids than most other cereals. These compounds are the building blocks of protein. Finger millet boasts the highest calcium content of all cereal grains, providing 13% of the DV per 1 cooked cup (100 grams), which is necessary to ensure bone health, blood vessel and muscular contractions, and proper nerve function. One cup (174 grams) of cooked millet packs contain:

S. No.	Nutritional value
1.	Calories: 207
2.	Carbs: 41 grams
3.	Fiber: 2.26 grams
4.	Protein: 6.11 grams
5.	Fat: 1.7 grams
6.	Phosphorus: 25% of the Daily Value (DV)
7.	Magnesium: 19% of the DV (76.6 mg)
8.	Folate: 8% of the DV
9.	Iron: 6% of the DV
10.	Potassium: 108 mg

Millets are rich in niacin, which helps our body to manage more than 400 enzyme reactions. Niacin is also important for healthy skin and organ function. In fact, it's such an important compound that often added to processed foods to enrich them. Millet, especially the darker varieties, is also an excellent source of beta-carotene. This natural pigment acts as both an antioxidant and as a precursor to vitamin A, helping our body fight off free radicals and supporting the health of eyes. As millets are important sources of nutrients, can play a significant role in improving nutritional security and preventing diseases caused by imbalanced nutrition. They are gluten-free and contain as much protein as wheat does. In terms of macronutrients, millets are either similar or superior to major cereals. They also contain several micronutrients, vitamins, insoluble dietary fiber, and phenolic compounds, which are essential for health benefits. They are thought to have several health benefits including the ability to address diabetes, aging, cancer, celiac disease, and cardio-vascular disease (Bhat *et al.*, 2018). Millet-based health food items are common and exhibit longer storage life. Durairaj *et al.* observed a significant increase in height, weight, and hemoglobin level of the school children who regularly consumed millet-based health food (Durairaj *et al.*, 2019). Even though millets are produced in adverse climatic conditions and can provide nutrition that otherwise are hard to find, their acreage continues to decline, and production and yield have stagnated.

Millets	Protein (g)	Carbs (g)	Fat (g)	Minerals (g)	Fiber (g)	Ca (mg)	P (g)	Fe (mg)	Zn mg	Energy (KCal)	Thiamin (mg)	Niacin	Riboflavin mg	Folic acid mg
FM	7.3	72	1.3	2.7	3.6	344	283	3.9	2.3	336	0.42	1.1	0.19	18.3
S	10.4	70.7	3.1	1.2	2	25	222	5.4	1.6	329	0.38	4.3	0.13	20
PM	11.8	67	4.8	2.2	2.3	43	–	11	3.1	363	0.38	2.8	0.25	45.5
FxM	12.3	60.2	4.3	4	6.7	31	290	2.8	2.4	351	0.59	3.2	0.11	15
LM	7.7	67	4.7	1.7	7.6	17	220	9.3	-	329	0.30	3.2	-	-
KM	8.3	65.9	1.4	2.6	5.2	35	188	1.7	0.7	353	0.33	2	0.09	23.1
PM	12.5	70.4	1.1	1.9	5.2	8	206	2.9	3.7	354	0.41	4.5	0.01	9.0
BM	6.2	65.5	4.8	3.7	13.6	22	280	18.6	3.0	300	0.33	4.2	0.10	-

FM: Finger millet; S: Sorghum; PM: Pearl millet; FxM: Foxtail millet; LM: Little millet; KM: Kodo millet; PM: Proso millet; BM: Barnyard millet

Thiamin-Vitamin B1; Riboflavin-Vit. B2

Health benefits of millets

As already mentioned that millets are rich in nutrients and plant compounds, offer multiple health benefits.

Rich in antioxidants

Millets are rich in phenolic compounds, especially ferulic acid and catechins. These molecules act as antioxidants to protect your body from harmful oxidative stress. Antioxidants found in millets can neutralize the free radicals that lead to cancer and dispose of other toxins from the body, especially in the kidney and liver. Quercetin, curcumin, ellagic acid and other beneficial catechins can help rid the system of any foreign agents and toxins by promoting proper excretion and neutralizing enzymatic activity in those organs. Studies in mice link ferulic acid to rapid wound healing, skin protection, and anti-inflammatory properties. Meanwhile, catechins bind to heavy metals in your bloodstream to prevent metal poisoning. While all millet varieties contain antioxidants, those with a darker color such as finger, proso, and foxtail millet - have more antioxidants than their white or yellow counterparts.

Controlling blood sugar levels

Today's concern is growing over the third aspect of malnutrition i.e. overweight and obesity. This is due, mainly, to the over-consumption of energy-dense foods (especially 'empty' calories) but also to other factors, such as insufficient exercise and genetics. Together, these lead to diet-related diseases such as Type-2 diabetes and cardiovascular disease. Now a day's diabetes is a disease found in millions of people around the world. Millet is a beneficial food staple in many developing countries (where diabetes is less frequently found), perhaps because one of the effects of millet is a reduced chance of Type-2 diabetes. Millets are rich in fiber and non-starchy polysaccharides, two types of undigestible carbs that help in controlling of blood sugar levels. Millets have low glycemic index (GI)-that it's unlikely to spike blood sugar levels. Thus, these crops are considered as an ideal grain for people with diabetes. For instance, a study in 105 people with Type-2 diabetes determined that replacing a rice-based breakfast with a millet-based one lowered blood sugar levels after the meal. A 12-week study in 64 people with prediabetes gave similar results. Foxtail millet is an everyday food in parts of India. Millet produced a significant fall (70%) in blood glucose in diabetic rats according to research. After eating 1/3 cup (50 grams) of foxtail millet per day, they experienced a slight reduction in fasting and post-meal blood sugar levels, as well as a decrease in insulin

resistance (marker for Type-2 diabetes). It occurs when our body stops responding to the hormone insulin, which helps regulate blood sugar. A 6-week study in rats with diabetes, a diet containing 20% finger millet led to lower fasting blood sugar levels and a drop in triglyceride and cholesterol levels. Magnesium is considered one of the most important minerals for increasing the efficiency of insulin and glucose receptors in the body, thereby preventing this disease. A 30% reduction in diabetes has been seen in populations divided between diets with or without magnesium.

Lowering cholesterol

Millets contain soluble fiber, which produces a viscous substance in our gut. In turn, this traps fats and helps in reducing cholesterol levels. Results from a study in 24 rats found that those fed with foxtail and proso millet had significantly reduced triglyceride levels, compared with the control group. Dietary fiber actually eliminates dangerous “bad cholesterol” (LDL) from the system, while promoting the effects of “good cholesterol (HDL). Additionally, millet protein may also help to lower cholesterol. A study in mice with Type-2 diabetes fed them a high fat diet with millet protein concentrate. This led to a decrease in triglyceride levels and significant increase in adiponectin and HDL (good) cholesterol levels, compared with the control group. Adiponectin is a hormone with an anti-inflammatory effect that supports heart health and stimulates fatty acid oxidation. Its levels are usually lower in people with obesity and Type-2 diabetes.

Cancer risk

Recent research has revealed fiber to be one of the best and easiest ways to prevent the onset of breast cancer in women. In fact, women can reduce their chances of breast cancer by more than 50% by eating more than 30 grams of fiber every day. Breast cancer is one of the most common and deadliest forms of cancer.

Prevention of cardiovascular disease

Millets are rich sources of magnesium that help in alleviating blood pressure and the risk of heart strokes, especially in atherosclerosis. The potassium found in millets keeps blood pressure low by functioning as a vasodilator and mitigating cardiovascular risk. The plant lignans prevalent in millets can convert into animal lignans in the presence of microflora in the human digestive system and safeguard against heart disease.

Gastrointestinal disorders

The fiber content in millets eliminates disorders such as constipation, excess gas, cramping, and bloating. Millets also shield us from an immune-mediated enteropathic disease called celiac that gets triggered by the ingestion of gluten in vulnerable individuals. By regulating digestive process, nutrient retention is improved and reduces chances of more serious gastrointestinal conditions like gastric ulcers or colon cancer. Regular digestion and elimination of waste helps to optimize kidney, liver, and immune system health, as these organ systems are closely related to the body’s metabolic activities.

Respiratory system

Research showing that millet can significantly improve the quality of life for people suffering from childhood asthma, and can also prevent it from developing in the first place. Although some of the evidence is controversial, it is shown that significantly less wheezing and asthma attacks (by more than 15%) was seen in children who had large intakes of grains like millet. However, as wheat is a common allergen that is associated with asthma and wheezing, millet does not have the same components and does not have this negative effect.

Gluten-free diet

Millets are gluten-free grain, making them a viable choice for people with celiac disease or those following a gluten-free diet. Gluten is a protein that occurs naturally in grains like wheat, barley, and rye. People with celiac disease or non-celiac gluten sensitivity must avoid it because it triggers harmful digestive symptoms, such as diarrhea and nutrient malabsorption. Replacing cereals such as wheat, barley, rye-based foods made from gluten-free grains that include rice, millet, corn, amaranth, sorghum, quinoa, buckwheat, wild rice can help people adhering to a gluten-free diet. As gluten-free, millets have prolific potential in foods and beverages and can satisfy the rising demand for gluten-free foods and suitable for individuals with celiac disease. While purchasing millets, care should be taken to look for a label that certifies it gluten-free to ensure it hasn't been contaminated with any gluten-containing ingredients.

Elevated bioavailability of some minerals

In India, people typically use sprouted grains as weaning foods for infants or as easily-digested foods for the elderly. A study at Central Food Technological Research Institute, Mysore (India), concluded that malting millet elevated the bio-accessibility of iron, manganese, and calcium while reducing the bio-accessibility of zinc with no variation in copper.

Potential downsides

Despite multiple health benefits, they also contain anti-nutrients - compounds that block or reduce our body's absorption of other nutrients which may lead to deficiencies of those nutrients. For example, one of such compounds is phytic acid that interferes with potassium, calcium, iron, zinc, and magnesium uptake. However, a person with a balanced diet isn't likely to experience adverse effects. Other anti-nutrients called goitrogenic polyphenols may impair thyroid function, causing goiter - an enlargement of thyroid gland that results in neck swelling. Nevertheless, this effect is associated only with excess polyphenol intake.

For example, one study determined that goiter was significantly more prevalent when millet provided 74% of a person's daily calories, compared with only 37% of their daily calories. Furthermore, one can lower millet's anti-nutrient content significantly by soaking it overnight at room temperature, then draining and rinsing it before cooking. Sprouting reduces anti-nutrient content. Certain health food stores sell sprouted millet, though one can also germinate it on your own. To do so, place soaked millet in a glass jar and cover it with a cloth that's secured with a rubber band. Turn the jar upside down, rinsing and draining the millet every 8–12 hours. There will be small sprouts beginning to form after 2–3 days. Drain the sprouts and enjoy them right away. Keeping in mind that sprouts have a short shelf life and are more prone to foodborne illness. To ensure safety:

- Keep sprouting container clean
- Use filtered or bottled water (NOT tap water)
- Rinse sprouts frequently
- Empty any remaining water from sprouts before storing
- Store sprouts in a cool, dry location
- Wait 8 to 12 hours before refrigerating to ensure they are cool and dry

Conclusion

Millets have substantial potential to contribute toward food and nutritional security. Their nutritional value suggests that millets act as antioxidants, detoxifying agents, immune modulators, and many other forms. It can also help small farmers eliminate the middlemen to generate

sustainable livelihoods and hence should be brought out of NUS and considered as another staple food along with rice and wheat. With so many benefits offered by millets, these are to be included in the public distribution system (PDS) alongside rice and wheat so that they receive an appropriate Minimum Price Support. Appropriate implementation of relevant regulations, continued research and development for improved varieties, availability of quality seeds, and adequate support for cultivation and technology for processing and marketing of millets are necessary in this regard.

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SUSTAINABLE AGRICULTURE IN NAGALAND: EXPLORING THE PRACTICES OF ZABO FARMING

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Abstract
Nagaland, one of the states in Northeast India, is home to seventeen major tribes and several minor tribes. This region is renowned for its vibrant festivals, which often coincide with agricultural activities. Each tribe has its own unique approach to farming, reflecting their distinct agricultural traditions. The tribal communities in Nagaland have developed and embraced indigenous methods of land and water management that prioritize ecological preservation and sustainable utilization of natural resources. Among these practices, Zabo farming stands out, being practiced by the Chakhesang Naga tribe. This article focuses on the sustainable and integrated farming practices of the Zabo Farming System, which are designed to optimize resource utilization, minimize environmental impact and provide eco-friendly produce to the local community.

Keywords: Chakhesang Naga tribe, Indigenous, Nagaland, Sustainable, Zabo farming system

Introduction

The northeastern Indian state of Nagaland was admitted as the sixteenth state to the Indian union. It occupies an area of 16,579 sq. km, having a population of 19.78 lakhs as per 2011 census. Nagaland is primarily characterized by a rolling and hilly landscape, located between 25'06 °N and 27'04 °N latitude and 93'20 °E and 95'15 °E longitude. The state possesses abundant and varied natural resources, which can be attributed to its distinctive geographic position. The state is primarily characterized as agrarian, with 70% of its population involved in and reliant on agriculture (Anonymous, 2017). An old, conventional farming method known as shifting or Jhum agriculture is used extensively in the state. This traditional farming system is believed to have originated as early as the Neolithic period around 7000 B.C. to 1000 B.C., as evidenced by historical records **(**Hazarika, 2006).

In the North East region, specific communities have cultivated distinct farming systems that draw upon traditional agricultural knowledge and practices cultivated and safeguarded over centuries (Singh and Gupta, 2002). These practices prioritize the sustainable utilization of locally available resources while concurrently preserving the agricultural biodiversity indigenous to the area. The NE India presents a unique challenge due to limitations in capital infrastructure, transport, undulant topography, etc. As a result, the region was unable to fully embrace the ambitions of the green revolution in the 1960s. Consequently, traditional farming techniques remain prevalent and the adoption of modern technologies for economic production is still limited. Therefore, the region continues to rely on traditional or natural farming systems, which are inherently considered as 'organic by default' can be strategically transform to 'organic by design' for promotion of organic

agriculture in these hilly regions of India. The current article aims to emphasize the sustainable and traditional Zabo farming system implemented by the local tribe of Nagaland.

Zabo farming system- farming methods and approaches

Indigenous farming practices and traditional knowledge pertaining to sustainable agriculture exists among the tribal people in North East Region. One such system is Zabo farming, which is practiced by the Chakhesang Naga tribe of Kikruma village (**Fig. 1**), situated at an altitude of 1270 m above mean sea level in the Phek district of Nagaland. This form of integrated farming system has its roots in indigenous practices and has been passed down through generations. The word Zabo (locally called Zabü) means "impounding runoff water and utilization." It is an approach to farming that integrates forestry, agriculture, horticulture, fishery, and animal husbandry activities by using harvested rainwater (Amenla and Shuya, 2021) and recycling systems for proper soil management and biodiversity conservation (Pulamte, 2008).

The farming system consists of a three- tier system structure. The hilltop encompasses a protected forest area; the mid-hilly section serves as a residential area for the villagers and includes water-harvesting ponds called Rüza/ Razü and the third lowermost section is used to carry out agriculture (paddy cultivations), horticulture (fruits and vegetables) as well as activities related to animal husbandry and fishery **(Fig. 2).**

The protected forest area maintained by the village communities serves as a catchment area where surface runoff from rainwater after siltation is collected in the water harvesting pond constructed by the community or farmers. To prevent water percolation, the bottom surface of the pond is puddled thoroughly, while the bunds are compressed using puddled soil to prevent water seepage. Through gravitational flow and man-made drainage channels, the run-off water is directed towards the main harvesting ponds. Silt retention tanks or small ponds are strategically built to filter and accumulate sediments, debris and organic matter, allowing clean run-off water to flow into the main harvesting pond. Depending on the water requirements for crops and livestock, multiple water harvesting ponds may be excavated. The accumulated water is then released for irrigation by opening an outlet at the base of the pond or using half-cut bamboo channels that allow water to flow from one field to the next until reaching the final plot. Any excess water is drained into fishery ponds. The sharing of harvested water among different families or the community is mutually agreed to ensure equal distribution of irrigation water during the crop season.

Paddy cultivation plays a central role in the Zabo farming system. As the region receives ample rainfall during the monsoon season, there is usually sufficient water available for paddy cultivation. However, in the event of poor rainfall, supplementary irrigation is provided using water from the Zabo ponds. Local paddy seedlings are nurtured in nurseries from mid-March to mid-April, and transplantation takes place in June- July. The pond retains water throughout the entire plant growth period and is drained prior to the harvesting season, typically in October to early November. When fish culture is practiced alongside paddy cultivation, fish fingerlings are released into the dug-out pit located almost centrally in the pond during the puddling stage (end May- early June). In this case, the pond is not fully drained off and fish are harvested while allowing small fish and fingerlings to continue growing again in the standing water, with additional water supplied from the primary catchment area. In other instances, post paddy cultivation, water is entirely drained from the pond and it is prepared again for cultivating winter vegetable crops. The yields obtained from paddy cultivation and fish production range between 1400-2500 kg/ha and 40 to 80 kg/ ha, respectively (Singh et al. 2018).

Fruits and vegetables are grown and livestock is reared in the vicinity or just below the ponds area. Livestock commonly found in this system includes goats, cattle, poultry, etc. These animals are allowed to roam and grace in open forest areas surrounding the enclosures. The manure produced from these livestock seeps down into the drainage channels, providing a rich source of nutrients for the paddy crops. During the dry season, typically in March-April, the ponds dry out, and it is during this time that repairs are carried out on the harvesting ponds. All the families or the community members who have wet terrace ponds in the irrigation command area come together to clean the drainage channels and siltation tanks. The sediment collected from the tank is abundant in organic matter and nutrients, making it highly valuable for agricultural purposes.

The entire farming system revolves around this cycle and the community continues to maintain a harmonious and sustainable way of life, benefiting from the interdependence between the various components of the system.

Conclusion

Zabo farming system, developed by our ancestors, is a unique and well-established agricultural method that is still widely practiced among the Chakhesang Naga tribe in Nagaland. The entire farming system revolves around this cycle and the community continues to maintain a harmonious and sustainable way of life, benefiting from the interdependence between the various components of the system. Future thrust requires more research and extension activities to enhance productivity and long-term adaptability of such farming practices in this modern era.

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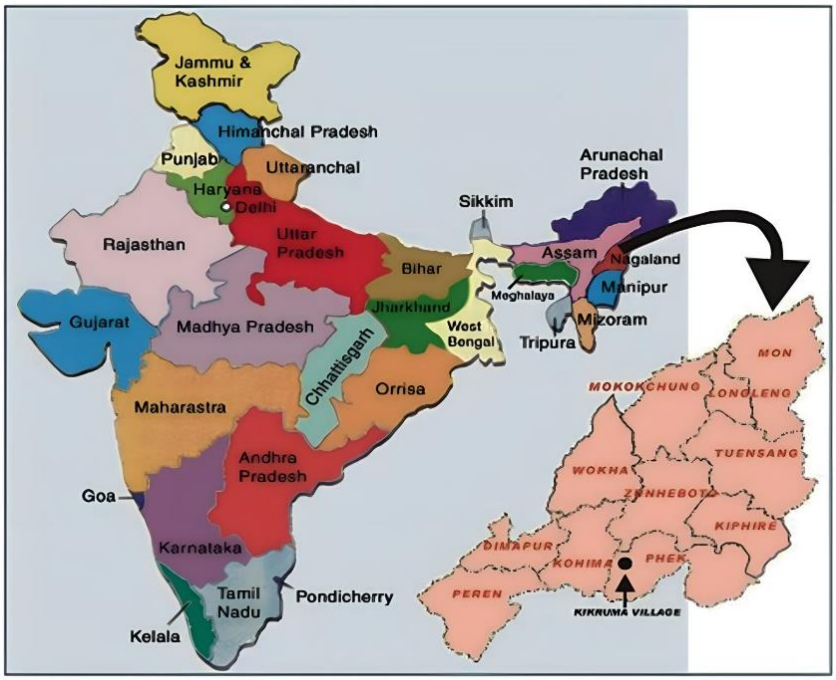

Fig. 1. India map indicating the location of Kikruma Village, Nagaland (Amenla and Shuya, 2021)

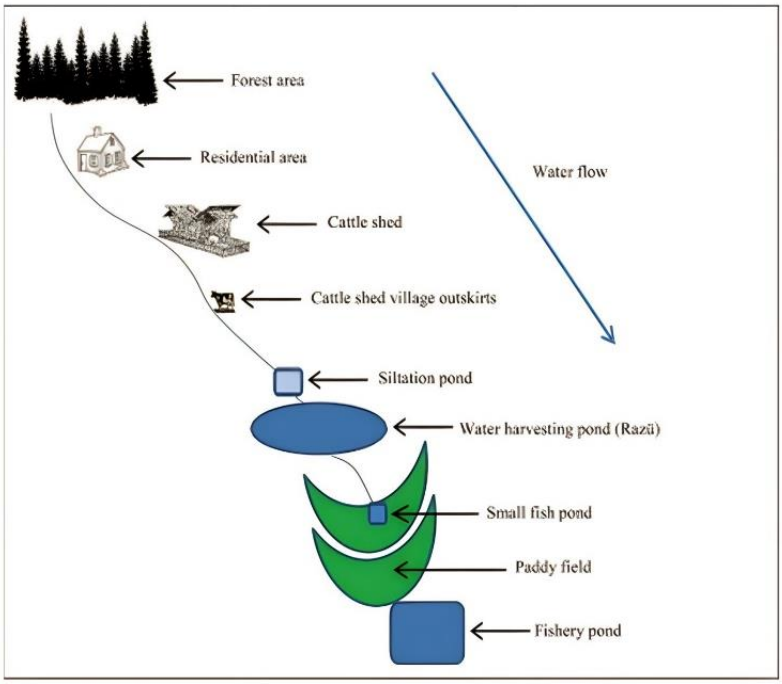

Fig. 2. Graphic representation of Zabo farming system (Amenla and Shuya, 2021)

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NUTRI-CEREALS FOR FUTURE FOOD AND ENVIRONMENT SECURITY

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Abstract
Millets are an important source of nourishment for millions of people in India. For centuries, millet has been a part of the culture and traditions of indigenous people and even offered food security to them. In India, eight millets species ie. Sorghum (Jowar), Pearl millet (*Bajra*), Finger millet (*Ragi*), Proso millet (*Cheena*), Foxtail millet (*Kodo*), Barnyard millet (Indian barnyard millet) and Little millet (*Sawaan*) are commonly cultivated under rainfed conditions and are considered as a staple diet for the people living in the dryland regions. Production of millet can support the livelihood of small landholding farmers and even provide jobs to women and youth. This paper aims at focussing the importance of Nutri-Cereals for Future Food and Environment Security.

Introduction
Sorghum and millets are a staple diet of millions of people living in the dryland regions of India. These are less water and less nutrient demanding crops and are favoured under dry, high temperature conditions due to their productivity and short growing season. The most widely grown millet is pearl millet, which is an important crop in India and parts of Africa. Finger millet, Proso millet, and foxtail millet are also important crop species. It was introduced into the United States in the 19th century. Millet has become increasingly popular in the United States because it is a gluten-free grain alternative to wheat. Millets are rich in dietary fibre, protein, vitamins,and minerals, making them valuable part of a balanced diet. Besides, high nutritional value, these are cheaper compared to meat products, and as such can address the malnutrition scourge the country is undergoing. In addition to the traditional cooking methods, coarse grain has been used mainly in the weaning food preparation and other malted food production. Sorghum is used in glucose and other beverage preparation. *Ragi* and wheat mixed vermicelli is available in the market in a form of instant food. Government of India has reintroduced millets into public diets across the country. Noteworthy initiatives such asPOSHAN 2.0 emphasise the promotion of dietary diversity and food fortification while also supporting traditional knowledge systems and integrating millets. Realizing the importance in food-chain, various state governments are putting up their sincere efforts by including millets in state government programmes. This paper highlights the importance of millets as nutri-cereals for future food and environment security.

Area, Production and Productivity of Minor Millets
About 15.9 million ton (MT) of millets are produced in India from nearly 12.3 million ha area, which constitutes about 6% of the national food grain basket. Area under millet crops has shown a decline of 28% in 2022-23 from average area of 2009-2013 (**Table 1**). The decline in area is more pronounced in sorghum and small millets. Except *bajra*, production of other millet crops has

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decreased during the corresponding period. Except *ragi*, there has been improvement in average yields of other millet crops. In the past seven decades (1950 to 2021), share of millets in total food grain production has shown a 3.85 times reduction (22.17% to 5.76%) (Tonapi et al. 2023). Apparently, this reduction in share has been ascribed to loss of millets acreage to other food (rice, maize), commercial (sugarcane, cotton) and remunerative crops (soybean) rather than their ability to produce high. This is evident from the fact that despite huge losses in acreage, total millet production was maintained. Development and adoption of improved varieties/hybrids have played a noteworthy contribution in productivity improvement of these crops. Area, production and productivity of millets during 2009-13, 2014-19, 2019-2020, 2021-2022 and 2022-2023 are given in **Table 1**.

Table 1. Area, production and yield of millets during 2009-13, 2014-19, 2019-2020, 2021-2022 and 2022-2023

Millets	Area (000 ha)					Production (000 MT)					Yield (kg ha^{-1})				
	2009-2013	2014-2019	2019-2020	2021-2022	2022-2023	2009-2013	2014-2019	2019-2020	2021-2022	2022-2023	2009-2013	2014-2019	2019-2020	2021-2022	2022-2023
Sorghum	6684	4910	4480	3800	3721	6101	4404	4380	4151	4075	913	897	1051	1092	1095
Bajra	8480	7142	6770	6841	7033	9029	8738	8900	9781	9785	1065	1223	1265	1430	1391
Ragi	1211	1104	970	1218	1115	1914	1710	1680	1701	1669	1580	1549	1662	1396	1497
Small millets	773	570	460	429	474	428	403	340	367	380	554	707	804	857	800
Total millets	17149	13726	12680	12288	12343	17472	15255	15300	16000	15909	1028	1094	1195	1194	1028

Source: Agricultural Statistics Division, Department of Agriculture & Farmers Welfare, New Delhi. Adapted from Tonapi et al. (2023).

The main reasons for such a declining trend in area are decreasing per capita availability of land in consequence to increasing population and increasing demand of land for other purposes, the relative area planted in native millets - often called "minor cereals" - decreases to the benefit of cash crops such as sugarcane, potato, sunflower, cotton or turmeric and of other cereals like rice and wheat. Certain varieties of millets like pearl millet (*bajra*) or little millet are also gradually abandoned because they are low-yielders. They have further been stigmatized as "cereal of the poor". This negative connotation is arguably at the root of changes in food preference in the rural areas and of the quasi-inexistant urban demand for such cereals. The Public Distribution System (PDS) and its exclusive focus on rice and wheat should also be questioned in this context. Indeed, the introduction of rice - supplied at subsidised prices through the PDS - replacing *ragi* as main staple had dramatic effects on people's nutrition. In the Deccan Plateau, the women first welcomed rice into their diet because of its less time-consuming preparation. But within a few years, people began noticing a general faltering in their health. The Anemia spread can be generally seen in the villages due to unbalanced diets.

MINOR MILLETS: IMPORTANT FOR SUSTAINABLE LIVELIHOODS, CLIMATE RESILIENCE AND FOOD AND NUTRITION SECURITY

Minor millet crops are called nutria-cereal which are small seeded annual grass includes like finger millet (*Eleusine coracana* (L.) Gaertn),Barnyard millet (*Echinochloa frumentaceae* L.), Little millet (*Panicum sumatrense*), Foxtailmillet (*Setaria italika* L. P. Beauvois), Proso millet (*Panicum miliaceum* L.) and Kodo millet (*Paspalum scrobiculatum*). Some other crops are Pearl millet (*Pennisetum*

glaucum (L.). In the different part of the country, the millets known by different names as finger millet (Mandua, Ragi), barnyard millet (Sanwa, Jhangora), foxtail millet (Koni, kakum), proso millet (Cheena), little millet (samai, gindi, mutaki, kutki), kodo millet (khoddi, arugu, varagu, Kodon), pearl millet (Bajra) amd sorghum (Jowar). The cereals considered in this paper include sorghum, pearl millet, finger millet, foxtail millet, proso millet, barnyard millet, *kodo* millet and little millet.

Sorghum (*Jowar*) ***(Hordeum vulgare):*** Sorghum (Jowar) has been the principal staple food in arid and semi-arid tropics of India. The industrial use of sorghum is more predominant as compared to other coarse grains. It is used in alcoholic beverages. Bread making industry uses wheat-sorghum combination. Commercial weaning food industries utilize the sorghum-cowpea combination and sorghum-soybean combination. It has 10.4 g protein, 66.2 g carbohydrate, 2.7 g fibre macro and micronutrients.

Sorghum (*Jowar*)

Pearl millet (*Bajra) **Pennisetum glaucum :*** Pearl millet, *Pennisetum glaucum,* is also known as spiked millet, *bajra* (in India). About 2 000 years ago the crop was carried to eastern and central Africa and to India, where because of its excellent tolerance to drought it became established in the drier environments. Pearl millet is used in various industrial products. 100 gm edible portion of pearl millet consists of 11.6 g protein, 67.5 g carbohydrate, 8 mg iron and it has 132 micro-gm of carotene which is highly essential to safe guard our eyes. Even though it has some anti-nutrients such as pytic acid, polyphenol and amylase inhibitors, however, after soaking in water, the germination and other cooking procedures reduce the anti-nutrients. Pearl millet is used as an important source of food, feed and fodder wherever it is cultivated.

Pearl millet (*Bajra)*

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Finger Millet (*Ragi*) **(*Eleusine coracana* (L.) Gaertn.) :** Being originally native to the Ethiopian highlands, Finger millet was introduced into India approximately 4000 years ago. It is highly adaptable to higher elevations and is grown in the Himalayas up to an altitude of 2300 m. It is the most important small millet in the tropics (12% of global millet area) and is cultivated in more than 25 countries in Africa (eastern and southern) and Asia (from Near East to Far East), predominantly as a staple food grain. The major producers are Uganda, India, Nepal, and China. Finger millet has high yield potential (>10 t/ha under optimum irrigated conditions) and grain stores very well. In India, it is cultivated on 1.8 million ha, with average yields of 1.3 t/ha; The major finger millet growing states are Karnataka, Andhra Pradesh and Tamil Nadu.

Ragi is a versatile millet with high value of calcium 344 mg/100g. No other cereal has this much calcium. The iron content of *ragi* is 3.9 mg/100g, which is higher than the other cereals except *bajra*. *Ragi* has been recommended as a wholesome food for diabetic patients. Traditionally *ragi* is used as the weaning food in the form of porridge gruel etc. Now *ragi vermicelli* an instant food is available in the market. At the ICRISAT genebank, 5949 finger millet germplasm accessions from 24 countries are conserved for use in research and development.

Finger millet (*Ragi*)

Proso millet (*Cheena*) **(*Panicum miliaceum* L.):** Proso millet was domesticated in Manchuria and introduced to Europe about 3000 years ago, followed by introduction in the Near East and India. Proso millet is well adapted to many soil and climatic conditions. Being a short season crop with low water requirement, it grows further north than the other millets and also adapts well to plateau conditions and high elevations. Proso is found high in mountains; in the former USSR up to 1200 m and in India up to 3500 m. Proso millet generally matures between 60-90 days after planting and can be grown successfully in poor soil and hot dry weather. It is an easy crop to grow and it seems to be better adapted than most crops to primitive agricultural practices. Proso millet requires very little water, possibly the lowest water requirement of any cereal, and converts water most efficiently to dry matter/grain. This is not because of its drought resistance but because of its short growing season. At the ICRISAT genebank, 842 Proso millet germplasm accessions from 30 countries are conserved for use in research and development.

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Proso millet (*Cheena*)

Foxtail millet (*Kodo*) **(*Paspalum scrobiculatum* L.):** *Kodo* millet was domesticated in India almost 3000 years ago. It is found across the old world in humid habitats of tropics and subtropics. It is a minor grain crop in India and an important crop in the Deccan plateau. The fibre content of the whole grain is very high. *Kodo* millet has around 11% protein, and the nutritional value of the protein has been found to be slightly better than that of foxtail millet but comparable to that of other small millets. As with other food grains, the nutritive value of *Kodo* millet protein could be improved by supplementation with legume protein. Foxtail millet is fairly tolerant of drought but cannot tolerate water logging.; it can escape some droughts because of early maturity. Due to its quick growth, it can be grown as a short-term catch crop. It is adapted to a wide range of elevations, soils and temperatures. Its grain is used for human consumption and as feed for poultry and cage birds.

Foxtail millet *(Kodo*)

Barnyard millet (*Echinochloa colona* (L.) Link, *Echinochloa crusgalli* (L.) P.B.) : *E. crusgalli* domesticated in Japan 4000 years ago and *E.colona* domesticated in India. Barnyard millet is the fastest growing of all millets and produces a crop in six weeks. It is grown in India, Japan and China as a substitute for rice when the paddy crop fails.

Barnyard millet

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Little millet (*Kutki, Sawaan*) **(*Panicum sumatrense* Roth.ex.Roem.& Schult) :** Little Millet (*Panicum sumatrense*, Syn.: *Panicum miliare* auct. non Lam.) is a species of millet in the family *Poaceae*. In India *kutki, Sawaan* are some of the names in Hindi for little millet. In Bengali it is called as *Sama*. In Gujarati *Gajro, kuri*. In Marathi it is called as *Sava, Halvi, vari*. In *oriya* it is called as Suan. It represents the weedy progenitor of *P. psilopodium* grown throughout India to a limited extent up to altitudes of 2100 m, but is of little importance elsewhere. Little millet is another reliable catch crop in view of its earliness and resistance to adverse agro-climatic conditions. The stover is a good fodder for cattle.

Little millet

Nutritional Value of Minor Millets

The data in **Table 2** show the nutrient content of millet compared to major staple foods in a raw form. Raw forms, however, are not edible and cannot be fully digested. These must be prepared and cooked as appropriate for human consumption. In processed and cooked form, the relative nutritional and antinutritional contents of each of these grains is remarkably different from that of raw forms reported in this table. The nutrition value in cooked form depends on the cooking method.

Table 2 Nutrient Content of Various Millets with comparison to Rice and Wheat
(Source: Millet Network of India, http://www.milletindia.org)

Crop / Nutrient	Protein (g)	Fiber (g)	Minerals (g)	Iron (mg)	Calcium (mg)
Pearl millet	10.6	1.3	2.3	16.9	38
Finger millet	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Proso millet	12.5	2.2	1.9	0.8	14
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Barnyard millet	11.2	10.1	4.4	15.2	11
Rice	6.8	0.2	0.6	0.7	10
Wheat	11.8	1.2	1.5	5.3	41

Millets, like sorghum, are predominantly starchy. The protein content is comparable to that of wheat and maize. Pearl and little millet are higher in fat, while finger millet contains the lowest fat. Barnyard millet has the lowest carbohydrate content and energy value. Millets are also relatively rich in iron and phosphorus. The bran layers of millets are good sources of B-complex vitamins. Millets also feature high fiber content and poor digestibility of nutrients, which severely limit their value in nutrition and influence their consumer acceptability. Finger millet has the highest calcium content among all the food grains, but it is not highly assimilable. The protein content in millet is

very close to that of wheat; both provide about 11% protein by weight, on a dry matter basis. Millets are rich in B vitamins (especially niacin, B_6 and folic acid), calcium, iron, potassium, magnesium, and zinc.

Apparently, sorghum and millets have high nutritional value and are used in several bakery products. Also, with the health-conscious middle class in India gaining numbers as a result of rapid economic growth, products made of these cereals have no dearth for demand. They are highly nutritious as being a good source of fibre, protein, zinc, iron and B-vitamins. The Indian Council of Medical Research has worked out the nutritional superiority of millets compared to rice (on a 100 g weight basis). Fox tail millet has 81% more protein, little millet has 840% higher fat, 350% higher fibre and 1229% higher quantity of iron. *Kodon* millet also contains 633% more minerals. Finger millet has 3340% higher calcium and pearl millet has 85% higher phosphorus. In addition, these millets are also very rich in vitamins such as Thiamine (Fox tail millet), Riboflavin (Pearl millet), Niacin (*Kodo* millet) and Folic acid (Pearl millet). By virtue of being highly nutritious, millets possess several medicinal properties such as improving digestibility, curing coronary heart diseases, diabetes etc. Eating a meal with *chapatis* made from pearl millet provides sufficient Vitamin A required for body that otherwise would have come from a kilogram of carrot. Taking a meal made from Fox tail millet provides protein equivalent to what an egg contains, a meal of *Ragi* bowl provides calcium much more than what could have been obtained by drinking three glasses of milk. A breakfast of little millet provides more iron than what could have been obtained by consuming 50 gm of leafy vegetables. As these carrot, egg, milk and leafy vegetables are not at all within the reach of poor people, the millets are rightly described, from the nutrition point of view, as the "poor man's gold." In spite of all these values having these millets, they were named as coarse cereals. Even though coarse cereals are consisted of valuable macro and micronutrients, they have still the secondary importance. This is the right time to change the name of these nutritious grains as **"Nutri-Cereals".**

A rich source of dietary fibre **:** The dietary fibre of sorghum is 89.2%, pearl millet 122.3% and *ragi* 113.5%. Rice has the lowest percentage of dietary fibre as compared to other cereals. Health benefits of dietary fibre are immense. Dietary fibre has the tendency to absorb water and to act as a bulking agent. It facilitates faster transition of food in the gastrointestinal tract, reduces the retention time of faeces in the colon. It would bind bile salt and help in increasing the loss of cholesterol and act as a hypo-cholesterolemic agent and therefore, useful in dietary management of cardiovascular diseases. Dietary fiber, such as that in a high-fiber cereal, can help you lose weight because it is slow to digest, so you may feel less hungry. Cereal can support weight control if you eat it as part of a healthy meal or snack with fruit and fat-free yogurt or milk. The extra fiber from fruit and protein from dairy products can decrease your hunger, manage your weight and reduce your risk for obesity-related chronic diseases such as type 2 diabetes and heart disease.

A rich source of calcium : If we analyse the nutritive value of coarse grains, *ragi* and *jowar* are rich in calcium and dietary fibre. The calcium intake of women in Asia and Africa are considerably below the recommended level. Due to calcium deficiency during pregnancy and lactation, child may develop poor skeletal formation. In addition, inadequate calcium intake during pregnancy compromise the health of the mother, calcium from the mother's skeleton might be used to support fetal growth and breast milk production. Because of the calcium deficiency the mother may be affected with vascular system and hypertension. Calcium supplementation during the second half of pregnancy may reduce the incidence of pregnancy induced hypertension and pre-eclampsia.

Rich Source of Vitamins: Sorghum and millets, in general, are rich sources of B-complex vitamins. Some yellow-endosperm varieties of sorghum contain ß-carotene which can be converted to vitamin A by the human body. In view of the photosensitive nature of carotenes and variability due to environmental factors, yellow-endosperm varieties of sorghum are likely to be of little importance as a dietary source of vitamin A precursor. Detectable amounts of other fat-soluble vitamins, namely D, E and K, have also been found in sorghum grain. Sorghum , as it is generally consumed, is not a source of vitamin C. On germination, some amount of vitamin C is synthesized in the grain and on fermentation there is a further rise in the vitamin content. Among B-group vitamins, concentrations of thiamin, riboflavin and niacin in sorghum were comparable to those in maize. Other B-complex vitamins present in sorghum in significant amounts are vitamin B6 (0.5 mg per 100 g), folacin (0.02 mg), pantothenic acid (1.25 mg) and biotin (0.042 mg) (United States National Research Council/National Academy of Sciences, 1982). Available data are very meagre regarding the vitamin content of pearl millet, finger millet and minor millets. In thiamin and riboflavin content these millets differ little from sorghum. Niacin content, however, is lower in some of them.

HEALTH BENEFITS OF MILLETS

- **Controls Blood Sugar:** Millet is rich in higher complex carbohydrates, which means it takes longer to digest standard wheat flour and is a low-glycemic index (GI) food. Food that has low-GI stops our blood sugar from spiking after eating.
- **Improves Gut Health:** Millet is a great source of dietary fibre. Insoluble millet is also known as a probiotic and that means that millet keeps the good bacteria in our gut healthy. It also makes our bowel movement more regular and reduces the risk of colon cancer.
- **Lowers Bad Cholesterol:** The high values of soluble fibre in millet can reduce the amount of LDL or “bad” cholesterol in the blood and absorbs cholesterol. There are other studies that also show that millet can raise HDL or “good” cholesterol levels.

Millets contain no gluten, so they are not suitable for raised bread. When combined with wheat (or xanthan gum for those who have celiac disease) they can be used for raised bread. Alone, they are suited for flatbread. As none of the millets is closely related to wheat, they are appropriate foods for those with celiac disease or other forms of allergies/intolerance of wheat. However, millets are also a mild thyroid peroxidase inhibitor and probably should not be consumed in great quantities by those with thyroid disease.

Compared to other commonly grown cereals such as rice, corn, or wheat, it is possible to grow millets under drought-like conditions and in uneven non-irrigated conditions. It has a low water footprint. Millet also has a high carbon content and it helps maintain and even increase soil carbon levels.

According to the Director-General of Food and Agriculture Organization of the United Nations, Qu Dongyu, “Millets are incredible ancestral crops with high nutritional value. Millets can play an important role and contribute to our collective efforts to empower smallholder farmers, achieve sustainable development, eliminate hunger, adapt to climate change, promote biodiversity, and transform agrifood systems.”

Alcoholic beverages: Millets are traditionally important grains used in brewing millet beer in some cultures, for instance by the Tao people of Orchid Island and in Taiwan. Various peoples in East Africa brew a drink from millet or sorghum known as *"ajono",* a traditional brew of the *Teso*. The fermented millet is prepared in a large pot with hot water and people share the drink by sipping it through long straws. Millet is also the base ingredient for the distilled liquor *rakshi* in Nepal and the indigenous alcoholic drink of the Sherpa, *Tamang*, *Rai* and *Limbu* people, *tongba*, in eastern Nepal. In Balkan suhail countries, especially Romania and Bulgaria, millet is used to prepare the fermented drink boza.

CLIMATE RESILIENT CROPS

Being C4 crops, millets are efficient users of water and nutrients for growth, highly tolerant to warmer temperatures and to some extent to flooding, tolerant to salinity thus ensure good germination and very good plant stand. Being tolerant to abiotic and abiotic stresses like drought, heat, flood,salinity, they are most promising sources for food during climate change. Climate resilient traits of such crops and top producing states are given in **Table 3**.

Table 3. Climate resilient traits of millets

Millet	Duration (days)	Adaptation for impacts ofclimate change	Top producing state
Pearl millet	80-95	Highly resilient to heat and drought, come up in very poor soils, but responsive to high input management	Rajasthan
Sorghum	100-125	Drought tolerant, excellent recovery mechanism from stresses, highly adapted to wide range of soils, altitudes and temperatures, responsive to high input management	Maharasthra
Finger millet	90-130	Moderately resistant to heat, drought and humidity, adapted to wide altitude range	Karnataka
Foxtail millet	70-120	Adapted to low rainfall, high altitude	Karnataka
Kodo millet	100-140	Long duration, but very hardy, needs little rainfall, comes up in very poor soils, good response to improved management	Madhya Pradesh
Barnyard millet	60-90	Very short duration, not limited by moisture, high altitude adapted	Uttarakhand
Little millet	70-110	Adapted to low rainfall and poor soils- famine food; withstand waterlogging to some extent	Madhya Pradesh
Proso millet	60-90	Short duration, low rainfall, high altitude adapted	Maharashtra

Source: Tonapi et al. (2023)

GOVERNMENT INITIATIVES FOR PROMOTION OF NUTRI-CEREALS

Government of India included coarse cereals under National Food Security Act in 2013 and National Food Security Mission; celebrated 2018 as National Year of Millets with recognition of millets as nutri-cereals because of their added advantages. Since 2018 the Indian Government has taken many steps to promote the production of millet.

- Millets are included by the Ministry of Women and Child Development under *Poshan Mission Abhiyan*.

- The Government of India has hiked the Minimum Support Price of Millet to incentivize its production for farmers.
- The government has also included millets in the public distribution system in order to provide a steady market for millet.
- The government has also encouraged the marketability of millets by building value chains through Farmer Producer Organization.
- UnitedNations General Assembly (UNGA) declared 2023 as the International Year of Millets on 5th March 2021 on the behest of the Government of India.

The main objective of International Year of Millets is to raise awareness about the nutritional and environmental benefits of millets by promoting their cultivation, production, consumption; diversifying processing equipment and technologies; and catering to various domestic and international market segments. ICAR-Indian Institute of Millet Research, Hyderabad has been revitalizing millet production by sharing best management practices, research and technology at the National and International level. The India Government initiatives from 1972 to 2023 in India for millet production are being mentioned in **Table 4**.

Table 4. Government initiatives for increasing millet production in India

Year	Activity
1972	Establishment of the International Crops Research Institute for the Semi Arid Tropics with mandated crops of sorghum, pearl millet**,** chickpea, pigeon pea and groundnut.
1974	Launching of Central Sector Scheme on minikit programme of pre-release varieties of Coarse Cereals."1979 Launching of Demonstrations of Intensive Cultivation of Coarse Cereals in ST/SC areas.
1982	Inclusion of Location Rereleased Varieties/Hybrids under Central Sector Scheme on minikit programme of coarsecereals.
1985	Setting up of All India Coordinated Pearl millet Improvement Project by ICAR
1986	Setting up of All India Coordinated Small Millets Improvement Project by ICAR. 1987 Setting up of National Research Centre for Sorghum by ICAR.
1994	Launching of Centrally Sponsored Integrated Cereals Development Programme in Coarse Cereals based CroppingSystem.
1995	Introduction of Front Line Demonstration Programme by Department of Agriculture and Cooperation.2000 Visit of FAO Mission on Special Programme for Food Security from November 19-29, 2000
2000	First National Seminar on Sustainable Development of Coarse cereals on February 7-8, 2000 at the State Institute of Agricultural Management Durgapura, Jaipur.
2000	Introduction of Macro-Management Mode of Agriculture to Provide Greater Flexibility in Programme Implementation to the State Government.
2001	Second National Seminar on Outlook of Coarse cereals in the New Millennium during November 27-28, 2001 at Krishi Bhavan, Gandhi Nagar, Gujarat.
2003	Up gradation of Computer Facilities in Crop Development Directorate under DACNET Project of Department ofAgriculture and Cooperation.
2004	Third National Seminar on Millets: Research and Development Future Policy Options in India during March 11-12, 2004at Mandor, Jodhpur.
2010	Fourth National Seminar/Brain storming on Millets at Hyderabad.
2011	Initiatives for Nutritional Security through Intensive Millets Promotion 2011 Accelerated Fodder Development Programme
2013	Inclusion of Coarse Cereals under Food Security Bill

2013	Inclusion of Coarse Cereals under National Food Security Mission during XII Plan w.e.f.2014-15
2017	NITI Aayog of Government of India Releases the National Nutrition Strategy for Nourishing India and Recommends that the Ministry of Agriculture and Farmers Welfare Strengthen Cereal Productivity and Production diversity – including the production of Coarse Cereals such as Millets
2018	Millets Officially Declared as Nutri-cereals
2018	Government of India Declared as the National Year of Millets (NITI Aayog, 2018)
2018	The Indian Government Launched the Sub-mission on Nutri-cereals under NFSM with an outlay of Rs. 300.00 crore for 2018–19
2018	Government of India has sent a Proposal to United Nations for declaring 2023 as the International Year of Millets to Promote Greater Production and Consumption of Millets
2021	UNGA approved and Declared 2023 as the International Year of Millets 2023 Celebrated International Year of Millets

Source: Anonymous (2014) and Dayakar Rao et al., (2021)

INTERNATIONAL YEAR OF MILLETS (2023)

On the occasion of 2023 being declared as the International Year of Millets, Prime Minister Narendra Modi said, “Millets are good for the consumer, cultivator and climate. They are a rich source of balanced nutrition for consumers. They benefit cultivators and our environment since they need lesser water and are compatible with natural ways of farming.” He added “Raising awareness to create 'Millet Mindfulness' is an important part of this movement. Both institutions and individuals can make a tremendous impact. While institutional mechanisms can encourage production of millets and make it profitable via policy initiatives, individuals can make health-conscious and planet-friendly choices by making millets a part of their diet.”

EPILOGUE

Sorghum and millets being important staples in the semi-arid tropics of Asia and Africa for centuries are still the principal sources of energy, protein, vitamins and minerals for millions of the poorest people in these regions. These crops are grown with limited water and nutrient usually without application of any fertilizers or other inputs by a multitude of small-holder farmers in harsh environments where other crops grow or yield poorly. Because they are mostly consumed by disadvantaged groups, they are often referred to as "*coarse grain*" or "poor people's crops". They are not usually traded in the international markets or even in local markets in many countries. The farmers seldom, therefore, have an assured market in the event of surplus production. There is need to improve the productivity and production, availability, storage, utilization and consumption of these food crops to ensure household food security and nutrition of the poor inhabitants of the semi-arid tropics. The productivity of these crops can be increased by adopting recommended package of practices. Being less water and nutrient demanding crops, they will also help protecting the environment. Even though coarse cereals are consisted of valuable macro and micronutrients, they have still the secondary importance. This is the right time to change the name of these nutritious grains as *“Nutri-Cereals”.*

Conclusion

Millets are commonly cultivated under rainfed conditions and are considered as a staple diet for the people living in the dryland regions. These crops sustain the lives of the poorest rural people and will continue to do so in the foreseeable future. Sorghum and millets grow in harsh

environments where other crops do not grow well. Improvements in production, availability, storage, utilization and consumption of these food crops will significantly contribute to the household food security and nutrition of the inhabitants of these areas. As these crops have less water and less nutrient demand, will help protect the environment.

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DECISION-MAKING IN AGRICULTURE USING MACHINE LEARNING MODELS

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Indian Agriculture: past and present scenario

Agriculture is a prime occupation for at least 75% of the population in India. Being an agrarian state, Indian agriculture has greatly transformed over a period of time in terms of achieving self-sufficiency in food production. The production of food grains in India during 1950-51 was 50.8 million tons, and gradually from the 1960s onwards, India witnessed a significant shift in the production of food grain with a series of revolutions, and the Green Revolution was one of the greatest game changers. During 2021-22, India produced a record 314.5 million tons of food grain to the tune of over 500% increase in comparison with the production of 1950-51 (TOI, 2022). Through the green revolution, various high-yielding varieties of staple crops were introduced and subsequently helped in achieving self-sufficiency in food grain production. Earlier, before the green revolution, Indian farmers were cultivating crops using conventional agricultural practices relying less on chemical fertilizers. The farmers mainly used courtyard manures and crop waste to enrich nutrients in the soil. The indigenous soil microbiots were well flourished and conserved adding fertility without harmful residues. Gradually, since the 1960s, the use of chemical fertilizers and pesticides has drastically increased to meet the crop production of the fast-growing population. As a consequence of the indiscriminate use of agrochemicals, led to unprecedented environmental disturbances and most challenging health issues. The agriculture fields were also one of the contributors to the greenhouse gases. Despite various challenges, Indian agriculture has seen tremendous resilience and produces sufficient food grain and other food groups to meet the needs of the growing population under the climate change scenario. The farmers are now becoming literate with respect to the use of various smart applications to monitor their crops like weather-based decisions on sprays to control pests, irrigation schedules, crop harvest, post-harvest handling, and market information.

How do machine learning models help decision-making in the agriculture sector?

The data-driven approaches in agriculture are becoming more popular in recent times. Advanced techniques such as artificial intelligence and machine learning will offer new prospects to progress agricultural productivity, efficiency, and sustainability. The machine learning (ML) models mainly operate on data-driven insights by analyzing the data and providing valuable inputs to monitor the crops in a real-time. ML models can be used for various applications in the field of agriculture such as crop modelling through simulations, soil health monitoring, water management, weed management, disease management, and precise use of chemical fertilizers and breeding aspects. On the other hand, deep learning models (DL), work efficiently when dealing with complex data and provide valuable insights to improve agricultural production. DL mainly helps in the precise analysis of images for pests, disease detection, and analysis of weed management, time series analytics,

genomics, and language processing. Recent literature surveys confirm that the majority of the ML/DL applications were mainly intended for crop management (68%), while 10% on soil management, 10% on water management, 12% on livestock management, and within crop management, the yield prediction was 20% and disease detection was about 19%. Out of fifty contributing countries in the use of ML in agriculture, china was the highest with 24.9%, India was about 10.1% and Africa was the least with 3%. A major contribution comes mainly from Asian countries (55%), The USA (20.7%) was the second highest after China, Australia about 9.5%, Spain 6.8%, Germany 5.9%, and Brazil, UK, and Iran about 5.62% (Benos et al., 2021).

Crop Management

ML models such as artificial neural networks (ANN) support vector regression (SVR), K-nearest neighbour algorithms (KNN), and random forest (RF) models were frequently used in yield prediction. These models use large data and try to predict the yield more precisely and to measure the accuracy RMSE, R square may be used. Yield prediction will give farmers great insight into the extent of production from the field at different crop stages so that the farmer can also make decisions to improve the yield of the crop. It also helps in making decisions on profit-making with available market scenarios and in moving produce to a better market to earn a better income. This activity will ensure farmers a stable income and reduce the economic burden (Manendra et al., 2023).

Pest, Disease, Weed management and Quality produce

Convolutional neural networks (CNN) are used for the disease classification tasks from the complete multi-crop dataset. CNN has shown its capability in the industry, particularly for assessing plant visual symptoms, pest incidences, pest load, and detection of weeds (KD Nuggets, 2023, Bal and Fatih, 2021). Apart from CNN, the SVM, ANN, and RF models were used for this purpose in order to take quick actions such as timely sprays, weed removal, and other plant protection measures so that the yield of the crop remains unhurt. High-quality agriculture products fetch better prices at the markets and the quality of the crop is mainly determined by the soil nutrients, cultivation practices, weather conditions, and crop characteristics. ML algorithms such as RF, ANN, CNN, and SVM were able to assess the quality of the produce and provide a quick guide regarding harvesting and storage strategies to safeguard the quality of the produce.

Irrigation, Soil and Weather management

Irrigation management is one of the most important tasks in agriculture, and ML models like RF, SVM, LSTM, and deep networks were commonly used for this. These models can be used to assess the need for irrigation in the field and water quality. These models can able to assess the moisture stress problem in the crops and accordingly water requirement at different stages. This activity will help the farmers work remotely to schedule the irrigation to the crops so that the crops will help to solve the water stress problem and help the crop to produce better yields.

Soil management with respect to soil properties, soil health, nutrients, spatial variability, and suitability would be very important to generate better yields. ML will also help in analyzing the different soil parameters when it is analyzed with the spatial images and it provides valuable insights to understand the suitable crops for the soil. Models will help in assessing the fertilizer requirement of the crop at different growth stages as per the soil nutrient status. CNN's, RF models were mainly used for this purpose and this will help in quality production. Weather prediction in recent times yielded better crop management and now farmers can able to use weather predictions

and make decisions on land preparation, sowing dates, irrigation schedules, plant protection schedules, intercultural operations, weed management, harvesting dates, post-harvest management strategies, and marketing of the produce. ML models such as RF, ANN, LSTM, SVM, and Naïve models were widely used for accurate weather predictions (Baburao et al, 2023).

Conclusion

In the view of broad spectrum of agriculture and environmental sustainability, the ML models facilitate various management strategies. Global convergence research which mainly focuses on knowledge sharing across disciplines will have a positive impact on society and it includes improvement of environmental footprint and ensuring human well-being. In this direction, ML in agriculture has a considerable potential to create value. An ML technique along with necessary IoT equipments, drones, and GIS is a way of creating precision in agriculture. We discussed in brief about applications of ML under broad categories such as crop management, irrigation, soil and weather management, pest, disease, weed management, and quality produce. ML models such as support vector machines (SVMs), convolution neural networks (CNN), random forest (RF), K-nearest neighbour (KNN), K-means clustering, XGBoost, and AdaBoost were extensively used in the agricultural sector in order to make decisions in day to day agricultural practices.

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SMART AUTOMATION IN AQUACULTURE: RECENT ADVANCEMENTS AND FUTURE PROSPECTIVE

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Abstract

With the continuous development of science and technology, intelligence and informatization in aquaculture has become a new trend. Smart aquaculture cannot only realize real-time monitoring, prediction, warning, and risk control of the physical and chemical factors of the aquaculture environment but can also conduct real-time monitoring of the characteristics and behaviours of the fish, which infers the changes of the aquaculture ecological environment. Smart automaton highlights different benefits for the aquaculture industries which includes monitoring and control systems, feeding operations, water quality managements, fish health assessment and harvesting processes. Smart automation includes the integration of artificial intelligence, robotics, Internet of Things (IoT), edge computing, 5G and advanced algorithms for real-time monitoring of fishes, efficient management of the water level and pumping functions, which ultimately leading to enhanced decision-making by liberating the manpower completely and realize the green and sustainable aquaculture. Smart Robotic systems equipped with vision-based sensors and robotic arms can accurately identify, sort, and harvest fish, minimizing stress and reducing labour-intensive manual operations. Additionally, advancements in automated data collection and management systems have enabled efficient tracking and analysis of production data, allowing optimization of processes, and improved overall farm management in aquaculture. While automation offers significant advantages, it also poses challenges related to initial investment costs, technical complexities, and potential job displacement. Moreover, there are ethical considerations regarding animal welfare and environmental impact that need to be addressed when implementing automation technologies in aquaculture. Therefore, by adopting and further developing these automation technologies, the aquaculture and fisheries sector can overcome operational challenges, improve profitability, and contribute to the high-quality production by providing valuable reference for promoting the smart, ecological and efficient development of the sector.

Introduction

Aquaculture, the farming of aquatic organisms such as fish, crustaceans, molluscs, and aquatic plants, is one of the fastest growing food sectors in the world. As the human population continues to grow exponentially, the demand for seafood is also increasing rapidly. Aquaculture is helping to meet this increasing demand in a sustainable manner. However, aquaculture operations require constant monitoring and control of various environmental parameters to optimize growth and ensure the health of cultured species.

This extremely complex task of setting up and maintaining the aquaculture industry requires fine-tuning many variables to produce an optimal outcome. Technology integrated with efficient algorithms helps create a framework for the intelligent aquaculture industry. (Vo, Et.al 2021). Therefore, smart automation in aquaculture aims to apply smart modes which solves problems in traditional aquaculture.

Recent advancements in sensors, monitoring equipment, and control systems are facilitating increased automation of aquaculture systems. Water quality sensors can continuously monitor parameters such as dissolved oxygen, pH, temperature, and salinity. Cameras and computer vision techniques enable monitoring of fish behaviour and growth. All of these sensors and monitoring systems are connected to control systems that can automatically control factors such as water flow, aeration, feeding, and lighting based on the sensor data. Automated feeding systems can provide fish with optimal feed amounts at the right times based on fish growth stage and environmental conditions. Automated grading and harvesting systems can efficiently handle and process fish once they reach market size. (Lloyd Chrispin 2020). Smart automation technologies are enabling aquaculture farms to gain more control and improve efficiency.

While automation is enabling increased efficiency, control, and productivity of aquaculture operations, there are challenges to overcome. Automation equipment can be expensive, especially for smaller scale farms, although costs are coming down over time. There is also a learning curve for farmers to understand and utilize these advanced systems. Data connectivity and management is another issue, as many aquaculture farms are located in remote areas.

The future of smart automation in aquaculture is promising. Advancements in artificial intelligence, edge computing, and 5G connectivity will enable new capabilities such as predictive analytics to optimize system control and gain valuable insights. Robots may take over dangerous and repetitive tasks such as net cleaning and harvesting. Drone and satellite monitoring could provide aquaculture farms with real-time data on environmental conditions over large areas.

Automation Function in Aquaculture

Table 1. Function of automation in aquaculture.

	Predict	Automate
Water	Water Quality Threats	Aeration, Water Quality measures
Health	Disease Outbreaks	Predicts Parasites, symptoms, monitor disease and health
Production	Forecast Growth	Estimation of Biomass, Feed Optimization, Counting

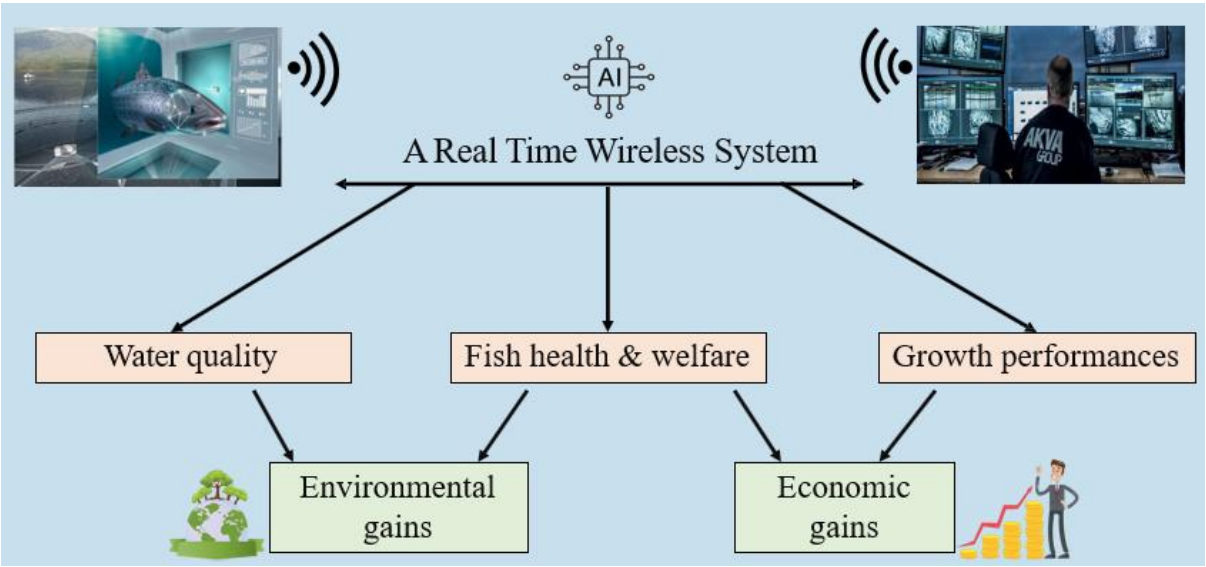

Fig. 1. System of Automation in Aquaculture

Body

Smart aquaculture systems use sensors, actuators, and intelligence technologies to provide an automated and sustainable system for raising aquatic organisms. These systems involve the use of sensors and other technologies to control factors such as lighting, pH balance, temperature, and oxygen levels, as well as the size and density of the population of organisms in the tank.

Technologies in Automation

❖ **Water Quality monitoring**

Sensors can monitor important water quality parameters like pH, dissolved oxygen, temperature, nitrite and ammonia levels (Nguyen et al., 2022). Machine learning models can analyse the sensor data to detect abnormal conditions and predict future changes (Nguyen et al., 2022). This allows farmers to proactively adjust aeration, feeding and water treatment to maintain optimal conditions for fish growth.

Intelligent fish farm collects water quality information using sensors.
Regulated by: fertilizing and spraying chemicals on unmanned boat.

Long-time accurate detection of aquaculture water quality parameters provides a reliable data source for automatic control and intelligent decision-making of intelligent fish farm.

The detection of DO mainly includes the Clark electrode method (Tai et al., 2016).

Advantages

- Fast response time
- Stable measurement results
- Low maintenance (Tai et al., 2016).

❖ **Feed management**

AI systems use data from sensors, cameras and fish behaviour to optimize feeding schedules and amounts (Vásquez-Quispesivana et al., 2022). Factors like fish size, activity levels and water conditions are taken into account to ensure fish receive the right amount of feed (Vásquez-Quispesivana et al., 2022). This improves feed efficiency, reduces waste and minimizes environmental impacts.

Automatic feeding system in some developed countries such as Norway, Japan, and the United States has entered the application stage, which has achieved accurate controlled feeding (Wang et al., 2021).

Reduces FCR: Reduces FCR by 30%, profit margins will only go upwards! (Davis et al., 2018).

Advantages

- Appetite Based Intelligent Feeding
- Superior Production Performance
- 24 x 7 Feeding System
- Reduced Feed Wastage
- Homogenous Growth
- Less Pollution

❖ **Disease detection**

Machine vision systems use cameras and image processing algorithms to detect diseases and abnormalities in fish. They can identify symptoms like skin lesions, deformities, and discoloration that indicate diseases (Vo et al., 2021). This allows farmers to intervene early before diseases spread. The same systems can also sort fish by size, weight and quality for more efficient sale and harvest (Vo et al., 2021).

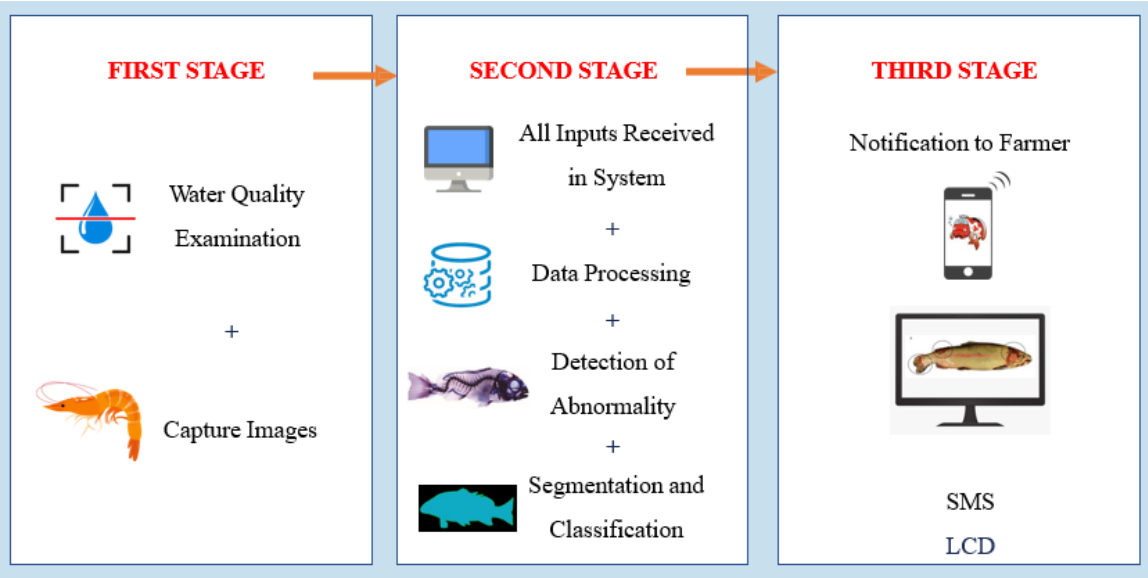

Fig. 2. Process of health management with the help of automation.

Advantages

- Early Detection of Diseases.
- Regular behaviour check-up.
- Early warnings notifications.

Future Prospective

- As machine learning, computer vision, IoT, and robotics technologies continue to improve, they are likely to play an even greater role in automating aquaculture farms and optimizing production. Areas of potential future development include:
- Fully automated fish tracking and behaviour analysis to optimize stocking density and welfare.
- Advanced disease detection using deep learning models trained on large datasets.
- Fully automated aquaculture systems controlled by AI with minimal human intervention.
- Use of drones and autonomous underwater vehicles to monitor aquaculture ponds.
- Integration of blockchain and cloud technologies for traceability and remote farm management.

Benefits of Automation in Aquaculture

- Origin of production close to the market demand
- Improved environmental control
- Reduced losses caused by major disasters
- Reduced management environment
- Lower production costs
- Improved aquatic product quality
- Reduced costs of production
- Reduced energy consumption
- Reduced staffing
- Reduced workload
- Reduced control
- Increased overview

- Increased security
- Increased fish welfare

Conclusion

Smart automation and intelligence systems have the potential to transform aquaculture by improving yields, reducing costs, and promoting sustainability. Recent technological advancements are enabling greater automation, but high costs currently limit adoption. As technologies continue to improve and costs decline, smart aquaculture systems are poised to play an increasingly important role in meeting the world's growing demand for seafood.

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DRONE AND INSECT-PEST MANAGEMENT BY DRONE : AN OVERVIEW

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Abstract
Drones are semi-automated devices with the potential to become fully automatic in the near future, which has enormous consequences for agricultural planning and pest management.

The pest management drone-mediated technologies show great potential and offer a promising alternative to traditional pest management approaches. They should be widely supported for their effective use as a component of integrated pest management practices in Indian agricultural research and technology development.

Introduction
Drones or miniature unmanned aerial vehicles, have a number of advantages over traditional aircraft, including great efficiency, a reduction in labour costs, the ability to cover a large area quickly, the ability to save time and energy, and environmental safety. (Meng et al., 2018; Shamshiri et al., 2018).

A decline in the world's output of food grains is mostly a result of the biotic stressors produced on by pests and diseases, which are well recognized to cause severe damage. The crops grown in India are currently under threat from invasive alien pests like fall army worm (*Spodoptera frugiperda* J. E. Smith) in maize and the rugose spiralling whitefly (*Aleurodicus rugiperculatus* Martin) in coconut, which have both recently caused considerable damage in 2018 and 2019. (Lal and Bikram, 2019).

Advancement in technology is required in this field because the current methods for applying pesticides and fertilizers take more time and are less effective. [FAO, 2018; Rolle et al., 2020].

Applications to control insect pests
1. Drone-mediated remote sensing : Drones can be fitted with either a hyper-spectral sensor, which has hundreds of narrow spectral bands, or an RGB (red, green, blue) sensor, which is a multispectral sensor having between 3 and 12 wide spectral bands.

2. Aerial photography with drones : Drone-captured images are sent to a cloud data centre where they are analyzed using spectrum analysis technologies to determine the extent of insect damage (Gao et al., 2020).

3. Insect pest sampling using drones : In order to provide an attractive force to attract insects that penetrate the electric field, a DD-screen (double-charged dipolar electric field screen) is attached with the drone. The caught insects are unable to escape the trap due to the electric field's strength (Takikawa et al., 2020).

4. Precision pesticide application using drones
5.Precision releases of natural enemies carried out by drones
6. Mating disruption and sterile insect technique (SIT) using drones

Benefits of Drone Use in Agriculture

Recent studies predict that by 2025, the global drone industry for agriculture would increase at a compound annual growth rate of 35.9% and reach $5.7 billion.

1. Analysis of soil and fields
2. Crop surveillance
3. Plantation
4. Animal management
5. Spraying crops

6. Examine crop health
7. Refrain from using too many chemicals
8. Be ready for weather issues
9. Track growth

Gains from using agri-drone

- Protection
- Effectiveness
- Water-wise
- Affordable and simple to maintain

Agri drones' limitations

- A connectivity problem
- Subject to the weather
- Subject to the weather
- Expertise and capacity

Here are some examples of how the best drone technology is applied:

• **Agriculture**. Crop height is measured and recorded by drones. They employ lidar remote sensing technology, which illuminates the crop with a laser and measures what is reflected back to compute

distance. This can support sustainable farming methods and assist farmers maximize agricultural production.

•**Biological surveillance**. Drones that have biological sensors travel to dangerous locations to breathe. Additionally, they have the ability to detect certain microorganisms and air components.

Conclusion

The pest management drone-mediated technologies show great potential and offer a promising alternative to traditional pest management approaches. They should be widely supported for their effective use as a component of integrated pest management practices in Indian agricultural research and technology development. Precision insect pest management strategies are increasingly including drones.

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LEVERAGING AI AND MACHINE LEARNING FOR SMART IRRIGATION SYSTEM MANAGEMENT

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Abstract

Water scarcity and sustainable water management are critical concerns in modern agriculture. Smart irrigation systems, powered by Artificial Intelligence (AI) and Machine Learning (ML) algorithms offer innovative solutions to optimize water usage and improve agricultural productivity. By leveraging real-time data from soil moisture sensors, weather stations and other sources, these systems make data-driven decisions to precisely deliver water to crops based on their individual needs. Customized irrigation strategies, remote monitoring capabilities and water use efficiency reporting empower farmers to make informed decisions and achieve higher crop yields. Additionally, the integration of smart irrigation data with broader crop management practices supports sustainable agriculture efforts by reducing water wastage, minimizing chemical usage and conserving natural resources. As the agricultural sector faces challenges from climate change and resource constraints, smart irrigation system management through AI and ML provides a sustainable and efficient solution to ensure food security and environmental preservation in the future.

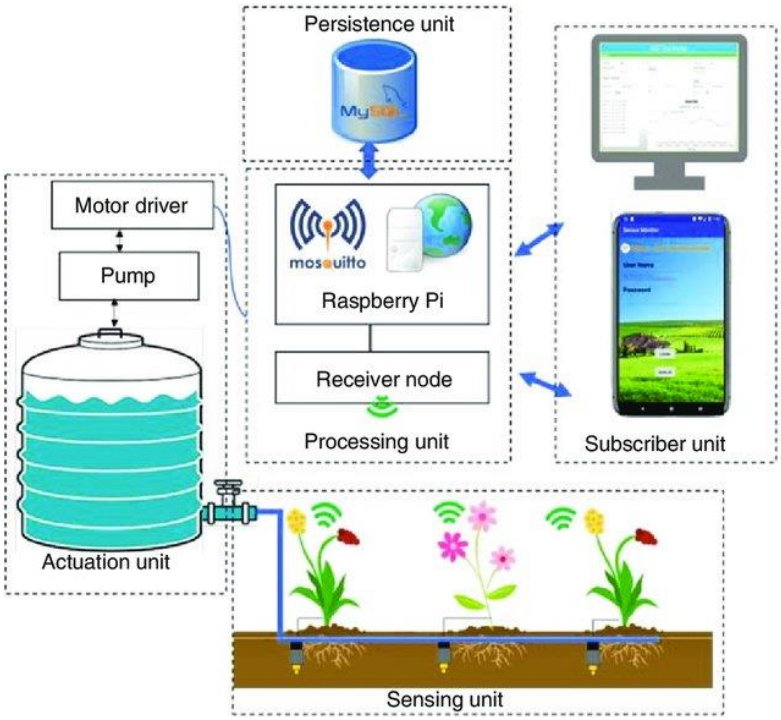
Introduction

Water scarcity is a growing concern in agriculture sector (Li *et al.,* 2018, Borsato *et al.,* 2020), with the traditional irrigation methods often leading to inefficient water usage and unsustainable practices (Mallareddy *et al.,* 2023). However, advancements in technology, particularly in the fields of Artificial Intelligence (AI) and Machine Learning (ML) are offering innovative solutions to address these challenges (Tace *et al.,* 2022; Velmurugan *et al.,* 2020; Blessy, 2021). Smart irrigation systems driven by AI and ML algorithms are revolutionizing the way water is managed in agriculture (Abioye et al., 2022). The Indian economy continues to receive significant support from its most crucial commercial fiber crop (Prajapati and Subbaiah, 2018). In arid and semi-arid regions, irrigated agriculture stands as the largest consumer of water (Parmar *et al*., 2023, Kunapara *et al*., 2016). Furthermore, remote sensing and GIS play a pivotal role in agriculture by providing valuable temperature estimation data (Parmar *et al.,* 2019). This technology has become extensively employed, enabling precise monitoring and analysis of temperature-related factors crucial for agricultural planning and decision-making. This article will explore the benefits and features of smart irrigation system management through AI and Machine Learning.

Understanding Smart Irrigation Systems

Smart irrigation systems go beyond traditional timer-based watering. Smart irrigation systems are technologically advanced solutions designed to optimize and improve the efficiency of irrigation practices in agriculture, landscaping, and other water-dependent industries (Obaideen *et al.,* 2022; Vallejo-Gomez *et al*., 2023; Talaviya *et al.,* 2020). It leverages real-time data and intelligent

algorithms to optimize irrigation schedules and water delivery to crops. Smart irrigation systems ensure that crops receive the right amount of water precisely when and where it is needed by various factors, including soil moisture levels, weather forecasts, evapotranspiration rates and crop water requirements (Obaideen *et al.,* 2022). These systems ensure that water is used in a more precise and controlled manner which leading to benefits such as water conservation, sustainable crop production and reduced operational costs (Ali *et a.,* 2023; Sharifnasab *et al.,* 2023). Predicting agricultural drought, which leads to substantial yield losses in major crops, is a more challenging task compared to assessing meteorological and hydrological droughts. This difficulty arises from the intricate interplay between crop genotype, soil moisture availability, and climate conditions (Pandya *et al.* 2022). The smart irrigation system consists of several interconnected components that work together to optimize water usage in irrigation field. The diagram of typical IOT- based smart irrigation is present following below.



IoT-Based Smart Irrigation System Diagram (Khriji *et al.,* 2021**)**

1. **Soil Moisture Sensors:** These sensors are buried in the soil at different locations to measure the soil moisture levels. They collect data about the moisture content and transmit it to the central system. The erratic fluctuations in soil-water potential can adversely affect crop productivity (Vadalia and Prajapati 2022).
2. **Weather Station:** A weather station collects real-time weather data, including temperature, humidity, and rainfall, from the surrounding environment. This data helps to adjust the irrigation schedule based on weather conditions.
3. **Controller Hub:** The central hub or controller processes data received from soil moisture sensors and the weather station. It calculates the irrigation requirements and sends control signals to the actuators.

4. Actuators: Actuators control the irrigation mechanisms. They can be connected to valves, pumps, or drip systems to release water into the fields or garden beds. The controller sends signals to the actuators to initiate or stop irrigation based on the analyzed data.
5. **IoT Gateway:** An IoT gateway is responsible for collecting data from various sensors and sending it to the cloud for further analysis. It acts as a bridge between the local network and the cloud.
6. **Cloud Platform:** Data from multiple IoT gateways is sent to the cloud platform, where advanced analytics and algorithms process the information. The cloud system can determine optimal irrigation schedules based on real-time and historical data.
7. **Mobile/Web Application:** Users can interact with the smart irrigation system through a mobile app or a web interface. They can monitor soil moisture levels, weather conditions, and control irrigation remotely.
8. **Communication Protocols:** The system uses communication protocols like Wi-Fi, cellular networks, or LoRaWAN to connect various components and transmit data.
9. **Power Supply:** Components require a power source, which can be battery-powered, solar-powered, or connected to the electrical grid.

Overall, the IoT based smart irrigation system continuously collects data, processes it and adjusts the irrigation schedule to optimize water usage, conserve resources, and promote efficient plant growth.

Key components and concepts of smart irrigation systems

1. Sensors and Data Collection: The foundation of smart irrigation systems is real-time data collection. Soil moisture sensors, weather stations (temperature, humidity, wind speed), plant health indicators and even satellite imagery provide essential information about the current environmental conditions and crop health. These sensors continuously collect data and provide real-time information to feed AI and ML algorithm. AI and ML algorithms process this data to create a comprehensive picture of the field's water needs, enabling timely and targeted irrigation decisions.

2. Data Analysis and Decision-Making: AI and ML algorithms play a pivotal role in optimizing irrigation schedules. By analyzing historical data, these algorithms can identify patterns and trends related to crop water requirements, weather patterns and other variables. The system then uses this knowledge to predict future water needs and adjust irrigation schedules accordingly. This data-driven decision-making process enhances irrigation efficiency, conserves water and promotes sustainable agricultural practices.

3. Automation and Control:

One of the significant advantages of smart irrigation systems is their ability to deliver water with precision. Rather than uniformly applying water to an entire field. These systems can target specific areas based on their unique water requirements. This targeted approach minimizes water wastage, reduces runoff and prevents overwatering. This will ensure that crops receive optimal moisture levels for healthy growth.

4. Integration with IoT and Automation

Smart irrigation systems are often integrated with the Internet of Things (IoT) devices and automation technology. IoT sensors continuously monitor soil moisture, weather conditions, and other relevant parameters, relaying the data to the central AI system. Automation allows the system

to adjust irrigation schedules and control water delivery without human intervention. Farmers can remotely access and manage the system through mobile applications, ensuring real-time monitoring and control from anywhere.

5. Water Conservation and Cost Savings

By maximizing irrigation efficiency and reducing water wastage, smart irrigation systems contribute significantly to water conservation efforts. With water being a precious and often limited resource in agriculture, these systems help farmers use water more responsibly and sustainably. Global warming further compounds the water-related challenges, as the evaporation rate is anticipated to rise, leading to drier conditions on the ground and increased water vapor in the atmosphere over time (Pandya and Gontia, 2023). Mulching reduces input costs, increases yields, enhances water productivity, and minimizes the risk of yield reduction during dry spells between irrigations (Prajapati and Subbaiah, 2019). Mulching emerges as a highly effective approach in conserving water resources (Prajapati and Subbaiah, 2015). Moreover, reduced water usage leads to cost savings on water bills, making smart irrigation systems an economically viable and environmentally friendly choice for farmers.

6. Climate Adaptability

Climate change introduces unpredictability in weather patterns, posing challenges to traditional irrigation methods. Smart irrigation systems backed by AI and ML are adaptable to changing climate conditions. The algorithms can quickly analyse real-time data and adjust irrigation schedules to suit the evolving weather patterns, ensuring that crops are adequately watered despite climate fluctuations.

7. Customized Irrigation Strategies

Smart irrigation systems can be tailored to specific crop types, soil conditions and microclimates. The ability to customize irrigation strategies based on the unique requirements of each crop allows farmers to achieve optimal growth and yield outcomes. Whether it's adjusting the irrigation frequency for drought-tolerant crops or providing more water to moisture-sensitive plants. Extremely high temperatures that develop later in the season under row covers can also reduce production of crops like tomatoes and peppers. Altering the land configuration offers a promising avenue to enhance both water use efficiency and minimize soil erosion in field crops (Vadalia *et al.* 2022). The smart irrigation systems offer flexibility to cater to diverse agricultural needs.

8. Remote Monitoring and Alerts

AI and ML-driven smart irrigation systems come with remote monitoring capabilities, providing farmers with real-time insights into their fields. Through mobile apps or web interfaces, farmers can access data on soil moisture levels, weather forecasts, and system performance from anywhere at any time. Additionally, these systems can send alerts and notifications in case of abnormalities or deviations from the desired parameters, enabling prompt action to address potential issues.

9. Water Use Efficiency Reporting

Smart irrigation systems generate detailed reports on water usage and irrigation efficiency over time. These reports provide farmers with valuable insights into their irrigation practices, helping them identify areas for improvement and make informed decisions to optimize water use. By tracking water use efficiency metrics, farmers can measure the impact of their sustainable irrigation efforts and work towards achieving higher water use efficiency in their agricultural operations.

Data-Driven Crop Management

Beyond irrigation, the data collected by smart irrigation systems can be integrated into broader crop management practices. AI and ML algorithms can analyze the data to provide recommendations on fertilization, pest control, and other agronomic practices. By combining various agricultural data sources, such as soil data, weather data, and crop health data, farmers can implement more holistic and data-driven approaches to crop management, leading to improved overall productivity.

Supports for Sustainable Agriculture

Smart irrigation systems align well with sustainable agriculture practices. By optimizing water usage, minimizing runoff, and reducing the application of fertilizers and pesticides, these systems contribute to environmental conservation and the preservation of natural resources. As the agricultural sector faces increasing pressure to adopt sustainable practices, smart irrigation systems offer a key component in achieving these goals.

Crop Health and Yield: Precise irrigation based on accurate data leads to healthier plants and increased crop yields. Over-watering can lead to root rot and other diseases, while under-watering can stunt growth and reduce yields.

Environmental Impact: Smart irrigation systems contribute to environmental sustainability by reducing water wastage, minimizing soil erosion, and preventing runoff of fertilizers and pesticides into water bodies.

Adaptability: These systems can be adapted to various scales, from small residential gardens to large agricultural fields, and can be customized for different types of crops and vegetation.

Challenges: Implementation of smart irrigation systems may require an initial investment in hardware, sensors, and software. Additionally, accurate data collection and algorithm development are essential for optimal performance.

Conclusion

Smart irrigation system management through AI and Machine Learning is revolutionizing sustainable agriculture by utilizing real-time data, AI-driven decision-making, and precise water delivery to enhance irrigation practices. This approach leads to heightened crop yields, reduced water consumption, and economical advantages. The integration of customizable irrigation strategies, remote monitoring, and data-driven crop management further amplifies these benefits. As technology advances, smart irrigation systems are poised to play a pivotal role in fostering a resilient and eco-conscious agricultural future, safeguarding both food security and the environment.

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STRATEGIES TO IMPROVE BODY PROTEIN RETENTION IN FISH

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Abstract
Protein retention in fish is a critical factor for successful aquaculture. Proteins serve multiple essential functions in the body, serving as both a source of energy and vital nutrients for growth and reproduction. Quality of feed, quality and quantity of protein, feeding management, feeding ration, nutraceutical, feeding frequency, and optimum environmental culture conditions parameters enhance the protein retention. In this review, we discuss the key factors that influence protein retention in a fish's body, such as stocking density, water quality, temperature, and salinity.

Keywords : Aquaculture, dietary protein, feeding management, Feed additives, nutrients

Introduction

Proteins consist of chains of amino acids connected by peptide bonds. They play a crucial role in the fish diet, supporting growth, reproduction, and survival, as indicated by Wilson and Halver in 1986. Inadequate protein levels in fish diets can lead to reduced growth.

The amount of protein in the diet is the most significant factor influencing fish growth and the cost of feeding. In aquaculture, feeding expenses typically account for 50-70 percent of total operational costs. Therefore, reducing dietary protein levels without compromising fish growth can substantially lower the cost of fish feed. Many fish species have specific dietary protein requirements to ensure they receive enough amino acids for optimal growth. If the diet contains excessive protein, only a small portion is used for growth, while the rest is converted into energy, resulting in increased feeding expenses and ammonia production. It is crucial to find the right balance in dietary protein inclusion from both economic and environmental perspectives and to enhance protein utilization for tissue development rather than energy production.

Proteins are continually broken down and replaced in the body, with a turnover time of around 24 hours. Maintaining optimal protein retention in fish bodies is fundamental for successful aquaculture.

Protein Retention

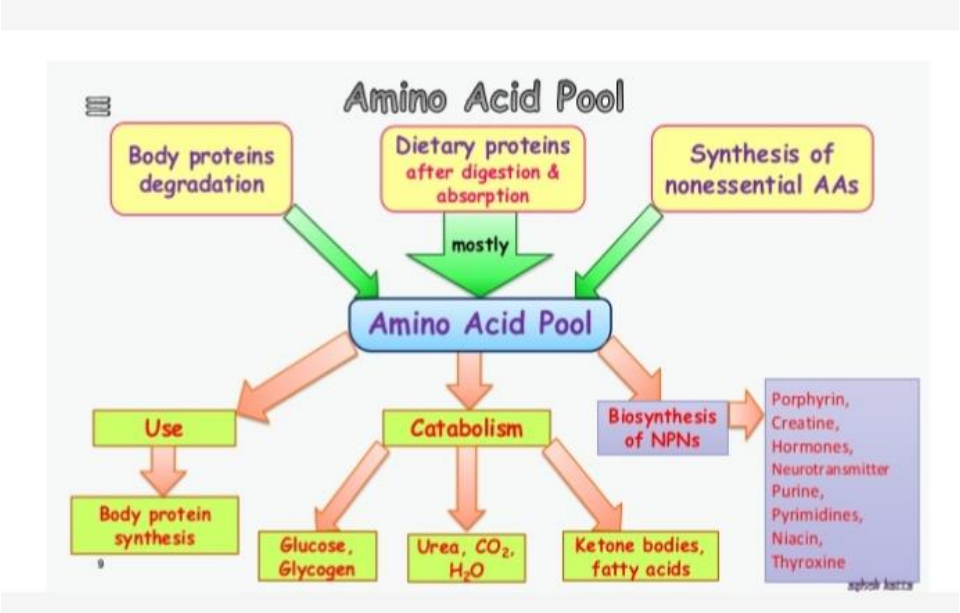
The quantity of protein retained in the body over a specific time frame directly serves as an indicator of the animal's growth performance.

Protein Retention determined by a number of endogenous and exogenous factors

- Feed intake

- Dietary protein and energy
- Dietary amino acid levels
- Life stage of fish
- Feed quality
- Feeding management
- Environmental conditions
- Genetically controlled rate of protein turnover (degradation)
- Dietary amino acid bioavailability

How to improve the protein retention:-



1. Quality of ingredients

A variety of raw materials can be used to create fish feeds, addressing deficiencies in amino acids and vitamins. In addition to their nutritional content, these ingredients have functional qualities, like water absorption and pellet binding, which greatly influence the production and physical quality of feed pellets. The use of top-quality ingredients rich in complete proteins improves the retention of protein in the animals. It's important to highlight that animal proteins tend to have superior retention compared to plant proteins, especially when dealing with less digestible and imbalanced plant protein sources, which can lead to reduced retention.

2. Protein Energy ratio

The deposition of protein in the body is influenced by the balance of available amino acids in the protein and the ratio of digestible protein to digestible energy (DP/DE ratios). A low DP/DE ratio can lead to reduced protein intake and slower growth, while a high ratio can cause stress due to ammonia pollution, hindered growth, and economic inefficiency.

Excessive energy intake coupled with low protein levels can result in the deposition of lipids as stored energy, but this doesn't necessarily translate to faster growth. Many commercial feeds today are formulated to enhance growth performance by leveraging the protein sparing effect of a high-energy lipid diet. This approach allows a greater proportion of dietary protein to be converted into muscle protein, promoting more efficient growth.

3. Quality and quantity of dietary protein:-

The quantity and quality of dietary protein are factors that influence nitrogen excretion.

Protein quality is largely determined by

- Ideal protein concept
- Amino acid profile
- Digestibility of protein
- Cost effectiveness
- Biological value
- Net protein utilisation

Biological value

This metric quantifies the percentage of absorbed protein from a food source that is utilized in building the organism's body proteins. Biological Value (BV) is determined using the formula:

BV = (Protein accretion / Protein absorbed) × 100.

It's important to note that dietary protein that cannot be broken down into its constituent amino acids and absorbed in the gastrointestinal tract is excreted in the feces, contributing to nitrogen losses in the fecal matter.

Net protein utilization (NPU)

This concept is also referred to as protein retention. Net Protein Utilization (NPU) provides a more reliable measure of feed quality compared to the Protein Efficiency Ratio (PER). NPU is calculated using the formula:

NPU = (Nitrogen retained / Nitrogen intake) × 100.

4. Digestibility of nutrients

Utilizing more easily digestible nutrients in extruded feed can enhance the feed conversion ratio, improve starch gelatinization, thereby increasing energy utilization, and enhance pellet characteristics, including durability and buoyancy.

5. Feed formulation

Feed formulation is the procedure of precisely determining the specific feed ingredients to be mixed or blended together to create a feed with the necessary nutrients and energy for animals, including fish. No single ingredient can be expected to fulfil all the nutritional requirements of cultured organisms. Through the careful selection of various ingredients in the right proportions, a compound mixture that is nutritionally balanced, appealing to the animals, and easy to store and handle can be devised. Inadequate feed formulation can lead to issues such as poor nutrient retention, caused by factors like indigestible ingredients or an inadequate protein-to-energy ratio.

6. Mixed feeding schedule

Employing a mixed feeding schedule that alternates between a low protein diet and a high protein diet has shown improved growth, feed utilization, and overall production when compared to continuous feeding with a high protein diet. This approach is seen as a potential means of cost reduction. The mixed feeding schedule, which involves both low and high protein diets, has been found to result in increased nitrogen retention and reduced nitrogen loss in carp and tilapia. This suggests that fish may not require a consistent daily intake of nutrients, as there are rhythmic metabolic activities at play.

7. Supplementation of additives and nutraceutical

Feed additives encompass both nutritive and non-nutritive substances, whether natural or synthetic, that are introduced in small quantities to enhance the nutritional value of a diet, thus improving feed consumption and nutrient utilization. Certain specialized additives, along with nutraceuticals (combining nutrients and medicinal properties), have the potential to enhance protein retention in fish. Moreover, lysine, as an amino acid, is efficiently utilized for building body protein, which can boost protein synthesis and deposition while reducing nitrogen losses. The incorporation of small amounts (less than 2%) of nutraceuticals, like plant extracts, can be beneficial for enhancing the growth of aquatic organisms.

8. By removing antinutritional factors

Food and feed items can contain various antinutritional elements that can negatively impact the digestibility of proteins and the availability of amino acids. These antinutritional factors can occur naturally, such as glucosinolates in mustard and rapeseed protein products, trypsin inhibitors and haemagglutinins in legumes, tannins in legumes and cereals, phytates in cereals and oilseeds, and gossypol in cottonseed protein products. The presence of these antinutritional factors can lead to significant decreases in the digestibility of proteins and amino acids.

9. Feed and feeding management

Optimize the storage duration for various feed types, e.g., store pelleted feed for less than 3 months. Ensure high stability and quality during storage and transport, minimizing moisture and fungal risks. Keep feeds free from physical, chemical, and biological hazards, like stones, pesticides, and pathogens.

10. Feed storage conditions

The ideal temperature range for storing feed is between 22 and 30 degrees Celsius. To prevent feed browning caused by the Maillard reaction due to a lack of available protein, it is essential to maintain humidity levels in storage below 75%. Additionally, the moisture content of the feed should be kept below 10% to prevent fungal growth and the risk of aflatoxin infection in fish. This is crucial for promoting healthy protein retention and fish growth.

11. Ration size

The protein requirements of fish can be affected by several nutritional factors, with ration being one of them. It is essential to adapt the feeding ratio based on various factors such as the fish's health, stocking density, and biomass. Growth reduction can occur as a result of both overfeeding and underfeeding, leading to nutrient loss and insufficient feed availability. Small fish typically require a standardized feeding ration of 4-8%, while grow-out fish thrive with 3%. To enhance protein retention, the check tray method can be employed, adjusting the feeding ratio according to the culture stage, stocking density, and culture system. Placing 4-6 check trays per hectare can yield improved results.

12. Feeding frequency

Feeding frequency refers to the number of meals provided to fish each day. The impact of feeding frequency on growth rate can differ among species. In many cases, increasing the feeding frequency does not lead to decreased growth rates and may even result in improved growth rates. The recommended feeding frequency typically ranges from 4 to 6 times daily, depending on the life stage of the fish.

13. Processing strategies

Diets with comparable levels of crude protein, but varying in protein sources or subject to different types of processing, can yield distinct outcomes in terms of retention performance.

14. Environmental factors

Environmental factors, including stress, stocking density, water quality, temperature, and salinity, have a significant impact on protein retention in fish. When stocking density exceeds the maximum capacity of a pond or water body, it can result in water quality deterioration and stress among the aquatic animals, ultimately leading to reduced growth.

Implementing effective management practices within the culture system is crucial to prevent stress-related diseases, deterioration of water quality, and other adverse effects. Such measures help enhance protein retention in the fish's body, promoting healthier and more productive aquaculture.

Functions of protein

Proteins serve multiple essential functions in the body, serving as both a source of energy and vital nutrients for growth and reproduction. Some proteins have a structural role, acting as components of supportive tissues, such as collagen and elastin. Proteins also function as precursors for important hormones and enzymes, including growth hormone and GnRH (Gonadotropin-Releasing Hormone).

In addition, proteins play a crucial role in transportation within the body, with examples including hemoglobin, lipoproteins, sodium-potassium pumps, and glucose transporters. They are also integral to the body's defense and immune systems. Furthermore, proteins are involved in the regulation of movement and muscle contraction, exemplified by proteins like actin and myosin.

Conclusion

Quality of feed, quality and quantity of protein, feeding management, feeding ration, nutraceutical, feeding frequency and optimum environmental culture conditions parameters enhance the protein retention.

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